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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

The organizing committee has selected a total of 400 contributions divided into 15 different areas of interest:

• Part A:

- mathematics
- physics
- informatics and automation engineering
- electrical engineering and instrumentation
- materials engineering

• Part B:

- mechanics and thermodynamics
- mechanical engineering
- production systems, technology and technological processes automatisation
- energetics and power engineering
- nuclear engineering
- chemistry
- biomedical engineering
- civil engineering
- architecture, town planning, geodesy and cartography
- transportation, logistics, economy and management

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Section 1

MATHEMATICS

Algebraical and Combinatorial Properties of Nonstandard Numeration Systems

P. Ambrož, Ľ. Balková, J. Hlinka, P. Kocábová, E. Pelantová

ampy@linux.fjfi.cvut.cz

Department of Mathematics, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

The theory of nonstandard numeration systems has many applications in various fields of the mathematics; e.g. in the mathematical modeling of quasicrystals and in the description of associated physical phenomena, further in the development of wavelets adapted for the models of quasicrystals and also in the design of aperiodic random numbers generators. In this project, we studied several different open problems more or less connected with the representation of real numbers in nonstandard systems.

Systems of β-numeration. Birth to the whole field of β-numeration was given by the works of A. Rényi [4] and W. Parry [3]. They (among others) showed that for an arbitrary number $\beta > 1$ any real number x may be represented in the polynomial numeration system whose base is given by $(\beta^i)_{i\in\mathbf{Z}}$, that is in the form of a power series in β with integer coefficients. Obviously, when β is chosen to be an integer, we get nothing but the usual representation in the classical numeration systems (e.g. binary or decimal system).

On the other hand, if we allow β being an irrational number, the situation changes dramatically. First of all, a real number may have more than one representation is such system; to avoid problems related with this fact, one particular among these representation is chosen to play the supreme role – it is the greatest one in the lexicographical order, called β-expansion (sometimes called also greedy expansion, because it is generated by the greedy algorithm). Further, the set of β-integers, i.e. of the numbers with the β-expansions of the form $x_k\beta^k + \cdots + x_1\beta + x_0$, is not closed under arithmetic operations. Hence the first interesting problem connected with these numeration systems is to provide (or least estimate) the values of $L_+(\beta)$ and $L_\times(\beta)$, which denotes the maximal number of fractional digits that can arise under addition respectively multiplication of β-integers. Moreover, the elements of the set of β-integers are not uniformly distributed on the real line – there is more than one possible gap between the neighbours. The sequence of these gaps between β-integers forms an infinite word, denoted u_β. The combinatorial properties of the word u_β are another often studied question. Strictly speaking, one usually investigates the subword and palindromic complexity of u_β, that is the functions counting for given n the number of different factors, respectively palindromic factors, of the length n in u_β.

Using the method proposed by Guimond et al. [2], we found quite reasonable estimates on the values of $L_+(\beta)$ and $L_\times(\beta)$ for the β-numeration systems, whose base β is an algebraic integer with minimal polynomial $x^3 - ax^2 - x - 1$, where $a \in \mathbf{N}$, $a \geq 2$. We showed that the number of fractional digits arising under addition of β-integers is $5 \leq L_+(\beta) \leq 6$ for $a = 2$ and $5 \leq L_+(\beta) \leq 6$ for $a \geq 3$, whereas under multiplication it is $4 \leq L_\times(\beta) \leq 6$ for all $a \geq 2$.

Another β-numeration system we have dealt with, is the system given by the minimal polynomial $x^2 - ax + b$, where $a, b \in \mathbf{N}$ and $a \geq b + 2$. In this case we have improved the already known [2] upper bound on the value of $L_+(\beta)$, by proving that $L_+(\beta) \leq [a - 1/a - 1 - b]$, where [ ] denotes the upper integer part. Moreover we have established values of the

complexity function of associated infinite word u_β: $C(n) = n+1$ for $b = 1$ and $n+1 \le C(n) \le 2n$ for $b > 1$ and also of the palindromic complexity function $P(n)$.

Linear recurrent systems. Another example of nonstandard numeration systems are the systems given by an increasing sequence of nonnegative integers $(u_n)_{n\ge1}$. A positive integer *N* is in them represented as $N = d_k u_k + d_{k-1}u_{k-1} + \cdots + d_1 u_1$, where d_n are integer coefficients. A representative of this class of systems, which we have studied, is the system having as the base the so-called m-Bonacci recurrent sequence $(F_k^{(m)})_{k\ge1}$, given by $F_i^{(m)} = 2^{i-1}$ for $1 \le i \le m$ and $F_{k+m}^{(m)} = F_{k+m-1}^{(m)} + \cdots + F_k^{(m)}$ for $k \ge 1$. The coefficients in the representation are chosen to take values 0 and 1.

We studied the properties of the function $R^{(m)}(n)$ defined as the number of different representations of an integer *n* in the m-Bonacci numeration system. We gave a matrix formula for calculating $R^{(m)}(n)$ from the greedy expansion of *n*. We determined the maximum of $R^{(m)}(n)$ for *n* with greedy expansion of fixed length *k,* we showed that unlike the Fibonacci case (i.e. when $m = 2$) the values of the maxima of $R^{(m)}(n)$ are not related to the sequence $(F_k^{(m)})_{k\ge1}$ itself, and we also described the palindromic structure of the sequence $(R^{(m)}(n))_{n\ge0}$.

Alfa-adic numeration systems. The last considered family of nonstandard numeration systems is closely related to the firstly mentioned β-numeration. These so-called α-adic systems are obtained as polynomial systems $(\alpha^i)_{i\in\mathbf{Z}}$, where α is a real number in modulus smaller than one. Indeed the relation with β-numeration system comes from the fact that such number α considered is usually an algebraic integer, conjugate of $\beta > 1$, which defines a β-numeration system.

We focused on one particular irrationality of requested type, namely on the number τ', which is the algebraic conjugate of the well-known golden mean τ. We considered τ-adic expansions of positive integers, negative integers and rational numbers and we showed that they are either finite (in the case of positive integers) or eventually periodic to the left (all other studied cases). We also provided algorithms to generate these expansions from scratch. Finally, we proved a reformulation of a famous theorem by Bertrand [1], stating that a real number has an eventually periodic α-adic expansion if and only if it is an element of the extension field $\mathbf{Q}(\tau')$.

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NURBS Representation of Curves and Surfaces in MAPLE

I. Linkeová*, K. Kundrátová, M. Bartoň

Ivana.Linkeova@fs.cvut.cz

*Department of Technical Mathematics, Faculty of Mechanical Engineering,
Czech Technical University in Prague, Karlovo nám. 13, 121 35 Prague 2, Czech Republic

The NURBS representation of curves and surfaces is the very principal element CAD/CAM/CAE systems today. The most positive aspect of the NURBS representation is its ability to model conics and free-form curves precisely. To use this very effective tool appropriately, it is essential understand the principle of the method as well as the ways of modifying the shape of the modelled object. The project was mainly focused on developing a NURBS code for MAPLE that would allow explaining the principles of constructing NURBS representation and enable demonstrating practical applications of NURBS curves and surfaces.

By means of NURBS method it is possible to create a piecewise rational curve or surface, which fits a set of control points. The calculation of NURBS requires four elements – shape modifiers: a set of control points, which have to be fit, a degree of basic functions, a knot vector and the weight of each control point. In practice, very often the set of control points is only known. The degree of basic functions is chosen in dependence on required continuity of the resulting curve or surface. Knot vector is a set of parameter values that specify parameter intervals for the individual basic functions. Modifying the position of knots influences the knot spans and hence changes the shape of the curve. Weights express the contribution to the shape of the curve at each control point.

NURBS, a very used tool of modern computer geometry, stands for Non-Uniform Rational B-Spline, i.e. piecewise segments of the well-known Bezier's curves. The basic difference between B-splines and polynomial curves is as follows: Each control point of the B-spline curve is provided with a parameter expressing the measure of its influence upon the shape of the curve. This parameter is called weight and it is a nonnegative real number. The higher the weight, the more this point affects the shape of the curve (the more the curve or surface, respectively, is tightened to this point). Rational B-splines are parameterized by rational functions. A point where two segments are joined is called a knot and a sequence of knots is known as a knot vector. For uniform B-spline, the distances between two knots, defined as a difference of parameter values in the knots, are the same for all neighbouring knots; these distances differ for non-uniform B-splines. Depending on their knot vectors, three types of NURBS curves (surfaces) are distinguished: clamped, which interpolate the endpoints, open and closed, where startpoints and endpoints are repeated in a cyclic manner.

The part mentioned above is implies that the shape of NURBS curve (surface) can be modified by four shaping parameters, which are sought to compute the parameterization of the curve. These necessary and sufficient input data of the curve are: the set of control points, the order of the curve, the set of nonnegative weights and the knot vector.

The area of constructing mathematical model for general free-form curves and surfaces is covered by many technical branches and other subjects like Computer Graphics, Computer Geometry, CAD Geometry, Geometry for Engineers, Constructive Geometry, Geometric Modelling, etc., at CTU and other universities in the Czech Republic and abroad.

The present syllabi of the mentioned subjects in both bachelor and master study in the Czech Republic focus on an exhaustive presentation of Ferguson's, Bezier's and Coons' curves and surfaces supplemented by solving selected problems by analytical and graphic means, while B-splines are presented only very briefly. As a result, the B-spline practice is only graphic without comprehending its analytical principles. With only minor exceptions, the NURBS representation is not included in the syllabi of bachelor and master studies. The very basics of NURBS are sometimes presented, but only at the very end of the courses and without necessary practice. Most of the doctoral courses do not offer a detailed NURBS presentation, either.

On the contrary, the syllabi of basic courses at foreign universities include not only the classical content mentioned above but also an effort to implement NURBS parameterization. Academic staff take advantage of creating its own software utilities for lectures and practices instead of commercial ones, since commercial software is oriented at interactive industrial applications of NURBS and therefore is not suitable for teaching theoretical principles.

Nowadays, the computer algebra system MAPLE, widely spread both in pedagogical and scientific community, does not include a package useful for the NURBS representation. Although MAPLE is equipped by *CurveFitting* library including commands computing curves from given control polygon, this is not an appropriate environment for computing NURBS curves because of the library's inherent restriction to the same weights in all control points. Commands for interpolating or approximating surfaces given by control points are not implemented in MAPLE at all.

Therefore, developing a NURBS representation code for MAPLE and integrating this module into CAD Geometry courses were the principal aims of the project. As a result, the following algorithms were developed and implemented:

1) Computation of the NURBS representation of conics. 2) Computation of the approximating NURBS curve (surface) from the control polygon, weights, curve order and knot vector. 3) Computation of an unknown knot vector from the given control polygon via both *length chord* and *centripetal* methods. 4) Computation of the interpolating NURBS curve from the given control polygon. 5) Computation of an open, closed and clamped NURBS curve.

These algorithms were integrated into the voluntary courses of CAD Geometry at the Faculty of Mechanical Engineering of Czech Technical University in Prague. Based on the experience gained during this project, the proposed algorithms will be further developed to allow the NURBS representation for MAPLE to be fully implemented into the compulsory Computer Graphics course at Faculty of Mechanical Engineering of Czech Technical University in Prague.

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Application of Mathematical Transformations in Image Recognition

K. Nováková

katka.novakova@dc.fjfi.cvut.cz

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, Prague 2, Czech Republic

Binary image of individual n-dimensional object is an information source for object recognition. The translation of object in $\mathbf{R}^n$ must not complicate the functionality of any recognition system, which is called translation invariant. Similar objects of various sizes are often supposed to be identical, which motivates the scaling invariance. The special applications require the rotation invariance of recognition system. Grain particle recognition, categorization, and counting are typical TSR invariant tasks, while the character recognition must not be rotation invariant due to pairs: WM, 25, 69, E3. Thus the properties extracted from given binary image should be invariant to translation (T), scaling (S), and rotation (R) of the original pattern, object, or image, respectively. There are many possibilities how to realize TSR invariant properties of *n*-dimensional binary images. The translation invariance can be achieved by using *n*-dimensional Fourier transform and amplitude spectrum, which is trivial. The rotation of original will cause rotation of Fourier spectrum. Thus the rotation invariance is based on envelopes, which are generated by rotation of Fourier spectrum. The resulting envelopes can be rescaled to normalized forms which are TSR invariant.

The papers present the applications of TSR invariant envelopes based on Fourier transform of 2D binary image. The envelopes were used for 2D binary image recognition. There are two basic approaches: envelope sampling in isolated points and variation approach on compact interval. The first recognition system uses TSR invariant envelopes as non-linear preprocessing for any artificial neural network, the second recognition system for proposed variation recognizer. Standard PCA technique is used as referential method. TSR preprocessing was based on some basic formulas. Having Fourier transform $\mathrm{F}_n(\overline{\omega})$ we can define the normalized spectrum as $\Phi_{\mathrm{f}}(\overline{\omega}) = \dfrac{\mathrm{F}(\overline{\omega})}{\mathrm{F}(\overline{0})}$. Then lower and upper envelopes are given by formulas $\mathrm{L}_{\mathrm{f}}(\omega) = \min\limits_{\|\overline{\omega}\|=\omega} \Phi_{\mathrm{f}}(\overline{\omega})$ and $\mathrm{U}_{\mathrm{f}}(\omega) = \max\limits_{\|\overline{\omega}\|=\omega} \Phi_{\mathrm{f}}(\overline{\omega})$. We can calculate the referential point $\omega^* = \mathrm{r}(\mathrm{L}_{\mathrm{f}})$ from lower envelope, where function r is satisfying $\forall \alpha \in \mathbf{R}^+ \; \forall \omega \in \mathbf{R}_0^+$: $\mathrm{r}\left(\mathrm{L}_{\mathrm{f}}\left(\dfrac{\omega}{\alpha}\right)\right) = \alpha\, \mathrm{r}(\mathrm{L}_{\mathrm{f}}(\omega))$. Finally we can find relativized envelopes as $\mathrm{L}_{\mathrm{f}}^*(\omega) = \mathrm{L}_{\mathrm{f}}(\omega^*\omega)$ and $\mathrm{U}_{\mathrm{f}}^*(\omega) = \mathrm{U}_{\mathrm{f}}(\omega^*\omega)$.

Digital processing of binary 2D image consists of five steps. The first step is only hypothetic discretization of given binary 2D image. Practical digital processing begins from discrete binary image. Approximation of $\mathrm{F}_2(\omega_1, \omega_2)$ as $\mathrm{F}_{2,N}(\omega_1, \omega_2)$ is realizable via discrete Fourier transform (DFT), which is fast (FFT) in case when N is power of two. The third step is approximation of $\Phi_{\mathrm{f}}(\omega_1, \omega_2)$ as $\Phi_{\mathrm{f}}^+(\omega_1, \omega_2)$. It produces a sparse matrix of normalized absolute values of DFT spectrum. The values of $\Phi_{\mathrm{f}}^+(\omega_1, \omega_2)$ are calculated via bicubic spline interpolation for any $\omega_1, \omega_2 \in \mathbf{R}$. It enables to calculate values of $\mathrm{L}_{\mathrm{f}}^+(\omega)$ and $\mathrm{U}_{\mathrm{f}}^+(\omega)$ for $\omega \in \mathbf{R}_0^+$, which is approximation of $\mathrm{L}_{\mathrm{f}}(\omega)$ and $\mathrm{U}_{\mathrm{f}}(\omega)$. The polar transform $\omega_1 = \omega \cos\varphi$,

$\omega_2 = \omega \sin\varphi$ is used for $\varphi \in \langle 0, 2\pi)$ and equidistant evaluation of $\Phi_f^+(\omega\cos\varphi, \omega\sin\varphi)$, which helps to localize extreme values of $L_f^+(\omega)$ and $U_f^+(\omega)$. The last step is approximation of $L_f^*(\omega)$ and $U_f^*(\omega)$ as $L_f^\oplus(\omega)$ and $U_f^\oplus(\omega)$. The lower envelope $L_f^+(\omega)$ is analyzed to obtain referential point $\omega^+ \in \mathbf{R}^+$ satisfying $L_f^+(\omega^+) = 0.5$. The adequate relativized envelopes are calculated as $L_f^\oplus(\omega) = L_f^+(\omega^+\omega)$ and $U_f^\oplus(\omega) = U_f^+(\omega^+\omega)$. Decision making based on $L_f^\oplus(\omega)$ and $U_f^\oplus(\omega)$ can be realized as artificial neural network (ANN) or in the style of variation calculus.

Three basic artificial neural networks were used in first recognition system: optimum linear associative memory (OLAM), radial basis function (RBF) and self organizing maps (SOM) with Kohonen learning. We can find out units with similar weights from the Sammon's mapping [Sammon (1969)], which is a good 2D insight into space of SOM weights and ratio of the good learned SOM.

The learning algorithm for variation approach can be summarized to several steps. First we must get inputs m as pattern number, a, b as lower and upper bound, and the patterns $\mathrm{e}_k(\omega)$, y_k^* for $k = 1,\ldots,m$. Second we set $\bar{v} = (1,\ldots,1)' \in \mathbf{R}^m$. Then we form $\mathbf{A} \in \mathbf{R}^{m\times m}$ as $\mathbf{A} = \int_a^b \bar{\mathrm{e}}(\omega)\bar{\mathrm{e}}'(\omega)\,\mathrm{d}\omega$ and calculate the threshold value $\theta_{opt} = \dfrac{\bar{v}'\mathbf{A}^+\bar{y}^*}{\bar{v}'\mathbf{A}^+\bar{v}}$. Now, we can form $\bar{b} \in \mathbf{R}^m$ as $\bar{b} = \bar{y}^* - \theta_{opt}\bar{v}$ and consequently we can form $\bar{\lambda} \in \mathbf{R}^m$ as $\bar{\lambda} = \mathbf{A}^+\bar{b}$. Finally, we have $w_{opt}(\omega) = \bar{\lambda}'\bar{\mathrm{e}}'(\omega)$.

Systems were used for classification of classes of basic 2D binary images and for classification of grain particles. In the first application there was each class represented by 70 discrete realizations. Images were transformed and the contours of amplitude spectra and relativized envelopes were studied. Two most significant principal components of PCA were able to separate the classes in the space of sampled envelopes. Recognition by artificial neural networks gives us good results. The calculus of variations helps to build up a new generation of binary image recognizers, where any class is represented via weight function. In second application, first TSR recognition system was applied to quality control in food industry based on grain classification. It operated here as grain classificator. All the programs were realized in the Matlab environment.

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Dynamics of Elastic Curves in Image Processing

Tomáš Oberhuber

oberhuber@kmlinux.fjfi.cvut.cz

Faculty of Nuclear Sciences and Physical Engineerings, Czech Technical University in Prague

As it was discussed in [1], mean curvature minimization is a problem with many applications in the physics of elasticity, image processing (for example so called image inpainting for restoration of images with scratches etc.), surface restoration[4] (in archeology) and if we also consider anisotropy we can find some applications in nanotechnologies.

Mean curvature is defined as a sum of principal curvatures at given point of the curve or surface. Integrating square of the mean curvature over all the curve/surface we obtain a functional describing the curvature of the curve/surface. Applying variational method called gradient flow on this functional, we get the fourth order partial differential equation which is usually splitted into two equations of the second order. This problem is known as the Willmore flow. The fourth order partial differential equations are intensively studied in present. Similar problems leading to the fourth order equations are for example surface diffusion [3] or Alen-Cahn equation.

For this contribution we consider only Willmore flow of graphs. It means that we will work only with surfaces which can be described as graph of some real function of two real variables. The same problem was studied in [2].

The authors of [1] use implicit scheme to solve Willmore flow. We decided to use method of lines and a Runge-Kutta type solver with adaptivity in time. The resulting schemes are of the explicit type. We developed two schemes. The first one is based only on the forward and the backward differences while the second one uses mainly central differences.

For the scheme based only on the forward and backward differences and the case of Dirichlet boundary conditions, we are able to show stability of this scheme. Stability for the scheme based on the central differences or Neumman boundary conditions remains open problem.

To measure convergence quantitatively we computed experimental order of convergence for both schemes. Since there is not known any analytical solution we solved equations with different right hand sides. They were changed in such way that the resulting systems have analytical solution which we choosed before.

We also present some qualitative results of our numerical experiments in the form of evolution of several graphs converging to surfaces with minimal curvature. For example reconstruction of spherical surfaces is presented.

Our scheme can be easily extended for a level set formulation of the Willmore flow which allow us to minimize curvature of more general curves and surfaces then graphs. Such scheme can be then applied to some problems in image processing.

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Analysis of Mixed Problem for Nonlinear Diffusion Equation in Lipschitz Domain

M. Beneš, B. Havrdová

benes@mat.fsv.cvut.cz, bohuslava.havrdova@seznam.cz

katedra matematiky, stavební fakulta ČVUT, Thákurova 7, 166 29 Praha 6

Let Ω be the Lipschitz domain, Γ denotes the boundary of Ω . We are involved with nonhomogeneous nonlinear diffusion equation

$$-\nabla.(A(x, y, u(x, y))\nabla u) + \beta_0 \boldsymbol{s}.\nabla u + \delta u = f,$$

where u denotes the concentration, coefficient of diffusion A is depending on location $[x,y]$ and the concentration u, the function f describes the distribution of internal source in domain. The domain is steady proceeding in the vector $\boldsymbol{s}$ with the velocity β_0 (β_0 = konst. > 0) and the elements of mass break down (δ = konst. > 0) or increase. The boundary Γ consists of two disjoint continuous parts Γ_1 and Γ_2. On the part Γ_1 of the boundary Γ is prescribed the Dirichlet boundary condition (the given concentration on the boundary) $u = h$, $h \in L_2(\Gamma_1)$, on the part Γ_2 of the boundary Γ is prescribed the Newton boundary condition (semi-permeabled boundary) $A(x, y, u(x, y))\,\partial u/\partial \nu + \alpha u = \alpha u_0$, $u_0 \in L_2(\Gamma_2)$, where α characterizes the permeability of the boundary (so called the coefficient of the permeability, α = konst. > 0) and u_0 the given concentration on the boundary Γ_2. Our goal was to prove the existence and uniqueness of the weak solution of the mixed boundary value problem for diffusion equation. We use the fixed point theorem using the Jegorov lemma ([1]) to prove the general properties of the weak solution in the Sobolev space. Some requirements for the data of the problem to prove the existence and uniqueness of the weak solution are presented.

We investigate also the numerical solution. Discretization in space is carried out by means of the finite element method, we obtain the FEM model

$$\mathbf{K(u)u = f(u)}.$$

The numerical solution of the system of nonlinear algebraic equations is obtained with a Newton method.

We present also the time dependent (non-stationary) diffusion problem with mixed boundary conditions. The FEM model has the following discretised (FEM) matrix form

$$\mathbf{C(u)}\,\dot{\mathbf{u}} + \mathbf{K(u)u = f(u)},$$

where $\mathbf{u}$ are the nodal values of the unknown variable. The time discretization is performed through a implicit finite-difference scheme

$$(\mathbf{C}(\mathbf{u}_{n+1}) + \Delta t\, \mathbf{K}(\mathbf{u}_{n+1}))\, \mathbf{u}_{n+1} = \mathbf{C}(\mathbf{u}_{n+1})\mathbf{u}_n + \Delta t\, \mathbf{f}(\mathbf{u}_{n+1}).$$

The solution of the system of nonlinear algebraic equations is obtained with a Newton-Raphson procedure.

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Determination of Reflecting Point on the Earth Shape

S. Olivík, M. Kočandrlová

olivik@mat.fsv.cvut.cz

Department of Mathematics, Faculty of Civil Engineering,
Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czech Republic

We can use many tools for determining the Earth shape. Same from these tools are satellite altimetry, remote sensing and Global Positioning System (GPS). If we combine satellite altimetry and GPS, we obtain a tool named GPS altimetry (or bistatic altimetry).

The main idea of GPS altimetry is to receive signal sent from GPS satellites and reflected on the Earth shape and to use it for determination of the point where the signal has reflected. As we wrote ahead, idea of GPS altimetry is to use one satellite as a receiver and another as sender. Senders can be GPS (Global Positioning System) satellites that gravitate at the high earth orbit (HEO), at the altitude of 20.200 kilometers. As a receiver can be used satellite that gravitates at the low earth orbit (LEO). That means altitude of 300 to 470 kilometers.

In the first approximation, there was used the reference sphere instead of Earth shape. The second step is to determine the reflecting point of GPS altimetry on the reference ellipsoid. The third and the last step is to compute detailed point on geoid, the best global approximation of Earth shape.

If we want to compute the reflecting point, we need some input data. There are three possible input data sets. We know (i) positions of both satellites, parameters of the reference ellipsoid, length of the reflected signal, velocity vector of receiving satellite and incidence angle between the velocity vector and reflected ray. Or we can obtain (ii) positions of both satellites, parameters of the reference ellipsoid and length of the reflected signal. The third possible input data set is (iii) positions of both satellites and parameters of the reference ellipsoid. This paper deals with the solution for input data sets (ii) and (iii).

The input data set (ii) leads to the solution called „Ellipsoid homothetic to the reference ellipsoid“.

In this model we use two rotational ellipsoids. The first ellipsoid Q_0 is the fully defined geocentric reference ellipsoid WGS 84. The second ellipsoid Q_1 is an ellipsoid of reflecting points. It results from positions of satellites as foci and the semi-axes derived from the length of reflected radar signal.

We determine the ellipsoid homothetic to the reference ellipsoid Q_0 so that the new ellipsoid touches the ellipsoid Q_1. The point, where are these ellipsoids touching each other, is the reflecting point P. The homothetic ellipsoid has the same polar flattening as the reference ellipsoid Q_0 . We express ellipsoid Q_1 in geocentric frame. Then we express one ellipse, whose rotation forms the ellipsoid Q_1. By stepwise derivation we obtain the equation of ellipsoid Q_1 in uniform coordinates. In the affinity, which transform the reference ellipsoid Q_0 to the sphere, we determine an image of the ellipsoid Q_1 - the non-rotational ellipsoid Q_1'. This transforms the initial problem to the problem how to find a point on ellipsoid Q_1' nearest to the reference ellipsoid Q_0, also on the adequate sphere. We solve this problem with the method of stepwise approximation. First we label the intersection of ellipsoid Q_1' and line segment between midpoints of Q_0 and Q_1' as a point P' . In this point we compute normal and tangent vectors $\mathbf{n}$ and $\mathbf{t}$ of Q_1' oriented inward and normal curvature radius r' in direction of $\mathbf{t}$. Now we determine new position of one end of line segment from the first step. It is a normal curvature centre $O = P' + r'\mathbf{n}$. The next steps are similar to the described process. To the point P' we designate a point P on the ellipsoid Q_1 and an intersection point P_r of the line

segment OP_0 and the reference ellipsoid Q_0 in an inverse affinity. The point O_0 is a midpoint of the reference ellipsoid Q_0.

The input data set (iii) leads to the solution called „Method of successive approach".

At the beginning we have only coordinates of two points S_1 and S_2 and parameters of the reference ellipsoid. Points S_1 and S_2 represent positions of both satellites. We connect these points into an abscissa. Then we pick out point P situated on this abscissa and we project it onto the surface of reference ellipsoid. We obtain point P'. Now we test if this point meets the conditions to be a reflecting point. If not, we pick out another point P from the abscissa S_1S_2.

The first intermediate point P of abscissa S_1S_2 is computed in a relation to a fraction of heights of satellites above the reference ellipsoid. The next points P are computed that way that we bisect the difference between the angles $S_1\,P'\,P$ and $S_2\,P'\,P$.

The projected point P' is determined with normal projection of the point P onto the surface of reference ellipsoid. This normal projection is developed with conversion between two coordinate system. The first one is the cartesian coordinate system related to the reference ellipsoid WGS 84. The second one is the ellipsoidal geographical coordinate system. If we compute latitude and longitude of the point with non-zero ellipsoidal height, we obtain a point situated on the surface (with zero ellipsoidal height). This is the point P'. After its backward conversion into the cartesian coordinates, we can compute the difference between the angles $S_1\,P'\,P$ and $S_2\,P'\,P$. If it is greater than specified constant, e.g. 10^{-9} meters, we pick another point P and repeat this process. Computation ends when the difference less than the specified constant.

Both of these presented solutions are iterative solutions. The first one products the reflecting point of bistatic altimetry and parameters of ellipsoid different from ellipsoid WGS 84. The second solution products the reflecting point on the surface of ellipsoid WGS 84.

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Section 2

PHYSICS

Analysis of Photonic Crystal Fibers Transmission Properties

M. Lucki*

luckim1@fel.cvut.cz

*Department of Telecommunications Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Proposals of transmission parameters optimalization in Index Guiding Photonic Crystal Fibers have been published in recent author's papers [1-3]. Index Guiding PCF offer a powerful control of important transmission parameters (loss, group velocity, nonlinear effective index cladding, dispersion property through the waveguide dispersion) resulting from flexibility of manipulation of structural parameters as the hole diameter d and the pitch Λ or the core's size [1]. Transmission loss (arising with the wavelength) could be limited by the increase of air-fraction volume by setting greater values of normalized hole diameter (d/Λ quotient). The optimalization of one chosen transmission parameter can't be done regardless of other parameters dependent on structural parameters. E.g. with the increase of the air-fraction volume, waveguide dispersion arises. We need to take into consideration the possibility of change of modal regime, too. Waveguide dispersion and modal regime is also dependent on normalized hole diameter. Thus, there is a requirement to monitor dispersion and modal regime not to bring about their deterioration. For instance, by increasing the air-fraction, loss is reduced but concurrently anomalous waveguide dispersion arises, higher-order modes may appear if only the normalized hole diameter is over 0.45 [2]; another example: if the output parameters for an Endlessly Single Mode Regime are being designed, the increase of losses or decrease of the dispersion must be taken into consideration (hence, a supercontinuum generation is limited).

Fundamental mode is concentrated in the core. Effective index cladding changes then with the power distribution. Optical nonlinearities of effective index cladding ensure required value of normalized frequency. The shorter the wave is the more light penetrates the core. The fiber ceases to be single mode as long as the condition of proper size of normalized hole is not fulfilled. Fiber is Endlessly Single Mode for any value of normalized hole diameter under 0.45 [2]. The smaller the holes are the more light leaks into the cladding region. On the other hand, by decreasing the value of normalized hole diameter the effective index increase but too much of light leaks into the cladding. For the value of normalized hole diameter over 0.45 [2] single mode regime will occur only for some range, unlimited by long waves but limited by the shorter waves and depends not only on the quotient of d/Λ but also on λ/Λ.

Another structural parameter governing the transmission properties is the diameter of a core. Core's size might be changed by the pitch or removal of internal hole rings. First option is but more complicated – by changing the pitch, value of normalized hole is being changed, too. By decreasing the core's diameter (or increasing the normalized hole diameter), the zero-dispersion point is being shifted to a shorter wavelength. This result with a significant dispersion at infrared region, which can be helpful for compensation of the dispersion with opposite slope induced by transmitted information or to generate supercontinuum spectrum. On the other hand it doesn't mean that by increasing the core's size we decrease dispersion. It is worth nothing over a certain value of the core's size. Once, higher order modes appear and new contribution are formed so that the dispersion once arises. There is also noticeable that lower losses occurred for smaller core. Propagation in small core is connected with the increase of power density. Nevertheless, by selecting the appropriate core diameter, zero-dispersion wavelength can be chosen over a wide range in the visible and

near infrared spectrum. This idea can be applied in the stage of fibers design. The combination of proper set of core's size and air-filled fraction in the stadium of fiber's design is the best solution to receive required range of theoretical losses (verified always by technological process), dispersion or modal regime. For example by increasing the normalized hole diameter and reducing the diameter of the core, losses are being reduced, theoretically to 1E-12 dB/cm at 1.55μm for core's diameter of about 16μm and normalized hole diameter of 0.59μm. Endlessly Single Mode PCF produced nowadays have attenuation of 0.8dB/km at 1550nm [1]. The technological problem is to keep up required geometry during the fiber drawing process. The microstructure cross-section profile of fiber is changing due to the effects of pressure and temperature variations inside the channels. The pressure of the air inside microstructure grows up with the decrease of the air volume in the perform. The control of temperature is required to hold on identical geometry. It makes the process very complicated. Fabrication of kilometer-long fibers is very expensive and disqualifies Photonic Crystal Fibers to many telecommunication purposes such as high-speed transmission systems. Nevertheless, thanks to unique optical nonlinearities, there is a possibility of metrological applications owing to a flexible choice of doping material, which can be sensitive for many physical quantities (e.g. temperature or density). Kilometer-long fiber is not necessary. By doping the core with a high-index material (Highly Nonlinear Photonic Crystal Fibers) we may achieve convenient properties like modified dispersion characteristics (parabolic). On the other hand, by doping the core with a low-index material or simply replacing the silica with the air channel in the core region we deal with totally new guidance mechanism – provided by the Band Gap quantum structure guiding fundamental mode [4]. Total Internal Reflection is not possible because the index of core is lower than the effective index cladding. It has been demonstrated [4] that the light can be guided in the air in required direction defined by unique properties of 2D photonic crystal. We can avoid the problem of silica absorption because significant part of the power is guided in the air. Because of such interesting properties it is worth deal with on Photonic Crystals and PCF's. The precision of fabrication seems to be a matter of time the same way as it seemed to be impossible to fabricate such type of fiber at all.

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Innovation of Laboratory Exercises on Thermodynamics

R. Novák, Z. Kohout, D.Tischler

Daniel.Tischler@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Contemporary level of knowledge in a world of physics should have reflection in curriculum of physics for all natural and technical branches of university education. It is also obvious that practical laboratory training plays more and more significant role in educational courses, namely for engineering education. An appropriate laboratory facilities can clear up more difficult physical topics and through practical measurements tasks can also contribute to more active involvement of students into problem instruction. Measurements of physical quantities by students, data and uncertainty evaluation is then playing the main role. We have assumed that improvement of the consistent quality in student laboratory training is becoming a necessary presumption not only for better student teaching but also for an adequate transfer of physics methods into the engineering practice. Due to the lack of time in physics lectures curriculum and sometimes also due to the lack of adequate background knowledge of students we have considered that some important physical problems could be implemented into practical training tasks.

Teachers of the Department of Physics at the Faculty of Mechanical engineering always appreciated the important role of laboratory training in physics teaching and they took great care both of high effectiveness of pedagogical process in laboratory teaching and also of reasonable technical performance of student laboratories equipment. Our students have always had sufficiency of high-quality study literature. At present is it the textbook [1] that fully respects the valid standards and present methods of uncertainty evaluation. Members of the Department of Physics have followed the development of the teaching methods and laboratory equipment round the world and some of them have actively participated in it. Their experience and finding were also presented at pedagogically focused international conferences [2-4].

Maintenance of satisfactory technical level of laboratory equipment has been getting difficult. The increasing prices of laboratory facilities and equipment are in contrast with decreasing amount of financial resources for laboratory innovation. But the maintenance of the high technical level is very important in order to attract students to experimental activities. They cannot be satisfied working with evidently old-fashioned devices that do not offer confidential data and results. From this point of view the financial support of the IGS grant should be appreciated, even if his amount made possible only partial improvement.

The financial support of this project was used for buying laboratory equipment : apparatus for latent heat of vaporization measurement, two calorimeters, a thermostat with tank, two resistant decades and laser pointer. These devices were used for improvemet of the following laboratory tasks:

Measurement of latent heat of vaporization: The old apparatus provided results substantially different from correct value, The reason was the vapor leakage and problems with vapor condenser weighing. The measurements required difficult handling with hot glass parts.

Operation of the new custom-made apparatus is simple and safe and the results of measurements are in good agreement with the correct value.

Measurements of heat capacity of metal bodies: The new thermostat and calorimeters replaced the parts of the old measuring set. First of all the high quality calorimetersdecreased the heat loses and put more precisely measurements of water bath temperature. The measured heat capacity values differ from correct ones in the range of several percentages.

The new resistant decades are parts of two measuring sets: Resistance measurement with bridge method and Resistance measurement with substitution method . In both cases the use of the new decades put more precise results.

The laser pointer was used as the light source for built in a mark lamp.

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Friction and Wear Characteristics of DLC/WC Coatings

T. Vítů, R. Novák

Tomas.Vitu@fs.cvut.cz

Department of Applied Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Diamond-like coatings (DLC) are well known for their excellent mechanical and tribological properties. DLC is a metastable form of amorphous carbon containing sp^3 bonds. This structure leads to very high mechanical hardness, chemical inertness and very good behaviour at industrial applications, e.g. as protective modification of sliding surfaces [1].

Nowadays the DLC coatings are widely used in industry. In order to improve the poor adhesion of DLC coatings on steel substrates, some metal or carbide interlayers are used. The tribological behaviour at room temperature (RT) has been already studied intensively. Previous studies showed that the tribological performance of the coating is dependent on deposition parameters, sliding conditions and environment [1, 2]. However, the tribological properties at elevated temperatures and their relation to above mentioned parameters are not clear.

A large set of DLC/WC coatings was prepared in an industrial scale deposition plant. The functional DLC layer was prepared by PECVD from acetylene. The Cr/WC interlayer was deposited by magnetron sputtering using a WC target. A combination with Cr/WC interlayer provides very good adhesion of DLC coating. The coatings were deposited on circular polished HSS samples with diameter of 20 mm. DLC coating thickness was around 2 μm, thickness of WC interlayer was 1 μm.

Tribological properties of DLC/WC coatings were studied with a high temperature pin-on-disc CSM Tribometer. In sliding tests as counter-parts three types of balls were used: ceramic balls Si3N4 and Al2O3 with diameter of 6 mm and steel balls with diameter of 6 mm or 5/16" (7.9 mm). All tribological measurements were done at the same conditions – 5000 cycles, normal load 5 N, linear speed 0.05 ms^{-1}, relative air humidity at RT was 40±5 %. The tests were carried out in temperature range from RT up to 500 °C.

The friction and wear behaviour of the DLC/WC coatings were examined with constant load by changing the counter-part materials and samples temperature. The tribological performance was evaluated with respect to the wear rates of balls and coatings, the friction coefficient and wear debris analysis. The coatings wear rates were evaluated on the basis of wear track profile measurements, the wear rates of balls were calculated from measurements of spherical wear cap using optical microscopy. The calculating of wear rate was done with respect to Ref. [2]. Each tribological test was repeated three times with standard deviation of 10 %. In this paper the average values of friction coefficient and wear rate are presented.

The results of sliding tests were evaluated with JEOL JSM-6460 LA scanning electron microscope. To determine the dominant wear mechanism the wear tracks were studied using optical microscopy and SEM. The element analysis of wear debris was done to characterize the material migration during the test.

Tribological tests of DLC coatings showed limitations at elevated temperatures. For most of the counter-parts (except Si3N4 ball) the tribological behaviour of DLC coating is stable up to 300 °C. We suppose the temperature of 300 °C could be the starting point of DLC graphitization [1, 3]. For temperatures up to 300 °C the wear tracks appeared very smooth,

thus only polishing wear occurred. For temperatures above 300 °C the friction coefficient was slightly decreasing due to carbon diffusion and graphitization of DLC film [4]. The wear tracks were coarser with numerous cracks, thus delamination of coating occurred.

The measurements with different steel balls showed dependence on ball diameter. The friction coefficient was lower for diameter 7.9 mm, because the enlarged contact area caused lower contact pressure. On the contrary, the coating wear rate was higher for diameter 7.9 mm. The wear particles were formed in very small but geometrically almost ideal balls with diameter of about 0.2 μm. The wear debris produced only very shallow scratches parallel to the sliding movement. The wear tracks appeared very smooth, thus the polishing wear mode occurred. At the temperatures above 400 °C the friction and wear were influenced by carbon diffusion.

Coating wear rate at measurements with Al2O3 ceramic ball was low and increased only at 500 °C. Mechanism of coating material removal was not made clear, but wear particle analysis approved that wear particles consisted of delaminated DLC particles.

The results showed problems at tribological tests with Si3N4 ceramic ball. According to our opinion the friction and the wear process were affected by tribochemical phenomena, especially at elevated temperatures. The complex tribological behaviour of Si3N4 balls will be studied in the future.

The wear rate and friction coefficient of DLC coatings at different temperatures certified that there was no clear proof of correlation between the wear rate and the friction coefficient. Friction and wear characteristics described in this study showed limitations of DLC applicability at elevated temperatures. The tribological behaviour of DLC coatings was influenced by chemical processes and carbon diffusion especially at elevated temperatures. Tested coatings were obtained from commercial production, thus the results of measurements could directly enhance level of customer service.

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Using SAR Interferometry for Landslides Mapping in Northern Bohemia

I. Čapková

ivana.capkova@fsv.cvut.cz

Katedra mapování a kartografie, Fakulta stavební
Thákurova 7, Praha 6

The SAR Interferometry Method

Synthetic aperture radar (SAR) interferometry is a method of processing of two scenes, acquired by a satellite carrying a SAR. The method can be used for digital elevation model (DEM) generation or for Earth deformation (subsidences, landslides) mapping. Two scenes acquired at a different satellite position (for DEM generations), or at a different time (for deformation mapping) are used.

However, it is not possible to obtain two scenes acquired at a different time, but at the same position. Therefore, the interferogram, which is the difference between the phases of the two scenes, is also influenced by flat-Earth phase (i.e. the phase corresponding to the Earth without topography) and topography. Both of these influences must be computed using the knowledge of precise satellite position and topography.

Residual Fringes

Imprecise satellite positions cause that both the flat-Earth phase and the phase corresponding to topography are subtracted imprecisely. The flat-Earth phase influence is major in comparison to topography and the interferogram therefore contains residual fringes, mostly in the range direction. If a fringe in the azimuth direction appears, it is caused by the fact that the range fringe frequency is changing.

The residual fringes are caused by three basic facts:

- satellite orbits are not precise enough (few cm),
- the two-way time between signal transmission and reception (range-timing) is errorneous, causing that the look angle is computed imprecisely,
- the difference in atmospheric delay between the two acquisition.

Geocoding Errors

During interferometric processing we also found out that the interferograms are geocoded in a wrong way, i.e. the coordinates of an object are wrongly computed. The shift in the azimuth direction was about 4 km, and the shift in the range direction was almost 2 km. These errors are very improbably caused by orbit errors: the range error relates to the range-timing error discused in previous section, and the azimuth error relates to an errorneous absolute time of reception of the first radar echo.

Residual Fringe Correction

Due to the fact that residual fringes are caused by two factors (except for atmosphere), there are two methods to reduce them:

- correcting for the orbit errors,
- correcting for scene timing (in both directions).

The number of residual fringes was almost 3 for the whole scene before any corrections. As already said, correction of the timing errors is quite easy, because the timing errors can be easily computed from the geocoding errors. On the other hand, correcting the orbit errors is much more difficult, at least with the information provided by the DORIS software. In addition, the satellite position is stated once per second (precise orbits) and during the interval the satellite moves by hundreds of meters and the satellite position for each point of the scene must therefore be interpolated by a function. The form of the function is therefore also very important.
Fortunately, the number of residual fringe reduced significantly after timing correction. We can attribute the rest of the residual fringes to atmospheric delay, which we expect to have a linear influence on the interferogram phase, in comparison to both timing and orbit errors. In addition, the number of residual fringes is less than one.

Results of Earth Deformation Mapping in Northern Bohemia
Three SAR scenes are available, forming two interferometric pairs, one with temporal baseline of 70 days (deformation pair), and the other with temporal baseline of 1 day (used for subtracting topography from the deformation pair). Unfortunately, it is not possible to confirm a deformation on the basis of one deformation pair, because the phase change may be caused by seasonal effects or noise.
On the basis of the phase changes in the deformation interferogram, we selected several areas suspicious of Earth-crust deformations and analyzed the conditions of landslides/subsidences happening in the area, for example:

- The Ervěnice corridor
- The northern border of the Nechranice dam
- Several smaller areas near the Krupka town

Conclusion
Correction of timing errors in both directions helped us to correct not only for the shift of the geocoded data, but also for residual fringes, which appeared in the original interferogram. The timing errors can be evaluated from the shift of the geocoded scene with respect to the terrain, or from the shift between the interferogram and radarcoded DEM (in 2-pass method). Using 3-pass method, the residual fringes are significantly reduced automatically.
Many smaller areas suspicious of Earth crust deformation were determined in the northern-Bohemian coal basin. However, detecting some kinds of landslides is impossible using SAR interferometry; detecting subsidences, which are usually significantly slower, is more reliable. Huger landslides may cause the surface to be very different for the two acquisition, therefore causing decorrelation of the interferogram.

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New Optoelectronic Methods for Testing Optical Systems

P.Novák

xnovakp9@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

One of the most important processes in the optical production is determination of differences of fabricated optical surfaces from their nominal shape. These differences are caused by the imperfect technological process of fabrication of optical elements. Every surface of optical elements must be fabricated within specified tolerances in order to satisfy production requirements, i.e. the shape and accuracy of optical surfaces must correspond to tolerances given by drawings and other documentation. The basic testing technique uses a reference surface that is compared with the tested (fabricated) optical surface using interference. The reference surface of a defined shape is called a calibre (calibration surface) and must be fabricated much more accurately than the tested surface. The quality of fabricated optical surface can be determined from the shape and the number of interference fringes between the calibre and the tested optical surface. Generally, it is much simpler to satisfy tolerances of optical elements with planar or spherical surfaces than optical elements with aspherical surfaces.

Other testing techniques are noncontact interferometric methods that can be implemented by interferometers, either Fizeau or Twyman-Green type. The interferometers use the principle of interference between the reference and tested wavefront. These techniques make possible to measure the shape of the surface using various phase calculation techniques that are based on computer evaluation of the interference field. However, interferometric methods have several drawbacks, especially sensitivity to mechanical vibrations and a limited measurement range. Several of these drawbacks may be removed by using testing methods that are based on measurements of the wave-front gradient. These methods are simpler and less expensive in comparison to interferometric, and one can obtain a similar measurement accuracy as the common interferometric methods.

The aim of the project was to propose and analyse several new methods for testing optical elements and systems in practice. We proposed the correlation method that makes possible to reduce disadvantages of above-mentioned methods and speed up the testing process of aspheric optical surfaces. The proposed method does not require to make a detail analysis of the interference field, i.e. determination of the shape and orders of interference fringes as it is necessary with the existing interferometric methods. Interferograms that correspond to required tolerances of fabricated optical elements can be generated using computer programs and the shape of interference fringes for tested optical elements is known in advance. By the correlation method, it is possible to evaluate whether the tested optical surface fulfils the tolerance requirements. We can apply the correlation analysis on the problem of similarity check of two interferograms X and Y, where the interferogram X corresponds to a nominal shape of the surface that is to be fabricated and tested (with given tolerances), and the interferogram Y corresponds to a real fabricated optical surface. A condition that is necessary for a minimum variance of two interferograms X and Y corresponds to maximization of the correlation coefficient R_{XY}. The value of correlation coefficient is a measure of similarity of the tested and nominal surface. The proposed method has been analysed and verified using computer simulation of reference and tested interference

patterns and different types of optimization techniques. The shape of interference fringes, which corresponds to the wave-front deformation during interferometric testing of the geometrical shape of optical surfaces, was simply simulated using appropriate aberration coefficients. We simulated several interference patterns of the nominal and tested surface and it can be concluded that the correlation method works perfectly in the case of relatively small deviations of both surfaces that is the most frequent case in practical optical testing. It can be also concluded that even small deviations (tenth of the wavelength of light) from the nominal shape causes a rapid reduction of the correlation coefficient R_{XY}. Setting an appropriate tolerance limits for the value of R_{XY}, one can make decisions about the quality of the tested surface.

Furthermore, algorithms for wave-front reconstruction using measurements of wave-front gradient were analyzed. The evaluation algorithms were tested and compared. These algorithms were implemented in software for wave-front reconstruction using the designed wave-front sensor. The whole measurement system was verified in a close cooperation with Meopta Přerov,a.s., on testing optical systems in UV and visible spectrum. The part of the project was also focused on the theoretical analysis of the influence of parameters of tested optical systems on the image quality.

This project also deals with an analysis of new method for evaluation of very small phase variations that uses the interference of polychromatic light using the principle of polarization interferometry. Small changes of phase cause the change of color of the interference field. The measured phase change can be determined from the change of color in the interference field, because even a small phase change has effect on the color of the interference pattern. The specific value of the phase change can be assigned to given color, and the phase change can be evaluated by using colorimetric methods. The detailed theoretical analysis of the phase evaluation problem was performed and the equations for evaluation of phase at particular points of the interference field were derived. It can be concluded from the performed theoretical analysis that the proposed approximate quadratic model is quite suitable for evaluation of the optical path difference smaller than 50 nm. The proposed method seems to be suitable for practical use in optical testing.

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Properties and Characterization of Nonlinear Optical Materials

L. Seidl

seidl@optics.fjfi.cvut.cz

Department of Physical Electronics, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Břehová 7, Prague 1, Czech Republic

Nonlinear optical materials are believed to be next step in many different branches of human being. I can mention telecommunication based on optical soliton wave-guides and in future also nonlinear optical switches. Other branches are optical processors, data storage based on holography and many more. In all of those cases we need to know how used materials work, what we can expect and what the theory of nonlinearities is about. Well known material $BaTiO_3$ and in second part new polymer is studied theoretically and in experiment.

The Classical Photorefractive effect is well known nonlinear optical effect. It was first observed in Lithium Niobate ($LiNbO_3$) by Arthur Ashikin in year 1966 in Bell's Laboratory. Townsend and LaMacchia observed this effect in Barium Titanate ($BaTiO_3$) in 1970. Until these days, the effect was widely studied by many researchers and different applications like data-storage, real-time holography or phase-conjugate wave-front generation has been published [1]. In this paper I present photorefractive pumped unidirectional laser oscillator with ring resonator employing two wave mixing process in $BaTiO_3$ crystal as energy inserting system. The operation of such oscillator has been studied in previous paper [2].

Now I introduce some theory clarification, which can be used to specify spatial shift φ of index grating inside photorefractive medium, which was previously assumed to be exactly $\pi/2$ because of diffusion only operation. Theoretical model [3] of such oscillator proceed from a properties of nearly degenerate two-wave mixing (TWM) process, employing TWM amplification and nonlinear phase shift of an amplified signal beam. Let's two optical beams with nearly same frequency intersect and interact with nonlinear photorefractive media. These two beams interfere together and create spatial light modulation (interference pattern) slowly moving perpendicular to the axis of an interacting angle. Velocity of moving is proportional to a spatial frequency of the interference pattern. Because of photosensitivity of the photorefractive materials, in bright areas electrons are photoexcited into conduction band. Because of diffusion electrons tend to go to dark areas, where they are trapped by acceptors. This process of excitation and trapping can be many times repeated. Thus light pattern may generate space charge redistribution. As a result spatially modulated electric field appears. In previous works it was strictly expected in diffusion only (no drift) operating materials, there is exactly $\pi/2$ shift between light and electric field patterns. This is the assumption I am pointing out in previous text. I am recommending to extend this to be $\phi=\pi/2+\phi'$ because all measured data in my previous work will fit better. My extension is about to precisely characterize same material behavior of photorefractive crystal.

This extension was published in poster section of Conference on Lasers and Electro-Optics (CLEO2005) held in Munich, Germany, in 12-17 June 2005. My poster was discussed by Mr. W. Królikowski [3] – one of the leaders in branch of photorefractive pumped ring resonator and also by other fellow from Spain working with exactly same experiment. Both accept it.

Other part of my work is concerned to photorefractive polymer layers. We established cooperation with Institute of Macromolecular Chemistry, Academy of Sciences of the Czech

Republic, with Prof. Stanislav Nešpůrek, Ph.D., D.Sc., as member of working group of Electronic Phenomena. At starting point we received azobenzene containing polybutadiene based polymer marked as LC2, which is capable of photo-reorientation. This reorientation is in fact photochemicaly induced trans-cis-trans isomerization of azobenzene groups resulting in their reorientation perpendicular to the electric field vector [4].

First of all we measured absobtion spectra to disclose the efficiency of using our HeCd laser operating at 442 nm. Although absobtion at 442nm is quite small in compare to optimal wavelength 362nm originally used by author of [4], we prepared same films of such polymer with different thickness by coating of quartz glass at room temperature. These coated quartz glasses were incorporated into experiment similar to one used in TWM to write on simple holograms (in fact one grating per exposition). We measured buildup time, diffraction efficiency and decay time of such incorporated grating. We also refutate a possibility of embossing gratings by coating created gratings by appropriate immerse.

Last experiments employ external electric field applied perpendicular to plane of polymer‘s film. This was done by three layer sample: first quartz glass was coated by Indium-Tin-Oxide (ITO), next polymer layer created by evaporating a solvent and finally other ITO coating was performed. Two step ITO coating with smart screening helps as to reach really high field strength applied to polymer film, approximately 5.10^5 Vcm^{-1}. This extremely high applied field leads to at this time not explained alternations of diffraction.

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Freezing Out of Impurities from Biogas - Investigation of the Formed Frost

P. Celunda

Pavel.Celunda@fs.cvut.cz

U 12107.3 Division of Compressors, Refrigeration and Hydraulic Machines, Faculty of Mechanical Engineering, Czech Technical University
Technická 2, 166 07 Prague 6, Czech Republic

As **it** is known, frost will form on a cold surface when the temperature drops bellow the dew point and will **also be** less than the freezing point of the condensable component. There are already **many** theories and empirical terms written on the theme of deposition, formation, growth or heat transfer coefficient of the frost **but nobody has been exploring the adhesion of the frost so far.**

It is really hard to say why it is so. **It is even harder when one realizes that the phenomena of the frost is bound with numerous technical problems** which make technologies even more difficult than they are. And **it is** not a few technologies which are bound to (forced to) deal with phase change. Just **to** mention hereby the evaporators of the coolers or heat pumps, doubled bodies of freezing-out heat exchangers in the homonymous technologies or the frosted windscreens which all of us had surely experienced. **Whenever a man is** headed to such a fundamental ignorance, **he realizes how cheap our knowledge of basic natural laws in 21st century is** and how much **can still be uncovered**.

Work, which has been done so far, has been supported by Internal Grant of CTU and Reduced Research Intent of MŠMT. From the resources of Internal Grant both the development and manufacturing of the new experimental instrument **have been covered**. From Reduced Research Intent resources for motivational tribute for participated solver **have been provided.**

How would you measure the adhesion of **such a substandard** material, **as the frost is**? **Adhesion of the porous, not homogenous layer which thermo physicals properties are sharply time dependent. Number of methods which could be chosen is huge** but with the modest budget **which is available has been quickly inclined to one of them**. It was decided to measure the resistance of the frost layer against the scraper. It sounds **easy**, but when you imagine that the initial period of the frost layer **is that sub-cooled drops get frozen and on their peaks crystal trees begin to grow, the imagine gets more difficult**. Even when **you revealed** that one of the biggest **drops** has **its** diameter about 0,03mm. **It is thought** to be crucial t**he adhesion of these drops to the surface though** how the time goes this initial **layer receives** more material by diffusion flow. **It is** not yet known how it **looks like** when frost gets older and rises higher upon the surface. **It is that, however, supposed that** the **mechanism, by which the frost adheres** to all known surfaces, is caused by the forces from these three groups:

- a covalent or chemical bonding mechanism,
- a dispersion of or fluctuation in electromagnetic interaction [van der Waals forces],
- a direct electrostatics interactions.

Known international researches which **have been** done on similar theme, namely on the adhesion of **water ice** on surfaces, picked up the electrostatic forces **like, according to** them, participating on the adhesion the most. According to this **the sample surfaces which will be tested are chosen**. To guarantee the **repeatable of** the experiment brand new laboratory **apparatus has been designed**. This **was what** caused some delay in the project, so

the tests have not taken place yet and the presentation of experimental data**,** their processing and final results **have not been done so far.**

Manufactured apparatus was drawn up like heat exchanger, with the scraper in the cooled chamber. This area will be cooled down by vapours from the liquid nitrogen [lN_2]. The cooling performance will be controlled by powered conductive wire which will be supplying the heat to the Devar-container with lN_2. The freezing-out medium will be the carbon dioxide injected to the chamber from pressure bottle. To **picture** the process of the deposition of the frost and the scraping itself **will be mentioned chamber socket with special microscop**e. The surfaces which are in connection with **the** deposited surface and the scraper **were need designed** and afterwards manufactured with high geometrical precisions. **There were** prescribed tolerances **of** about 0,01mm. The sample lies on the sliding bed which is also rotary. At the bottom of this bed [it means outside the chamber] is placed metal strip. On this strip **there** are the tensiometer sensors. **The desired data are finally to be obtained from this.**

What are the forces which are the most participating on the so unpleasant adhesion and how different is the adhesion on the different materials or layers of materials?! All these questions should be answered or confirmed by **the above** described experiment. The paper done on this theme, which is dealing with this phenomenon of the frost, will be hopefully presented **at** two international conferences. **Namely the experimental stand will be described in detai**l. The procedure of the experiments with the frost issued of the gas compounded of the $C0_2$, N_2 and gaseous H_2O will be described as well. This will be done **on different samples** of materials and solving the evaluation of the recorded results.

It shoul**d not be forgotten** that all this is done with the feedback **of** the application for new technology, **above all** the Freezing-out of the Impurities from Gasses with Manual scraping of deposited frost, which could be used in many environmental applications. **Finally it should** be said that **one**, which is already seriously **being consider**ed by Czech firms, is truly from the course of environmental technologies. **Moreover, it ca**n be revealed that by this technology **it** should be possible to **purify** landfill or bio gases to the quality of standard natural gas with very interesting economical parameters.

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Gas Flow Enhanced DC Corona Discharge for de-NOx Processes in N2-NOx Mixtures

S. Pekárek

pekarek@feld.cvut.cz

CTU, Faculty of Electrical Engineering, Department of Physics
Technická 2, 166 27 Prague 6

Corona discharges are very attractive for a wide range of industrial applications such as ozone generation, decomposition of volatile compounds and de-NOx processes. The important aspect for successful corona discharge application is however understanding of the discharge mechanism. This mechanism in a stationary medium is relatively good understood. However the mechanism of the gas flow enhanced corona discharge is much more complicated and not well understood in spite of several attempts to that have been made [1,2].

The application of the gas flow for discharge stabilization allows to increase the current voltage range of the discharge without discharge transition to spark. In this way it is possible to increase energy delivered to the discharge and thus to influence plasmachemical processes leading to de-NOx processes.

Effect of the gas flow on electrical parameters of the discharge can be demonstrated on the charge transport between electrodes. The charge transport – current density – certainly influences discharge regimes. Contrary to the charge transport in a stationary medium (which is influenced mainly by the applied electric field) the charge transport in case when the gas flow is applied can be written in terms of two components i.e. convective term and drift term as follows:

$$\mathbf{j} = \mathbf{v}N \pm \mu N\mathbf{E},$$

where $\mathbf{j}$ stands for current density, N is density of charged particles, μ is charged particles mobility, $\mathbf{E}$ is local electric field and $\mathbf{v}$ is a local velocity. It is evident that the flow convection becomes an important factor in corona currents when

$$\mathbf{v} \approx \mu\mathbf{E}.$$

From a rough estimation of numerical values for experimental conditions described in the following it is possible to conclude that the convection effects may significantly contribute to the discharge current and therefore to influence discharge regimes.

We have also performed an experimental study of nitrogen oxide decomposition by an atmospheric-pressure DC hollow-needle to plate electrical discharge in N_2-NO mixtures [3]. The nitrogen oxides react with primary radicals (such as O, N, OH) created during the discharge phase. However the most important initiating reactions in the corona discharge are due to the collisions of electrons of the electrical discharge with the component constituents. These reactions can produce the neutral species O, N and OH, which can have a central role in NO_x removal. The rate coefficients of reactions involving the electrons depend on the electrons energy. The electron energy distribution function depends on reduced electric field E/n. The reduced electric field except on the density of particles n depends on the applied voltage.

To clarify the role of NO concentration in the mixture with pure nitrogen N_2 on electrical characteristics of the DC hollow needle to plate atmospheric pressure discharge we performed

an experimental study of the discharge voltage versus current for NO concentration in the mixture 20 ppm and 200 ppm for the needle biased negatively, with the flow of the mixture through the needle 5 slm. We also studied the dependence of the discharge voltage versus NO concentration in the mixture for constant current 0.4, 2, 4 and 8 mA and finally we studied the nitric monoxide transformation as a function of energy density for initial NO concentrations 20, 100 and 200 ppm [4].

We found that for the constant discharge voltage the discharge current is increased with increasing NO concentration in the mixture. This result is probably associated with the fact that ionization processes for higher NO concentrations are more effective. From the other side for constant current with decreasing NO concentration discharge voltage is increased. The increased discharge voltage means increased reduced electric field *E/n*. Reduced electric field influences reaction rate of nitrogen oxides removal by reduction via the $N(^4S)$ radicals to molecular nitrogen. For these reactions to occur the values of *E/n* of 70 Td or more are necessary. From a rough estimation of the reduced electric field based on the expression for maximum electric field between a parabolic tip of a radius *r* and a plane at a distance *d* we obtain the value of the reduced electric field exceeding the value required for efficient NO reduction. Increased discharge voltage for the same current means increased energy density delivered to the discharge, which is reflected in increased production of electrons as starting particles for molecular nitrogen dissociation and consequently increased NO removal rate.

From our experimental results following conclusions can be taken:

- Electrical characteristics of the discharge are strongly influenced by the NO concentration in the mixture.
- The NO decomposition in the discharge strongly depends on the energy density.
- Almost complete removal of NO is obtained for lower NO initial concentrations.

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Atmospheric Dispersion Evaluation Using the Multiple Color Satellite Laser Ranging

K. Hamal, I. Procházka, J. Blažej, Yang Fumin*, Hu Jingfu*, Zhang Zhongping*, H. Kunimori, B. Greene***, G. Kirchner[a], F. Koidl[a], S. Riepfel[aa], W. Gurtner[aaa]**

hamal@troja.fjfi.cvut.cz

Czech Technical University in Prague, Brehova 7, 115 19 Prague 1, Czech Republic

* Shanghai Observatory, 80 Nandan Road, Shanghai, People Republic of China

** CRL, 4-2-1, Nukui-Kitamachi, Koganei-shi Tokyo 184-8795, Japan

*** EOS, Level 12, 75 Elizabeth Street, Sydney NSW 2000, Australia

[a] Observatory Graz-Lustbühel, Lustbühelstr. 46, A-8042 Graz, Austria

[aa] Satelliten Beobachtungsstation Wettzell, D-93444 Kötzting, Germany

[aaa] Zimmerwald Observatory, Universität Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland

We are reporting on our activity on Satellite Laser Ranging (SLR) using multiple wavelengths. Atmospheric dispersion study and the eye-safe wavelength region are both considered. To detect the returned signal, the Single Photon Avalanche Detector (SPAD) is operated in so-called Geiger mode. The silicon, germanium, and gallium arsenide phosphide based SPAD are used depending on the wavelength to cover nearly the entire optical region having the single photon response, temporal resolution better than 120 ps FWHM, and quantum efficiency of about 15 % [2]. The active area size and the compact design of the detector packages permitted their application in satellite laser ranging yielding sub-centimeter ranging precision in infrared and sub-millimeter precision ranging in the visible region. The active area of the detector used is from 100 to 200 μm. Detectors for the visible region are cooled thermo-electrically and detectors for infrared, based on germanium, are cooled cryogenically with a custom design liquid nitrogen Dewar. The design and diagnostics of a hydrogen Raman-shifted picosecond Nd:YAG laser operated at 10 Hz repetition rate are presented. Both the far-field beam structure and temporal picosecond pulse profile are monitored for different laser configurations. The optimum laser configuration has been implemented to the SLR station in Shanghai for two color ranging [1]. To operate the SLR station in Graz in visible range, three color ranging is accomplished by Nd:YAG SHG 532 nm, the first Stokes Raman at 682 nm and the first anti Stokes at 432 nm using Hydrogen. To operate the eye safe SLR in Tokyo at the 1540 nm wavelength, the laser was operating at 1064 nm to pump the first Stokes at 1540 nm using methane. To operate the SLR in Bern and Wettzell (move to Chile) Titanium-Sapphire based laser has been operating at 852 nm and SHG 426 nm. The multi-color set up has been established at the Shanghai observatory since 2004. The ranging has been successfully accomplished for retro-reflector equipped satellites up to a distance 30000 km with sub-centimeter precision. The results of direct measurements of atmosphere dispersion are presented and compared to existing atmosphere models.

To range satellites or Moon one has to consider several “contributors” to the overall accuracy of the SLR measurement chain: the SLR station itself, satellite retroreflector array,

and the atmosphere, as well. Current SLR technology aims toward millimeter accuracy. From the point of view of the SLR station, the RMS laser pulse duration, Start and Stop detectors RMS and the Event Timer jitter are involved. Due to different satellite retroreflector array geometries, to understand the ultimate limit, the best choice is perhaps the European Remote Sensing (ERS) satellite array and the optical spherical retroreflector, Luneberg sphere, on the board of the Meteor 3M satellite.

Related to the atmospheric dispersion, the existing models [4] are not yet explaining the contribution at millimeter accuracy level. The SLR at different wavelengths might contribute to understand the atmospheric mapping function down to millimeter and consequently sub-millimeter level. In fact, the multi-color SLR is a unique method for overall optical path dispersion model direct verification. The multiple color laser transmitter based on Nd:YAG picosecond laser generating the second harmonic frequency and the Raman Stokes and anti-Stokes frequencies is dedicated [3] for the new Shanghai SLR station, the part of Western Pacific Laser Ranging Network.

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Polarity Effects of DC Corona Discharge

S. Pekárek, J. Khun

pekarek@feld.cvut.cz

CTU, Faculty of Electrical Engineering, Department of Physics
Technická 2, 166 27 Prague 6

In the laboratory of electrical discharges of the Department of Physics FEE we study hollow needle to plate DC corona discharge enhanced by the flow of air or mixture of air with a pollutant through the needle. This research is oriented to ecological applications, namely to the study of ozone production and decomposition of volatile organic compounds.
Properties of the corona discharge are influenced by wide range of factors such as discharge voltage, current, geometry of electrodes, type of the medium – electronegative or electropositive gas; atomic, molecular gas or a mixture (air with a pollutant); flow rate of the gas etc. Corona discharge also exhibits important dependence on the polarity of the coronating electrode. This dependence is caused by the different mechanism of electron multiplication. If the coronating electrode is the cathode (negative corona) then avalanche multiplication takes place. The secondary process is the emission from the cathode, and possibly, photoionization in the bulk of the gas. On the other hand if the coronating electrode is the anode (positive corona), the remote large cathode does not participate in multiplication of electrons, on account of the weak field in its vicinity. The reproduction of electrons is ensured by secondary processes in the gas around the coronating electrode.
The discharge mechanism is reflected by the shape of the discharge, which can be observed visually. Thus for the needle biased negatively we found that at low energy dissipated between electrodes (usually obtained by combining a high flow rate with low driving DC voltage), the discharge is restricted to the small area surrounding the needle cathode. It takes the shape of a short luminous continuous jet, which is directed towards the plate anode. At higher energy dissipated between electrodes (usually obtained by combining a low-intermediate flow rate with a high driving DC voltage), the discharge is much more complex. The luminous jet directed towards the anode becomes longer and, simultaneously, the gap between the tip of the jet and the plane anode surface is frequently bridged by very thin filamentary discharges.
For the needle biased positively and for low energy dissipated between electrodes the discharge resembles a diffuse weakly luminous cone bridging the gap. With increasing energy the cone is superimposed with pulsed filamentary discharges. The different mechanism of the discharge is reflected by the discharge current-voltage characteristics.

Effect of polarity on ozone production:

In our previous works [1,2] we proved important dependence of ozone production for the hollow needle to plate discharge enhanced by the flow of air through the needle on the polarity of coronating electrode. We found that ozone production for the discharge with the needle negative is about two times higher than for the discharge with the needle biased positively. This conclusion is in agreement with the results obtained in [3] for the discharge in stationary air. This result can be at least qualitatively explained by the increase of the number of electrons in comparison with the positive corona and by the fact that that the reactive plasma region extends beyond the ionization region.
Reactive corona region is the region in which the most of ionization, excitation and reaction processes take place. Radius of this reactive region is affected by the discharge voltage. The discharge voltage for particular current depends on the polarity of the coronating electrode.

Thus radius of the reactive region for the discharge generated around a sharp point against the plate electrode in stationary medium is $r_{Ac} = \sqrt{\frac{rU}{E_{break}}}$, where r stands for curvature radius of the tip, U is the discharge voltage and E_{break} is the breakdown electric field which can be estimated as 25 kV.cm^{-1}. The increase of the reactive corona volume allows increasing discharge current, production of electrons and consequently higher ozone production.

With respect to these results concerning discharge polarity effect on ozone production an interesting problem will be the dependence of volatile organic compounds decomposition efficiency of the discharge on the polarity of the coronating electrode.

Effect of polarity on volatile organic compounds decomposition:

In the literature can be found a lot of studies concerning decomposition of different volatile compounds (toluene, trichlorethane, *n*-heptane etc.) by DC corona discharge for different polarities of the coronating electrode. The problem however is that most of these works were performed either for the negative polarity or negative polarity of the coronating electrode with different experimental set-ups, therefore serious comparison of the results is complicated. Most of the published works were also performed with positive polarity of the coronating electrode because the discharge seems to be more stable.
In our laboratory we performed the decomposition studies of *n*-heptane and toluene for the discharge with the needle biased negatively [4]. In order to clarify the influence of polarity of the coronating electrode we will investigate decomposition efficiency of *n*-heptane by the hollow needle to plate electric discharge also with the needle biased positively. For these experiments we will use the same experimental arrangement, so that our results will contribute to the solution of the decomposition efficiency polarity dependence problem.

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Comprehensive Diagnostics at the S-300 Z-pinch Generator

D. Klír, P. Kubeš, J. Kravárik, Yu. L. Bakshaev*, P. I. Blinov*, A. S. Chernenko*, S. A. Danko*, V. D. Korolev*, A. V. Korelskij*, E. V. Kravchenko*, A. Yu. Shaskov*, G. I. Ustroev*, and M. I. Ivanov**

klird1@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic
*RRC Kurchatov Institute, 1 Kurchatov Sq., 123182 Moscow, Russia
**Institute of Pulsed Systems, 115304 Moscow, Russia

The S-300 generator which was built in the Kurchatov Institute in Moscow belongs to the five most powerful Z-pinches in the world. It is capable of delivering a 3 MA current with a 100 ns rise-time into a load. Experiments on the S-300 generator at the Kurchatov Institute are mainly focused on the study of the implosion of wire-arrays since wire-array Z-pinches (more precisely the Z-machine at Sandia National Laboratories, New Mexico) are the world's most powerful (up to 290 TW and 1.9 MJ) and most efficient (15%) laboratory x-ray sources. The primary interest of our recent research has been the question of what would happen if we put a metallic wire or deuterated fibre in the centre of a wire array [1-3].

In order to study dynamics of Z-pinch plasma, the emphasis was put on an extensive set of optical, x-ray, electron and neutron diagnostics, part of which was developed and tested on the Z-150 device at the Department of Physics, Faculty of Electrical Engineering, Czech Technical University in Prague[4].

First, to provide time and space resolved information about visible emission, an optical streak camera was used. The streak camera was performed in the radial mode, i.e. with a slit parallel to the Z-pinch axis.

Second, X-ray radiation was detected with two X-ray pinhole cameras, XUV grazing incidence spectrograph, X-ray crystal spectrograph, and 11-channel soft X-ray polychromator. One X-ray pinhole camera, which was gated, recorded 4 frames with 2 ns exposure and 10 ns inter-frame separation. All four frames were filtered with 24 μm thick beryllium. The other pinhole camera, time integrated and differentially filtered (without a filter, and with 5 μm and 24 μm mylar), was used to observe the plasma in various spectral ranges with the spatial resolution of 100 μm. Even better spectral information was obtained by a time integrated XUV grazing incidence spectrograph which recorded the region between 2-25 nm. As regards soft X-ray spectrum, it was detected by a 2D spatially resolved mica-crystal spectrograph. Time resolved studies of soft X-ray emission was conducted using an 11-channel polychromator. The various combinations of glancing incidence mirrors, transmission filters, and semiconductor detectors enabled the detection of photons in channels of 50, 80, 120, 180, 270, 365, 600, 800, 1000, 1200 and 2200 eV.

Third, to obtain information about fast electrons emitted from a pinch plasma, the Cerenkov detector was used.

Further, the plasma was also probed by 5 pulses of a Nd:YAG laser (2 HG, 532 nm). It enabled us to obtain 5 shadowgraphs with 2 ns exposure and 10 ns inter-frame separation.

And finally, as far as neutrons are concerned, the neutron yield was measured by an indium activation counter. A time-of-flight analysis of neutrons was made possible by three axially and two radially positioned SSDI-8 scintillators.

This comprehensive set of diagnostic tools enabled us to observe the plasma dynamics published in [1]-[3]. The particularity of our Z-pinch experiments was the implosion of a plasma onto a fibre or a wire. First, it offered a possibility of how to transfer the current with a sharp rise-time in the vicinity of a wire or how to modify the shape of an X-ray pulse. Next, the wire in the centre of an imploding plasma introduced homogeneity to Z-pinch discharges. Last but not least, a wire could be used as a target for an imploding plasma and could serve as a diagnostic tool.

Another important result we found out was the fact that the implosion of a wire-array had the positive influence on the neutron yield. The neutron yield was one order in magnitude higher in the case of an imploding wire-array onto a deuterated fibre than without a wire-array (cf. [2] and [3]).

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Energy Transfer in Laser-Irradiated Foams of Various Pore Structures and Chemical Compositions

J. Limpouch, M. Kálal, J. Kuba, R. Liska, M. Šiňor, E. Krouský*, K. Mašek*, N.G. Borisenko, A.M. Khalenkov**, V.N. Kondrashov***, W. Nazarov******

limpouch@troja.fjfi.cvut.cz

Dept. of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Břehová 7, 115 19 Prague 1, Czech Republic
*Institute of Physics, AS CR, Na Slovance 2, 182 21 Prague 8, Czech Republic
**P.N.Lebedev Physical Institute, RAS, Leninskyi Ave. 53, 117 924 Moscow, Russia
***Troitsk Institute for Innovation and Fusion Research, 142190 Troitsk, Russia
****University of St. Andrews, School of Chemistry, St. Andrews, Fife KY16 9ST, UK

Foam layers may be used in targets for inertial fusion. The original proposal [1] was basically a variant of indirectly driven inertial fusion as it assumed conversion of laser radiation into X-rays in thin outer high-Z foil and then symmetric ablation pressure is achieved by smoothing of inhomogeneities in the X-ray energy distribution in a layer of low density foam. Shortly after the original proposal, a different approach was introduced that utilizes low-density foam as the outer layer of directly-driven ICF target [2]. In this scheme, low-density foam is proposed, both as an efficient absorber of laser radiation, and also for smoothing of transverse inhomogeneities in ablation pressure. When efficient laser absorption (70-95 %) in low-density foams was confirmed experimentally, both for normal and oblique laser incidence, simplified target irradiation scheme was proposed that can significantly reduce constraints on ICF reactor design. Alternatively, transparent underdense foam layer may serve as a dynamic phase plate for spatiotemporal smoothing of inhomogeneity patterns inside laser beams. Foam layers may be also utilized in EOS studies and in astrophysics dedicated experiments.

This paper is devoted to the scheme when the outer layer of target interacting with laser radiation is low-density foam. We study here experimentally laser penetration into underdense foam, energy transport and shock wave propagation in the foam material and acceleration of thin foil attached to the rear side of the foam layer. While in our previous experiments on laser PALS, plastic foams with relatively large cells of characteristic scales > 10 μm were used, the present experiment compares these foams with plastic foams with fine cells of scale length ~1 μm and also with foams including high-Z (Cl, Cu, Sn) additions.

Third harmonics (λ=438 nm) of iodine laser PALS was incident normally on 300 – 800 μm-thick foam layer with thin Al-foil on the target rear side. Laser pulse duration was 320 ps, laser energy was varied in range 50 – 250 J, the laser spot diameter was 300 μm at the target surface, best laser focus was situated ahead of the target. Side-on streaked X-ray slit image was used for the evaluation of the speed of energy transfer through the porous foam material. The arrival of shock wave on the rear side of the target was measured by optical streak camera detecting self-emission from the target rear side. Three-frame optical shadowgraphy measures the shape and velocity of the foil accelerated by the pressure of the heated foam matter.

It was found that laser radiation can gradually penetrate through significantly subcritical foam (≤1/4 of critical density n_c) with small pores of characteristic scale ~1 μm with speed of approximately 1.3 x 10^8 cm/s. This is very important as thin layers of such foams may be used as a dynamic phase plate for smoothing of inhomogeneities inside laser beams. However, for the same density and big pores of diameter >30 μm, laser is absorbed

near the foam surface and the region heated during the laser pulse is limited to 2 to 3 pore layers. When foam of higher density of ~ ½ n_c is used, the foam layer heated during the laser pulse is limited to less than 100 μm also for foams with small pores. In some shots, X-ray emission from the Al-foil is detected shortly after the onset of laser pulse and this is co-incident with pre-emission detected by optical streak. This is caused by preheat of Al-foil by fast electrons and/or X-rays. The optical pre-emission is more intense when foam with high-Z additions is used. The heat wave propagating inside the foam is faster than the pressure wave. For thicker foam layers, higher foam densities or lower laser intensities, the X-ray emitting region does not reach the target rear side. Thus, the foil is heated only moderately, and it is accelerated without significant expansion.

It was found that main pulse of optical self-emission from the target rear side starts approximately at the beginning of rear side motion, detected via optical shadowgraphy. The shock transit time through the target (measured by optical emission) increases with the foam density, with the foam cell size and also when high Z material is added. It decreases with laser intensity. The shock transit time is reproducible within ±5% accuracy for high quality TMPTA foam targets.

The measured velocities of the accelerated foil region reach up to 10^7 cm/s. Very high efficiencies up to 14% of laser energy transformation into kinetic energy of the accelerated foils were deduced from the experimental results. This is very important for future application of outer foam layers in target design for directly-driven inertial fusion. While very smooth shape of the accelerated foil region is detected after the onset of acceleration, evolution of small scale structures is observed 6 – 9 ns later. These structures can be attributed to growth of Rayleigh-Taylor and Kelvin-Helmholtz instabilities induced by the foam structure and density step. These instabilities can be potentially very detrimental for inertial fusion.

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Study of Neutrons at PF-1000

P. Kubeš*, J. Kravárik*, D. Klír*, V. Kaizr*,
M. Scholz, M. Paduch**, K. Tomaszewski**, L. Karpinski****

kubes@fel.cvut.cz

*ČVUT FEL Praha, Technická 2, 166 27 Praha 6
**IPPLM, Hery 23, 00-908 Warsaw, Poland

The reason why the plasma focus (PF) discharges are studied is the high efficiency of the x-ray generation, the acceleration of high-energy electrons and ions and (if one uses deuterium as a filling gas) the neutron production. A plasma-focus device is very convenient equipment for study of the neutron production from D-D reactions [1,2].

In this paper we give an overview of the studies on the correlation of visible, XUV, x-ray, high-energy electron- and neutron-production.

As far as the experimental set up is concerned, the measurements were performed within the PF-1000 facility at electrical energy of 600-650 kJ, voltage of 30-33 kV, and the maximum current of 1.5-1.8 MA. The length of both electrodes was 600 mm. The outer cathode (400 mm in diameter) consisted of 8 parallel stainless-steel rods distributed symmetrically. The inner copper anode was made in a tubular form and it was embraced (at its base) with an alumina insulator of 230 mm in diameter. The filling pressure of deuterium was 3 torr.

Moving on to the issue of diagnostics, the radiation from the visible to hard x-ray range was measured with temporal-, spatial- and energy-resolution. We employed one soft x-ray microchannel-plate (MCP) detector with 4 quadrants. That detector was shielded with a 5.2-μm polyester (C_8H_8) that transmitted the radiation in a window of 200-300 eV and above 600 eV. The MCP detection efficiency is low for visible radiation below 10 eV (less than 10^{-4} in comparison with XUV). The exposure time was set to less than 2 ns and the delay between exposures was in the range of 10-50 ns. The PIN-silicon diode, covered with 3-μm-thick aluminized mylar-foil, detected x-rays in the window of 200-300 eV and in the range above 600 eV, the some as MCP detector. Four optical frame cameras with a gating time of 1 ns and the inter-frame separation of 10 - 20 ns imaged the emitting plasma in the 10 nm visible spectral window around 589 nm. The visible streak camera had the axial position of the slit 3 cm in front of the anode top. The Ne102a scintillator covered with 10-μm-thick Al-foil detected x-rays in the range above 4 keV. Fast electrons of energies in range 50-400 keV were registered with three Cerenkov detectors (made of diamond or rutil crystals and shielded with 20-μm Al) located downstream (along the current sheath movement) and upstream (behind of the hole of 5-cm-diameter in the top of the anode, in opposite direction to the current sheath movement) as well as side-on. Seven scintillation probes Ne102 with photomultipliers were used to perform the detailed time-resolved measurements of the hard x-ray (3 - 5 cm of steal or of lead was used as a filter) and the neutron emission. They were situated downstream (at distances of 7.0 m and 16.3 m) and upstream (at distances of 7.0 m, 16.3 m, 30.3 m, 44.2 m and 58.3 m). For neutron yield measurement indium and silver-activation counters were applied.

The results of this research on the temporal- and energy-distribution of neutrons and temporal correlations of radiation, fast electrons, high-speed camera frames and neutrons, as produced in the deuterium current sheath and the plasma focus within the PF-1000 facility, can be summarized as follows:

X-rays and neutrons are usually emitted in two pulses. The first pulse correlates with the deep of the current derivative and with the minimum of a pinch diameter observed in visible frames. The second pulse is emitted 120-200 ns later with intense hard x-rays and a dominate neutron production. In this pulse the number of fusion-produced neutrons is 3-10 times higher than that in the first pulse.

The fast electrons are emitted mainly at the increase of the first pulse, but in both axial directions, i.e. downstream and upstream. A simple correlation between the fast electrons and fast neutrons has not been found.

The temporal evolution of neutron energies is manifested by the initial high energies of neutrons emitted downstream and final high energies of those emitted upstream with the continuous increase in energies of the neutrons upstream.

In the visible high-speed frames one can see the correlation of the first neutron pulse with the zipper-effect of the radiating plasma and with the spherical structure in a heel of the current sheath. The maximum of the second neutron pulse is observed during the explosion of the second pinch and corresponding development of strong instabilities. We have had no evidence of the zipper-effect in this phase. We have recorded only a dense structure in the heel of the current sheath, similar to that formed after the first pinch.

The recorded MCP frames showed evolution of the first pinch similarly to visible frames, but of considerably larger diameter. The XUV radiation is generated in the hot plasma layers of lower density, which surround the pinch column recorded in visible frames. In these layers the zipper-effect has not been observed.

If the zipper-effect corresponds to motion of deuterons, then their observed kinetic energy ranging ~ 10 - 100 keV can induce the initial beam-target mechanism of neutron generation and later the heating of plasma up to temperatures above 5 keV in the heel of the current sheath.

The origin of neutrons emitted in the two pulses seems to be of the beam-target mechanism with its continuous transformation into the “thermal” one. The most of the neutrons can have the beam-target origin, and “thermal” neutrons (in both pulses) constitute 20 – 30%.

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Advanced Lagrangian - Eulerian Methods for Simulations of Plasma Hydrodynamics

P. Váchal, R. Liska, M. Kuchařík

vachal@galileo.fjfi.cvut.cz

Czech Technical University in Prague,
Dept. of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
Trojanova 13, 120 00 Praha 2, Czech Republic

Arbitrary Lagrangian-Eulerian (ALE) methods are a popular class of methods for simulation of continuum mechanics problems with large shear deformation such as fluid flow and metal forming. The process consists of a classical Lagrangian step in which the mesh moves along with the modeled material, a rezone step in which the mesh is modified to preserve good quality throughout the computation, and a remapping step in which the solution is transferred from the old mesh to the new, rezoned one.

Our task was to develop new efficient techniques for the rezoning and remapping stages, incorporate these into the ALE simulation code which is currently under development in our department, and use this code to simulate selected complex problems from the field of fluid dynamics and plasma physics.

For mesh rezoning, the code originally used only very simple averaging suggested by Winslow more than 40 years ago. To avoid unnecessary smoothing of the mesh which results in loss of simulation information gathered so far, we suggested a more solution-sensitive method [1], which uses a combination of geometrical operations and numerical optimization to reposition the nodes (without their reconnection) and thus to untangle even heavily distorted meshes. This method can be either used for the actual rezoning after the Lagrangian step, or utilized as a preprocessor to other efficient techniques, which cannot handle invalid elements (e.g. inverted or nonconvex cells) in the starting mesh. One of these techniques, based on the Reference Jacobian Matrix (RJM), has been also incorporated into our ALE code. We developed a technique which improves the mesh quality by reconnection of the nodes so, that the interpolation error of selected state variable (e.g. density or temperature) is minimized. Further applications of this method include mesh improvement for solution of diffusion problems by Mimetic Finite Difference method [3]. This technique was so far implemented only on simplicial meshes, but its extension to polygons and polyhedra is under development.

As for remapping, we require that the method is conservative, preserves local bounds (a slightly weaker notion than monotonicity preservation) and remaps at least linear functions exactly. A very fast and robust method uses high-order intercell fluxes and a posteriori correction (so called Repair) of possibly created overshoots or undershoots in values of certain state variables. This method is guaranteed to work for scalar quantities and much progress has been done also in extension to systems of equations. We however believe, that better results can be achieved when the preservation of local bounds is enforced already during the remapping process, rather than repairing a posteriori. Also, it is surely advantageous when all state variables are remapped at once, rather than employing the equations sequentially (first mass, then momentum and finally total energy). Therefore we suggested an approach which uses constrained numerical optimization to combine low-order fluxes (which preserve local bounds by default) with higher-order fluxes (generally unconstrained) in a way that meets all

imposed requirements. While it seems to be a good alternative to the repair method, it is not very hard to construct an artificial example, where the stencil becomes too large and thus makes the optimization very time-consuming. Therefore, we developed another family of remapping methods, based on the popular classic idea of Flux-Corrected Transport (FCT), which is local by definition. The methods also combine low-order and high-order schemes according to local smoothness and are guaranteed to work always (giving the low-order result in worst case). Another great advantage is that major part of the computation is independent of mesh dimension and topology – most of the formulas are the same for any type of mesh.

The modified ALE code was successfully used to simulate a set of physical phenomena from the field of fluid dynamics and plasma physics, including Rayleigh-Taylor instability, laser-plasma interaction and impact of an accelerated aluminum disc on massive target [4]. Reference computations have been performed with various rezoning and remapping modules. Good results have been achieved even in cases, where conventional Lagrangian computations lose precision or even fail completely.

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Monte Carlo Simulations for Time-Resolving Energy Distribution

K. Řezáč

rezack@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The aim of this work is to reconstruct time-resolved energy spectra of particles which are emitted in intense bursts. A typical example is the emission of fusion neutrons (D-D reaction) from hot dense magnetized plasma on plasma focus or z-pinches devices. Classical time-of-flight method cannot be used for a neutron source with a long duration of emission which occurs in Z-pinches and plasma foci. In the case of a long emission, another method must be used, for example time-resolved spectroscopy method described in [3]. Several techniques for time-resolved spectroscopy have been developed [2–4]. According to paper [1] a Monte-Carlo technique gives the best results.

The basic reconstruction algorithm consists of two steps [2].

- The first step, without any prior knowledge of time evolution and energy distribution, is sampling of events by uniform random generation in the plane (t, E) at the source position. Then the algorithm tests if the event is detectable on all used detectors. When the test is passed, the event is accepted and the corresponding element in reconstruction matrix, accordant with the plane (t, E), is increased by one unit and the corresponding bins in every detector are decreased by one unit. The first step of reconstruction process stops when a lot of events are not passed the test (stop condition can be various, for example when defined ratio between the number of accepted events and the total number of recorded events is reached).
- The second step of the reconstruction follows the algorithm described at the first step. The difference is in sampling of events. The events are not sampled by uniform random generation but they are now governed by the probability function, which have been reconstructed in the first step. The second step is iterated in order to obtain a maximum reconstruction efficiency factor.

This Monte-Carlo technique was applied to data from experiment on the PF-1000 facility in Institute of Plasma Physics and Laser Microfusion in Warsaw. Among diagnostic tools, six detectors (scintillation-photomultiplier probes) were used for time-resolved measurements. Detectors were placed at different distances along the plasma focus axis, namely at 58.34 m, 16.34 m, 7.0 m, –7.0 m, –16.34 m and –58.34 m. Hard X-ray and neutron pulses were recorded with these scintillation probes with 1 ns resolution. After the normalization, these signals were used for simulation.

These Monte-Carlo simulations were used on data measured on PF–1000 facility during October 2005. A time-resolved energy spectrum of neutrons was reconstructed for the emission time in the range of –20 to 500 ns and the energy in the range of 1.5 to 3.5 MeV. The maximum emission of neutrons was found at the time between 130 to 170 ns. The mean energy of these neutrons was found around 2.9 MeV.

Our plan is to process older data gained from experiment on PF–1000 (Warsaw) and S–300 (Moscow) facilities. On the one hand, we would like to adapt our simulation to experiments. On the other hand, on the basis of these simulations, we can optimize number and distance of the detectors in the forthcoming experiments. Our work bears new piece of knowledge in using of detectors on both sides of the axis of plasma focus.

The program package with Monte-Carlo simulations for time-resolving energy distribution were implemented in FORTRAN 95 language and compiled by Intel® Fortran Compiler 9.0. The package contains graphics and text outputs.

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Pulsed Electronic Speckle Pattern Interferometry

P. Dvořáková, V. Bajgar, J. Trnka

Pavla.Dvorakova@it.cas.cz

Institute of Thermomechanics AS CR, Dolejškova 5, 182 00 Prague 8, The Czech Republic

Speckle metrology is an important part of optical measuring techniques based on speckle phenomenon. It can be used to measure changes in optical path lengths as a function of a test-object surface position. Speckle techniques utilize speckle that arises in space when a diffusely reflecting object is illuminated by laser light. The random pattern of dark and bright spots called a speckle pattern is observed when looking at or imaging a laser illuminated, diffusely reflecting surface with eyes or with camera.
Speckle pattern interferometry is a non-contact, full-field measuring technique that can be used to determine displacements at points on the surface of a diffusely reflecting object with accuracy in the order of a fraction of the wavelength of the illuminating light. Basic intereferometers (Michelson, Fizeau) are used in speckle pattern interferometry arrangement, and depending on the geometry of the interferometers, either in-plane [1] or out-of plane displacement can be measured. Generally, speckle pattern interferometry is an interferometric technique in which at least one of the interfering fields is a speckle field.

In speckle pattern interferometry optically rough surfaces are studied and thus the resulting interference pattern will be again a speckle pattern with randomly varying phase and amplitude (specklegram). Thus, in speckle pattern interferometry two specklegrams have to be captured - before object deformation and after object deformation. To obtain a fringe pattern, representing contours of constant displacement component, the correlation between the intensity distributions of the two speckle interference pattern is performed.

In case of an electronic record and processing of specklegrams, the speckle pattern interferometry is referred to as electronic/digital speckle pattern interferometry (ESPI/DSPI). The electronic speckle metrology technique combined with advanced computers, fast frame grabbers, and image processing makes ESPI very suitable for industrial applications.

The contribution deals with an application of ESPI for measuring a deformation profile of a thin steel plate loaded by a focusing a ruby laser beam. Monitoring of the normally loaded test-object determined Michelson-type ESPI sensitive to out-of-plane displacement.

Double exposure method was apllied to study a fast transient event caused by a shock load. The instrumentation was developed to permit synchronization of a laser control unit and an electronic part of the interferometer [2]. The application of the double exposure is conditional upon using both by charge-coupled device (CCD) camera with asynchronous reset mode and by double pulse laser HLS 2. Monochrome camera XC-8500CE in connection with frame-grabber acquisition card Matrox Meteor-II/Multi-Channel enabled us to capture two consequently images with delay a few microseconds ($15 - 50 \mu s$). The laser pulses were used both to generate and to record the bending waves. The high-energy laser pulse transferred energy to the plate and excites out-of-plane transient motion of the plate. The short duration of the laser pulse (15ns) effectively ‘freezes’ propageting stress waves during the exposure.

To capture an image at the moment of firing the laser, a few following requirements have to be followed. The pockels cell can be triggered $1300\mu s$ after triggering flashlamps. As soon as the first laser pulse fires ($6\mu s$ after triggering pockels cell) the unloaded specklegram is captured. After finishing the exposure time, which lasts $10\mu s$, the image is moved out from the light-sensitive elements of CCD to vertical shift registers. As soon as the image transfer from the light-sensitive pixels to the vertical shift registers is completed ($2\mu s$), the light-sensitive pixels are ready for the next exposure and the second 'loaded' specklegram can be taken.

The desired magnitude of a test-object displacement was revealed by correlating (subtracting) the two specklegrams. The subtraction produced a correlogram, showing fringes that contour regions of equal displacement. For points on the object that did not move between frames, their brightness remained constant (full correlation, minimum brightness of fringes).

The fringes can provide valuable information to the trained eye, but they have a few drawbacks. Analysis of the speckle correlogram was performed by intensity-based technique and fringe tracking were carried out to identify only the centres of fringes that means the whole width of a fringe represents the same magnitude of displacement. Moreover, from the fringe pattern alone it is impossible to determine the sign of the phase change. These drawbacks can be overcome by employing phase shifting methods that enable us to obtain data over the full field, not just at the maxima and minima.

It is obvious that speckle interferometry is very similar to holographic interferometry. In the holografic interferometry the double exposure methods is also applied for studying transient events and the pattern of interference fringes represents contours of constant displacement [3][4]. Holographic interferometry also relies on the interference of two speckle fields; however, both fields are almost the same. As opposed to speckle interferometry where two interfering fields are uncorrelated. Speckle interferometry uses the phase information carried by the speckles to determine the deformation of the object.

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Application of Atmospheric Dielectric Barrier Discharge for Polyethylene Powder Modification

J. Píchal

pichal@fel.cvut.cz

Czech Technical University, Faculty of Electrical Engineering, Department of Physics, Technická 2, 166 27 Praha 6, Czech Republic

Over last years study of various polymer materials including biocompatible materials has intensified. For modification of surface properties of such polymer materials were among others extensively used cold plasma treatment methods. Their application seems to be a convenient way to change treated material surface characteristics by introducing new surface chemical groups without affecting volume properties of treated material. As an example can be mentioned surface modification of powder particles from hydrophobic to hydrophilic ones or vice versa, which has many applications (adhesion and biocompatibility improvement etc.).

In various technologies as xerography, electrostatic powder coating, cosmetics and biotechnology plays an important role electrification of powder particles. In these technologies, powder particles must carry high specific charge and its value has to be controlled, however most of the plasma modifications have been directed towards films and flat materials. Since powder particles have a tendency to aggregation and are characterized with a large surface area per unit mass and also difficult to be handled with, research works relating with fine powder particles modification are relatively sparse.

In permanent search for new methods that would change characteristics of polymers in a considerable fashion and make them possible to be applied in more stressed parts, there were developed some methods of hardened layers creation on the surface of parts made from polymer based materials and several plasma treatment systems have been presented: e.g. plasma fluidized-bed reactor [1], plasma rotating-drum reactor [2], plasma batch reactor [3] and plasma downer reactor [4]. In respect to the powder particles treatment, major problems are connected with insufficient intercourse of plasma and powder particles, plasma inhomogeneouty, powder particles agglomeration and particles excessive heating.

Experiment described in this paper should verify possibility of atmospheric dielectric barrier discharge (DBD) plasma application for polyethylene powder modification. Employed plasma reactor was characterized with relatively high reaction rate (connected in the main with comparatively good powder particles dispersion in plasma and powder particles transit velocity in reactor).

For all experiments described in this paper polyethylene powder Borealis CB 9155-01 was used. The diameter of powder particles, idealized as balls, was approximately 250 μm. Their modification was performed in atmospheric DBD discharge generated between two large plane brass electrodes. All experiments were performed in stationary air under atmospheric pressure (743 ÷ 754) torr and room temperature (20 ÷ 23) °C.

Rectangular brass electrodes in the DBD reactor [5] were separated one from another by glass plate. One of electrodes was grounded and the second one was connected to a high-voltage transformer. The distance between the electrodes was 14 mm. Powder particles were gravity-fed in a continuous stream through the air plasma zone from a hopper at the top of the reactor to a collecting bin at the bottom. PE powder was repeatedly filled in the discharge channel of the reactor, number of transits through the plasma reactor was one of investigated parameters. The AC high voltage supply up to 22 kV (50 Hz) was used in experiments.

The average charge density in the inter-electrode region depended on three basic parameters: applied voltage and its amplitude, thickness and dielectric properties of cathode cover and spacing of electrodes.

The PE powder wettability was determined from dynamic capillarity rise according to the Washburn method [6] with a tensiometer. A 10 mm inside diameter glass tube, bottom closed with a porous membrane, was filled with 1 g of powder. Subsequently the bottom of the tube was put in close contact with a test liquid which penetrated up into the PE powder column by capillarity rising. After contact of the bottom tube with the liquid the weight of the penetrating liquid was measured as a function of time. Five samples were measured from each batch and average value and standard deviation were calculated. On some samples ESCA measurements were performed.

Experimental results expressed as process time function of capillarity of the powder in the tube (i.e. as a function of number of transits of the powder through the plasma reactor) have shown distinct increase of the powder capillarity (more than 200%) with growing number of transits.

Important aspect for practical application of plasma-modified powder is the time-stability of the effect. The aging was tested 17 and 23 hours and 60 days after modification. It was observed only very slow capillarity decrease. Additional long-time measurements indicate likelihood of the modified powder storage for several months.

The physico-chemical problems of the powder particles modification seem to be almost the same as in the case of solid films. The oxygen containing groups (mainly hydroxyl) are tied up to the surface of polyethylene and herewith the enhancement of about 8 per cent of the atomic oxygen on the surface was established. By studying of the contact angle, surface energy and surface wettability can be easily proved. Difficulty of powder treatment is related with the three-dimensional character of the powder and a large area to be treated.

It can be concluded, that described method seems to be an appropriate method also in the industrial – scale and that modified powder exhibits very good adhesion to metal surfaces.

Important aspect for practical application of plasma-modified powder is the time-stability of the effect, therefore further additional long-time measurements must be carried out.

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Modeling of Helical Structures in Plasma

M. Stránský

stransm@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Helical structures show up in final stages of many laboratory plasma discharges and astrophysical plasma. Mathematically helical structures are characterized by the measure called helicity [2]. The helicity of a field is defined as the scalar product of the field and its curl. This defines a scalar field, which can be integrated over the system volume to give the total helicity of the system. This quantity may or may not be conserved depending on the system in question. It has been shown that in the ideal magneto hydrodynamics theory (MHD) helicity is conserved when the diffusion of the magnetic field can be neglected, i.e. the magnetic field is frozen. However, this is only a sufficient condition.

We have shown that cylindrically symmetric stationary and steady state solutions are possible in the ideal MHD theory either with or without neglecting the term of the diffusion of the magnetic field [1]. The range of possible solutions with frozen magnetic field is by nature larger than the ones without the frozen field.

Stationary solutions may represent current fibers lasting relatively long time by themselves; however, it is more usual for these solutions to be unstable in which case they are likely to quickly change configuration or disintegrate totally. Stable stationary solutions are of importance if one wants to confine hot plasma for a long time. Having found these solutions, investigation of stability was pursued. Theoretical study of non-linear helix formation from linear perturbations was done and compared with laboratory results.

Axial magnetic field in helical pinches (z-pinches with axial field) inhibits, for most part, the m=0 instability. For some cases the m=1 instability can be also inhibited, but it frequently occurs in laboratory pinches. The conditions for the development of m=1 instability was investigated. Pictures of laboratory z-pinches often show a spiral shaped plasma fibers in final stages [3]. This is most likely a developed helical mode of m=1 instability far beyond linear perturbation. For a given pitch angle of the magnetic field helix in the initial unperturbed state of an axial symmetric pinch certain helical kink perturbations develop faster than others, with pitch angles in general different from the initial magnetic field helix. These may in the end develop into the before mentioned observed shapes. By measuring the pitch angle of the observed helix one could, in theory, deduce the most likely shape of magnetic field before the onset of the instability, as the relation between observed helix pitch and initial ratio of the axial to maximum azimuthal component of the magnetic field that was derived is uniquely invertible; however, it might prove difficult to justify the assumptions made to arrive at this conclusion.

The Faculty of electrical engineering at the Czech Technical University in Prague operates a small z-pinch device. This z-pinch discharge is usually initiated using a carbon fiber load with diameter of 15 μm and length close to 1 cm which is attached between electrodes in an evacuated chamber. The pinch is now driven by one capacitor (in past four were used) with capacitance of 3 μF and charging voltage of 20-30 kV. Typical maximum current of 80 kA is reached in 700 ns after the breakdown. During the current rise between 200 to 500 ns pulsed

emissions of XUV radiation occurs that can be attributed to implosion of carbon plasma onto the solid fiber and instability development. Following these events plasma expands rapidly away from the fiber in the m=0 mode, but occasionally an m=1 helix is seen in the Schlieren images [3]. This helix expands two orders magnitude slower (1000 m/s) than the m=0 mode, and its channel diameter expands almost unnoticeably. From the developed theory it was estimated that for the observed helices the ratio of magnetic field components was most likely $B_z/B_\varphi \sim 0.9 \div 1.1$. Our group also cooperates with a group at the Kurchatov institute in Moscow that operates the S-300 z-pinch device, and with the Institute of Plasma Physics and Laser Microfusion in Warsaw that operates the Plasma focus PF-1000 device. Similar results were found in these experiments too with the conclusion that in the Z-150 it is most likely that the helices that developed are just traces left behind after the rapid instability development, and that they linger on for a long time with slow expansion speed. In the S-300 they expanded relatively faster, but evidently slower than the corona expansion; the instability also indicates that the developed axial field in the pinch phase of this apparatus was relatively weaker (the predicted ratio of axial to azimuthal component was smaller). Helical structures also occasionally develop in the plasma focus PF-1000, probably affecting implosion leading to the second pinch. At the present time there is no other diagnostic that can measure the axial magnetic field at none of the mentioned facilities, so confirmation of these results is not possible now, but magnetic field measurements are planned in the future.

Since the helical m=1 modes that show up in the experiments can be attributed to the presence of axial magnetic field component before the onset of instability, a question needs to be answered – how the axial component is generated. One possibility is that it is generated by a stochastic process called the alpha effect. Numerical simulations of the alpha effect that can generate such field were performed with Bennet z-pinch as initial condition using a three-dimensional resistive MHD code. The results show that such mechanism in z-pinches is feasible, but it is not the only possible mechanism of axial field generation and some questions still remain to be answered.

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New Phase Evaluation Algorithm for Interferometric Measurements

A.Mikš, J.Novák, P.Novák

miks@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

In practice, various optical methods are used for making measurements of different physical and geometrical quantities, e.g. shape, static and dynamic deformation of surfaces, roughness, etc. These methods use the interaction of the optical wave field with the investigated object for quantitative analysis. Physical properties (amplitude, phase, frequency, polarization) of the wave are modified after the interaction with the object. Very important methods are phase techniques that use evaluation of the phase change. From these phase values, one can obtain corresponding physical and geometrical quantities. Various methods exist for phase evaluation in optical measurements. Nowadays, the computer aided methods use for phase evaluation three groups of methods: the interference methods, measurement of wave-front gradient, and phase evaluation using the equation for transport of energy in electromagnetic field. These measurement and evaluation techniques enable to use only the values of the intensity of investigated wave field.

The research deals with a proposal and analysis of new methods for digital phase evaluation in interferometric measurements. Interferometric methods usually use the interference of light for evaluation of phase differences between the reference and object wave field. The phase of the object wave has information about the investigated object. Consider two-beam interference, we can observe the interference field that is characterized by a specific interference pattern (fringes). Various methods [1] can be used for analysis and evaluation of the phase difference. Phase evaluation techniques are widely used in measuring methods of optical metrology (measurement of surface topography and roughness,) and optical microscopy (measurement of optical properties of investigated specimens).

Measurements of very small phase changes in optical measurement techniques are usually performed by interferometric methods that are based on evaluation of interference patterns that correspond to a phase change of the investigated wave field. If values of the phase change are small, it is difficult to determine accurately the phase values, and one needs very expensive measurement systems.

The aim of our work was to propose a new method for evaluation of small phase variations and derive theoretical formulas for phase evaluation using interference of polychromatic light. The phase change affects the color of the interference pattern. The color of the interference field can be assigned to a specific phase change and it can be evaluated using colorimetric methods.

Our work presents a relatively simple method for evaluation of small phase variations that can be applied in testing the quality of optical elements and systems [2-4]. In interferometric testig techniques, the phase is closely related to the wave-front shape and consequently to the quality of the tested optical system. A possible way for measurement of the wave-front deformation is shearing interferometry. The method is based on the principle of interference of two spatially sheared wavefronts. These wavefronts originate from one wavefront (the tested wavefront). The shear is performed by a proper shearing element that

forms two images of the tested wavefront that are separated by a mutual radial shift, lateral shift or rotation. We use the principle of polarization interferometry for calculation of small phase changes of the tested wavefront. Polarization interferometry is based on interference of differently polarized waves. It can be achieved using birefringent optical elements that are placed between two polarisers. One can use, for example, a Wollaston prism as a shearing element that is situated between two polarizers. A uniformly illuminated slit is then imaged into the plane of localization of interference fringes in the Wollaston prism. Due to birefringence, the tested wavefront is divided into two sheared wavefronts. The interference pattern can be observed by an additional microscope objective either visually or by a CCD camera. The microscope objective is focused on the exit pupil plane. If the tested optical system is aberration free, then the field of view will be uniformly colored because the path difference δ between sheared wavefronts is constant. For zero path difference the interference pattern is dark. However, if the tested wavefront is aberrated, then the wavefront exiting the tested optical system is a surface of a general shape and the field of view will be uniformly coloured no longer. Color interference fringes or a nonuniformly colored field of view occur because the path difference δ between sheared wavefronts is not constant. Using such interferometer in the case of small aberrations, we can detect the nonuniform color interference pattern that can be evaluated using our proposed technique. The color of the interference field depends on the path difference δ. It is possible to determine small phase changes by proper evaluation of the color of interference field, because even a small phase change has effect on the color of the interference pattern. The specific value of the phase change can be assigned to given color, and the phase change can be evaluated by using the colorimetric analysis.

The detailed theoretical analysis of the phase evaluation problem was performed and the equations for evaluation of phase at particular points of the interference field were derived. It can be concluded from the performed theoretical analysis that the proposed approximate nonlinear model is quite suitable for evaluation of the optical path difference smaller than 50 nm. The proposed method can be used even in the case of dependence of the phase of wave field on the wavelength of light or for wave-front deformation larger than 50 nm, but the optical path difference must be determined by appropriate optimisation techniques. The proposed method seems to be suitable for practical use in many areas of science and engineering, e.g. in topography of surfaces, roughness measurement, and optical microscopy.

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Theoretical Analysis of Aberrations of Optical Systems

A.Mikš, J.Novák

miks@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

Our research was focused on a theoretical analysis of aberrations of various optical elements and optical systems in industrial practice. The first part of the work analyses generally the wave aberrations of optical systems. The design process of optical systems requires to obtain residual aberrations of designed optical systems as small as possible. By analysis of the dependence of aberrations on the numerical aperture and field of view, it is possible to find values of numerical aperture and field of view, where the residual aberration is zero. Such values of numerical aperture and field of view are called correction zones. Values of correction zones are dependent on the criterion that is used for evaluation of the quality of optical systems. The work theoretically analyses the described problem and formulas are derived for expression of wave aberration coefficients in dependence on the values of correction zones. These formulas are derived for primary aberrations of optical systems (spherical aberration, coma, field curvature and distortion) of the third and the fifth order. The derived formulas for wave aberrations coefficients are very useful during the design of optical systems, because aberrations are in most cases corrected for some zone in the area of numerical aperture and for some zone in the field of view. The derived relations represent one possible formulation of wave aberration coefficients that is however very suitable for practical use. Finally, there was done an analysis of optimal values of correction zones and optimal position of the centre of reference sphere using derived equations. This analysis was performed for the case when it is required the maximal value of wave aberration to be minimized.

Furthermore, it was thoroughly analysed the case of calculation of polychromatic aberration coefficients for optical system design. The work deals with the influence of the wavelength of light on the values of wave aberration coefficients. Aberrations of optical systems can be generally caused by many reasons of the physical, material and technological origin. Aberrations of optical systems are also dependent on the wavelength of light. Such aberrations are called chromatic aberrations of optical system. It was proposed a methodics for calculation of the dependence of aberration coefficients on the wavelength, their interpretation and the connection to chromatic aberrations of the optical system. The method for calculation of chromatic aberration coefficients was carried out for the case of the imaging of axial point by the rotationally symmetric optical system. Relations that enable calculation of chromatic aberration coefficients up to fifth order were derived. These relations are accurate enough for most optical systems in practice. The stated method can be easily extended so as to be able to calculate aberration coefficients of an arbitrary order.

We have also presented the work that deals with the method of correction of spherochromatic aberration by system of thin layers. It is well-known from the theory of optical imaging that optical systems generally show a presence of a chromatic aberration that originates from a variation of the refraction index of glass on the wavelength of light. The chromatic aberration must be well corrected in order to obtain a good quality of optical image. In practice, it is used a proper combination of optical elements manufactured from different types of optical glass with a different dispersion in order to reduce the chromatic aberration. Our work shows a way how to correct spherochromatic aberration using a system

of thin aspherical layers. We have proposed a method for removing the spherochromatic aberration of optical imaging systems. Formulas for calculation of the thickness of thin aspherical layers were derived in our work. The proposed method seems to be especially suitable for correcting optical systems with zero chromatic aberration in the paraxial space. The elimination of the spherochromatic aberration is perfect in this case and the optical system is almost identical with the ideal optical system. Deposited thin aspherical layers also act as antireflective coatings. One may achieve three effects simultaneously with the proposed correction method: elimination of spherical aberration, elimination of spherochromatic aberration, and decreasing the reflectance of the optical system. The described method represents an advanced trend in correction of optical systems.

The last part of our work deals with the theoretical process of zoom lens design with respect to aberrations of optical systems. Optical systems with variable optical characteristics (zoom lenses) find broader applications in practice nowadays and methods for their design are constantly developed and improved. Our work describes a methodics of the design of zoom lenses using the third order aberration theory. It is often used the third order theory (Seidel theory) of aberrations for design of the new types of the optical systems. This theory provides us with analytical formulae for basic types of aberrations such as spherical aberration, coma, field curvature and distortion. There are several possibilities for calculation of the aberration coefficients that depend on the parameters of the optical system. The parameters are usually the curvature of surfaces, surface axial separations and the refractive indices of the glasses. The classical formulae for Seidel aberration coefficients are very complicated if we need to calculate the refractive indices of individual lenses even in such a simple case as a cemented doublet. It is practically impossible to obtain solution for complex optical systems. Using proposed modified formulae for Seidel aberration coefficients it is possible to calculate the shape and the refractive index of the glass of the individual lenses of the optical system. Another advantage of the proposed method is the possibility to determine, which elements of the optical system can be only simple lenses and which elements must have more complicated design, e.g. doublets or triplets. It is also shown the method for optical system design that permits to calculate the radii of curvature and optical glass types for individual lenses.

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Web Support of Physics Education

J.Novák

novakji@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

Considerable changes occur in teaching of physics on technical universities due to a recent transformation to the structured study program. During this process on the Faculty of Civil Engineering of Czech Technical University in Prague, a new conception of education of physics was proposed for newly introduced branches of bachelor study programs both in the theoretical and experimental area. The main aim of physics at technical universities is to introduce to students the fundamental principles and models that are important to understand the behaviour of real physical and technical systems. The lectures and physical theoretical courses should be supplemented by appropriate information sources (e.g. web pages) where particular problems are solved and the visualisation of the solution is done. This will certainly help students to understand better the theoretical lectures. Such interactive solution, that can be used as a multimedia support to lectures, seminars or for the individual study is presented in this work.

The project dealt with an innovation of physics education using internet and computer modelling. It was desirable to supplement the contemporary state of physics education for students of bachelor study programs with suitable information sources focused on the analytical solution or computer modelling of physical problems.

It was proposed a project that will improve the mentioned support for teaching physics. Within the project, a web page focused on the support of teaching of physics was designed and developed. The support was realized in the form of an interactive internet application with solved examples and computer programs that present the problem's solution and enable visualization of chosen problems. An appropriate and practical supplement of theoretical lectures was developed and the availability of information for students was increased. The created information resource can be used during lectures and seminars or as studying materials for individual students. Interactive presentation of the project, that will be accessible for anybody connected to internet, will lead to significant improvement of the accessibility of useful information for students and it will enable them to solve particular problems from physics. Furthermore, it will be possible to make computer modelling and simulation of individual physical problems using the developed computer programs that will be accessible on the project web page. In terms of improving the quality and making the teaching of physics more attractive for students, we decided to develop a collection of computer programs as a part of our internet application. These computer programs will serve lecturers during lectures to demonstrate given physical problems using a data projector, and show students interactively the influence of input parameters on the behaviour and solution of physical problems. Multimedia examples and computer programs were developed for individual problems from the area of the technical physics (mechanics, thermodynamics, electromagnetic field and optics). Created computer programs enable visualization of solved problems and make possible to change the input parameters that affect the solution of a problem. The students can use the mentioned programs individually for modelling of chosen physical problem with miscellaneous input parameters and conditions and visualize the

solution. This approach enables students to learn to apply theoretical knowledge that was acquired on lectures.

Other goal of the project was to improve the teaching process by the means of computer-aided education of physics for students. With respect to the development and availability of computer technology it seems to be considerable to use this technology in teaching physics. It is important to proceed from the "standard" theoretical teaching of physics to more attractive way based on "simulation and visualization" of practical problems using computers. This will help students better understand theoretical lectures and it will help them use theoretical knowledge in practical applications. This project also deals with problems of implementation of computer based modelling into the teaching of physics on technical universities. Together with the change to new study programs, a new approach in teaching physics was introduced. This enables to demonstrate solutions of particular mathematical and physical problems to students. It is also important that this approach can make physics more interesting and attractive to students. Students have the opportunity to get acquainted with the practical aspects of work with the computer and they can better understand the basic physical principles and problems. This computer support to the education of physics can be used in several areas: a multimedia support of lectures of physics, a supplement to physics seminars, and a necessary part of laboratory experiments. New courses were introduced that use computer technology to solve given physical problems, to simulate some physical phenomena and to find the dependence of the system time development on the values of input parameters. Students may apply acquired knowledge during their further study and of course when solving technical problems in their professional career. It is a very suitable supplement of the theoretical lectures of physics.

Moreover, an internet support of laboratory experiments was made in the form of a web page, where students can find instructions to individual laboratory experiments, materials considering the theory of measurement errors and the processing of measured data, computer programs that enable effective data processing and mathematical modelling and simulation of physical processes that students can meet in different laboratory experiments.

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Calibration of Spectra from Spectrograph with Toroidal Grating

J. Blažej, M. Vrbová, L. Pína, A. Jančárek

blazej@troja.fjfi.cvut.cz

Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic

We are reporting about calibration procedure of spectra from extreme ultraviolet (EUV) grazing incidence spectrometer with toroidal grating. Generally, the diffraction grating in the shape of Rowland's concave grating is the only spectral apparatus capable of producing and imaging a spectrum by a single katotropic process [1]. This property is significant mainly in EUV wavelength region, where only a grazing angle reflection can used and the experiment energy budget is adverse. The source of radiation and the object under study is a capillary discharge in nitrogen, where the pinching effect and the stimulated emission mainly at 13.4 nm wavelength region are expected [2].

To simplify an alignment of spectrometer during experiment an off Rowland circle registration scheme is used. In this scheme, spectra are recorded in a single plane and thus exact focusing of the input slit takes place only for one single wavelength, which corresponds to the intersection of the plane of registration with the Rowland circle. The image processing must be applied to reconstruct original wavelength positions. The cooled EUV-sensitive CCD camera is used in role of planar detector. It has 512×512 square pixels with 24 μm side. 16-bit dynamical range together with low-noise provide good data source for image post-processing. The most of image manipulation are provided with the Origin [3] software.

The first one problem is a geometrical distortion of acquired spectra origins from imaging of input slit to a plane. In standard spectrograph configuration the output slit or line CCD detector is used to overcome this problem. We are decide to use a planar CCD to improve signal to noise ratio. The use of EUV-sensitive CCD brings along several experimental difficulties and redundant data are welcome. To eliminate geometrical distortion of spectra the following method is used. Several horizontal profiles are taken on the image with good contrast line pattern. From the line pattern several well-defined lines are selected. Each horizontal profile is separately fitted by multiple Gaussian peaks at selected lines. Positions of their centers define a matrix of distortion. Each column of this matrix is fitted by a parabola. The radii of curvature of these parabolas are changing for different columns and this dependence has a minimum. The position of this minimum can be used for absolute calibration, see below. At this time, the generated matrix can be used for distortion elimination after its smoothing by the parabola fit. For distortion elimination – image warping – we are using open source program xmorph [4] with sophisticated wavelet amplitude correction to ensure the photometric data from original spectra. The result of these steps is an image with parallel spectral lines over entire screen.

The spectrometer dispersion curve is well known, but the experiment has two degree of freedom from the absolute calibration point of view; the position of zeroth order maximum on detector plate and the distance of detector from grating center. Both are experimentally unattainable. These two parameters for image calibration can be deduced from at least four different sources. The first one is the edge of filter. For this wavelengths can be used L-edge of aluminum. The problem is the absence of continuous source. Some experiment configuration generating a lot of lines can be used, but the final resolution of edge position

identification depends on actual spectra. Nevertheless, only one parameter can be evaluate from one edge and filtered spectra was not included in a particular analyzed spectra set.

The second one source of information is the width of spectral lines. It is proportional to focusing. The imaging of spectra to Rowland circle can be modeled as an imaging by a lens with variable focus length. Assuming a hypothesis about quasi-Gaussian character of input signal, the model of dependence of line width on wavelength can be derived. But we are not succeeding to find any algorithm for a reliable line with calculation from spectra with unknown spectral line intensities.

The third one source of information is a position of geometrically non-distorted spectral line derived from geometrical distortion. This invariant reduces the number of degree of freedom to one defining a relation between searched parameters.

The fourth one source is the assignment of known wavelengths to bright lines. It is depended on several presumptions about observed plasma source or on an independent spectral analysis of similar plasma source. We are presenting some results for selected spectra set with absolute calibration using above described methods. The precision and accuracy of results are discussed.

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Evaluation of Wave-front Deformation for Non-contact Measurements in Industry

P.Novák

xnovakp9@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

The research project deals with modern evaluation and measurement optical methods that can be used for optical testing in industrial practice. Wave-front measurement methods belong to the most frequently used techniques in optical metrology. Nowadays, a large number of methods based on various physical principles are developed for optical measurements. We studied computer aided methods that are based on intensity measurements at the set of chosen points in space. These evaluation methods use either interference of light or making measurements of the wave-front gradient. We proposed new phase evaluation methods and algorithms in order to improve present phase evaluation and measurement techniques, especially by simplification of the measurement device an evaluation technique, lower sensitivity to mechanical vibrations, etc.

Several different measurement methods can be implemented for optical metrology systems in industrial practice. Interferometric methods cover a large number of different measurement and evaluation techniques. These methods use the principle of interference of light for evaluation of phase differences between the reference and object wave field. The phase change of the object wave corresponds to the measured physical or geometrical quantity (shape, deformation, roughness, etc.). The research deals especially with phase evaluation algorithms that enable to make fully automatic analysis of the interference field. New method was proposed for computer evaluation of very small phase changes in optical testing.

One possible way how to determine the phase of the tested wave field (or wave-front deformation) is the use of the method of shearing interferometry that is based on the principle of interference of two spatially sheared wave-fronts. These wavefronts originate from a tested wavefront. The shear is performed by a proper shearing element, which forms two images of the tested wavefront that are spatially separated. Our work deals with a theoretical analysis of properties of a small and compact shearing interferometer. We used a compact shearing interferometer with the Wollaston prism as a shearing element that is situated between two polarizers. A uniformly illuminated slit is imaged into the plane of localization of interference fringes in the Wollaston prism. Due to birefringence the tested wave field is divided into two wave fields. The interference pattern can be observed by an additional microscope objective either visually or by a CCD camera. The shearing interferometer enables to determine the residual wave aberration of the tested optical system. The device is characterized by very small dimensions, which provide its easy portability. It is practically insensitive to vibrations and the mechanical design is also very simple. The measurement instrument (interferometer) is suitable for practical testing of the imaging quality of optical systems.

The same interferometer can also be used not only for wave aberration measurement, but also for measurement of the modulation transfer function (MTF) of tested optical systems. The wave-front deformation can be analysed using standard phase evaluation techniques for interferometry or new proposed colorimetric method. Our work proposes and analyses a relatively simple method for evaluation of small wave-front deformation. Small changes of

phase cause the change of color of the interference field. The measured phase change can be determined from the change of color in the interference field, because even a small phase change has effect on the color of the interference pattern. The detailed theoretical analysis of the phase evaluation problem was performed and the equations for evaluation of phase at particular points of the interference field were derived. It can be concluded from the performed theoretical analysis that the proposed approximate quadratic model is quite suitable for evaluation of the optical path difference smaller than 50 nm. The proposed method seem to be suitable for practical use in many areas of science and engineering.

Other phase evaluation techniques that were thoroughly investigated are methods that evaluate the phase gradient and subsequently calculate the phase change by an aproximation. The phase change usually corresponds to the deformation of tested wavefront with respect to some ideal (reference) case. Perhaps the most important testing technique is the Shack-Hartmann method that is based on the spatial sampling of the tested wavefront by the lenslet array. It estimates the wavefront local slopes (phase gradient). The sampled wavefront impinges on the detector that is usually situated in the focal plane of the microlens array and the specific intensity distribution is detected. Detected "diffraction spots" correspond to the intensity distribution after sampling by the sub-apertures of the microlens array. The position of each spot is dependent on the slope of the part of the wavefront that impinges on the corresponding microlens. One can determine the displacement of the spot positions with respect to the reference position that corresponds to an ideal (reference) wavefront. Phase values can be calculated from the measured phase gradient either by integration or by approximation using polynomials, e.g. Zernike or Legendre polynomials.

Our work deals with the analysis of suitable algorithms for the Shack-Hartmann wave-front sensor that was designed in our laboratory. We had focused on the analysis of different types of algorithms for wave-front reconstruction from the measured values of the wave-front gradient. We also elaborated the software for computer simulation and analysis of wave-front evaluation with the developed wave-front sensor. The whole measuring system was verified in a close cooperation with Meopta Přerov,a.s, on testing optical systems in UV and visible spectrum.

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Powder Diffraction in Research Centre Using Thermal Neutrons

S. Vratislav, M. Dlouhá

stanislav.vratislav@fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Solid State Engineering
Břehová 7, 115 19 Praha 1

Neutron scattering has always been an important tool for the provision of structural information on the atomic scale and for the understanding of dynamical properties of solids and liquids. The neutron has a unique combination of properties that make it indispensable for many problems in solid state physics and materials research. Neutrons have played a pivotal role in the investigations of phase transitions and co-operative phenomena, magnetism, structure (static and dynamics). Neutron diffraction (from powders and single crystals) is a basic technique, providing information on chemical and magnetic structures.

Center for Fundamental and Applied Neutron Research (CFANR) has been established in the frame of Nuclear Physics Institute of the Czech Academy of Sciences, situated in Řež near Prague, in order to perform neutron physics experiments as well as to provide experimental facilities and research experience for external users. CFANR covers also one group of Prague Technical University (our group: Laboratory of Neutron Diffraction, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague – LND CTU), one group of Technical University Freiberg (Germany) and one group of Nuclear Research Institute. Research activities of the neutron physicists of CFANR are concentrated at the medium power light reactor LVR-15 (10 MW mean power) which belongs to the neighbouring Nuclear Research Institute. CFANR operates seven horizontal channels for experiments in nuclear physics, solid state physics, materials research and neutron capture therapy and one vertical irradiation channel for neutron activation analysis.

LND CTU takes part in research activities of this CFANR and our research programme was concentrated to the powder neutron diffraction investigations. Our neutron diffraction group was participated in the GACR project: "Research center using thermal neutrons" No: 202/03/0981. The intention of this grant project was obtaining the financial support on renting the horizontal beam channels at the reactor LVR-15 with the aim at the maximum exploitation of all experimental facilities installed at the beam channels. Furthermore, improvements of the existing and new techniques are supposed in order to achieve a well equipped laboratory with the outlook of further internationalization of research.

In frame of this grant project we have been obtained results in structure parameters of the some promising technical materials: zeolites, ionic conductors, high temperature superconductors, different perovskite systems and we have improved the KSN-2 experimental facility. Research activities of the LND CTU group during of the period of the grant solution (from 2003 to 2005 year) were concentrated to the structure investigations as follows:

Zeolites and related microporous materials have common and diverse applications. Permanent interest in the structure investigation of zeolites (mainly of the synthetic origin) is stimulated by their potential practical use in the chemical technology. In the frame of this grant project the complete sets of structure parameters of NaY, NaX and NaLSX zeolites – faujasites with chemisorbed CH_3 (or CD_3) methyl groups were determined [1] (for NaY) and [2] (for NaX and NaLSX). We observed serious changes in the distribution and in the

coordinates of Na^+ cations after chemisorptions of methyl ions [2]. Methyl ions are located in X faujasite at the O4 and the O1 lattice oxygen [2] and in Y faujasite at the O1 lattice oxygen [1] only in α-supercavity.

Ammonium fluoroperovskites $(NH_4)_x M_{(1-x)} F_3$ and *ammonium halides* $(NH_4)_x M_{(1-x)} I$ (M= 3d or 4d metal) provide an interesting model system of the structure and the dynamics of the NH^{4+} ions. We determined the whole x-T phase diagram [3] (T – temperature, x – sample content) of the $(NH_4)_x M_{(1-x)} I$ system, where x is varying form 0.06 to 0.85 and M = Rb.

As a third part of our research activity we were continue our diffraction experiments on the different *perovskite systems* (in collaboration with Institute of Physics, Prague – dr. Z. Jirák). The structural, magnetic and transport properties of the $LaMn_{1-x}Co_xO_3$ system ($0 < x < 1$) was investigated over a wide temperature range, 10-900 K by neutron diffraction [4]. The results which were obtained on the perovskite systems with the mixed Mn^{3+}/Mn^{4+} valence have shown that the size of the La, Co cations plays an important role in the structural distortions and magnetic ordering phenomena.

Improved experimental facility represent a very good standard and may yield quite competitive results in the structure analysis and the magnetic ordering determination. *The KSN-2*, a double axis powder diffractometer, is intended to the structure and texture experiments with polycrystalline specimens and equipped with the auxiliary devices, e.g. programmed temperature control for cryogenic apparatus and heater furnace (closed cycle refrigenerator system mod. CP-62.ST/1, heater furnace mod. SVO-PT up 1000 K), texture goniometer TG-1, magnets. The KSN-2 is controlled by PCL 9812 computer and the different programs of the experiment control and data acquisition are available. This diffractometer offers good intensity with wavelengths in the range 0.095 to 0.141 nm and the best resolution value of $\Delta d/d = 0.00065$ was reached in the region $d \sim 1.2 \div 0.07$ nm. The diffraction patterns recorded are treated by Rietveld analysis method (code RIET-N, GSAS package, FULLPROF) and the complete structural parameters are determined. Both the experimental and the computing techniques for the structure and the texture analysis were developed.

We can note that the aims of the mentioned project "Research center using thermal neutrons" No: 202/03/0981 were fulfilled in the agreement with the grant schedule (15 papers and 35 conference contributions were published).

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Simulation of Short-Pulse Laser Interaction with Solid Targets and K-alpha Emission

O. Klimo, J. Limpouch

klimo@watt.fjfi.cvut.cz

Czech Technical University in Prague,
Dept. of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
V Holešovičkách 2, 180 00 Praha 8, Czech Republic

Solid targets irradiated by ultrashort intense laser pulses are efficient sources of fast electrons. These electrons, while propagating deeper inside the cold part of the target, collide with atoms and ionize them in inner shells, thereby causing emission of characteristic K-α photons. The K-α emission may serve as an efficient, bright ultrashort X-ray source, suitable for time-resolved X-ray diffraction and it may also be used as a convenient diagnostic to study the fast electron generation and transport itself.

In this contribution we study the processes of laser plasma interaction and generation and emission of K-α photons from the target using numerical simulations and compare our results with recent experimental measurements [1]. In our model, we calculate the K-α emission in three successive steps. First, we use a 1.5D hydrodynamic/atomic code Ehybrid to treat the laser driven expansion of plasma from a solid target, induced by ASE (Amplified Spontaneous Emission) and by intrinsic laser prepulse. As a significant influence of ASE prepulses on K-α yield even for pulses with low fluencies was reported, the results of Ehybrid code are used to estimate shape and scale of plasma density profile and its average ion charge at the time of the main laser pulse arrival. Second, the interaction of the main laser pulse with the preplasma calculated by Ehybrid code is computed by our 1D3V relativistic electromagnetic PIC (Particle in Cell) code, which evolved from the code LPIC++. The code is enhanced to treat both field and collisional ionization, which makes it possible to start the simulations with more realistic initial conditions and follow the evolution of plasma during the interaction. Both ionization processes are included in a Monte Carlo probabilistic way. The field ionization probability is calculated using the ADK ionization rate, while for collisional ionization probability, Lotz cross section is implemented. The new electrons coming from ionization are injected in the simulation with zero initial velocity. Our code is also able to treat Coulomb collisions, but as they are computationally expensive and the collisional frequency in hot low density preplasma is relatively low, we switch them off here. The final step of our model consists in postprocessing of hot electrons resulting from the PIC simulations by our MC (Monte Carlo) code [2], which is specially tailored to calculate K-α emission from the target surface with temporal and spatial resolution.

Our computational model was used to reproduce and give more insight into the recent experimental measurements of K-α emission from laser irradiated copper foil targets provided by our colleagues from Max-Born-Institute in Berlin. For the experimental conditions, hydrodynamic calculations predict that plasma density profile on the target surface before arrival of the main laser pulse is exponential in the vicinity of critical surface with almost linearly decreased subrcitical part. Using this profile in PIC simulations, we find that when the field ionization is taken into account, the distribution of fast electrons, accelerated by the resonant plasma field, changes very significantly. With ionization taken into account the distribution is 4 times lower in energy of hot electrons. We explain this decrease by the field

ionization, which takes place in the subcritical part of the profile. The number of electrons in the subcritical region increases and as the electron density overcomes the critical one, both, the laser reflection and the critical point move against vacuum and the resonance plasma wave disappears, until the laser pulse maximum reflects from the target and the ionization saturates. Postprocessing the resulting fast electrons with our MC code, we find a reasonable agreement with the experimental K-α yield, when the ionization is taken into account [3]. Without ionization, the experimental results are significantly overestimated. The experimental dependence of K-α yield on the laser incidence angle is also reproduced in our simulations with ionization, while without ionization our simulations predict a different behavior. We conclude that our results demonstrate the important influence of ionization in short-pulse laser target interactions, when plasma ionization changes on a time scale comparable with the laser pulse duration.

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Complex Measurement of the Pixel Detector Support Structures – Thermal Performance and Pressure Drops of the Basic Modular Cooling Loop

V. Vacek

Vaclav.Vacek@fs.cvut.cz

Department of Applied Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 27 Praha 6, Czech Republic

The ATLAS pixel and micro-strip detectors are divided into around 320 linear and disk-like arrays of sensor tiles with a total silicon area in excess of 20 m^2 [1]. The linear arrays ("staves") have lengths varying between 80 and 160 cm with up to 13 sensors tiled along them. The total dissipation of the semiconductor tracking detectors will be ~ 60 kW. The evaporative cooling system must have a high modularity to minimize the amount of the detector out of service in the event of a local fault; more than 200 parallel channels with adjustable flow rate and evaporating temperature will be supplied from a central compressor station comprising three parallel compressors.

The safeguarding of the sensitive and expensive semiconductor detectors and electronics in the difficult high radiation environment imposes new and non-standard constraints on the cooling system. This has led to the choice of saturated fluorocarbon ($C_nF_{(2n+2)}$) refrigerants, which combine high dielectric strength with good chemical stability under ionizing radiation and compatibility with the materials used in the construction of the ATLAS inner tracking detector.

In addition to these concerns, the total amount of structural material must be minimized to reduce background from secondary particles. Coolant is evaporated in the structures to be cooled, to allow a very low circulating coolant mass flow (1–3 g $.s^{-1}$/ 100W to cool). The coolant tubing is of thin (200μm) wall aluminum and it is not possible to locally fit flow control valves or regulators on the cooled structures as is normal practice on evaporators in industrial cooling applications.

Silicon pixel tiles are glued to a support and thermal drain structure machined from carbon-carbon. Heat enters the flat side of a 'D'-shaped aluminum tube (200 μm wall; $ID_H = 3.6$mm) held in contact with rear of the carbon-carbon support by an 'Ω'-shaped carbon-fibre extrusion. The difference in coefficient of thermal expansion of the tube and support is accommodated by a sliding thermal grease contact between the two.

Although the silicon detector substrates must be continuously operated between 0ºC and –7ºC (depending on their proximity to the circulating high-intensity proton beams) for a 10 year operational lifetime at the LHC, thermal impedances in the support structures channeling heat from the detector tiles to the cooling fluid dictate an in-tube fluid evaporation temperature around –25ºC. The evaporation of the C_3F_8 refrigerant (saturated vapor pressure 1.8 bar_{abs}@-25ºC) was convenient in this regard [2].

There were some unforeseen design changes imposed to the support and thermal drain structure of pixel part of the detector. Additional tube insertion into the existing support

structures has been suggested. The simplest approach of say 3mm ID circular pipe or „D" shaped tube with ID_h ~ 3.1 mm having 300μm wall thickness and 100μm gap between surfaces has been selected and simulated. It appeared that ΔT (additional ΔT due only to insertion of new pipe) can be kept to 5 degrees if thermal conductivity of epoxy is ~ 1 W/mK or more. The next issues to verify was a pressure drop profile over the modular Bi-stave loop.

The real single Bi-stave loop has been designed and constructed at CERN for the experimental measurements recently. All employed pressure, temperature and flow sensors were calibrated and verified. The dedicated DAQ system was assembled to monitor adequate data and a user friendly recording software solution in PVSS II was written. Numbers of experimental runs were preformed for the various configurations of the staves within the standard Bi-stave loops:

1. plain stave plus stave with inserted round tube,
2. stave with "D" shaped inserted tube and plain stave,
3. stave with inserted round tube and stave with "D" shaped inserted tube

forming the loop.

Flow of refrigerant was altered to achieve the different sequence of the staves in series.
The changed behavior of the Bi-stave loop was evaluated both from the point of temperature profile variations and namely from the pressure drop profile changes which will considerably affect stable behavior of the standard cooling loop and consequently the whole cooling system.

If combination of the stave with inserts become necessary it is recommended to couple plain stave with "inserted stave in such manner that plain stave comes as the second unit downstream. Once the both staves with inserts have to be coupled the total dissipated power has to be reduced to the 75 % of the nominally expected power load to fulfill the silicon surface temperature specifications during the detector lifetime [3].

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Double Beta Decay of Mo100 in the NEMO 3 Experiment

L. Vála *, J. Jerie **

ladislav.vala@utef.cvut.cz

*Institute of Experimental and Applied Physics
Czech technical University in Prague
Horská 3a/22, 128 00 Praha 6 - Albertov
** Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague
Břehová 7, 115 19 Praha 1

The positive results of neutrino oscillation experiments (SuperKamiokande, SNO, and KamLAND) obtained in the last few years have demonstrated that neutrinos are massive particles. This has increased the interest in double beta ($\beta\beta$) decay experiments, and is reflected in the large number of proposed future experiments searching for neutrinoless double beta decay.

Neutrinoless double beta decay ($0\nu\beta\beta$), unlike two-neutrino double beta decay ($2\nu\beta\beta$), is a process which violates lepton number conservation by two units, and is a probe for physics beyond the Standard Model. The observation of this decay would prove that neutrinos are Majorana particles; it would also constrain the mass spectrum and the absolute mass of the neutrinos. The NEMO 3 detector is devoted to the search for $0\nu\beta\beta$ decay by means of the direct detection of the two electrons emitted in double beta decay. NEMO 3 combines a tracking detector with a calorimeter for simultaneous particle detection and energy measurements. The experiment is located in the Fréjus Underground Laboratory in France at the depth of 4800 m water equivalent. The detector accommodates almost 10 kg of different, highly enriched (95% – 99%) $\beta\beta$ isotopes: ^{100}Mo (6914 g), ^{82}Se (932 g), ^{116}Cd (405 g), ^{130}Te (454 g), ^{150}Nd (34 g), ^{96}Zr (9 g), and ^{48}Ca (7 g). A detailed description of the detector and more information about the NEMO 3 experiment is given in Ref. [1].

The NEMO 3 detector has been taking data, for the $0\nu\beta\beta$ decay search and the $2\nu\beta\beta$ decay measurements since mid-February 2003. During the first running period (Period I) between February 2003 and September 2004 the main background, for most of the studied $\beta\beta$ channels, was Radon ($A(Rn) \cong 900$ mBq) inside the tracking wire chamber filling gas. This background does not allow us to reach the designed sensitivity for the $0\nu\beta\beta$ decay search. Nevertheless, the Radon level inside NEMO 3 has been decreased by a factor of ten after the installation of a tent around the detector, which is supplied with Radon-free air from an anti-Radon factory. The latter consists of two tanks filled with 1 ton of charcoal, cooled down to -50°C through which the air is flushed. Radon from the air is trapped in the charcoal where it decays before getting to the output of the factory. Although the activity of Radon at the input point of the anti-Radon factory is around 10 – 15 Bq/m^3, the output activity, during Period II (from October 2004 up to now) is about 3 mBq/m^3.

In order to measure $\beta\beta$ decay of ^{100}Mo, two-electron events are selected from data. Among the selection criteria there are, for instance, the following conditions: an event has to contain two tracks coming from the same vertex in the ^{100}Mo foils, the curvature of each track has to correspond to a negative charge, both tracks have to be associated to fired scintillators, and the time-of-flight has to satisfy the hypothesis of two electrons emitted simultaneously from the same vertex. In addition a threshold of 200 keV is applied on energy of each electron. After the analysis of Period I data, corresponding to efficient running time of 0.93 y, the obtained half-life of the $2\nu\beta\beta$ decay of ^{100}Mo to the ground state (g.s.) of ^{100}Ru is $T_{1/2} = [7.48 \pm 0.03(stat.) \pm 0.54(syst.)] \times 10^{18}$ y if the Single State Dominance model [2] is

considered. As regards the 0νββ decay, the two-electron events are looked for in the energy window for the summed energy of the electrons (E_{ee}) between 2.8 and 3.2 MeV. The expected background for Period I in this energy window is 8.1 ± 1.3 and 7 events have been observed. The resulting half-life limit for the 0νββ decay of ^{100}Mo is then $T_{1/2} > 4.6 \times 10^{23}$ y at 90% C.L. [3]. All these results are issued from Period I data only. An improved half-life limit for the 0νββ decay, thanks to the reduced Radon background, is expected from Period II data, which is now being analysed.

As the NEMO 3 detector is capable of identifying electrons, positrons, α-particles, and photons, it is possible to look also for ββ decays to excited states. In the case of ^{100}Mo, we are studying the ββ decay to the 0_1^+ state of ^{100}Ru where the emission of two electrons is followed by two γ-rays of 590 and 540 keV respectively which come from the $0_1^+ \rightarrow 2_1^+ \rightarrow$ g.s. cascade. These photons are often scattered inside the NEMO 3 detector. In order to study this particular decay, the eeNγ channel (i.e. a channel with two electrons and N photons where N = 2, 3, 4…) and specific selection conditions were constructed. The two-electron events, like for the ββ decay to the ground state, are first selected. Then the event selection for the 2νββ decay mode is refined with specific energy cuts applied on both electrons and photons (500 keV < E_{ee} < 1200 keV, $E_{\gamma\gamma}$ < 1200 keV, E_γ < 600 keV). Afterwards the time-of-flight of the photons is tested: only events with two photons satisfying the hypothesis that they were emitted simultaneously with the electrons from the same vertex are kept. Except the energy window for the summed energy of the two electrons ($E_{ee} \in [1.5 – 1.9]$ MeV), where the 0νββ decay candidates are searched for, the selection criteria are similar for the 2νββ and 0νββ decay modes.

The half-life for the 2νββ decay of ^{100}Mo to the excited 0_1^+ state of ^{100}Ru obtained for Period I data is $T_{1/2} = [5.7^{+1.3}_{-0.9}(stat.) \pm 0.7(syst.)] \times 10^{20}$ y. This result is in a good agreement with values measured previously in spectroscopic experiments using HPGe detectors [4]. No evidence for the 0νββ decay of ^{100}Mo to the excited 0_1^+ state has been found. Then the resulting half-life limit for this decay is $T_{1/2} > 7.1 \times 10^{22}$ y at 90% C.L. which is at present the best experimentally obtained limit. The preliminary results from the Period II data with reduced level of Radon background, corresponding to 0.45 y of efficient running time, confirm these values.

The further accumulation of data without Radon, which was the main source of background during Period I, will allow the improvement of the half-life limits for the 0νββ decay of ^{100}Mo with transitions to both the excited 0_1^+ state and the ground state of ^{100}Ru.

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Thin Films for Waveguide Biosensors Deposited by Pulsed Laser Deposition

L. Cudzik , M. Jelínek*,*** , T. Kocourek*, J.Bulíř* , V.Studnička***

L.Cudzik@sh.cvut.cz

*Institute of Physics, Academy of Sciences CR,
Na Slovance 2, 182 21 Prague 8, Czech Republic

**Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, V Holešovičkách 2, 180 00 Prague 8, Czech Republic

***Department of Natural Sciences, Faculty of Biomedical Engineering,
Czech Technical University, nám. Sítná 3105, 272 01 Kladno 2, Czech Republic

Immediately after the invention of basic principles of coupling light into waveguiding structures, there were intentions to use optical waveguides and optical fibres for sensing purposes. These efforts lead to development of wide range of sensors in late 1980th [1,2]. These sensors were used as humidity sensors or as gas detectors. With a quick development of bioengineering, there is a huge need for biosensors. This type of sensors serves to detect biological objects and to monitor biological reaction kinetics [3]. Biosensors are using the principles of chemical sensors and they represent a modern part of integrated photonics.

Planar dielectric waveguide is an optically transparent structure that consists of a thin layer of high refractive index material, which is surrounded by layers of material of lower refractive index. The light within the middle layer propagates through the waveguide due to frustrated total internal refraction on the boundaries. The propagating beam has to fulfill the "condition of transversal resonance", this condition ties together wavelength of the light, physical dimensions of the layers and its refractive indeces [2]. From the view of geometrical optics, we can say, the light of a specified wavelength can propagate within the waveguides only under certain angles with respect to the normal. These angles are numbered and these numbers are called the mode numbers. When you want to incouple the light into the waveguide, you have to respect the condition of transversal resonance and point the laser on the structure under certain angle that you have to derive from that equation. There are three possibilities to incouple the light into the waveguide. End-firing from the edge of the waveguide, through the grating buried in the waveguiding structure or through the optical prism.

When the light totally reflects on the boundary of the layers, a part of the energy reaches the other side of the border. It's called an evanescent field and its main property is that it is decaying exponentially with increasing distance from the boundary. Typical distance of this decay is ~100nm, but it depends on the refractive indeces difference [2]. However, within this distance from boundary, the electromagnetic field inside the waveguiding layer can "sense" the conditions outside the layer. If a biological reaction takes place on the surface of the waveguiding layer (typically some protein binding), it affects refractive index near the waveguiding layer [1,4]. If we want to incouple the light in that place, the incoupling angle will vary with the refractive index change.

In the laboratories of AS CR we try to create waveguiding structures suitable for biological sensing. There are multiple experimental arrangements, however we decided to use "resonant mirror". The most popular type of sensor is the incoupling grating sensor. The prism is obsolete in this setup; however the preparation is more complicated, because the grating has to be etched into the waveguide. Resonant mirror doesn't need a grating, however lays down more complex conditions on substrate. The final structure should consist of a prism and a substrate made from the prism material. The experiments are still in progress. On the substrate there are to be deposited two layers. A ~100nm thick buffer layer (SiO_2) of n~1.4 and on it the ~200nm TiO_2 thick TiO_2 layer of n~1.9. The upper layer of the waveguide is the air. Depositions are carried out in the vacuum chamber evacuated to 5.10^{-3} Pa and then filled with oxygen up to 5Pa. So far only the depositions of TiO_2 had been made. The laser beam impacts the titanium target, plasma is created and it propagates towards the substrate and condensates on it. On the surface Ti ions react with oxygen and TiO_2 molecules are created. We used a KrF excimer laser, λ=248nm, its frequency is 10Hz, number of pulses per deposition varies from 10.000 to 30.000, laser energy density on target was 1(Sample A), 2(B) and 3 $J.cm^{-2}$(C). We reached the deposition rate of 0.02nm per pulse. The experiments proceeded at room temperature to obtain amorphous films. The depositions were followed by various tests to get information about the film. First of all the alpha-step test was done to determine the film thickness. According to the alpha-step test the thickness of the films was 300-500nm, this was lately confirmed by the analysis of T and R curves from the spectroscope. XRD tests proved, there was no crystallinity, and all the films were amorphous. Finally the optical spectroscopy laboratory provided the measurement of T and R curves. This test casted doubt upon the amorphousness, because the calculated refractive indeces for samples B and C (n = 2.36 (633nm))corresponded to anatase form of TiO_2. Sample A refractive index was 2.03 (633nm), and this is quite close to amorphous TiO_2 (n=1.9). The project will now continue and the waveguides, which meet the essential demands on quality, are to be examined with m-line technique to observe the coupling and to obtain information about guided modes.

The complete sensor will be examined first as a chemical sensor, and after that, biological samples will be deposited via laser deposition method called MAPLE. This process is capable to deposit a thin film of biological material without destroying its bonds and maintain the biological activity [1].

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Luminescence of Ferroelectric $Sn_2P_2S_6$ Crystals

Z. Potůček, Z. Bryknar

potucek@troja.fjfi.cvut.cz

Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Department of Solid State Engineering, Trojanova 13, 120 00 Praha 2

Tin hypothiodiphosphate $Sn_2P_2S_6$ is uniaxial semiconductor ferroelectrics with large values of pyroelectric, piezoelectric, and linear electrooptic coefficients that possesses pronounced photoconductivity. In addition it is also very promising photorefractive material with fast photorefractive grating recording times and a high two beam gain coefficient in the red and near-infrared spectral region. Photorefractive properties of brown tinted $Sn_2P_2S_6$ crystals were improved by modified growth conditions in comparison to conventional orange tinted crystals [1]. However, the nature of photorefractive centers was not satisfactorily explained up to now. Although the study of luminescence can provide valuable information about defect energy levels within the band gap, which influence photorefractive properties and photoconductivity, only the emission spectra of photoluminescence of $Sn_2P_2S_6$ crystal at temperatures lower than 35 K have been briefly reported in [2]. Therefore, a detailed study of photoluminescence (PL) and thermoluminescence (TL) of five nominally pure $Sn_2P_2S_6$ crystals was performed within wide temperature (12 – 360 K) and spectral (260 – 1200 nm) regions.

Under excitation with band gap light at low temperatures all investigated $Sn_2P_2S_6$ crystals showed PL in the red and near-infrared spectral regions [3]. The significant differences between PL emission spectra of brown and orange tinted crystals were observed. The emission spectrum of the brown tinted crystal consists of a broad asymmetric emission band peaking near 1.66 eV at 12 K. The emission band peak shifts to the lower energy side with increasing temperature and the integral PL intensity steeply decreases. On the contrary three pronounced emission bands peaking near 1.99, 1.28, and 1.06 eV are evident in the spectra of the orange tinted crystals.

The emission spectra of all the crystals studied are fitted well with a superposition of five Gaussian curves [3]. The parameters of Gaussian curves follow individual temperature dependencies but at a given temperature only the curve amplitudes are sample-dependent. This result indicates that the PL emission spectra of the $Sn_2P_2S_6$ crystals consist of five overlapping bands of nearly Gaussian shape with a sample-independent peak position and FWHM at a given temperature. The position of 1.98, 1.72, 1.48, 1.28, and 1.02 eV and FWHM of 0.37, 0.27, 0.32, 0.25, and 0.27 eV were found as fitting parameters for the overlapping emission bands at 12 K. The positions and FWHMs change only slightly with increasing temperature. Therefore, the observed dependence of the shape of the PL emission spectra on temperature and the crystal studied is predominantly caused by the changes of relative intensities of the overlapping emission bands. The emission spectrum of the brown tinted crystal at 12 K mainly consists of the bands peaking near 1.48 and 1.72 eV whereas the band peaking near 1.98 eV is completely absent. Contrariwise three bands peaking near 1.02, 1.28, and 1.98 eV are the main features of the emission spectrum of the orange tinted crystals.

At steady-state excitation the changes of PL intensity were observed with time of crystal illumination at low temperatures [4]. Monochromatic light with the wavelength shorter than about 510 nm decreased at 12 K PL intensity of the $Sn_2P_2S_6$ crystal cooled in the dark whereas excitation with a longer wavelength increased the PL intensity. Subsequent heating of the crystal enabled to observe weak TL within 15 - 240 K that was spectrally similar to PL in the red and near-infrared spectral regions. The glow curve of integral TL of the brown

tinted crystal possesses a rather rich composite structure with two pronounced glow peaks near 22 and 41 K and five rather weak peaks near 53, 59, 68, 81, and 102 K at the heating rate of 0.082 K/s. Contrariwise three peaks near 192, 204, and 216 K are the main feature of the glow curve of the orange tinted crystals. The glow curves of integral TL of all the crystals studied were fitted well by superposition of functions describing the shape of glow peak in the case of general order kinetics. The performed decomposition revealed 17 glow peaks with strongly sample-dependent intensities. The activation energies of thermal ionization and the frequency factors corresponding to charge carrier shallow traps related to the glow peaks were found as fitting parameters within 50-542 meV and 10^7-10^{11} s^{-1}, respectively.

The integral intensity of PL and especially that of the emission bands peaking near 1.48 and 1.72 eV was in the case of the brown tinted crystal much higher than in the case of orange tinted crystals [3]. In addition, the inspection of the chemical composition by the PIXE method did not reveal any impurities in the crystals. These facts indicate that intrinsic lattice defects are responsible for observed PL of the $Sn_2P_2S_6$ crystals. Annealing of the orange tinted crystals in vacuum at 300 ºC caused a substantial increase of integral PL intensity in comparison to the as-grown crystal and their brown coloration. Particularly the intensity of the emission bands peaking near 1.28, 1.48, and 1.72 eV increased. Moreover the PIXE analysis revealed that the content of sulfur in the brown tinted crystal is about 2 % lower than in the orange tinted crystals. Therefore, we propose that at least three PL emission bands of the $Sn_2P_2S_6$ crystals peaking near 1.28, 1.48, and 1.72 eV are connected with sulfur vacancies whose concentration increases during annealing in vacuum together with the intensity of these emission bands. The sulfur vacancies probably create donor energy levels within the band gap of the $Sn_2P_2S_6$ crystal and may captured free electrons created by band gap illumination in the conduction band while the free holes created in the valence band are captured on several types of acceptor levels. Then PL emission bands could be associated with the radiative recombination of donor-acceptor type that is common in semiconductors.

We assume that crystal illumination with the wavelength shorter than 710 nm at 12 K changes the charge state of luminescence centers, which are responsible for the PL of $Sn_2P_2S_6$ crystals, and created free charge carriers are captured by shallow traps [4]. The glow peaks of TL, spectrally similar to PL, are then associated with the thermal release of charge carriers from shallow traps followed by the radiative decay of luminescence centers excited by their recapture.

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Radial oscillations of cavitation bubble in liquid

V. Sopko, L. Samek, P. Amaral*

vit.sopko@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University
Technická 4, 166 29 Prague 6, Czech Republic
*Department of Materials Engineering, Instituto Superior Tecnico
1049-001 Lisboa, Portugal

We consider that a spherical bubble of radius $R=R(t)$ is situated in an unbound incompressible non-viscous liquid. The bubble is filled with non-conductive heat mixture of ideal gas and vapour of surrounding liquid. The center of the bubble is situated in the origin system coordinates axes, with respect to symmetry set task, so far liquid flow is radial and non-turbulent. Equation for pressure $p(r,t)$ and radial velocity $v(r,t)$ of the liquid in time t, neglecting the volume forces, is a valid Euler´s hydrodynamics Equation

$$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial r} = -\frac{1}{\rho}\frac{\partial p}{\partial r}. \tag{1}$$

Where $r \geq R$ is the length of radius vector mass element of liquid and ρ is density of liquid. For non-turbulent flow may be generalize velocity potential $\varphi(r,t)$, so that $v = -\partial\varphi/\partial r$. This formula we are substituting into eq. (1) and we integrate from r to ∞. We obtain

$$\frac{\partial \varphi}{\partial t} - \frac{v^2}{2} = -\int_{p(r)}^{p_\infty} \frac{\mathrm{d}p}{\rho} = \frac{p(r) - p_\infty}{\rho_0}, \tag{2}$$

because for $r \to \infty$ is $\varphi = 0$, $v = 0$ a $p(r) = p_\infty$. The last term in (2) hold for incompressible liquid $\rho = \rho_0 = \text{const}$. Near the surface of the bubble $r = R$ has liquid speed $V = \mathrm{d}R/\mathrm{d}t$. Inserting the continuity equation $v = VR^2/r^2$ into equation $v = -\partial\varphi/\partial r$, and than integrate, we get

$$\varphi = VR^2/r = (\mathrm{d}R/\mathrm{d}t)(R^2/r). \tag{3}$$

The equations $v = VR^2/r^2$ and (3) we substitute into eq. (2) and for $r = R$ will be

$$R(\mathrm{d}^2R/\mathrm{d}t^2) + (3/2)(\mathrm{d}R/\mathrm{d}t)^2 + \left[p_\infty - p(R)\right]/\rho_0 = 0. \tag{4}$$

This equation describes pulsation of the cavitation bubble, which is situated in an unbound incompressible non-viscous liquid, where p_∞ is the gas pressure in infinity and $p(R)$ is pressure in liquid near the bubble surface. Equation (4) solved Rayleigh and Lamb and for velocity $V=\mathrm{d}R/\mathrm{d}t$ and time τ of collapse an empty spherical bubble in liquid, with $p_\infty = \text{const.}$, obtain

$$V = \sqrt{(2p_\infty/3\rho_0)(R_0^3/R^3 - 1)}, \qquad \tau \doteq 0{,}9146\, R_0\sqrt{\rho_0/p_\infty}. \tag{5}$$

Frequency of short radial oscillation of a spherical bubble in liquid

A spherical bubble of radius R_0, is filled with gas and is situated in inviscid, incompressible liquid, thus the pressure of gas in the bubble follows $p_0 = p_\infty^0 + 2\sigma/R_0$. The gas pressure p_0 is in the bubble, which radius is R_0, p_∞^0 is pressure in infinity and σ is the liquid's surface tension. In the bubble is only ideal gas, which state of matter depend on volume of the bubble polytrophic, so gas pressure p_p in the bubble, which radius is R, is given by formula

$$p_\mathrm{p} = p_0(R_0/R)^{3\gamma} = (p_\infty^0 + 2\sigma/R_0)(R_0/R)^{3\gamma}. \tag{6}$$

Where γ is polytrophic exponent. Gas diffusion and heat transfer between bubble and ambient are neglected. Gas in the bubble follows $p_\mathrm{p} = p(R) + 2\sigma/R$, from this we count

$$p(R) = p_{\mathrm{p}} - 2\sigma / R = (p_{\infty}^{0} + 2\sigma / R_0)(R_0 / R)^{3\gamma} - 2\sigma / R. \quad (7)$$

At certain moment is liquid inserted into acoustic field, which pressure is changing harmoniously with the time, so for pressure in infinity is valid $p_{\infty} = p_{\infty}^{0} - p_{\mathrm{A}} \cos \Omega t$. Where Ω is angular speed of acoustic wave, which amplitude of pressure is p_{A}; wavelength λ is higher than balanced radius of the bubble $\lambda \gg R_0$. Substituting from equations $p_{\infty} = p_{\infty}^{0} - p_{\mathrm{A}} \cos \Omega t$ and (11) into eq. (4), we obtain non-linear differential equation second order, which describes oscillations of gas filled bubble in acoustic field in liquid [1].

$$R(\mathrm{d}^2 R / \mathrm{d}t^2) + (3/2)(\mathrm{d}R / \mathrm{d}t)^2 + [p_{\infty}^{0} - p_{\mathrm{A}} \cos \Omega t - (p_{\infty}^{0} + 2\sigma / R_0)(R_0 / R)^{3\gamma} + 2\sigma / R] / \rho_{\mathrm{O}} = 0. \quad (8)$$

The solution of equation (8) for relatively short radial oscillation of the bubble in liquid

May the bubble is filled with gas oscillating radially around its balanced radius R_0 with relatively short amplitude deflection. For the radius of the bubble $R(t)$ is valid, $R = R_0(1 + \varepsilon x)$, where relatively small change from balanced radius of the bubble εx is small compare to1, thus $(R - R_0) / R_0 = \varepsilon x$; where x is equal about one and for small parameter ε is valid $0 < \varepsilon \ll 1$. Equation (8) we divide by R, than we substitute from equation $R = R_0(1 + \varepsilon x)$, and $p_{\mathrm{A}} = \varepsilon P p_{\infty}^{0}$, where parameter P is equal about one and we get

$$\varepsilon R_0 \ddot{x} = -\varepsilon^2 \frac{3R_0^2}{2R_0(1+\varepsilon x)} \dot{x}^2 + \frac{p_{\infty}^{0}}{\rho_0 R_0 (1+\varepsilon x)} (\varepsilon P \cos \Omega t - 1) + \frac{1}{\rho_0 R_0} \frac{p_0}{(1+\varepsilon x)^{3\gamma+1}} - \frac{2\sigma}{\rho_0 R_0^2 (1+\varepsilon x)^2}. \quad (9)$$

Different powers of $(1+\varepsilon x)$ in this equation, we expand by the binomial theorem and modify.

$$\varepsilon \ddot{x} \rho_0 R_0^2 = \left(-p_{\infty}^{0} + p_0 - \frac{2\sigma}{R_0} \right) + \varepsilon \left[P p_{\infty}^{0} \cos \Omega t + p_{\infty}^{0} x - p_0 (3\gamma + 1) x + \frac{4\sigma}{R_0} x \right] + \varepsilon^2 \left[-\frac{3}{2} \rho_0 R_0^2 \dot{x}^2 - \right.$$

$$\left. - P p_{\infty}^{0} x \cos \Omega t - p_{\infty}^{0} x^2 + \frac{p_0}{2} (3\gamma + 1)(3\gamma + 2) x^2 - \frac{6\sigma}{R_0} x^2 \right] + \varepsilon^3 \left[\frac{3}{2} \rho_0 R_0^2 x \dot{x}^2 + P p_{\infty}^{0} x^2 \cos \Omega t + p_{\infty}^{0} x^3 - \right.$$

$$\left. - \frac{p_0}{6} (3\gamma + 1)(3\gamma + 2)(3\gamma + 3) x^3 + \frac{8\sigma}{R_0} x^3 \right] + \varepsilon^4 \ldots . \quad (10)$$

The term in the first parenthesis of this equation is equal to zero. Modification of eq. (11) to

$$\ddot{x} + \omega_0^2 x = \frac{p_{\mathrm{A}}}{\varepsilon \rho_0 R_0^2} \cos \Omega t - \varepsilon \frac{1}{\rho_0 R_0^2} \left[\frac{p_{\mathrm{A}}}{\varepsilon} x \cos \Omega t + \frac{3}{2} \rho_0 R_0^2 \dot{x}^2 - \frac{p_0}{2} 9\gamma(\gamma + 1) x^2 + \frac{4\sigma}{R_0} x^2 \right] + \varepsilon^2 \frac{1}{\rho_0 R_0^2} \times$$

$$\times \left[\frac{p_{\mathrm{A}}}{\varepsilon} x^2 \cos \Omega t + \frac{3}{2} \rho_0 R_0^2 x \dot{x}^2 - \frac{9}{2} p_0 \gamma (\gamma + 1)^2 x^3 - p_0 \gamma x^3 + \frac{6\sigma}{R_0} x^3 \right] + \varepsilon^3 \ldots . \quad (11)$$

where

$$\omega_0^2 = (3\gamma p_0 - 2\sigma / R_0) / (\rho_0 R_0^2). \quad (12)$$

From eq. (11) is evident that in liquid, when $p_{\mathrm{A}} = 0$, the bubble may make small radial oscillations with frequency $f_0 = \omega_0 / (2\pi)$. If we admit in (12) $\sigma = 0$, we obtain for ω_0 result, which was considered by Minnaert, when he neglected the surface tension and pre-assume, that the bubble oscillates with simple harmonic motion. Eq.(11) is possible to solve by applying Bogoljubov-Mitropolskij method of asymptotic expansion [2], whose solved eq. $\ddot{x} + \omega_0^2 x = \varepsilon f^{(1)}(\Omega t, x, \dot{x}) + \varepsilon^2 f^{(2)}(\Omega t, x, \dot{x}) + \ldots$, which is obtainable from eq.(12) by a suitable substitution.

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Detector for Experiment with Hypernuclei $^{10}_{\Lambda}$Be and $^{10}_{\Lambda}$B

B. Sopko, T. Horažďovský, D. Chren, Z. Kohout, L. Majling, O. Majlingová*, M. Solar, V. Sopko**

sopko@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering,
Czech Technical University Technická 4, 166 29 Prague 6, Czech Republic

* Department of Technical Mathematics, Faculty of Mechanical Engineering,
Czech Technical University Technická 4, 166 29 Prague 6, Czech Republic

** Department of Theoretical Physics, Nuclear Physics Institute,
250 68 Rež, Czech Republic

This project deals with study of weak decay of hyper nucleus. A hypernucleus is a nucleus which contains at least one hyperon in addition to nucleons. The first experiment with relativistic hypernuclei was carried out many years ago. Physics motivation for preparing experiment on Nuclotron in JINR at Dubna is a remeasurement of parameters of non-meson decay of hypernuclei $^{10}_{\Lambda}$Be and $^{10}_{\Lambda}$B.

Detection of pair of α particles will be realized by matrix of scintilation detector, for determination of exact position of decay. This measurement is necessary to carried out on several detectors and in final stage is claimed to be find not only source of particles, i.e. decay of hypernuclei, but also energy balance of decayed particles. Realization of matrix detector was carried out in JINR Dubna and setup of this detector inclusive fixation of 16 photo-multipliers was designed and made at Department of Physics, FME CTU in Prague.

At present hypernuclei are produced in strangeness exchange reaction (K^-,π^-) or by associative production of strangeness (K^+,π^+).

From series of significant achievements of hypernuclear physics, we recall disclosure series of one-particle level of hyperon in nuclei [1] and selection of suitable model of realistic YN interaction: solution of Faddeev equation for the lightest hypernucleus $^{3}_{\Lambda}$H which exclude four from six options of Nijmegen interaction [2].

A systematic study of decay peak covers whole area of atomic numbers [3]. Data obtained by different types of methodics are studied and dependency on atomic number was discovered. Serious problem remains for ratio of lifetime $\Gamma^n/\Gamma^p \left(\Gamma^n \equiv \Gamma\left(n\Lambda \to nn\right), \Gamma^p \equiv \Gamma\left(p\Lambda \to pn\right)\right)$.

At present was measured width of Γ^n a Γ^p only for four hypernuclei for these is valid

$$0.5 \le \left(\Gamma^n/\Gamma^p\right)^{exp} \le 2 \text{ and } \left(\Gamma^n/\Gamma^p\right)^{teor} \square \left(\Gamma^n/\Gamma^p\right)^{exp}.$$

Varieties of suggestions were applied for elimination of this disagreement: for example inclusion of influence of heavy mesons (kaons), influence of multi-particle events, influence of quark degree of freedom but without any outstanding success. Highly probable reason is fact that has not been yet find technique how to measure final states of residual nucleus. For studying of weak decay we want to apply different type of hypernuclei production namely collision of relativistic heavy ions. Hypernuclei are produced in a beam of ions and decay in a distance of tens centimeters form a target. First experiments of this type

[10] were accepted with hesitation. In Dubna the S. Khorozov et al. [5] applied for identification of hypernucleus change of charge during pion decay

$$ {}^{A}_{\Lambda}\mathrm{H} \rightarrow {}^{A}_{\Lambda}\mathrm{H} + \pi^{-} $$

and reliably determined time of life of ${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{4}_{\Lambda}\mathrm{H}$. Now is going to be prepared a new experiment [6,7]. System of detectors for detection of alpha particles that enables reconstruction of the peak in region of hypernucleus decay and energy distribution for partial transition of $\Gamma^{n}_{\alpha\alpha 2}\left({}^{10}_{\Lambda}\mathrm{Be}\right)$, $\Gamma^{n}_{\alpha\alpha 1}\left({}^{10}_{\Lambda}\mathrm{Be}\right)$, $\Gamma^{p}_{\alpha\alpha 2}\left({}^{10}_{\Lambda}\mathrm{B}\right)$ and $\Gamma^{p}_{\alpha\alpha 1}\left({}^{10}_{\Lambda}\mathrm{B}\right)$.

Exclusive channels of weak decay of hypernuclei ${}^{10}_{\Lambda}\mathrm{Be}$ and ${}^{10}_{\Lambda}\mathrm{B}$ truly offer important information about spin dependence on weak interaction. Continuation of searching for other measurable values of $\Gamma^{n}_{\alpha\alpha 0}\left({}^{10}_{\Lambda}\mathrm{B}\right), \Gamma^{p}_{\alpha\alpha}\left({}^{10}_{\Lambda}\mathrm{Be}\right), \Gamma^{n}_{\alpha\alpha}\left({}^{10}_{\Lambda}\mathrm{B}\right)$ could allow analysis of P-shell hypernuclei [9].

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New Bichromophoric Molecule Based on Aminoperylene as an Acceptor

M. Dvořák, Z. Surovec*,
M. Michl, D. Pánek, M. Nepraš*, V. Fidler

DvorakM@km1.fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Physical Electronics
V Holešovičkách 2, 180 00 Praha 8, Czech Republic

*University of Pardubice, Faculty of Chemical Technology, Dept. of Organic Technology,
Studentská 95, 532 10 Pardubice, Czech Republic

The photophysics of rigidly linked multi-chromophoric systems has attracted considerable interest spurred by the aim of designing molecular electronic devices that can possibly act as, e.g., nanoscopic bipolar transistors.

Recently we have synthesized bi- and tri-chromophoric molecules consisting of donors and acceptors rigidly linked by a triazine ring [1], which may hold promise in this respect. Steady state absorption and fluorescence, fluorescence lifetime [2,3], and fluorescence up-conversion studies [4] showed that (i) donor and acceptor moieties are practically decoupled in the electronic ground state and (ii) excitation of the donor part causes ultra-fast electronic energy transfer – probably of the through bond type – to the acceptor part. The next logical step would be to try and control this direct photo-induced process by a third chromophore attached to the ring.

In the context of these investigations we report here on the absorption and fluorescence study of newly synthesized rigidly linked bichromophoric molecule APyTCAPer, consisting of aminopyrene as a donor, triazine ring as a linker and aminoperylene as an acceptor, and corresponding model donors and model acceptors which closely mimic photophysical behavior of individual moieties.

The APyTCAPer compound, when dissolved in dioxane, has two absorption bands centered at 350 nm and 440 nm resulting from overlapped absorption spectra of the donor and the acceptor part of the bichromophoric molecule, respectively.

The model acceptor compounds have a spectral “window” with low absorption around 350 nm, exactly where the absorption maximum of model donor compounds is located. This allows us to suppose that even in the bichromophoric molecule, a direct excitation of the donor or acceptor subunit localized excited state is possible.

The emission fluorescence spectra of the bichromohore show the acceptor-like fluorescence band only, centered at 500 nm, after an excitation into the both above mentioned absorption bands. No donor-type emission is observed even if the bichromophore is excited directly into the donor type absorption band centered at 350 nm.

Fluorescence decay kinetics were measured by the EI FS/FL900 instrument using TCSPC method. The EAI nF900 nanosecond flash lamp filled by nitrogen was used as an excitation source at 340 nm, and IBH NanoLED-05A was used for 455 nm.

The fluorescence kinetics observed at 500 nm is of the same character whether the bichromophore is excited into the donor or acceptor absorption band, respectively. In both cases, the fluorescence lifetime is about 3.9 ns.

We suppose that the acceptor-like fluorescence that follows an excitation into the donor-type absorption band is due to the intramolecular electronic excitation energy transfer (IEEET) from the donor to the acceptor subunit of this new bichromophore. On the basis of previous experiments with formerly synthesized types of bichromophores [4], we assume that the IEEET here occurs also on the time scale of hundreds of femtoseconds.

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Peculiarities of Temperature Dependence of Volt-Ampere Characteristics of InP:Mn Schotky Diodes.

H. Kozak*, B. Sopko*, K. Zdansky**

kozakh@student.fsid.cvut.cz

*Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

**Institute of Radio Engineering and Electronics, Academy of Sciences CR, Chaberska 57, 18251 Prague 8, Czech Republic

High quality InP-based semiconductors, both bulks and thick epitaxial layers, are promising materials for the preparation of radiation detectors. InP detectors [1, 2] can be used at room temperature in the energy range 10 – 500 keV. The room temperature operation is related to the high band gap energy and high mass density. It is important to prepare pure samples so that carriers originating from electron-hole pairs created during the radiation impact could reach collecting electrodes of the detector device. Preparation of Schottky-type blocking contacts would be of great advantage for good performance of detectors.

Results of intensive investigation of electrical properties of Schottky barrier contacts based on *n-type* InP has been demonstrated in numerous papers [3, 4]. At present Schottky contacts on the *p-type* InP can be made with large barrier height and low leakage current which can not be reached on the *n-type* InP. Thus the preparation and study of Schottky barrier based on *p-type* InP is very important.

In this contribution we present the results of study the temperature dependence of volt-ampere characteristics of *p-type* InP:Mn Schottky diodes at temperatures 320-100 K.

InP single crystals used in this study were grown using the computer controlled Czochralski (LEC) technique. The polycrystalline InP was synthesized from 6N purity In and P by a modified vertical Bridgman method. The n-type background concentration of intentionally undoped single crystals was about $1 \cdot 10^{16}$ cm^{-3}. The prepared semi-insulating InP single crystals were grown by doping the melt with $4 \cdot 10^{-3}$ wt% Mn for compensation of the spontaneous background n-type conductivity. In the case of Mn doped InP the conductivity is p-type at the room temperature. The binding energy of Mn represents the position of Mn energy level above the valence band.

An eutectic solution ohmic contact was deposited on the back side of the sample and annealed at 623 K under an argon atmosphere for 5 min. The Ni Schottky contact of thickness 40 nm and diameter of 1 mm was realized on the front side of the sample.

Ni Schottky diodes prepared on *p-type* InP:Mn have been studied by current-voltage (I - V) and capacitance-voltage (C - V) measurements on the temperature range of 320-100 K. Capacitance – voltage measurements have been carried out at 1 MHz frequency.

Quantitatively, within the framework of thermionic emission theory, describing the rectifying behavior of Schottky diode the forward current is a function of bias voltage V:

$$I = I_s \left[\exp\left(\frac{qV}{nk_B T} \right) - 1 \right] \qquad (1)$$

where

$$I_s = A^{**}T^2 \exp\left(\frac{-q\phi_B}{k_B T}\right) \quad (2)$$

$$\phi_B = \frac{k_B T}{q} \ln\left(\frac{A^{**}T^2}{I_s}\right) \quad (3)$$

$$A^{**} = \frac{m^*}{m_0} 120 \text{ A cm}^{-2} \text{ K}^{-2} \quad (4)$$

Here, I is the measured current (A), I_s is the saturation current *(A)*, V is the applied voltage *(V)*, A^{**} is the effective Richardson constant *(A cm^2 K^{-2})*, T is the absolute temperature *(K)*, n is ideality factor, k_B is the Boltzmann constant *(J K^{-1})*, q is the electronic charge, and ϕ_B is the barrier height *(eV)*. The value of A^{**} is about 10 A/K^2 for InP.

The obtained barrier heights are in the range of 1.12÷1.69 eV and saturation current densities of the diodes is evaluated as $(4\div7)\cdot10^{-9}$ A at room temperature. The doping concentration was determined from C-V measurements as Na-Nd=$5\cdot10^{17}$ cm^{-3}. The calculated ideality factors of the diodes are 1.1÷1.18 at room temperature, and much greater than unity at low temperatures. This increase of n with decreasing T indicates non-ideal Schottky barrier contact and the current flow mechanism across the contact is due to the thermionic emission and other mechanisms.

The very important circumstance is that on the characteristics of the forward current is observed long segment corresponding to $I \approx \exp(qV/k_BT)$-1, which is typical for recombination in the space-charge region. However under higher voltages, this observed dependence I (V) dependence sharply deviates towards high voltages. It is obvious to suppose that in the range of high forward currents part of applied voltages drops on the resistivity of substrate.

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Simulations of Socio-economical Systems

H.Lavička *, F.Slanina **

lavicka@fjfi.cvut.cz

*Department of Physics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7,CZ-11519 Prague, Czech Republic
**Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 2, CZ-18221 Prague, Czech Republic

Philosophers and scientists in the 19th century started to investigate many natural as well as social and economical phenomena. In fact, the 19th century was not only a revolutionary era for natural sciences which were used in industry. Society have changed from agricultural medieval structure to modern society with a new classes and new relations. Philosophers and sociologists started to investigate the new relations and some of them (e.g. K.Marx) suggested directions of future development of society. Next generation of thinkers tried to argue using more exact methods and the first "natural law" of economics (Pareto's law) was formulated. Italian plutonomist Vilfredo Pareto observed that the higher end (approximately $1-5$ % of population [3]) of wealth distribution follows the power-law $P(w) \sim w^{-\alpha-1}$, where exponent α is stable for an investigated country in a given period of time. Different countries have different α but real values are close to 1.5 and values of α are slowly changing in time. Finally, Pareto's law can be observed in ancient Egypt under rule of Pharaohs.

General universality of the power-law tail is a surprising phenomenon that is asking for explanation. Studies of multiplicative random processes with repulsion from zero can be a mathematical source of power-law distributions. However, number of implementations of the process are unlimited. Another deterministic point of view can be found, when Lotka-Volterra equation is used, where power-law of wealth distribution is observed too. Finally, analogy of directed polymers in random media [2] can be used as a sample. In these methods, models are formed by a kinetic equation that describes the exchange of wealth in a society of agents and global redistribution which is analogous to repelling from zero in stochastic processes.

Empirical studies of lower end of the distribution of wealth have shown exponential behavior [3] and this fact was interpreted as a conservation law for total wealth, which leads to the robust Boltzmann exponential distribution that is analogous to the energy distribution in a gas of elastically scattering molecules. However, different studies accept fact that economic activities can be treated as inelastic scattering what can explain the power-law tail of wealth distribution. The assumption of total wealth increase can be reasonable (e.g. rising GDP).

Model of agents which interacts using inelastic scattering interaction was investigated theoretically in [1] with mean-field assumption and the power-law of wealth distribution was derived for specific values of parameters. The mean-field assumption counts with fact that every person is connected with anybody else. Reality is different and society have its own structure of connections which have been measured (small-world effect, existence of close communities and power-law degree distribution). Authors of [4] suggest model of society that has first two mentioned properties of the complex networks (including society).

The investigated model is based on a model introduced in [1] with fact that the interacting agents are placed on Watts-Strogatz network and so only some of all possible connections are allowed for scattering interactions, where the network can be tuned by single parameter that controls number of shortcuts in society. Interaction between the agents is pairwise, essentially instantaneous and positive. Pairwise interaction with combination with inhomogeneous networks lead to two possible ways how to execute Monte Carlo step. The first is an agent initiated model where an agent is taken with uniform distribution from set of

all agents and his/her partner is chosen from set of possible partners. The second possibility is random chosen edge, where the agents at the end of the edges scatters each other. This model is called an edge initiated model.

The simulation program computed social tension in society along edges of the network of social contacts, distribution of wealth and correlation of wealth and connectivity what can show structural dependence of wealth among the network.

Evolution of social tension for agent initiated model show rise and fall from maximal value for small values of rewiring but higher values of probability of rewiring lead to two peaks, peak and plateau and finally one peak with fast decay. Wealth distribution is power-law with unrealistic values of α around 1 for small values of rewiring probability but for higher values the law is broken. Behavior have changed between 0.00007 and 0.0001 for system size 10000 but system size 20000 and more shifts the crossover to smaller values. It means that more shortcut broke power-law. Finally, correlation of wealth and connectivity is rising function of connectivity what means that more connections lead to more wealth for small values of probability of rewiring but for higher values, agents with less connections are benefited and the correlation of wealth and connectivity have minimum.

Evolution of social tension for edge initiated model shows similar behavior like in the previous case. One peak can be observed for small values of probability of rewiring and two peaks, one peak and plateau and finally, one peak with fast decay is present for higher values of probability of rewiring. Distribution of wealth shows crossover from power-law to non-power-law behavior between 0.00007 to 0.0001 for system size 10000 and the value is shifted for system size 20000 to smaller values of probability of rewiring. Correlation of wealth and connectivity is rising function of connectivity.

A model of wealth distribution based on inelastic scattering interaction which is known for physicists for 4 centuries but in contrast to previous physical models it would be model with positive friction which produce energy (wealth). The model on network of social contacts can produce power-law with different values of α in contrast to mean-field model [1] for small values of probability of rewiring (closed communities without many shortcuts). Connectivity is positive factor of wealth in most of the cases.

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Choice of Auditory Characteristic for Next Evaluation of Switched Reluctance Machine

R. Jurc* **, S. Fingerhuth, O. Jiricek*, M. Vorlander****

jurcr1@fel.cvut.cz

*Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Institute of Technical Acoustics, RWTH Aachen University, 52056 Aachen, Germany

Switched reluctance machines (SRMs) are electric rotary motors in which the stator and the rotor have salient poles. SRMs can appear in a wide variety of construction (single-phase, two-phase etc.); each construction possibility offers advantages and disadvantages for certain applications. SRMs are devices with wide practical use, being found in washing machines, vacuum cleaners, fans, white goods etc. This wide practical use offers important possibilities in the investigation of the acoustic optimization of this machine type.

The basic principles of noise development in switched reluctance machines are presented in reference [1]. Following this, psychoacoustic quantities (metrics), which allow an objective evaluation of sound quality of SRMs, are presented. The purpose of section [1] is to demonstrate that the successful acoustic optimization of a SRM should be performed based on both technical and psychoacoustic know-how.

The sounds of switched reluctance machines are often considered to be "loud" or "noisy". They are more annoying to human subjects than the sounds of a universal motor, although the two devices have comparable spectra. Consequently, the subject is interesting in terms of the investigation of product sound quality. Furthermore, the human hearing impression of SRM sounds can be compared with the sounds of other products. This comparison helps detect some common and also divergent features which influence the human hearing impression.

Recently, several switched reluctance machines were tested in a subjective test. In this test, the sense of the pleasantness was evaluated, with the adjective pair "*pleasant – unpleasant*" used for this purpose. Similarly, this pair was used in listener tests of a number of other products, see [4]. Several psychoacoustic metrics (loudness, sharpness and roughness) were then calculated. The results of all listener tests show that loudness alone is not a sufficient criterion for the pleasantness of SRM sound although it is the most important one, see [1]. Furthermore, the loudness spectra of SRMs ([1]) and vacuum cleaners ([3], [4]) are similar; consequently the evaluation of SRM sounds is compared with the evaluation of vacuum cleaner sounds.

The investigation of sound quality and also the development of control strategies leading to better sound quality for SRMs have yet to be completed at present. One listener test, though, was performed, the primary purpose of which was the choice of auditory characteristics. The experimental subjects chose the most suitable designation from 79 auditory characteristics. Each auditory characteristic is described by a pair of two opposing adjectives. Twenty-five auditory characteristics were chosen from the whole list of characteristics, and will be used in the next listener test for the evaluation of SRMs sound quality.

The main purposes are the *reduction* of the number of variables and the *detection* of a structure among the variables. In the research to follow, factor analysis (FA) was used. This statistical method reduces the attribute space from a larger number of variables to a smaller

number of factors. Seven factors, which explained 91,33% of total variance, were extracted by use of FA. Nevertheless, these factors correlated with a great number of original variables. The rotation method was used to minimize the number of variables that correlated with other factors. Videlicet - this rotation - gives solutions where some variables have high loadings for one factor and low loadings for the others.

The attribute space was reduced to seven factors. These factors were named and will be used in upcoming research. What is important is that certain related variables explained the same factor. For instance, the pair *unpleasant – pleasant* and *pleasant – annoying* explained one of these seven factors, which was termed *pleasantness*. Similarly, the metallic factor was explained by the pairs: *metallic – non-metallic* and *metallic – dull*. This means that factor analysis selected factors which are described by using some closely related variables.

These seven extracted factors create the attribute space of SRM sounds. The use of this space helps determine nearly all attributes of SRM sounds. The information of these features leads to an explication of the reasons that influence the sound quality of SRMs. Next, these seven factors detected the structure among auditory characteristics and will help in future evaluation of SRM sounds.

Nevertheless, for the future, certain tasks should be investigated. Firstly, the reliability and validity of the listener tests should be determined. As several sound attributes were extracted by use of factor analysis, a number of listener tests should be performed to lead to next deeper investigation of sound quality evaluation for SRMs. The development of control strategies leading to better sound quality will be also investigated in future research. Secondly, human hearing impression will be compared with a number of psychoacoustic metrics to determine the relationship between physical features and hearing impression. Finally, test results can be compared with the evaluation of vacuum cleaners. This comparison will help in detecting some common and also distinct features which influence the human hearing impression. However, the aim of the next research will be the finding of tools which lead to the improvement of the sound quality of switched reluctance machines.

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Section 3

INFORMATICS
&
AUTOMATION ENGINEERING

Range Control MPC Approach for Two-Dimensional System

J. Roubal*, V. Havlena*

roubalj@control.felk.cvut.cz

* Department of Control Engineering, Czech Technical University in Prague,
Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

There are many industrial processes which have distributed parameters behaviour. Consequently, these processes cannot be modelled by lumped inputs and/or lumped outputs models for correct representation.

This paper deals with two-dimensional dynamic processes (systems with parameters dependent on two spatial directions) which can be described by lumped inputs and distributed output models. These models can be mathematically described by partial differential equations [1]. Unlike ordinary differential equations, the partial differential equations contain, in addition, derivatives with respect to spatial directions. Consequently, the partial differential equations lead to more accurate models but their complexity is larger.

The dynamic behaviour of the distributed parameters system, which is described by the partial differential equation, can be approximately described by a finite-dimensional model, for example, by using the finite difference method [4]. Then the ordinary differential equation model with large dimension is obtained and can be used for a finite-dimensional controller design. Unfortunately, for online solving of an optimization problem, e.g. the model predictive control approach, the large model dimension introduces a problem for the control design. Therefore a model reduction method has to be used.

Variables of every real process have certain limits given by laws of physics. Unlike the classical control law, the model predictive control (MPC) considers explicitly the future implication of current control action. This approach enables us to include the constraints on inputs/outputs to the control algorithm [2]. In [3], the range control approach is described for lumped inputs and lumped outputs systems. In this paper, this concept is applied for the distributed parameters system.

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The paper is organized as follows. In section 2, the distributed parameters model for the finite controller design is developed. It is supposed a heat transfer process described by the following partial differential equation on an open set $\Omega = (0,L_1) \times (0,L_2)$

$$\rho c \frac{d\Theta(x,y,t)}{dt} - \lambda \left(\frac{\partial^2 \Theta(x,y,t)}{\partial x^2} + \frac{\partial^2 \Theta(x,y,t)}{\partial y^2} \right) = f(x,y,t)$$

and the Newton boundary condition on the boundary of the set Ω

$$-\lambda \frac{\partial \Theta(x,y,t)}{\partial n} = \alpha \left(\Theta(x,y,t) - \Theta_s(x,y,t) \right),$$

where ρ [kg/m^2] is a surface density of a medium, c [Ws/(kg K)] is its thermal capacity, λ [W/K] is a thermal conductivity (independent on the temperature Θ), f [W/m^2] represents

a surface heat source distribution, α [W/(mK)] is an external heat transfer coefficient and Θ_s [K] is the surrounding temperature. This model is transformed to the finite dimensional model using the finite diference method. The spatial derivatives are replaced by differences [4] and the discrete model in the standard state space notation is obtained

$$\begin{aligned} \boldsymbol{x}(k+1) &= \boldsymbol{A}\boldsymbol{x}(k) + \boldsymbol{B}\boldsymbol{u}(k) \\ \boldsymbol{y}(k) &= \boldsymbol{C}\boldsymbol{x}(k) + \boldsymbol{D}\boldsymbol{u}(k), \end{aligned}$$

where $\boldsymbol{x}$ is a vector of states, $\boldsymbol{u}$ is a vector of system inputs, $\mathbf{y}$ is a vector of system outputs and $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{C}$, $\boldsymbol{D}$ are matrices of the system.

Therefore the dimension of the model above is too large, the model is transformed to the balanced basis, that is described in section 3, where the system states are ordered such that the first state has the biggest influence on the system input output behaviour, the second has less influence and so on. Then we can truncate the states with small influence on the system input output behaviour, the dimension of the system decreases and the truncated model does not lose much information about the origin system.

In section 4, the basic idea of model predictive control with the range control approach is described. The main idea of the range control concept is to replace the set point reference by low and high limits. This methodology leads to a very stable and robust control because the manipulated inputs do not compensate the high-frequency component of the noise.

In section 5, this methodology is applied to a heat transfer process as a demonstration example. The predictive controller with the range control strategy is compared with the classical predictive control approach. The expected results is obtained. In the case of the range control approach the manipulated variables are smoother than in the classical predictive control approach because the manipulated variables do not compensate the high-frequency component of the measurement noise or inaccuracy of the model at high frequencies. The predictive controller with the range control strategy leads to more "calm control".

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Feature Selection Based on the Training Set Manipulation

P. Křížek*, V. Hlaváč*, J. Kittler**

krizekp1@fel.cvut.cz

*Center for Machine Perception, Department of Cybernetics,
Faculty of Electrical Engineering, Czech Technical University,
Karlovo nám. 13, 121 35 Prague 2, Czech Republic
**Centre for Vision, Speach and Signal Processing, University of Surrey,
GU2 7XH Guildford, United Kingdom

The *curse of dimensionality* [1] and the consequent issues (*i.e.*, poor generalisation, computational complexity) are the main reasons for restricting data dimension. In literature, there are two approaches leading to dimensionality reduction referred to as *feature selection* and *feature extraction*. While feature selection methods reduce the dimensionality by selecting the best subset of the input features, the feature extraction algorithms transform the original features into another space. The target application and the training data character determine which method is more appropriate. Our work focus on the *feature selection*.

John et al. [4] group feature selection algorithms into two categories. *Filters* are classifier-independent methods. Their solution relies on the intrinsic properties of the training data thus, it is relevant to a larger family of classifiers. *Wrappers* are classifier-specific. Feature subsets selected by this approach are optimised for a preselected learning algorithm which is involved in the definition of the objective function. The solution lacks generality, since a feature subset that is optimal for one classifier is not necessarily optimal for another classifier. Wrappers tend to over-fit and their computational complexity is high.

The most common way to select features is using either f*eature weighting* or *subset search* methods. *Feature weighting* procedures rank features according to their individual discriminative power and select the top-ranked candidates. However, this does not enforce a good complementarity between features and thus, the results are not reliable. *Subset search* methods evaluate the goodness of feature sets through an objective function. This becomes computationally expensive in higher dimensions. Both approaches can be sequential [1,2] or randomised [4].

In this paper, we propose a novel filter feature selection technique. We were inspired by the Adaboost algorithm [3] and the idea of weights being dynamically assigned to the training samples during the learning process in order to reflect how difficult each sample is to discriminate. Adaboost is usually used jointly for selecting a small number of important features from a very large set of potential candidates and for building the final strong composite decision rule. However, selected features are designed for a specific weak classifier and Adaboost can select the same feature more than once. From the feature selection point of view, the conventional Adaboost algorithm can be interpreted as a wrapper using a forward greedy selection strategy.

Our concept of feature selection draws on the idea of the information conveyed from the successively re-weighted training set. In contrast to Adaboost, the weights are changed so that the selected feature appears irrelevant to any potential classifier whereas in Adaboost only to one particular weak classifier. We are able to discover hidden relationships among features, and identify irrelevant and redundant features by analysing the weights evolution during the selection process and its effect on the candidate and the already selected features. Weights manipulation principle is the main difference as compared with the standard feature selection approach, since in the latter the use of the same training set fails to reveal any new

information. The proposed algorithm is expected to be much faster than standard sequential techniques, because the search is constrained to one-dimensional spaces.

Selecting features in low dimensional spaces has been the ambition for decades. It was established early on that in most cases, even statistically independent features cannot be selected on the basis of their individual merit [1]. The work on feature selection using pairwise evaluation also proved disappointing. In all these efforts, the fixed training set was used for the feature sets evaluation. Our conjecture is that if the training set is dynamically modified to reflect already selected features, similarly to Adaboost, then the selection on the individual basis becomes possible. No information is lost as the weights act as a memory of the selection process and connect all features together.

Although with unmodified training set it is not possible to select features in one-dimensional subspaces without a significant information loss we show in experiments with publicly available synthetic and real-world data that by virtue of the training set manipulation features can be selected based on their individual merit. The performance of the proposed method is compared with the *Sequential Forward Floating Search* (SFFS) wrapper, see [2]. As a classifier, the most commonly used algorithms such as Gaussian, *k*-NN, SVM with linear kernel, and C4.5 are employed. In order to have a reliable ground-truth regarding feature type, we added shifted and scaled replicas of the original features, as well as noisy features with $N(0,1)$. All data sets were normalised so that each feature had zero mean and unit variance. We split the data using ten-fold stratified cross-validation technique to acquire independent training and test sets. Each experiment was rerun ten times with different seeds of the random generator (*i.e.*, 100 runs in total) in order to obtain statistically meaningful results. Classification errors were averaged over all runs. The performance of commonly used learning algorithms using features selected by the proposed method was comparable or better, *i.e.*, smaller test error and fewer selected features, than that obtained with features selected by the traditional state-of-the-art technique.

Our results also suggested that the training set manipulation scheme finds features which perform well with all classifiers considered and delivers the solution by orders of magnitude faster then the corresponding wrapper approach. Note that if the generalisation of a classifier is not good on a data examined, the original data set can be divided into training, validation and test sets. The optimal number of features or the best classifier can be found on the validation set, however, at the expense of less data in each of the sets.

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Improved Version of Algorithm FastICA for Independent Component Analysis

***Z. Koldovský, **P. Tichavský and ***E. Oja**

koldovsk@kmlinux.fjfi.cvut.cz

*Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

**Institute of Information Theory and Automation, Pod vodárenskou věží 4, P.O. Box 18, 182 08 Prague 8, Czech Republic

***Neural Networks Research Centre, Helsinki University of Technology, P.O. Box 5400, 02015 HUT, Finland

Recently, Blind Source Separation (BSS) techniques [1] became very popular in the signal processing community. Its purpose consists in extraction of unknown original signals from their mixtures. Independent Component Analysis (ICA) is one of the most popular methods for BSS based on the assumption of mutual independence of the original signals, thus, their are acquired as independent components. While in 1990s, the essential problem has been studied [1] and basic algorithms [2] have been developed, nowadays, rather specific applications are of interests. Nevertheless, some theoretical questions are still opened, in particular, the theoretical analyses of the accuracy of developed algorithms are often missing. A natural question is: Is there any limit for separation performance, and can we reach that?

One of the most widely used ICA algorithms is FastICA [2], a fixed point algorithm first proposed by Hyvärinen and Oja in 1997. It is one of the most popular and widely used ICA algorithm thanks to its speed, accuracy and selectivity, mainly. The algorithm is using a fixed-point iteration scheme for finding the local extrema of a contrast function, which might be considered for an extension of the algorithm by Shalvi and Weinstein or of any kurtosis-based or fourth-order cumulants-based algorithms [1]. There are two varieties of the FastICA algorithm: the deflation or one-unit algorithm and the symmetric algorithm. The deflation approach, which is common for many other ICA algorithms, estimates the components successively under orthogonality conditions. The symmetric algorithm estimates the components in parallel. This consists of parallel computation of the one-unit updates for each component, followed by subsequent symmetric orthogonalization of the estimated demixing matrix after each iteration.

The present authors published recently an asymptotic performance analysis of both variants of the FastICA algorithm in [3], deriving the exact expression for this error variance. Furthermore, it is compared with the Cramér-Rao lower bound (CRB) for ICA (see [1] and reference therein) and showed that the accuracy of FastICA is very close, but not equal, to the CRB. There are two main reasons why the original versions of the FastICA algorithm do not achieve the CRB. First, both approaches (the deflation and the symmetric one) utilizes orthogonal constraint [1] which forces the estimated components to have their sample correlations exactly equal to zero. The fact that the correlations are estimated from finite amount of data causes limitation on the separation accuracy. Second, if all original signals have the same distribution, it is well known that the optimal nonlinear function used in the FastICA is the score function of the distribution. However, the distribution is unknown since

the separation is blind. In the original version of FastICA some fixed nonlinearity is used which works well for wide class of signals, but this limits the separation accuracy, also.

It is very important that based on the analysis of FastICA it is possible to estimate the accuracy of separation from the acquired signals. Moreover, the theoretical insight into the method provides a way how to improve the method.

In this paper, an improvement of the algorithm FastICA, called EFICA, is proposed. It comes from generalization of the symmetric approach via weighted symmetric orthogonalization step together with the fact that a different nonlinear function for each estimated component can be considered. Performance analysis of this generalization is straightforward, and it provides a criterion for choice of the optimum weighting to achieve efficient separation of a selected component. Based on this, an optimum refinement procedure is proposed, which consists in individual choice of the optimum weighting for each component. It is shown that the method is efficient, i.e. its accuracy attains the CRB, provided that the nonlinear function used in the algorithm equals to the score function of each original signal.

Next, to achieve the efficiency in practice, an adaptive (parametric) choice of the nonlinearity used is done for each estimated signal. The choice was optimized for signals with Generalized Gaussian Distribution, because this class covers a wide variety of typical unimodal distributions. Thereunto, the proposed algorithm is endowed by a check of saddle points which prevents the iteration process from stopping in an undesired stationary point of the contrast function that corresponds to a minimum, whereas a maximum is to-be found. The check of saddle points improves global convergence of the algorithm significantly [3].

The proposed algorithm EFICA is compared with several competitive ICA methods in terms of accuracy and speed. It gives superior results provided that the signals have Generalized Gaussian distribution. The complexity is only slightly (about three times) higher than that of the original FastICA. The Matlab™ implementation of the method is published on web site http://itakura.kes.tul.cz/zbynek/downloads.htm.

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Design and Construction of an Automatic Unmanned Helicopter Model

O. Špinka

spinkao@fel.cvut.cz

Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

Goal of the project presented here is to design and build a control system of an autonomous unmanned rotorcraft. Our aim for the year 2005 was to design and build the hardware of this control system and to develop basic software, which would be able to measure the attitude and position of the chopper in space, to store those data in a non-volatile memory and to send them to the ground station using a wireless data link. This equipment would enable us to perform test and identification flights, whose purpose would be to test the functionality of the airborne system and to measure dynamic parameters of the rotorcraft. Those parameters are needed in the controller design process.

Similar projects were already successfully finished abroad (see [1], [2] and [4] for example), but from our local point of view, should we ever succeed, this work would mark a significant achievement. Nonetheless, some novel methods of construction and testing shall be used in the course of our work. This project is very demanding from various points of view; it utilizes very sophisticated hardware and software, and therefore it is very hard to design, build and test. From the control theory point of view, helicopter control was always treated as being no easy task, as helicopters are non-linear, non-stable MIMO (Multiple Inputs, Multiple Outputs) 6 DOF (Degrees Of Freedom) systems featuring relatively fast dynamics. It is also a character-building project for purely human reasons (it takes longer then expected, it costs more then anticipated and it poses more problems and setbacks then initially thought).

All targets mentioned in the first paragraph were fulfilled successfully. A modular system, comprising of encapsulated functional blocks was designed and built, with well-known industrial bus CAN (Controller Area Network) as an interconnection medium. This solution makes separate design, build and testing of respective components possible. It also allows to update or change specific parts of the system with relatively little fuss, whenever need arises.

Let us now briefly describe the modules of the control system. The core member is the **main control computer**, whose purpose is to gather and store measured data from the whole system and to communicate with the ground station. Later, this would be the place where the control algorithm runs. The EXM32 industrial embedded computer from the MSC company, based on the Renesas SuperH 7760 200MHz RISC processor, is being used for this purpose. More information about this computer can be found at the manufacturer's web pages (http://www.msc.com). In close cooperation with the manufacturer the Linux 2.6.14 operating system has been ported to this board, and drivers were developed for the HW peripheries we use (that is for Compact Flash, Ethernet controller and CAN bus controller). A huge effort had been put into this work until we managed to get the system running reliably.

The next important node of the control system is the **servo control unit**, which controls the servomotors that drive the actuators of the helicopter (that is the collective and cyclic controls, tail rotor pitch and engine throttle). This application-specific embedded computer had been developed fully in-house. It is based on the 16-bit Renesas 2638F

industrial microcontroller (for more info see the datasheet that can be downloaded from the manufacturer's web site, http://www.renesas.com).

Last important member is the **navigation unit**. Currently we use an inertial navigation module developed by our colleagues at the department of measurement, which provides angular velocities and longitudinal accelerations in all three axes. More information may be found in [1].

Wireless Ethernet (WiFi) link is used to transfer commands and data between the chopper and the ground station. Also a modeler RC (Radio Control) set is preserved, to allow manual control of the helicopter whenever needed (for safety reasons as well as for dynamics identification purposes, when the helicopter has to be controlled manually).

Parallel with the development of the hardware of the control system we also successfully started the controller development program. An interesting mathematical model [2], suitable for miniature helicopters, had been selected as the most appropriate for the computer simulation purposes. Along with its implementation, an SDRE-based (State Dependent Riccati Equation) [3] controller is currently being developed for our chopper.

A lot of people contribute to this project. Not mentioning the author of this document, there are people from the department of measurement who developed the inertial navigation module (J. Roháč and K. Draxler) and people from the control theory group who are helping us with the mathematical model and controller development (namely Š. Kroupa and D. Pachner). Also pre-graduate students in their last year of study are involved; J. Novotný is working on the main control computer software and contributed to the Linux port, and O. Herm works on the servo control unit. Both students shall use their results in their diploma theses.

Currently, the control system hardware development is finished and the basic software is being completed. The whole system will now undergo a thorough testing process, where all possible bugs and issues shall be traced and eliminated. Then the first test flights would be performed. The very first preliminary test flights, which served to set-up and tune the helicopter and to test the payload carriage, were already carried out successfully. We shall be able to collect first flight data, which would serve for dynamic parameters identification (see [4] for more details), in a relatively short time.

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Analytical Modelling of Linear Codes

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science , Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

In this paper, we describe a probabilistic model for estimation of the numbers of cache misses during the sparse matrix-vector multiplication (for both general and symmetric matrices) and the Conjugate Gradient algorithm for 3 types of data caches: direct mapped, s-way set associative with random or with LRU replacement strategies. Using HW cache monitoring tools, we compare the predicted number of cache misses with real numbers on Intel x86 architecture with L1 and L2 caches. The accuracy of our analytical model is around 96%.

Sparse matrix-vector multiplication (shortly SpMV) is an important building block in algorithms solving sparse systems of linear equations, e.g., FEM. Due to matrix sparsity, the memory access patterns are irregular and the utilization of cache suffers from low spatial and temporal locality. An analytical model for SpMV is developed in [3], where the dependence of the number of cache misses on data and cache parameters is studied. We have already designed another analytical model in [1], but here it is further extended for symmetric matrices.

A common method for solving sparse systems of linear equations appearing in FEM is the Conjugate Gradients algorithm (CGA) [4]. Such a sparse system of linear equations with n variables is usually represented by a sparse (n x n)-matrix A stored in the **format of compressed rows.** A suitable format for storing symmetric sparse matrices is the SSS (**symmetric sparse skyline**) format in which only the strictly lower triangular submatrix is stored in the CSR format and the diagonal elements are stored separately in array diag (for details see [2]).

2 Cache model

The cache model we consider corresponds to the structure of L1 and L2 caches in the Intel x86 architecture. An s-way set-associative cache consists of h sets and one set consists of s independent blocks (called lines in the Intel terminology). We distinguish 2 types of cache misses: Compulsory misses (sometimes called intrinsic or cold) that occur when empty cache blocks are loaded with new data and thrashing misses (also called cross-interference, conflict or capacity misses) that occur when useful data are loaded into a cache block, but these data are replaced prematurely.

3 Assumptions of the model

The model is based on the following simplified assumptions (same as in [1]):

1. There is no correlation among mappings of arrays into cache blocks. Hence, we can view load operations as mutually independent events.
2. We assume that the whole cache size is used for input, output, and auxiliary arrays.
3. We assume that each execution of algorithm starts with the empty cache.
4. Thrashing misses occur only within the subroutines for SpMV.

4 Comparison with previous work

Our analytical probabilistic model for predicting cache behavior is similar to the model in [3], but we differ in 2 aspects. We have explicitly developed and verified a model for *s*-way set associative caches with LRU block replacement strategy and obtained average accuracy of predicted numbers of cache misses equal to about 97% for both SpMV and CGA. We have derived models for both general and symmetric matrices. In contrast to [3], (1) our results indicate that cache miss ratios for these 2 applications are sensitive to the replacement strategy used, (2) we consider both compulsory and thrashing misses for input arrays.

5 Conclusions

We have derived probabilistic models for estimations of the numbers of cache misses for data caches of 3 types: direct mapped and s-way set associative with random and with LRU replacement strategies. We have derived these models for 3 algorithms: general and symmetric SpMV and CGA. We have concentrated on Intel architecture with L1 and L2 caches. Using HW cache monitoring tools, we have verified that that the real number of cache misses was predicted with average accuracy 97% in case of SPMV algorithm for CSR format and 95% in case of SPMV algorithm for SSS format. and 96% in case of CGA algorithm. The errors in estimations are due to minor simplifying assumptions in our model.

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Cache Emulator for SMP Systems

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Every modern CPU use a complex memory hierarchy, which consists of levels of cache memories. It is really difficult to predict the behavior of this hierarchy for the given program (for details see [1, 2]). The situation is even worse in SMP (symmetric multiprocessing) systems. The Cache emulator (shortly CE) can simulates the behavior of caches inside SMP system and compute the number of cache misses during a computation. All measurements are done in the "off-line" mode on the one CPU; the CE uses own virtual cache memory for the exact simulation. It also means that another CPU activity doesn't influence the behavior of the CE. This work extends Cache Analyzer introduced in [3].

The cache model for one CPU we consider, corresponds to the structure of L1 - L3 caches on vast of modern memory architectures [1]. Every level of cache is *s-way set-associative* (or *direct mapped*). We also assume that the whole cache size is used only for data and that the operand read does not cross cache block boundary.

The CE has many important advantages in comparison to the HW CPU cache monitors:

- The CE is supported on every platform, because the CE is implemented as a C library and can be easily included in every program.
- The measurements are not influenced by other processes due to the "off-line" mode of the measurement.
- The CE can measure effects of memory functions not supported by the CPU core (for example "read once" operation) and can serve for the development of more effective cache hierarchies.
- The user can easily change cache configuration or number of CPUs for the measurement by the *#define* statement. Parameters for real systems can be easily included from predefined files.
- The user can measure the cache behavior only in an area of interest.
- The measurements with conditions are supported.
- The "off-line mode" guarantees that small quantities of cache misses can be also exactly measured.

But the CE has also potential drawbacks:

- Read operations in the CE are about 1000 times slower (the real value depends on the task and the number of simulated CPUs) than HW memory reads because in the CE are all read (or write) operations simulated by software. This drawback is reduced by the fact that the user can measure the cache behavior only in the area of interest.
- The CE requires the additional memory for its own virtual cache memory.
- Only data caches are assumed not TLB neither other parts of memory architecture.
- Only the numbers of cache misses are measured not effects of these misses (memory latencies, conflicts or stalls).
- Some cache misses cannot be measured (for example these caused by stack operations in CALL-RET sequences).

- For caches which can hold both data and instructions, the effect of loading instructions into the cache is omitted. This drawback is not usually significant because code-sizes of inner loops are much smaller than data-sizes used by these loops.
- The current version of CE supports only MESI coherency protocol.
- Coherency misses are solved on the statistical basis.
- The user must have source code in C language and modify it (explicitly include read operations for the CE).

All results were measured on this HW configuration:

1) Intel Celeron 2,4 MHz, 512 MB RAM, 128 KB L2 cache, 8 KB L1 cache running OS Windows XP with Intel C compiler version 7.01.
2) SMP system 4* Itanium2 1,3 Ghz.

For validation of the CE, we have run some test tasks on this computer including subroutines from linear algebra package in 2 forms:

- The original code was measured by the HW cache monitor (performance counters in the IA-32 architecture).
- The modified code was measured by the CE.

Results from these tests are almost the same. For sure, they can not be exactly the same, because both measurements and the analytical estimation are inexact in different ways, which are discussed above. For simplicity, we can say that differences between these results were smaller than 20%.

We have implemented a cache emulator to study quantitative parameters of the cache behavior during different types of the computation. We have also discussed advantages and drawbacks of this emulator. The emulator has been verified on different types of usual tasks. The results were very similar as these obtained from HW cache monitor.

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A New Diagonal Blocking Format and Model of Cache Behavior for Sparse Matrices

Ivan Šimeček, Pavel Kordík

xsimecek, kordikp@fel.cvut.cz

Department of Computer Science , Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Abstract

Algorithms for the sparse matrix-vector multiplication (shortly *SpM×V*) are important building blocks in solvers of sparse systems of linear equations. Due to matrix sparsity, the memory access patterns are irregular and the utilization of a cache suffers from low spatial and temporal locality. To reduce this effect, the *diagonal register blocking* format was designed. This paper introduces a new combined format, called *CARB*, for storing sparse matrices that extends possibilities of the diagonal register blocking format.

1 Introduction

There are several formats for storing sparse matrices. They have been designed mainly for the *SpM×V*. The *SpM×V* for the most common format, the *compressed sparse rows* (shortly CSR) format, suffers from low performance due to the indirect addressing. Many studies were published about increasing the efficiency of the *SpM×V* [1,2].

There are some formats, such as *register blocking*, that eliminate indirect addressing during the *SpM×V*. Then, vector instructions can be used. These formats are suitable only for matrices with a known structure of nonzero elements.

The overhead of a reorganization of a matrix from one format to another one is often of the order of tens of executions of a *SpM×V*. So, such a reorganization pays off only if the same matrix *A* is multiplied with multiple different vectors, e.g., in iterative linear solvers.

2 The register blocking formats

These formats are designed to handle randomly occurring dense blocks in a sparse matrix. We will discuss only about *diagonal register blocking* (shortly *DRB*) [3,4]. Nonzero elements of *A* are grouped into **dense** diagonal blocks whose sizes can differ. In the DRB format, nonzero elements that have no diagonally adjacent nonzero elements are called *isolated* elements. Storing a matrix as a set of small dense blocks is the most common technique for improving performance of the *SpM×V*.

3 New formats for sparse matrices

We have designed a cache-adaptive heuristic-based register blocking format (shortly *CARB*) which differs from classical DRB format in these aspects.

1. In the classical DRB format, all nonzero elements must be in diagonal blocks and isolated elements are stored as blocks of size 1. In many cases, the amount of memory for storing all these isolated-element blocks can be reduced. Simply speaking, in the CARB format, isolated elements are stored in the CSR format, while the blocks in the DRB format.

2. The CARB format allows diagonal **partially full** blocks to reduce the number of blocks. The maximum "sparsity" of diagonal blocks can be defined by a *block heuristic*.
3. The CARB format splits very long diagonal blocks into smaller ones, whose can be fit into the cache.

4 Evaluation of the results

All results were measured at Pentium Celeron 2.4 GHz, 512 MB@ 266 MHz, running OS Windows XP with the following cache parameters:

SW: Microsoft Visual C++ 6.0 Enterprise edition and Intel compiler version 7.1

All cache events were monitored by Intel Vtune performance analyzer 7.0.

4.1 Test data

We have written a program GEN that generates symmetric, positive definite matrices produced by discretization of two elliptic partial differential equations with Dirichlet boundary condition on rectangular grids. We have also used 52 real matrices from various technical areas from MatrixMarket and Harwell sparse matrix test collection.

4.2 Performance improvement of the *SpM×V*

For synthetic matrices, the *SpM×V* using the CARB format is about 20% for type `float` and 35% for type `float` faster than using the CSR format.

Significant speedups (more than 10%) were achieved for 42% of real matrices, whereas significant slowdowns (more than 10%) were achieved for 10% of them.

5 Conclusions

We have designed new format for storing sparse matrices that combine advantages of the compressed sparse row (CSR) format and the classical diagonal register blocking (DRB) format. This new format extends possibilities of register blocking formats and can significantly improve the performance of the *SpM×V*.

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Recursive Implementation of High Performance Numerical Algebra Library

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

For a good performance of every computer program, the efficient cache utilization is crucial. In numerical algebra libraries (such as BLAS or LAPACK) is the good cache utilization achieved by the explicit *loop restructuring* (for details see [1, 2]). It includes *loop unrolling-and-jam* which increase the FPU pipeline utilization in the innermost loop, *loop blocking* (that is why we called these codes shortly *blocked*) and *loop interchange* to maximize the a cache hit ratio. After application of these transformations, these codes are divided into two parts. Outer loops are "out-cache", inner loops are "in-cache". Codes have almost the same performance independently on the amount of data, but all these code transformations require the difficult cache behavior analysis. In this paper, we represent the recursive implementation of some routines from the numerical algebra library. This implementation leads to cache-sensitive codes due to the "natural" partition of data without need to analyze the cache behavior.

We choose these basic subroutines:

1. Matrix-matrix multiplication[1] (`GEMM` in BLAS notation),
2. Symmetric matrix-matrix multiplication (`SYRK` in the BLAS notation).
3. Backward substitution (`TRSM` in BLAS notation),
4. Cholesky factorization (`POTRF` in LAPACK notation).

The standard codes of these routines have good performance due to high cache hit ratio only for small sizes of the order of the matrix. For good cache utilization for larger values, it must be modified. In numerical algebra packages, this is achieved by the explicit loop restructuring. But effective cache utilization can be achieved by divide-and-conquer approach too. These codes, whose use recursive-style formulations, we called these codes shortly *recursive*.

The motivation idea of the recursive codes is to divide the matrices into disjoint submatrices of the same size (see [3, 4]). The resulting code has much better spatial and temporal locality.

For demonstration purpose we choose the *gemm, trsm,* and *potrf* subroutine.

The gemm subroutine

We consider input real matrices $A(i,k)$, $B(k,j)$. A task is computed the matrix $C(i,j)$, such that $C=A \cdot B$. We consider the partitioning of all matrices *A, B, C* into 2 submatrices.

gemm(*A,B*) =

$C_1 = \text{gemm}(A_1, B)$, $C_2 = \text{gemm}(A_2, B)$. (recursion by *i* variable)

$C_1 = \text{gemm}(A, B_1)$, $C_2 = \text{gemm}(A, B_2)$. (recursion by *j* variable)

$C = \text{gemm}(A_1, B_1) + \text{gemm}(A_2, B_2)$. (recursion by *k* variable)

procedure syrk

[1] In real cases, an algorithm for GEMM subroutine used the Strassen's method, but it is the recursive algorithm too.

We consider input real matrices $A(i,k)$, $B(i,j)$. A task is computed the matrix $B'(i,j)$, such that . $B'=B - A\,A^T$.

syrk(A,B) =

$B_1' = B_1$ - syrk(A_1, A_1),

$B_2' = B_2$ - gemm(A_2, A_1^T),

$B_3' = B_3$ - syrk(A_2, A_2). (recursion by *i* and *j* variable)

B' = B - syrk(A_1, A_1) - syrk(A_2, A_2). (recursion by *k* variable)

procedure potrf

We consider input real symmetric matrix A. A task is computed the symm. matrix L, such that $A = L\,L^T$. We consider the anticlockwise partitioning of matrices A and L into 3 submatrices.

potrf(A) =

A_1 = potrf(L_1),

A_2 = trsm(L_1,L_2),

A_3 = potrf(A_3- syrk (A_2)).

The main differences between blocked and recursive-based codes are

- The cache analysis of some routines for linear algebra is difficult, much more difficult than the recursive formulation of them.
- Blocked codes can have different the “in-L2-cache” loop and the “in-L1-cache” loop. This can lead to even higher cache hit ratio.
- The recursive style of expressions is very easy to understand and results in error-free codes, but some routines are hardly expressed in the divide-and-conquer style.

All results were measured on this HW configuration: Intel Celeron 850 MHz, 256MB RAM, 128 KB L2 cache, 16 KB L1 cache running OS Linux Debian with Intel C compiler version 6.01. All tested subroutines reach performance about 80% in comparison to the tuned ATLAS library. We can conclude that recursive codes achieve very good performance due to the effective cache utilization. In comparison with other (more complicated) methods, no cache behavior analysis is needed.

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Optimization of SESOL Package

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The high performance of nowadays programs (including numerical algebra packages) is achieved by explicit loop restructuring (mainly loop blocking). These transformations result in better temporal and spatial locality. In this paper, we introduce some basic techniques for improving the performance of programs. Then, we describe source code transformations based on loop reversal and loop for the SESOL (as an example of a mathematic modelling tool) code. We have concentrated on nowadays IBM PC processor's architecture with L1 and L2 caches. Our optimizations results in the significant performance improvement.

1 Tuning scientific code

This part of this article It deals with software optimization techniques, which can considerably improve the efficiency of computer codes - solvers used in mathematical modelling in particular. For a good performance of computer programs on the modern processors, efficient cache utilization is crucial. In numerical algebra libraries (such as BLAS or LAPACK), proper cache utilization is achieved by explicit loop restructuring (see [3, 4] for details). It includes loop unrolling-and-jam, which increases the FPU pipeline utilization in the innermost loop, and loop blocking and loop interchange to maximize the cache hit ratio. After application of these transformations, these codes are divided into two parts. Outer loops are "out-cache", inner loops are "in-cache". Codes have almost the same performance independently of the amount of data, but all these code transformations require a difficult cache behavior analysis. Every mathematical algorithm from the numerical algebra can be relatively easily rewritten into pseudo-code: Every mathematical operation in the algorithm is simply transformed into one subroutine from the linear algebra package. This simple algorithm leads to very transparent, error-free codes. But these codes do not respect the inner architecture of the CPU and the memory hierarchy and suffer from low temporal and spatial locality. If the data cache size is less than the total memory requirements for storing all input, output and auxiliary arrays, then due to thrashing misses, part or all of these arrays are flushed out of the cache and must be reloaded during the next iteration. These drawbacks can be also reduced by the applications of software transformation techniques. These transformations result in better temporal and spatial locality and/or in more efficient utilization of inner pipelines. In particular, codes for dense linear algebra consist mainly of loops. A number of software transformations techniques have been developed for effective restructuring of these loops in recent years.

2 General algorithm for tuning scientific codes

Firstly, we should identify performance hotspots - pieces of code (mainly loops) that consume the majority of the CPU time. With advantage one can employ profiling tools for this goal (Intel VTune Analyser in our case). Modern processors support also measurement of machine-dependent events. These features not only allow the user to identify the most time-consuming parts, but also parts with bad cache utilization, etc. Then, we try to tune these parts by software transformations of the source code. The next section demonstrates this procedure on the sequential solver SESOL of the GEM3 package.

3 Evaluation of the results

All results were measured at these 4 platforms:

1. mobile AMD(R) Athlon(R) at 2.4 GHz, 1 GB, 512 KB L2 cache, running VMWare,
2. Intel(R) Pentium(R) 4 at 3 GHz, 512 MB, 1 MB L2 cache, running OS Linux,
3. Intel(R) Pentium(R) 4 at 3.2 GHz, 3 GB, 1 MB L2 cache, running OS Linux,
4. Intel(R) Itanium(R) 2 at 900 MHz, 6 GB, running OS Linux,

We have used SW: GNU G77 compiler version 3.3

Intel compiler version 7.1, both with only switch `-O3`.

All cache events were monitored by the Cache Analyzer [2].

Final version passed the FOOT benchmark on the x455 in 10.0 s, cutting down the solver's execution time to 56% ! Let us recall that the effects of such tuning are platform dependent. On another machine (Intel Pentium 4), the same procedure produced a 2.5 times faster code. For parallel (message passing) programs, one can generally use the same optimizations, although the results may be limited due to distribution of data across independent nodes. Here, reduction of the communication overhead is usually even more important.

4 Conclusions

In the article we emphasized the coupling between mathematical modelling and computer science. In its first part we have introduced some basic code transformation techniques such as loop interchange, loop fusion, loop unrolling, and software pipelining. The second part demonstrated the power of the software optimization techniques: Applied on the solvers' codes, the "art of tuning" can multiply their speed and hence highlight the efficiency of the underlying mathematical methods.

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Cache Misses Analysis by Means of Data Mining Methods

Pavel Kordík, Ivan Šimeček

kordikp, xsimecek@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

It is really difficult to predict the cache behavior even for a simple program (for details see [1, 2]) because every modern CPU use a complex memory hierarchy, which consists of levels of cache memories. One challenging task is to predict the exact number of cache misses during the sparse matrix-vector multiplication (shortly $SpM \times V$). Due to matrix sparsity, the memory access patterns are irregular and the utilization of a cache suffers from low spatial and temporal locality. It is really difficult to predict the cache behavior for all cases of input parameters. The cache misses data were also analyzed by means of data mining methods. This is the main topic of this paper and we will discuss the data mining analysis bellow in the more detailed form.

At first the data had to be preprocessed. It was transformed into the native format of the data mining application WEKA [3] where almost all experiments have been performed.

We tried to predict the number of cache misses from input variables (read operations, size of matrices, bandwidth etc.). The data mining methods from the category of decision trees, bayes classifiers and neural networks were used. The detailed description of these methods can be found in [4].

Because WEKA is designed to solve mainly classification problems, we had divided the output attribute "number of cache misses" into 10 intervals (classes). We achieved just 62% classification accuracy by Bayes based methods (Bayes Net, Naive Bayes Simple, etc.).

Other methods were unable to give any results because of memory demands. When we studied why the performance is so low, we found out that the data should be further preprocessed. New data set were created from the original one by leaving out redundant measurements with low additional information. It consisted from 1500 records that representatively described number of cache misses (almost uniformly distributed). With this new data set we achieved for data mining methods following classification accuracies:

- Multi Layer Perceptron MLP (92%),
- Radial Basis Function network RBF (93%),
- Decision tree C4.5 (95%),
- etc.

This accuracy is perfect so we can conclude that using data mining methods, we can estimate the number of cache missed with relatively low error.

Data mining also allows us to find out which input variables (features) are most important in estimating the number of cache misses (feature ranking).

Again, we performed several experiments with method for feature ranking available in WEKA. The results show that the most important feature is

- *readCount* (number of read operations),
- *nonZero* (number of nonzero elements in the matrix),
- *width* (the bandwidth) feature.

Surprisingly the *size* (size of the matrix) feature was on the fourth position in average – gaining much lower significance than we expected.

We have implemented a simple cache analyzer, collected data about cache misses and along with analytical estimation of cache misses we analyzed data by means of data mining methods. The results of data mining analysis are very promising for our further research leading to models reducing the number of cache misses.

We would like to thank to students Miloš Klíma and Michal Chalupník for performing some of the above described experiments as their semester projects from the course Neural networks and neurocomputers.

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A Theoretic-framework for Quantum Steganography

M. Dobšíček, J. Kolář, R. Lórencz

dobsicm@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Quantum information processing has proved to be a fruitful tool in several advanced cryptographic tasks. For example quantum key distribution establishes a string of random bits shared by two spatially separated parties in an information-theoretically secure manner. Classical solutions for this problem offer only computational security. Beyond quantum key distribution there are other promising directions of research such as quantum secret sharing, quantum data hiding, authentication of quantum messages and quantum steganography, to name a few of them. It is important to note that while in classical theory the terms 'data hiding' and 'steganography' are interchangeable, in quantum theory they have different meaning. Quantum data hiding is rather closer to secret sharing.

Our research during the last year focused on quantum steganography. By this term we refer to methods of hidden communication within framework of quantum mechanics. Similar to classical steganography, hidden communication is done via embedding a message into a redundant part of a cover medium.

Embedding methods differ significantly in the medium access level. The main levels are 1) quantum noise, 2) error correcting codes and 3) data formats, protocols, etc. Quantum noise level is not much about theory of information in the sense of entropy but it is a clean race in the technology available to the steganographer and steganalyst. To put it more to the context, let us take a look at the first commercially available products for quantum key distribution. For these tools to work as securely as proposed by the theory the single photon emitters and detectors are crucial. Nevertheless, usable single photon sources are often substituted with industry-standard weak coherent pulse approach. Whilst practical, this approach suffers from non-zero probability of multiple-photons events. Apart from the introduced security loophole, these extra photons can be used for steganographic purposes while legitimate key distribution seems to happen.

On the level of quantum error correcting codes (QECC) the situation is very similar. First steps along this line were accomplished by J. Gea-Banacloche in [1]. He proposed to encode the message to be hidden into the error syndrome. When compared to the classical counterpart, the QECC scheme has a greater capacity for such purposes. This is due to the fact that quantum errors are continuous and a bunch of extra qubits is needed to preserve the desired quantum state. For example, the Shor code is a [9,1,3]-QECC. On the other hand, QECC- based embedding techniques are not suitable for steganography in the sense of communication but rather for watermarking tasks. To let the QECC work correctly most of the time it is needed to remove the deliberately inserted errors before the ordinary correcting stage takes place otherwise the data could be corrupted. Of course, such an error-based watermark can be removed only by a person who knows the mark exactly, i.e. instead of an unknown communicated message only a yes/no-kind of copyright statement is delivered. Interesting results arise from data authentication perspective. In order to tie up the mark with the data properly the mark has to have a form of superposition (linear combination) of basic errors, e.g. of bit-flip and phase-flip error.

M. Dobšíček studied the connection with authentication schemes of quantum messages in more depth. He analyzed a scheme proposed by M. Curty et al. in [2] and concluded that the

data and the authenticating tag have to be tied using an entangling unitary operation, see [3] for more details. In a subtle way this coincides with the demand for 'superposition of errors'.

Finally, embedding messages at the level of data format is expected to be the most widely used in the future. In digital data formats, tens of methods are known that exploit redundancy in JPEG images, MP3 music files, binary executable files and so on. However, there are no such formats in quantum domain by this time. It is too early to predict how and when will the technology reach this stage. Generally speaking, we distinguish quantum steganography without entanglement and with entanglement indepedently of the format.

Consider the following situation using the least significant bit technique. We have a digital information and deliver this information quantum-mechanically. It is the most expected scenario – classical enduser interface accompanied with quantum coprocessor and broadcasting quantum channel. Two parties who want to establish a steganographic channel agree on a non-standard base encoding and measurement on the qubits which correspond to least significant bits. Other parties who are not aware of this deal treat all qubits in a standard base. In consequence, these parties may obtain wrong classical bit values but due to their low significancy they can hardly detect it. Additionally, once the qubit carrying hidden information is collapsed by a measurement, no later leakage of the stego key used for encoding enables to obtain that past hidden information. There is no classical analogue for this pretty striking property. Of course, the difficult part for the steganographer is to properly select positions of bits which are the least significant.

Regarding the quantum steganography with entanglement it is possible to use schemes which are based on superdense coding. Basically, an EPR-pair is being shared and an unitary transform applied by one party to its particle is immediately projected to the state of the particle of the other party. The first qubit is then sent off and joint measurement on both of them reveals the applied operation and in turn the communicated bit value. Another interesting possibility is to entangle own particles with a quantum machine in some corporation and see if it is possible to either retrieve 'secret' information from that corporation in an unobtrusive way or upload information (e.g. a virus code) if we go really far with imagination, in the same way.

To conclude, we have identified the basic framework for quantum steganography, recognized the usual elements such as superdense coding/teleportation and encoding to non-orthogonal quantum states, which are used through quantum cryptography, and pointed out few interesting questions.

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Auto-detection of the Sensors Discredibility in a Control Loop via Evolutionary Algorithms

D. Klimánek, B. Šulc

David.Klimanek@fs.cvut.cz, Bohumil.Sulc@fs.cvut.cz

Department of Instrumentation and Control Engineering, Czech Technical University in Prague Technicka 4, 166 27 Prague 6, Czech Republic

When operating a control loop, the correct function of the controller depends on data usually acquired from a controlled variable sensor. A problem may occur when the output information from the controlled variable sensor is biased. Then malfunction detection of the sensor used for measuring the controlled variable can become a very important task. It is sometimes difficult to detect changes in the properties of the controlled variable sensors, because they are not apparent from the control loop behavior. The problem is as follows: although the control loop seems to work properly, the consequences of such a small sensor malfunction (sensor discredibility) can become substantial and expensive. It is easy to imagine, e.g. a combustion ratio control where deviations from an optimal ratio value have no principal influence on the operation of the device, but late discovery of an increase in harmful emissions may be very costly. Sensor redundancy may not be an acceptable solution if it requires expensive measuring equipment.

The project attempts to find new ways toward sensor discredibility detection that differ from the usual utilization of redundant measuring equipment, i.e. hardware redundancy. To avoid additional costs, we are working on a way to detect sensor discredibility with the use of software tools. Software detection, or the software redundancy, can substitute one or two redundant pieces of measuring equipment that are sometimes expensive. Thus, the task is to improve the function of the controller so that it is able to indicate biased sensor properties. Only if an operator is warned, will he or she be able to assess the harmful effects resulting from an incorrect sensor function and a make decision about replacing the sensor.

The key to software sensor discredibility detection lies in determining the residual variable (residual function) as the difference between the sensor model output and the real sensor outputs. The idea underlying discredibility detection is then as follows: find a parameter vector of the sensor model for which the residual function is minimal. It is assumed that at the time when the sensor provides correct data the parameter vector of the sensor model represents the correct parameters and the residual variable is equal or close to zero. If a sensor discredibility occurs, some of the parameter optimization algorithms is applied for a search of new values of the sensor model parameters that will again achieve a minimum of the residual variable. In this way, a discredibility detection task is transformed to an optimization task. An extreme increase of any of the parameters may signal the beginning of sensor discredibility.

In principle, any optimization methods could be used for the optimization task. The problem is that the sensor model input is an unknown dynamically changing variable. Therefore, the choice and the parameter selection must include an element of random selection from many alternatives. This is fulfilled by the methods of so called evolutionary algorithms. The high computational time requirements do not matter in the case of sensor discredibility detection, because they follow from the character of sensor discredibility that the loss of credibility is a gradual development. It differs in this way from standard fault detection, where the discovery of a fault is required to be as quick as possible. One of the

evolutionary algorithms is a simulated annealing method. The usual general presentation of the method has been transformed in a way that uses terms from the field of sensor discredibility and facilitates understanding of the used procedures. The simulated annealing is based on an analogy with thermodynamics, according to which solids are heated and cooled gradually to a crystalline state with minimum energy. This process is known as annealing. The task is to find the parameter vector of the sensor model minimizing the residual function. The algorithm runs in iterations. In each of the iterations, a vector of the potential sensor model parameters is randomly generated, and a residual value is evaluated. The values are generated within chosen limits of the expected values for each of the parameters.

The described way of sensor discredibility detection has been applied to a simple example of a control loop. As an object where the control variable has been measured by a sensor, was a cascade of two tanks. The control (process) variable was the level in tank 2. The general aim of the proposed control scheme is to enhance the function of a standard PI controller so that the controller would be able to warn the operator about changes in the properties of the control variable sensor. The value the sensor model input (estimated value of level in tank 2), which as a value of a real physical quantity is not available to us, can be determined indirectly from the steady-state characteristics. These express the dependence of the sensor model input on the values of the manipulated variable u (opening of the inlet valve) and the load represented by the values of the steady state flow rate through the tank cascade. It is possible to express this relation by a formula or by a table.

The described software detection of sensor discredibility via the simulated annealing has proved a suitable tool for detecting simulated changes of sensor properties. The simulated annealing algorithm found the simulated sensor discredibility in hundreds of iterations. In the case of the used application, this disadvantage does not matter, because the sensor discredibility does not lead to the fatal errors in the control loop operation. However, by early detection we can avoid some harmful effects that may result from sensor discredibility. Comparing our results with work which attempted detection via the genetic algorithm, both algorithms have proved to be useful utilities. There is no significant difference between the algorithms; their good convergence depends mainly on the algorithm settings.

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Analysis of Service System with Priorities

Lukáš Konopka

konopkl@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,
Czech Technical University in Prague, Technická 2, 166 27 Praha 6 – Dejvice

Multimedia services are very sensitive to delay and therefore new demands are put on data networks that are very often used for the transmission of these services. As data networks are mostly working on packet-switching principle the delay during transmission may be affected by increasing traffic. Therefore priorities are implemented into network nodes (Let us note that network is in fact an interconnection of network nodes and data termination equipments) in order to reduce the delay.

The network traffic consists of packets flow belonging to services like Telnet, FTP, VoIP, etc. Priorities reduce delay of delay-sensitive traffic (i.e. video, voice) that is affected by common traffic (i.e. data). The implementation of priorities requires the division of packets into priority classes with respect to its service membership. Let us note that each service has different delay requests. This classes are distinguished each other by a class number. The class number expresses the sensitivity to delay. It stands that a packet with lower class number is during accepting to service in a network node preferred to a packet with higher class number.

Priorities may be classified according to its behaviour. Following priority mechanisms are distinguished:

- **Non pre-emptive priority,**
- **Pre-emptive priority.**

Pre-emptive priority terminates or interrupts the service of packet with higher class number and immediately starts the service of arriving packet with lower class number. Non pre-emptive priority provides that packets are waiting without any respect to class number until the service is finished and then they are served according to its priority number and queue discipline (usually FIFO).

In network nodes (i.e. routers, switches) pre-emptive mechanisms may be encountered. In order to evaluate the asset of these mechanisms the analysis must be accomplished. Unfortunately real networks are too complicated to be analyzed and therefore the simplifying mathematical model of a network node must be utilized. Let us suppose that a network node may be described by queuing system of the type $\overline{M}+\overline{M}/M/1/\infty$ according to Kendall's classification and that packets may be considered to be requests. In system with finite memory capacity the mean time of delay may be encountered smaller than in system with "infinite" memory capacity. Therefore the model with "infinite" memory capacity has been chosen. It means that two independent flows are supposed where the first one is preferred to the second one. Also the steady state is supposed which means that probability characteristics are time invariant. With respect to foregoing assumptions following terms for class number x may be defined:

- **x class number**
- **A_x mean offered traffic**

- **λ_x arrival intensity**
- **μ_x service intensity (note if the subscript x is missed then it stands $\mu=\mu_1=\mu_2$)**
- **t_{osx} mean service time (note if the subscript x is missed then it stands $t_{os}=t_{os1}=t_{os2}$)**
- **A total offer equal to the sum of A_x**
- **E[D_x] mean time of delay**

Let us note that $A_x=\lambda_x/\mu_x$ and $\mu_x=1/t_{osx}$.

Main aim of analysis is to find the relation among basic flow parameters and mean time of delay. There are two ways how to describe this relation. The first one is the analytical solution and the second one is the simulation.

Analytical solution of mean time of delay were derived in [1] with respect to foregoing assumptions and therefore there are only resulting equations mentioned

$$E[D_1] = \frac{1 + A_2}{\mu(1 - A_1)}, \tag{1}$$

$$E[D_2] = \frac{1 - A_1 + A_1^2 + A_1 A_2}{\mu(A_1 + A_2 - 1)(A_1 - 1)}. \tag{2}$$

Simulation program was written with help of Object Pascal and was based on Monte Carlo method. Its main purpose is to offer solution of queuing systems that cannot be easily described on analytical way.

Comparison of both methods and results of analysis were written in [2] and also will be presented on CVUT Poster 2006.

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Web Resources Integration Using Semantic Web Technologies

Martin Švihla, Ivan Jelínek

svihlm1@fel.cvut.cz, jelinek@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering
Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

We discuss in this paper results of the research of the IGS grant regarding to web resources integration problem. There are usually various information sources dedicated to one knowledge domain on the web. For example, information about movies and cinemas in specific area can be published on information portals, online magazines, blogs, wikis or web databases. These resources are usually presented in traditional web formats. The information integration based on semantic web technologies can be then divided into the two main problems. The first task is to create semantic web metadata that extend the current resources. The second problem is how these metadata can be aggregated and processed in order to create a complex information service for human users.

Our previous work [1] was focused on the former issue. We have designed and implemented a tool that can semantically enrich dynamic web pages generated from a relational database. The system has been designed to be simple and flexible, so it could be easy to make it part of an existing web application. If various web sites from one knowledge domain adopted this system and made agreement on one ontology, they would be able to publish RDF metadata that has the same vocabulary. That means those metadata would create a transparent and public information representation, which can be used by any interested part on the web.

This work is focused on the next step, which is an information aggregation, processing and publishing. We designed the model, capable of harvesting, merging, processing and publishing of information in one particular knowledge domain. The first step of this process is a search for interesting pieces of information on the web. Then RDF metadata are downloaded by some crawler, preprocessed and stored in a knowledge base. This knowledge base can contain various information describing one object coming from different web resources, but this data are merged so they are compact knowledge. Content of this knowledge base can be again published as RDF metadata, or it can be a data source for web portal that serves various advanced features for human users, for instance a semantic search.

To fetch web content into the search engine index we created two different crawlers, one for crawling the HTML pages and another one for RDF metadata. These agents cooperate asynchronously. The former crawls HTML pages in a specified domain and searches for hyperlink references to RDF documents. These references are passed to the RDF crawler, the content of HTML pages is not stored. The RDF crawler is designed to collect the metadata. A basic set of URLs is provided by the HTML crawler, but not all RDF documents must be referenced from HTML.

In order to create the knowledge base we tried two existing RDF repositories. First we used YARS (http://sw.deri.org/wiki/YARS), but then we switched to Sesame (http://www.openrdf.org). We did also some experiments with indexing of fetched data [2].

Then we filled the knowledge base with metadata using our crawlers. These metadata were from our previous project [3], where we annotated people and publications on the web portal of our department.

Having the knowledge base full of metadata we had a good base for experiments on a possible usage of aggregated information.

The first use-case is a semantic web search. On the top of the knowledge base we built a web-based user interface. When an end-user searches for a particular web page, he or she queries the knowledge base by a meaningful query, which is a simple sentence consisting of subject, predicate and object. A subject and a predicate can be selected from the list of ontology classes and properties in the knowledge base, objects can be only a literal now.

An answer for this query is found in metadata, but according to the index structure the search engine is able to assert which HTML web documents are annotated by these particular metadata. Final search result contains not only found RDF statements (in a human-readable format), but also a list of links to classical web resources, as it is common in normal search engines. This way the end-user searches HTML pages by means of metadata.

The second way of using integrated sources is publication web portal. We developed a simple web portal that contains information about publications from aggregated sources. This information is stored in the knowledge base and the portal is only user interface to them. The portal enables search over publications by various attributes and it publish publication information in various formats (HTML, BibTeX or plain text).

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Stand-in Agents in Large-scale Multi-agent Environment with Dynamic Communication Inaccessibility

D. Šišlák

sislakd@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Praha 2, Czech Republic

Cooperation and coordination in the distributed multi-agent systems is conditioned by the ability of agents to communicate. It is expected that each agent can interact with any other agent using a reliable communication infrastructure. However, in many situations an agent may become inaccessible from the other members of the multi-agent community due to a failure of the communication links, network traffic overload, dynamic changes of the network topology in a mobile ad-hoc networks, agent leaving the communication infrastructure for accomplishing a specific mission, agent failing to operate, etc. In our previous contributions in the area, the concept of communication inaccessibility in the multi-agent systems [1] and the formal approach to inaccessibility quantification [2] have been defined. The link accessibility in the multi-agent system is defined as a quantity describing how likely can be established a direct communication link between two agents. Path accessibility represents likelihood of establishing a relay path – connection through an arbitrary number of other agents. In dynamic systems, possibly with mobile agents, the accessibility values change over time. In those cases, time-averages are used to describe the system nature.

Different value of either of the accessibility quantities specify completely different set of problems to be solved. In the situations with low path accessibility we need to investigate mechanisms how the agents can coordinate and plan commitments even if they are temporarily inaccessible. Providing solutions for these problems is highly domain specific. In the situations with high path accessibility and low link accessibility we need optimize the forwarding mechanism so that the optimal number (and right location) of the relay nodes is used. The second class of problems is substantially more domain independent.

Inaccessibility solutions can be divided into mechanisms providing remote awareness – providing the inaccessible agent with the information about the inaccessible part of the infrastructure and remote presence – an ability of inaccessible agent to act remotely (by e.g. stand-in agents acting on the inaccessible agent behalf). Some inaccessibility solutions are based on agents individual maintenance of their social knowledge and acquaintance models or by deployment of various kinds of middle agents such matchmaker agents, brokers or stand-in agents. A generic model of the middle agent is suggested and presented in this work. Relevant routing and relating mechanism are well defined in network theory and practice.

The boundaries of usefulness of various inaccessibility solutions have been established, without taking into account the cost (number of middle agents and messages) of the overall solution. However, the optimization is crucial in the situations where the path accessibility is almost complete, while the link accessibility remains limited. Many real-world systems operate in this node and most of them are resource constrained.

Therefore, in this contribution, the problem of optimal positioning of middle agents in the distributed dynamic multi-agent system and message flow optimization between these agents to ensure optimum balance between efficiency and redundancy is addressed. It is not restricted the algorithm use to particular type of middle agent, as it can be integrated with stand-in or other.

Proposed optimization algorithm tries to: optimally connect the multi-agent system, be local – operate with the local environment information only, adapt to the changing environment both in time and place, be efficient in cost and the middle-agent community needs to be stable. The solution is base on virtual payments combined with social dominance model.

The work also addresses integration of designed algorithm with the generic middle agent architecture. Unlike classical middle-agent architectures where the prime functionality is devoted towards matchmaking and negotiation, the integration extends the concept of middle agent by its capability to autonomously migrate in the network, clone and destruct copies. The algorithm is integrated in the swarming controller part of the middle-agent. It takes care of middle agent existence (position) in the system and manages information flows through the agent, more specifically the knowledge to transfer or actions to take. The module must balance between two extreme cases of knowledge handling: propagation to all visible targets or no propagation at all. Knowledge base is a domain specific knowledge structure of the middle agent. The information evaluator classifies and indexes the knowledge, so that the index values can be used by swarming controller to manage its activity.

The designed algorithm for the optimization of the middle agent community in an inaccessible environment has been evaluated. In the experiments, it was shown that this solution is efficient in communication, is robust with respect to important environment changes and ensures complete system connectivity in the environments with high path accessibility and low link accessibility. In contrast generic routing algorithm, the proposed solution can be integrated with any type of middle agent, making it useful even in the partially disconnected environments.

The future research work will focus on the algorithm tuning and automatic environmental adaptation; many internal parameters are currently set in an arbitrary manner and their learning from the environment can further increase the usability of the solution. To validate the algorithm in the real environment, it will be integrated with the solutions currently used for ad-hoc networking in challenging environment.

Full description of the designed solution can be found in other publications [3, 4].

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Parellel Magnetic Resonance Imaging Reconstruction

J. Petr, J. Kybic, V. Hlaváč

petrj5@cmp.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo nám. 13, 121 35 Prague 2, Czech Republic

Parallel MRI (pMRI) is a way to use data obtained simultaneously from several receiver coils to increase the speed of MRI acquisition. The receiver coils have distinct spatial sensitivities. Therefore, the measured data contains more information about the position of the radio-frequency signal than data obtained by a single coil. The idea is to speed up the acquisition by sampling the imaged object more sparsely and compensate the arising data loss by the use of additional information obtained by a higher number of receiver coils. The key contribution of our work is design of a new reconstruction algorithm working in image domain. We emphasize on the speed of the reconstruction process and minimization of the reconstruction error.

An image acquired by a coil with varying spatial sensitivity can be interpreted as a point-wise multiplication of the coil sensitivity and the ideal image retrieved by a coil with homogeneous sensitivity. This is linear transformation from the ideal image to the coil-image. MRI images are acquired in Fourier domain or as it is referred to in MRI books – k-space (that is caused by the character of the MRI image acquisition process). In pMRI, acquisition is accelerated by acquiring only every M-th line in k-space along one image axis. This speeds up the acquisition M times. However, it also causes aliasing along one image axis in the retrieved images. This aliasing is also linear transformation from the ideal image to the image with aliasing. Therefore, the composite transformation of the two mentioned transformations is also linear. Invertibility of this composite transformation is assumed. This is generally the case of a reasonable coil configuration (the coil sensitivities should be distinct from each other and the number of coils must be equal to or higher than the acceleration factor) and it is an implicit assumption of all reconstruction methods. The task of pMRI is to find a proper inverse linear transformation that reconstructs the ideal image from a set of images with aliasing that were acquired simultaneously using a set of coils with distinct spatial sensitivities. For the process of estimation of the reconstruction transformation a set of reference images without aliasing has to be known.

Standard pMRI methods working in image domain estimate the sensitivities of all coils first and then are trying to find the inverse transformation in each point independently. In our method (PROBER), we estimate the reconstruction transformation directly using the reference images without aliasing. These images contain both the ideal image and the images with aliasing (by introducing aliasing artificially). We search for a reconstruction transformation that minimizes the difference between the ideal image and the reconstructed image (reconstruction transformation applied on the images with aliasing).

The sensitivities of the receiver coils are smooth and slowly changing in space. We assume that the same applies for the reconstruction transformation. Therefore, the reconstruction coefficients are not minimized directly. Instead, we approximate the reconstruction coefficients using B-splines and the coefficients in B-spline basis are estimated in order to minimize the reconstruction error. B-splines are piecewise polynomial functions with compact support. They are widely used for its desirable properties in approximation of smooth functions.

We define the total reconstruction error as the sum of square differences of the reconstructed image and the ideal reference image. The reconstruction error is a function of

the B-spline coefficients. We compute partial derivatives with respect to each B-spline coefficient and set them to zero in order to find the coefficients that minimize the reconstruction error. This yields a system of linear equations with the same number of equations as the number of parameters. This system is solved using a standard Gauss-Newton elimination method. With the known B-spline coefficients it is an easy task to find the reconstruction transformation and apply the transformation on the input images with aliasing in order to reconstruct the ideal image.

Since the sensitivity maps are changing slowly in space, it is not necessary to have full-resolution images for the estimation. Instead, we acquire low-resolution images without aliasing together with the accelerated images. For this purpose a variable-density (VD) images are retrieved. Variable density image is an image with a fully sampled center of k-space (i.e. low-resolution images without aliasing that serve as reference images for the estimation) and sub-sampled outer part of k-space (full-resolution image with aliasing). VD-images are used for both estimation and reconstruction and are acquired in not much longer time than the standard sub-sampled images.

We have tested three pMRI methods (GRAPPA, mSENSE and PROBER) on a set of 20 phantom and in-vivo images. We measured the error as a difference between the reconstructed images and a perfect image that was averaged over ten measurements without aliasing. We have measure the error only over the part of the image where was any object present. The results proved that all three methods have comparable quality of reconstructed images. In several datasets, our method has the lowest reconstruction error. It demonstrates that our new method should take place among the other mentioned methods in everyday practice of parallel MRI reconstruction.

Most of the methods that work in image domain estimate the reconstruction transformation independently in each point. This makes the reconstruction time to increase significantly with high image size. We have proposed an algorithm that uses a smooth model instead of computing the reconstruction coefficient independently and pixel-wise. This regularizes the reconstruction transformation and makes the method more robust to noise in the reference data. Our method offers approximately the same reconstruction quality as GRAPPA and mSENSE for most coil configurations. There are coil configurations where our method offers higher reconstruction quality than both of the mentioned methods. This makes our method a good alternative for pMRI reconstruction.

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Formal Description of Adaptive Web System for E-learning Purposes

M. Bureš, I. Jelínek

buresm3@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

A basic principle of Adaptive Hypermedia System (AHS) [1] is an adaptation of source document in accord to particular user's characteristics, preferences and needs. Such characteristics are stored in a data structure, shaped by user model [2]. Such systems has favorite implementation domain in E-learning [3], [4]. Adaptation of hypermedia document in E-learning systems can improve effectiveness and ergonomic quality of E-learning process. In contemporary state of AHS area there is several problems as low reusability of prepared adaptive content, tendency of constructed adaptive system to become inconsistent, when there are some changes made in architecture or adaptation logic, relative large implementation overhead, absence of suitable architectural and development methodology for construction of adaptive hypermedia systems etc. The aim of our work is to develop methodology, which solves mentioned problem by setting unified logical architecture of AHS described by formal means. Such formal description will be consistently used to propose solutions to contemporary drawbacks of adaptive hypermedia systems.

In this paper we describe a principle of architectural formal description, its application to methodology part of our work and experimental verification related to the project solved as a part of research supported by grant CTU0507113. There are two basic claims to the formal description, which is a core of the whole work. At the first, it has to be defined at the proper level of abstraction to be flexibly applicable in various cases of implementation. At the second, it has to be consistent to be applicable to all algorithms and methodology work schemes that originate from it. This is fulfilled by long-term development of formal description based on the theory of sets, mathematical logic and theory of graphs. One of basic feedback loops in our work is a "re-factoring" of formal architecture in accord to feedback gained by implementation pilot projects. Beside the purpose of giving general architecture and implementation methodology of adaptive hypermedia system, mentioned formal architecture is a base for following algorithms or working schemes: reduction of overhead, when an author prepares an adaptive hypermedia document, compatibility of E-learning adaptive document and AICC-compatible learning management system (LMS), automated verification of output of adaptive hypermedia system, methodology of implementation of adaptive features in an existing web application or calibration of AHS output to avoid too rapid stressing changes of working environment (focus is set to the web application GUI) within AHS.

There are three of five pilot projects verifying our proposals, which are an implementation of simple experimental adaptive LMS systems (as we have declared as one of outputs of grant CTU0507113). In this paper we will deal more particularly with an algorithm of automated verification of adaptive hypermedia system output. Experimental implementation of this algorithm is a part of one implementation pilot project – experimental adaptive LMS in .NET done as diploma work on CTU Prague.

Adaptive hypermedia system based on hiding of fragments of hypermedia is susceptible to produce some malformed output, when a value of user profile is not correct of id there is an error in a definition of adaptation logic. In comparison to non-adaptive web application, such errors are often more difficult to detect. This frequently mentioned drawback can be partially solved by automated verification of adaptive hypermedia or adaptive system output. The basic point is following: when we adapt hypermedia document, there is semantic information that determines the adaptation logic. When we use an idea of adaptation techniques [2] previously defined in the area and formalize them suitably, we can verify the output effectively and in automated way. In our proposal we use oriented graphs for definition of structure of hypermedia and for semantics defined in the adaptive documents. Inconsistency that can lead to malformed or nonsense output is detected by comparing of constructed oriented graphs.

In the pilot project, we use two basic adaptation techniques: hiding and displaying of fragments determined by condition based on vales of general levels of user (can be set for particular enrollment of student to course) and prerequisite hiding of fragments. Particular fragment of hypermedia document is displayed only when a user reads another fragment with prerequisite information and express a feedback he understood the information in this fragment. The verification of adaptive hypermedia document checks consistency of defined prerequisite bindings in automated way. All possible transitions within a complex adaptive hypermedia document (E-learning course) are written to matrix representation of oriented graph. Then in similar fashion, prerequisite bindings between the fragments of adaptive hypermedia are written to a matrix and two constructed matrices are compared. When there is some prerequisite information in fragment that can't be reached by student in the document, an error is reported and change of topology (adding a proper link) is suggested.

An adaptive behavior of web application as a principle is modern and required trend which requires a change in traditional approaches in the area which often leads to implementation of local isolated experimental systems. Our proposal of unified general architecture that is basic for topics like reusable adaptive E-learning content or implementation of adaptive features in existing web portal and, simultaneously, that is basic for implementation of stand-alone adaptive hypermedia system is a contribution to the state of the area that will be developed in the further research.

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Computing Seeds in Generalized Strings

M.Voráček, B. Melichar

voracem@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

Generalized strings are special strings having a set of symbols instead of one symbol in a single position, *v = {a} {c, g} {g} {a, c, t} {a, c}* is an example of a generalized string. Generalized strings are extensively used in molecular biology to express polymorphism in *DNA* sequences, e.g. the polymorphism of protein coding regions caused by redundancy of the genetic code or polymorphism in binding site sequences of a family of genes. In practice, the sets of nucleotides in single positions of *DNA* sequences are represented by single symbols of the extended *IUB/IUPAC* alphabet. There exists a special symbol for each possible combination of nucleotides, e.g. *v* is then represented as *v=asghm*.

Discovering regularities in biological sequences is much of interest of biologists because the regularities usually represent important structural and functional elements. In this paper we focus on the computation of a special type of regularity called *seed*. A seed of generalized string is its proper substring such that there exists a generalized superstring having each position covered by its occurrence.

Our algorithm for computing seeds is based on the analysis of *deterministic subsets* of states of *Generalized Suffix Automon* (*GSA*), a special type of finite automaton accepting all suffixes of a given generalized string. The presented algorithm is the first attempt for searching seeds in strings using finite automata. The algorithm is simple and straightforward and can be easily modified to solve related problems (e.g. searching for *periods*).

GSA is built in two main steps. In the first step, the non-deterministic version of *GSA* is built and in the second step, the deterministic *GSA* is built by determinization of the non-deterministic one. The non-deterministic version of the automaton has exactly *n+1* states and only the rightmost state is final. The automaton has a transition for each symbol from the symbol-set *x[i]* leading from state q_{i-1} to state q_i and moreover it has ε-transitions leading from the initial state to all other states except the final one. The precise number of states of the deterministic *GSA* with respect to the size of the generalized string being preprocessed is not known and it is an open problem. The results of our experiments show that the size of deterministic *GSA* is less than quadratic in practice *[1]*.

Our algorithm requires the states of automaton to have additional information that is computed during the determinization. Each state *q* must have memorized its *depth*, what is the length of the longest sequence of transitions leading from the initial state to *q*. Moreover, each state must have also memorized its deterministic subset (*d-subset*), what is the set of states of corresponding non-deterministic finite automaton having the same left language as state *q*. *Left language* of a state *q* is a set of strings for which there exists a sequence of transitions leading from the initial state to state *q*.

We require the d-subsets to be represented as ascendentally ordered lists called *position lists*. The algorithm starts with the computation of *position lists* of strings belonging to left languages of the states of *M*. That is performed using the information stored in the *d-subsets* of the states. Consequently, the computed position lists are sorted. In the next stage, the algorithm computes the minimum length, which a string, say *u*, must have to cover a superstring of *x* with respect to its positions. There exist 3 conditions, which must be satisfied

by u with respect to its length. Firstly, its complete occurrences must cover the center part of x. Secondly, a suffix of u must cover the uncovered prefix of x and finally, a prefix of u must cover the uncovered suffix of x. Even if the longest string from the left language of a state (given by the depth of state) is not able to satisfy those length conditions then the state is not processed more.

Left languages of the remaining states are extracted and only the strings having the length greater or equal to the minimum length are selected from these languages. The strings in the current set have such lengths that they are able to cover the desired superstring but it is knot known whether prefixes and suffixes of strings match with the uncovered suffix, prefix of x, respectively. This problem is solved very easily. We let *GSA* to process u symbol by symbol. If some its prefix longer than the uncovered suffix length is accepted then it is also a suffix of x and covers the uncovered suffix of x. We use the same idea to verify whether the prefix of x is covered but we let process reversed string u^R by the generalized suffix automaton for reversed generalized string x^R. If both verifications succeed then u is a seed of x.

The presented algorithm computes all the seeds of a given generalized string x of length n in $O(max((n' n \log n),||Seed(x)||))$, where n' is the number of states of used deterministic *GSA(x)*.

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Numerical and Symbolical Polynomial Methods

P. Kujan*, M. Šebek*, M. Hromčík**

kujanp@fel.cvut.cz

* Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University
Technická 2, 166 27 Prague 6, Czech Republic

** Centre for Applied Cybernetics, Faculty of Electrical Engineering, Czech Technical University
Technická 2, 166 27 Prague 6, Czech Republic

Many control procedures rely on computations with polynomials and polynomial matrices. There even exist a selfcontained theory for the control systems synthesis that is based completely on manipulations with polynomials. This approach is called polynomial or algebraic. In addition, some interesting control applications calling for polynomial matrices can be found outside the range of standard algebraic approach. Namely, the control system of a special type DC/AC voltage converter [1] is considered. This task is based on computations of polynomial determinants in more variables and the evaluation of polynomial roots.

As for implementation of procedures for polynomial matrices, most users still rely on CAS (Computer Algebra Systems) such as MATHEMATICA, MAPLE or MuPAD and other. However, there is now also software [2] and other, dedicated entirely to efficient (numerical or symbolical) algorithms for polynomials and polynomial matrices. These tools are typically much faster compared with general symbolic routines. On the other hand, the issues of numerical stability and reliability must be considered when using the numerical programs in respective applications.

The multilevel converter is a power electronics device built to synthesize a desired AC voltage from several levels of DC voltage, see [1]. A key issue in the fundamental switching schema is to determine the switching angles such that just the fundamental voltage is generated and undesirable higher order harmonics are suppressed. As the application of interest here is a three-phase system, the triplen harmonics in each phase need not be cancelled as they automatically cancel in the line-to-line voltages. Specifically, in case of $s = 4$ DC sources, the desire is to cancel the 5th, 7th, 11th order harmonics as they dominate the total harmonic distortion. The mathematical statement of these conditions leads to a set of transcendental equations and, after trigonometric substitutions $\cos(n\omega\theta_i) = T_n(cos(\omega\theta_i)) = T_n(x_i)$ where $T_n(x_i)$ is Chebyshev polynomial of the first kind order n, to a set of polynomial equations

$$p_1(x) = x_1 + \ldots + x_4 - m, \quad p_i(x) = \sum_{j=1}^{4} T_i(x_j), \quad i = 5, 7, 11 \tag{1}$$

where $p_i(x)$ is polynomials in unknown variables $x = (x_1, x_2, x_3, x_4)$ and m is the modulation index. Further, the solution must satisfy condition $0 \leq x_1 < x_2 < x_3 < x_4 \leq 1$. Finally the only one solution from all that minimize THD (Total Harmonic Distortion) was chosen. This optimal solution is in the best conformity with desired output harmonic signal after filtration of higher harmonics.

Fundamental problem is in solution of the set of equations (1). It is a polynomial set of equations and its solution is more complicated in comparison with linear set of equations. It is important to say that this formulation of solved problem is very universal, purely mathematical and appeared in many others branches (graphics, robotics, mathematics).

There are number of methods how to solve the set of equations and every has specific advantages and disadvantages. But generally it is very complicated problem that is almost unsolvable for large sets of equations. This case occurs just for large number of DC sources (the task for $s > 6$ is very difficult and calculation is very time-consuming). So it is suitable to simplify the set of equations before the beginning of computing. In this case it possible to substitute symmetric polynomials or Newton identities.

The methods that solve this problem and belong to most widely are: numerical iterative, elimination, Groebner basis and analytical solution. Majority of methods was programmed and analyzed in system MATHEMATICA with using of the authors package for effective polynomial computations [2].

The aim of this study is analysis of elimination method where the equations are eliminated by computing resultants of two polynomials. The resultant is computed as determinant of special Sylvester type matrix. It is square (large) n-D polynomial matrix with special structure. The determinant of this matrix is solved by the efficient numerical algorithm, which is based on n-D DFT and modified for special structure of Sylvester type matrices.

One would expect that substituting the generic symbolic determinant routines with dedicated nD-DFT numerical polynomial determinant solvers should increase the performance of the elimination procedure considerably and that the problem could be resolved for a much larger number of DC sources. Surprisingly, the situation gets rather complicated. The problem is that the successive evaluation of polynomial determinants leads to accumulation of rounding errors. These errors are crucial during computations the roots of polynomial and backward substitution with subsequent finding others roots. The more equations are to be resolved, the more severe these problems get.

There are a lot of other investigate methods for solving resultants. Namely: Bezout, Dixon and Macaulay formulation and their modification. Relatively satisfactory results are given by solving numerically Groebner basis. Very interesting and effective is analytical method. This is applicable in case one-phase system only. The problem of solving the set of polynomial equations is converted to solving linear set of equations with sequential calculation zeros of polynomial. This approach miscarried generalize so far for tree-phase system.

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Supporting Creation of Semantic Annotation Through Induction of Inter-concept Relation Patterns

Jan Uhlíř

uhlir@labe.felk.cvut.cz

CTU, Department of Cybernetics, The Gerstner Laboratory

This research aims at providing users with a simple methodology and an easy-to-use toolkit for semantic tagging that allows users to focus on the meaning of the annotated content while the tools will handle the formal aspects of the semantic annotation process. We build on analysis of general requirements for semantic annotations, which can be found in [2]. Unlike various other tools aimed at semantic mark-up automation (such as S-CREAM, Annotea, etc. – a brief survey of tools can be found in [1]) we do not believe that the human intelligence can be completely eliminated from the annotation process. We propose an alternative scenario, in which we provide human annotator with informed guidance through the annotation process based on analysis of existing annotations in a particular domain.

We experimented with conceptual graph annotations by representing several story abstracts using Conceptual Graphs (CG) [5]. We mainly wanted to investigate whether semi-graphical representation of a narrative is understandable and acceptable for readers, how annotation graphs can be easily created, and how the conceptual graph representation can be mapped to other formal representations for semantic annotations. Our research is based on results of an experiment, which is described in more details in report [3].

Creation of semantic annotations is a process of finding an unambiguous mapping between content statements (e.g. narrative sentences) and elements in ontology. This means that semantic annotations provide a binding between information resources and shared conceptualizations of the world. By *semantic annotation* we mean a bi-partite graph that consists of two types of nodes – entities of existence (concepts and individuals), and conceptual relations between entities. The first node type designates an individual (instance) of a concept (class, conceptual type) or a concept itself, when the whole class of individuals is referenced (e.g. Person: Allan Turing vs. Person). The latter node type designates a named relation between two or more concepts or individuals, whose types are specified for the relation.

DNA (Dynamic Narrative Annotation) tool is a prototype implementation of the proposed methodology. It serves as a test bed for annotation pattern-learning algorithms investigated in our research. The ability of DNA tool has been extended by means of an *annotation palette* feature. This feature allows users to quickly pick a concept from a color-enhanced palette of most frequently used concepts and use this concept to highlight individuals in an annotated content. Such highlighted individuals will be automatically added to the knowledge base as instances of the selected concept. They also automatically appear in the annotation graph where the user may further specify relations with other concepts or individuals. This is a process allowing description of contexts, in which each concept exists relative to a particular narrative or story.

We have studied capabilities of pseudo-Bayesian approach applied to the semantic annotation domain. In this approach existing semantic annotations are explored with respect to a particular domain and a narrative type. Our principal concern is finding answers to the following questions: **1.** Can typical structures consisting of concepts, individuals and their semantic relations be identified and found in a collection of existing semantic annotations, which describe contents of certain narrative type in a domain; **2.** How incremental local context of a concept or individual in a semantic annotation can be computed, represented, and

explored in order to provide users with intelligent guidance through the annotation process; **3.** What is the size of the input set of annotations that will enable significant results.

Analysis of data set consisting of a certain amount of existing semantic annotations aims at finding typical structures described by means of dominant estimated marginal probabilistic distributions. Finding such structures that we call *annotation patterns* is the first step. Let us assume that there are some typical structures in the input data set and that the algorithm is able to learn such patterns. The next step is to apply a pattern-matching algorithm based on a hierarchical similarity measure, which will pre-select a set of patterns. Pre-selected patterns can be applied to the emerging annotation based on a current context of the annotation. We are trying to find a similarity measure vector that is additive (i.e. the measure of a larger structure can be computed from measures of its components with respect to the additive principle) and hierarchical (i.e. we can use intermediate results to match sub-structures). Pre-selected patterns are proposed to the user as guidance in the annotation process in the third step. The user may then pick and apply one of the proposed sub-graphs or refuse them all. Applying a pattern or adding a concept to the annotation graph independently changes the current annotation context. It triggers invocation of the pattern-matching algorithm again. The first step of this approach can only be applied when a rather large set of input data is available. This fact emphasized importance of the parallel research aimed at persistency and efficient retrieval of large data sets.

We have developed a Persistent Knowledge Framework – a data persistency layer, which allows versatility in knowledge base storage methods. It allows knowledge bases to be stored in post-relational databases (i.e. Hibernate or Cache), relational databases or xml repositories. PKF is intended to make physical data storage transparent for knowledge intensive applications. It allows better scalability of PKF-based applications (e.g. ontological editors, annotation tools or reasoners) and brings higher compatibility with various knowledge bases (see [4]). PKF provides applications with a common interface enabling knowledge acquisition, retrieval, and manipulation. It also allows applications easily share components and features. Knowledge bases are manipulated uniformly regardless of the storage method being used. The only requirement is that each knowledge base storage method must be compliant with PKF data storage interface.

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Cooperative Planning in Multiple Robots Systems

Jan Faigl, Miroslav Kulich*, Libor Přeučil

xfaigl@labe.felk.cvut.cz

Department of Cybernetics, *Center of Applied Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Cooperative planning for multiple mobile robots is studied in several contexts of multiple robots system. One specific domain is an inspection task upon robot path planning. The inspection task has several variation, such as *Searching in Polygon*, *Pursuit-evasion Problem* or *Watchman Route Problem*, that are classical problems in mobile robotics. An application of the inspection task can be in search and rescue scenario, in which possible victims have to be found [1]. The problem is to find a route such that a robot surveys whole working space while it moves along the route. The given problem can be constrained so, that the environment is a priori known and it is represented as a polygon with holes. Moreover, a visibility range of the robot can be limited. The problem is more complex in case of multiple robots.

Several existing approaches are based on decomposition of the search problem into two subproblems, determination of sensing locations and planning routes over found points. The sensing locations are places in the environment where sensing is performed in order to scan all points of the environment. The first problem is also known as *Art Gallery Problem* (AGP) and the second problem is *Multiple Traveling Salesman Problem* (MTSP). Both problems are known as NP-hard. The Art Gallery Problem for a polygon with holes P is more precisely defined as the problem of finding a minimum set of points G (guards) in P such that every point in P is visible from some point of G. An approximation solution of the AGP can be based on randomized dual sampling schema [2]. It is an incremental algorithm, that in each step samples the environment and selects sample (point) that sees the largest still not covered area of the environment. The sampling procedure is repeated until whole environments is covered.

Sensing locations found by the algorithm that solves AGP stand for the input cities for the MTSP algorithm. Our solution is based on a self-organizing neural network algorithm extended for environments with obstacles [2]. The algorithm finds an approximate solution of the Euclidean instances of the MTSP for m salesmen. A path of each particular robot (salesman) is represented by a ring of neurons, where neighboring neurons are connected. The algorithm consists of two main steps. In the first one, the closest neuron of each ring is determined for randomly selected city. The second step is an adaptation procedure of the closest neuron to each city. The winner neuron as well as few neighboring neurons are moved towards the city according to value *G (gain)*, which is decreased in each adaptation cycle. The algorithm terminates whenever each city has a unique neuron closest to it.

If a visibility distance of a robot is small compared to the size of a working environment a number of sensing locations is too high to solve the MTSP problem in a reasonable time. Experiments show that a learning procedure for the used neural network algorithm is achieved in less than 40 steps. The value of G is high in the first cycles of the learning process inducing that neurons are moved by a long distances. G is decreasing during adaptation, what causes only local changes in the network. The time of the adaptation procedure depends on a number of neurons that increases with a number of cities. The number of cities (sensing locations) moreover increases with decreasing visibility distance.

Solution cost of MTSP for a large number of cities can be reduced by using a hierarchy of cities in neural network learning procedure [3]. A network is firstly trained for a small fraction of cities from the whole set of sensing locations in order to roughly sketch the paths. Then a learned structure of the environment is used to enforce learning procedure of a larger problem. This approach significantly reduces a number of iterations in the largest problem, where time requirement of single iteration is the most expensive. This leads to the overall speed up.

Two polygonal maps were used in verify the developed algorithm experimentally - *TestArea* with 105 vertices and 2 holes and *PhysicalBuilding* with 105 vertices and 3 holes. The first map represents an office building with a large free-space, while the second one consists mainly of corridors. Hierarchies were computed for visibility distances from range 0.9-6.0m so, that a number of cities was up to 1000. Several tests were performed for each hierarchy and for 2 and 3 salesmen. The longest route from each particular solution of MTSP was used to compute average length of route over all solutions. Average the longest route found by the proposed algorithm was not longer than 5% and time requirement was up to 37% of the algorithm without cities hierarchy. Despite, time complexity of the proposed algorithm in the last layer of the hierarchy is the same as time complexity of the algorithm without cities hierarchy, the algorithm with cities hierarchy is three times faster than the original one.

If robots have to move along found routes as fast as possible, the routes must respect dynamic and kinematic constrains of a real robot. Solution of MTSP consists of points to visit. Smoothed trajectories represented as spline composed of cubic polynomials were found using optimization technique [4]. A fundamental problem of generating trajectories in an environment with obstacles is how to generate a collision free trajectory. Splines must be enforced to be close to found points to satisfy collision free path, because trajectories are generated after AGP and MTSP part are solved. It leads to suboptimal trajectories and slow velocity profile along them. A solution of this problem can be based on moving found sensing locations to gain a faster spline trajectory with regard to inspection of the whole environment.

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Algorithms of Physical Layer Processing for Wireless Multi-User Communication Systems

M. Kníže, J. Včelák

knizem@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technnical University in Prague,
Technická 2, 166 27 Prague 6, Czech Republic

The network information theory originated already by Shannon is currently one of the most challenging branch of communication theory. Precisely using the information-theoretical tools we have tried to answer several emerging questions concerning the physical layer processing in the context of multiple users. The presented approach is built on our previous and recently published works regarding single user channel [1], but now multiple users are accommodated in the channel.

In both cases, single and multiple users, there is assumed the channel model consisted of finite set of mutually independent parallel block-fading multiple-input and multiple-output (MIMO) channels. Described general channel model is employed since many practical schemes reasonably fit such model. The delay-limited channel environment with finite number of channel observations in the frame and finite number of orthogonal frequency bins are typical examples when the described parallel channels are the well suited model. Throughout the whole investigation we bear in mind there is no channel state information available at the transmitter. Again, such settings can be exploited by many practical applications. Well known optimal coding resides in the coding over the multiple parallel channels. The goal was to identify the equivalently optimal coding for such non-ergodic (finite number of channel realizations composed in one frame), i.e. informationally non-stable, environment.

There appears the following question. Is there some way to fully replace the optimal joint encoding by simple two level processing?

Let the first level be assumed to be performed as the optimal coding with no regards of multiple channels. Such outer code is applied separately for each out of the set of parallel channels and it is given by optimal Gaussian codebook achieving the capacity. The rate symmetry condition is involved on all rates achievable per single channel. This implies that now the Gaussian codebook is shared among all channels. With no other processing, the performance of the capacity of such system is associated with the worst realization of fading observations over the presumed set. This detrimental feature we want to remove by the additional successive easily implementable processing.

The second stage is determined to be the linear unitary transformation preserving power. For the single user case, we have derived so called virtual multiple access analogy relying on well known classical tools developed for the multiple access channel, [2]. Then we have defined the design criterion specifying mathematically the ultimate goal which is to make the maximum achievable rate (employing the rate symmetry condition and satisfying the conditions originated from virtual multiple access analogy) identical to the joint encoding capacity achievable by Gaussian codewords spanning over the whole set of parallel channels. The qualitative conclusion was that there are some very simply specified sets of precoders providing the same performance in terms of distribution of maximum achievable rate as the joint coding. The optimal precoders are given as full real Hadamard precoder and full

complex field diversity (CFD) precoder for single-input and single-output (SISO) channel and Kronecker-product Hadamard precoder is optimal for MIMO channel.

Assuming more real users in the overall system model, we have to cope with additional degrees of freedom. There appears the superior multiple access and virtual multiple access superposition. The superior multiple access influence corresponds to the real users assumed in the channel and the virtual multiple access channel regards the virtual users (according to the parallel channels). In the case of no precoding we arrive at the set of parallel multiple access channels with cardinality given as the number of parallel channels. With joint encoding there is just one multiple access channel and no virtual users and with the second coding given as precoding we have to investigate mentioned superposition of virtual and real users at once.

The information-theoretical description of such system is more difficult and it needs special attention. We have provided such investigation. The information-theoretical results are mostly given as the condition yielding the boundary or the shape of the achievable capacity region. The rate condition of symmetry is applied to the virtual multiple access channel in the same way as it was done in the single user case. The rates of particular real users are allowed to be generally different. The special requirement on equal rates among users might be reasonably applied for some application as well. Such capacity region is explicitly shown for the case of no precoder (only outer codes), optimal one stage joint coder applied separately for each user (no cooperation) and the most highlighted is the case with unitary precoding.

The last mentioned capacity region for the precoder has the boundary determined by more vertices than in the case of joint encoding (or equivalently one channel only). There are some other lines specifying the shape which are originated by the interaction of virtual multiple access channel and superior multiple access channel.

The standalone question remains what is the proper scalar quality well regarding the ultimately measured performance. We have used the sum-rate since such value is related closely to the overall achievable performance. Through the simulations (IID Rayleigh MIMO channel was used), we have proved similarly as in the case of single user channel that the optimal precoders (achieving the same performance as the joint encoding) are the full CFD, full Hadamard for SISO and KP Hadamard for MIMO. Moreover, increasing the signal to noise ratio, the performance of KP CFD precoder is also very close to optimality.

In the future research it remains to investigate the features of linear precoding in the broadcast channel.

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Design and Realization of Experimental Robotic Walking Platform

J. Zikmund *, S. Čelikovský **

zikmuj3@fel.cvut.cz

Department of Control, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

* Communication and Cybernetics Research Institute, Ecole Central Nantes 1, rue de la Noë, 443 21 Nantes cedex 3, France

** Institute of Information Theory and Automation , Academy of Sciences of the Czech Republic, Pod vodárenskou věží 4, 182 08 Prague 8, Czech republic

This project was interested in design of an experimental device for study of a robotics walking. The aim was development and solution the simple benchmark model for an experimental part of work in this research area, with respect to be applicable for a research work and a system and control education as well.

The purpose of the theoretical part of this project is to develop novel nonlinear control concepts that might be used for modelling and control design for the walking bipedal robots including their testing on the laboratory models. The motivation to study walking robots arises from diverse sociological and commercial interests, ranging from the desire to replace humans in hazardous occupations (mine clearing, nuclear power plant inspections, etc.) to the restoration of motion in the disabled. Such a motivation has lead to a massive research and development activity in the field of walking mechanisms and impressive amount of technology has been engaged and specifically developed to build walking robot prototypes. Nevertheless, conceptual control breakthroughs have not been always keeping pace with the technological one. This project is therefore concentrate on developing deeper control theoretical concepts to be used for controlled bipedal walking then constructing and testing complicated mechanisms. The appropriate methodology was first studied theoretically in order to achieve deeper insight into structural properties of underactuated and hybrid highly nonlinear systems, where bipedal robots are typical example.
As a matter of fact, from the point of view of control theory, design of human-like walking two-legged robots provides an important impulse to approach deeper its major contemporary challenges being many degrees of freedom, underactuation during important phases of walking, hybrid character of models to be used, stability, highly interactive dynamics, control goals defined in an intrinsically global manner, influence of uncertainty and many others. In other words, biped walking mechanisms present a typical example of complex controlled dynamical system. Control of complex dynamical systems is a newly emerging topic motivated the rich variety of new control applications and enabled by constantly increasing computing power of the contemporary control hardware. To turn the available computing power into the efficient control of the complex industrial systems, a new generation of design methods is necessary taking advantage from system structure to overcome their complexity. To bring a granted progress, a deeper theoretical insight into structural properties must be gained.

Loosely speaking, complex dynamical systems are those that cannot be approached by classical methods, with common model too much simplifying reality. This opens new areas of hybrid and hierarchical systems as a possible way how to treat complex dynamical systems.
The aim of this project is to develop a novel theoretical concepts and techniques to design, model and control bipedal walking mechanisms. In particular, an important structural issue of finding the largest exact linearizable part of robot model is studied. The theory of integrability of differential forms based on Pfaff-Darboux theorem is used in this respect. If successful, such an approach would reduce dimension of the zero dynamics, thereby facilitating its analysis for purposes of stable walking design.
Secondly, we continue research of what is the minimal and the simplest configuration of a biped robot that still might be called walking robot. In this respect, laboratory experiments as well as theoretical modelling and computer simulations will be performed.
Further, the impulse map caused during contact with ground is studied in detail. Namely, double support phase model will be considered dynamically, first with slow dynamics to study possibilities to control various positions during double support phase. Later on, faster dynamics will be studied, having impact map as its limit case. The outcome would be two-fold. First, one would know how realistic the existing impact models are. Secondly, for the case of unexpected disturbance causing large deviation of walking robot from an expected double support standard position, the strategies to correct such a situation may be designed.
Finally, for the walking trajectory planning and its stable tracking, the possibility of using the well known output regulation approach is studied. Output regulation framework means basically tracking a reference generated by an autonomous neutrally stable system. Here, an interesting idea arises to find a suitable ideal model (path generator) that would be kind of passive walking device when all energy losses are neglected. Then, existing output regulation results, including some recent numerical methods, might be used to force real robot follow that ideal path generated by mentioned path generator.
The basic framework for the investigation is state space hybrid system being combination of several continuous time models of the dynamical system with discrete switching rules among them. The main theoretical technique for the investigation would be mathematical apparatus from differential geometry, mathematical analysis and algebra combined with well established control theoretical tools.

First physical model is realized like a variable kit of simple parts allowed to change the mechanical configurations of legs. Each part is designed for wide scale configurations of legs. Basic model formed from two legs consists of four uniform “joints” parts and four uniform “legs” parts fixed on main “body” platform with electronics. All mechanical part are made from aluminium alloy. The joints are actuated by fast DC motors.
In this case the height of the platform is 60 cm with 1.2 kg weight only. For the control as simple as possible is used universal PC control/measurement card.

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Image and Video Processing for Image Quality Evaluation Using Artificial Neural Network

K. Fliegel

fliegek@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

A novel approach for objective image quality assessment is presented in this paper. Reliable methods are often required to evaluate the quality effects of the visual artifacts appearing in a digital image processing while using lossy image compression. In order to achieve a high performance of the system for image storage or transmission we need to investigate the effect of distortion on the perceived image quality. Methods of image quality assessment can be divided into two main groups: subjective and objective [2]. Subjective methods (evaluation by the group of human observers) offer the most precise results. These methods are time consuming, costly and they cannot be easily automated. There were numerous attempts to objectivize the evaluation of the subjective image quality. Among many possibilities the HVS (Human Visual System) modeling seems to be most promising. There are two main subsystems in image or video quality evaluation systems. The first subsystem computes the values of particular measures. The second one combines these values into a resulting quality score. Measures can be combined using simple mathematical formulae or by more advanced approach. It was shown [1] that the Artificial Neural Network (ANN) [3] is a suitable method to combine the particular measures.

Optimization of the previously proposed model [1] for image quality evaluation with Artificial Neural Network (ANN) has been done. The main aim of this approach is to automatically derive a score that is the same as, or at least well correlated with the Mean Opinion Score (MOS) obtained from the subjective votes of many observers. Advanced method of data preprocessing (Mutual Information - MI and Principal Component Analysis - PCA [4]) has been applied to obtain good prediction of the image quality which is close to subjective results from the group of observers - Mean Opinion Scores (MOS) [2]. The proposed model achieves good prediction performance for used test samples.

The model itself consists of the following main parts: the impairment feature extraction block and ANN as a combiner. The original and distorted images are decomposed into several resolution bands and orientations using oriented multichannel pyramidal decomposition to extract RMSE of distorted image and mimic the Human Visual System (HVS) [2] that decomposes the input information in a similar way. This property is based on the neuron response of the brain cortex that is known as its selectivity to spatial frequencies and orientations. At first the 2D symmetrical Gaussian highpass filter is used to process the input image. Then the input image goes through the pyramidal decomposition using the chain of three 2D symmetrical Gaussian lowpass filters and downsampling with the factor of two. The outputs from the pyramid decomposition are then filtered by the oriented filtration in four directions (0, 45, 90 and 135°). The oriented filtration process is used as a consequence of the high sensitivity of the HVS to the image edges [1]. Additionally RMSE and Mean Absolute Error (MAE) for the whole error image are computed. The impairment feature vector is then preprocessed using PCA or MI analysis.

The impairment feature vector is forwarded to the multilayer backpropagation ANN or Radial Basis Function Network (RBFN) to obtain the predicted quality score. After the training process, ANN is able to predict the image quality. In order to train and then evaluate the performance of the proposed model we need the set of results from subjective image quality tests. This set contains Mean Opinion Scores (MOS) obtained by a group of human observers. Methodology for the subjective image quality assessment has a quite strict requirements for the viewing conditions described in the ITU-R BT.500 recommendation [2]. We have conducted number of the subjective tests using a slightly modified methodology in our laboratory. Our laboratory is equipped with the reference source of the video signal - digital video tape recorder (DVCam format) - and professional calibrated CRT display. The types of the scenes were selected in order to emphasize textures, natural scenes, faces and contrast areas. Human observers evaluated the image quality according to the recommendation using Double Stimulus Continuous Quality Scale (DSCQS) method. This method uses the quality evaluation scale in range [0, 100], where 0 denotes the worst and 100 the best image quality. After carrying out the MOS experiment for 125 samples, we divided the database into two parts. The training set to train the ANN contains 100 randomly selected samples for training while using K-fold Cross-validation (K=10) [3]. The other set contains 25 samples to test the ANN's accuracy. Matlab programming environment was used for all computations. The proposed quality assessment model has been trained and tested using a set of distorted images from several image compression algorithms.

Quite good prediction performance of the proposed model was reached when comparing MOS and ANN output by means of correlation coefficient. It was shown that the performance of the model [1] could be even improved while utilizing suitable data preprocessing e.g. MI or PCA to decrease feature vector dimension and model complexity. Proposed model is suitable to assess image quality in multimedia systems and enhance their rate/distortion efficiency. It can be generalized for the assessment of color images and video sequences. In our next work we would like to focus on further optimization of the impairment feature extraction block while using more features and analyzing the suitability of them.

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Computer Support of Creativity and Development of Artifacts in Conceptual Design

M. Tlapák, J. Bíla

Miroslav.Tlapak@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technicka 4, 166 07 Prague 6, Czech Republic

Introduction

Emergent Knowledge Discoveries (EKD) and Emergent Synthesis in Conceptual ReDesign Process (CRDP) have been demonstrated in numerous papers [1-4]. Emergent Knowledge Discoveries are formed in a different informational environment than known Knowledge Discoveries in Databases.

At first, the retrieval process is performed on a special data and knowledge structures (contexts). At second, the activities of human problem solver and the occasional factors influenced on the run of EKD process. At third, the result of EKD process is a knowledge structure with uncertainties. The second and third characteristics are near to EKD methods of Emergent Synthesis.

Our theory for EKD and the algorithm CRDP has been described in our papers. Comparing with some other systems for computer supported synthesis of novel solutions in conceptual design from recent time, e.g., GALILEO or AIDA our product is concentrated more on the emergence investigation than on the conceptual design of commercial products.

Preliminaries

The proposed method starts with a description of known solutions of the solved problem. (Hence the problem is not described by any other formal expressions and is simply described by these solutions.) The goal of the ReDesign is to find (to discover) better solutions than they are these introduced solutions. Human problem solver works with set S (Known Solutions), set Q (criteria and directions of needed improvements) and set P (formation variables and parameters). Respecting elements in sets S, Q, P human solver collects all knowledge elements and forms a ground set X (set of knowledge elements – x_1, x_2, ... x_n).

On the set X there are constructed three contexts Local context (**LOC)**, Global context (**GLB**) and Problem context (**PCX**). The essential hypothesis for the proposed solution synthesis is, that knowledge elements do not represent a novel solution explicitly but they catalyze and code a novel solution.

The method at first eliminates dependent elements in X, constructs maximal sets of independent elements (bases of a matroid) and localizes elements of bases in context **GLB**. Then the method constructs possible novel knowledge elements computes quantities of **DE** (Degree of Emergence). The goal of the method function is to extend some of the "old" bases by a novel knowledge element.

Degree of Emergence

In our works there has been introduced variable "*Degree of Emergence*" (**DE**) and its fuzzy interpretation as a "linguistic variable" **DEF**. There was introduced a formula for DE computation and its applicability has been demonstrated and tested by examples.

By the Degree of Emergence are evaluated and quantified the distances between known solutions and novel emergent solutions.

Implementation

The original algorithm of the method was implemented in BORLAND DELPHI 7 and was tested on pre-formed examples of the type: • a novel principle for measurement of gas flow, • conceptual redesign of a standard power station into the form of the Dam-Atoll sea power station, • conceptual redesign of a standard power station into the form of the sea pontoon power station, • conceptual redesign of a regional power supply scheme. The program is now used for discoveries of emergent solutions in appropriate fields of mechanical and civil engineering.

The program works in 4 steps:

S1. The distances between fields of activities and between principles set up.

S2. The contexts on X are formed.

S3. The positions of known solutions and of a novel element $\mathbf{x_e}$ are located in contexts **GLB** and **PCX**. The known solutions are represented by trees composed of Fields of Activities and Principles. Trees have Fields of Activities in first level and it Principles in second and third level. In a similar way is represented a supposed novel knowledge element x_e.

S4. The quantities **DE** and **DEF** are computed. This step has two sub-steps. In the first sub-step there are developed all combinations of possible novel solutions. In the second sub-step there are computed quantities of **DE** and **DEF** for all combinations generated in previous sub-step. Discovered elements are written to memobox with all substantial characteristics.

After this computation an expert must interpret suggested solutions (novel knowledge elements) and select better solutions.

Conclusions

• A Context description and application of special fuzzy concepts have been used.

• The methods for development and application of Local (**LOC**) and Problem (**PCX**) contexts are common for all solved problems. However the content of Global context depends on semantics of problem field. (E.g., for the discoveries of emergent algebraic structures are needed other ontology than for synthesis of technological devices).

• Tuning procedures influence the computation of quantities of **DE** (**DEF**).

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Mapping Unknown Environment via Covering by Group of Reactive Robots

K. Košnar, L. Přeučil

kosnar@labe.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Building map of an environment still remains a fundamental task in mobile robotics. Possible map representations can be split into two diverse groups:

The first one, so called *metric map* defined in a given frame of reference, is typically applied for occupancy grids or polygonal maps. The other kind of representation is devoted to *topological map* types.

To create a map in a global frame of reference, the robot needs to be well localised. Therefore, usage of previous types of maps leads to execution of simultaneous localization and mapping (SLAM) techniques.

On the other hand, the topological map stores information about spatial relations between certain places of interest. Then, a core problem stands in how to distinguish between different places based on information coming from the robots' sensors. Solution of a related problem then bids to answer the question "Is this new place or a already visited one?", in cases, two or more sensory observations are similar. To overcome the sketched problems we apply Spatial Semantic Hierarchy approach described in [2].

Our approach to mapping by group of reactive agents combines some principles from swarm robotics area with topological maps. We apply ideas derived from the ant-colony optimization [3]. In this approach, each individual robot is assumed to have only limited capabilities and resources. Robots behave in a reactive manner and respond only to their own sensory inputs. The communication between robots is established in an indirect way - purely through modification of the common environment. The robots drop pheromone marks in the environment and all other robots are capable to read these landmarks.

Then, the topological map could be based on landmarks in the environment. Information about spatial relations between these landmarks is stored in a graph structure, whereas the nodes represent distinctive places and edges represent sequences of actions, which guide the robot from one place to another. The edges can also carry some additional information (e.g. distance between two neighbour landmarks). The additional quantitative features can be effectively used for navigation purposes within the topological map and the respective environment.

As we focus to indoor type of environments, corners of obstacles may serve as landmarks. As the corner detection itself seems to be an easy task, nevertheless reliable and practical application of the previous tends to be ambiguous, if based purely on sensory data from the robots. Therefore, the pheromone markings of landmarks are used to support the navigation process as each pheromone landmark has its' unique identifier then. This approach solves both problems of the topological maps: To describe and find the landmarks in question and to distinguish them from each other.

The pheromone landmarks also carry information how the robot can execute movements from its' current location. This is done by leaving a notice what kind of behaviour the robot in question performs, which way he continues, etc.

For the sketched purpose the robots are equipped by eight short-range infrared rangefinders, odometer and detector of pheromone marks. The robots can also create new pheromone marks from scratch and/or can modify the existing ones. Each robot performs three main reactive behaviours: Follow right wall, follow left wall and go straight ahead through a free space. While there are two types of corners, the convex and concave ones, six basic behaviours can be applied to leave a corner. Whenever the robot leaves the corner, it disables a proper corner detector to avoid detection of the corner in question. After the procedure of leaving a corner is over, standard (previous) behaviour of the robot is resumed. The standard behaviour represents straightforward collision free driving of the robot with all the sensors active.

Whenever a robot locates a landmark without a pheromone marking, the robot creates a new one. If a pheromone marking exists already, the robot reads it, and subsequently decides (based on information stored in this pheromone) how to change its' behaviour and update the information in the pheromone. If no other constrains are applied the robot preferably chooses behaviour which has not been applied yet or uses the oldest previously used one. The previous law application ensures coordination of group behaviour to cover the environment in shortest time [1].

The robots also keep information about links between landmarks. They remember what behaviour attaches to which places as well as distances between the places. Integration of all fragments of part information carried by each robot leads to creation of complete topological map. If we use a standard Euclidean metric space and if the environment is assumed to be rectangular a complete polynomial map can be calculated.

Information from all the robots is gathered first and subsequently processed offline. Thus we obtain a set of distances between landmarks from each robot. While each landmark has a unique pheromone marking, it is easy to combine information within one or multiple robots. The used algorithm computes real positions of landmarks and structure of links between them. The used optimization procedure is robust against particular robot malfunctions, not providing the desired data. These cases lead only to non-complete mapping of the environment in the regions, where these robots were operating exclusively.

Positions of landmarks are computed by minimization of a quadratic objective function. If all the distances are well defined, there is only a single solution free to rotation, translation and mirroring (in total providing 4 DOF). Smart sequence of evaluation steps ensures stepwise locking of the mentioned DOFs and leads to unambiguous solution.

The described procedure represents a build-up of the complete topological map by a group of reactive agents (robots) as well as determinates real positions of landmarks in the operating environment.

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Three-dimensional Information System for Historical Monuments Documentation

J. Preisler, K. Pavelka

jiri.preisler@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Enginnering, CTU in Prague, Thakurova 7, 166 29 Prague

There are many documentations of historical monuments nowadays, except for classic documentation (papers, photos, videos…) few of them have also geometric 3d model. In many cases there is however problem with integration of this historical monument documentation in one compact information system.

An idea to make such project came at in summer 2003. The object was clear – to make application for creating and presenting 3d information system of any real object, especially for reprocessing of historical monument.

Look and function of the information system

Main program of information system is designed as Windows 32 application. All data can be saved on local disk (in XML file format), but it's also possible to save all data to SQL relation database. At the present time saving data to relational database Firebird and MySQL is possible. The main interest of storing data in SQL database is in partitioning data and application, on this account it's possible that more than one user can use the same 3d model with all documentation at the same time and all of them can work with the same information. When someone (user with administration access) changes, add or delete any information, other users can see changes momentarily.

Advantage of using SQL database server is potency of use information system not only in local net but also on the internet. The only thing user need to access information system is to have computer with Win32 application, internet access and access rights (server name, username and password) to database. Because of connection speed it's possible to use local 3d model (data file saved on local machine) and other information (texts, pictures…) enlink from database.

The final program is possible to launch in operation system with win32 architecture, that means Windows 95, Windows 98, Windows NT, Windows 2000, Windows ME a Windows XP. Server with database may run on Linux, Windows, and a variety of UNIX platforms.

Charles Bridge three-dimensional information system

The first model created in described information system is famous historical bridge crossing the Vltava River in Prague, Charles Bridge.

Charles Bridge is a famous historical bridge. Its construction started in 1357 under the auspices of King Charles IV. At the present time is bridge under reconstruction. Presented poster describes process of constructing virtual 3d model of the bridge in a state before reconstruction as well as system potential to show geometric modifications during reconstruction. The entire virtual model is primary created by Laser scanning, details are specified by digital camera.

This model is created in collaboration with GEFOS Company (Laser scanning), GET Company and Charles University in Prague - Faculty of Science (geology survey of the bridge). The project started in autumn 2004 and now is working on this project in progress.

The following steps are used during creating three-dimensional information system for Charles Bridge:

- The entire virtual model is primary created by **Laser scanning** (document in Autodesk AutoCAD 2005).
- **Importing model to information system**
  whole model is imported to information system via .dxf format (Autodesk AutoCAD format).
- **Creating details**
  next were taking photographs (using digital camera) all over the bridge (total around 2.000 photos). One by one are digitized in surface editor (product part of information system). Every stone is digitized and to every stone is assign material for real visualizing of the model.
- **Assign external information**
  to every part of model is possible to assign miscellaneous kind of information. For the first time is to every object (stone) of model assign type. By type of the object are assigned next information (for stone: age, texture, source…). All this information can be stored in SQL database or local XML file.
- **Presenting 3d model**
  finished model can be locked and given for use to end user. They can use the same application for viewing, printing, exporting, finding, eventually for editing any stored information.

Now is totally finished only one part of the Charles Bridge (one abutment and one span), the rest of Charles Bridge is now under construction.

Conclusion

Actual version of application for creating three-dimensional information system for historical monuments is fully functional. Our future work plans to develop special plug-ins for cooperation with other information and graphic systems.

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Using SVG for Generating Maps on PDA and Mobile Phone

P. Vana

pavel.vana@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Mapping and Cartography, Thákurova 7, 166 29 Praha 6 - Dejvice

The development of the Internet opens up new possibilities of the map presentation for the general public. This situation requires new ways of map formation which should be adapted to it and consequently, a new field of digital cartography, for which we can find several adequate terms such as web cartography or web maps or maps on the Internet, is beginning to develop.

1. Analytical and theoretical part

During the analysing the present state of the maps on the Internet, it has been found that raster maps, in comparison with the maps based on vector formats, prevail. The search for the reasons of that situation was not difficult at all. Raster maps, for example, can be obtained easily (by scanning) and they also have a better support of their display in the browsers (JPEG, GIF and PNG have the direct support of display). The nature of raster graphic facilitates higher security of the source data for the dynamically generated maps and moreover, the use of special web technologies makes it possible to minimize even the major drawback of raster graphic – the size of transmitted files (by the use of MrSID format or Zoomify technology).

Why to try to make the vector maps, then? As various complementary functions can be easily added to the vector graphic as well as it is possible to carry out interconnection with the descriptive attributes of the elements saved in the database. There are several formats of vector graphic, which can be used on the web. One of the most advantageous seems to be relatively new SVG format.

Speaking of the vector maps on the Internet, we usually mean dynamic maps, those that are generated from a data warehouse according to the user demand. Programming solutions, which enable to make such maps prepared for online display on the PDA devices or mobile phones, are based on the server web technologies.

Our decision on which web technology to use for the generating maps depends on the demands on the functionality of the generating maps, on the way of the saving of the source data and their type, on the possibilities of the chosen technology and last but not least, it also depends on the server where the maps are generated. There are several options. The solutions of big commercial companies are usually based on the technology of Microsoft.NET, which uses the languages such as Visual Basic.NET or C#. Noncommercial or smaller projects can use PHP or Python programming languages or so called CGI scripts that can be programmed in C++ or Java.

The solution proposed is based on the combination of three web technologies – GML language as a source of data, XSL language as a means of map formation and SVG language used for drawing the map on PDA.

GML (Geography Markup Language) is the language used for the saving of geographical data including the descriptive attributes, which employs Extensible Markup Language (XML) for the notion. GML is being developed under the auspices of Open Geospatial Consortium (OGC).

XSL (Extensible Stylesheet Language) is a language used for the transformation of XML language into other formats. The means of XSL make it possible to do the transformations which lead to the conversion of XML document into the other XML document having completely different structure of the elements and the attributes. Those transformations are called XSLT (XSL Transformations).

SVG (Scalable Vector Graphic) is the language used for the description of two-dimensional vector graphic, which employs Extensible Markup Language (XML) for the notion. SVG is being developed under the auspices of the World Wide Web Consortium (W3C). The version SVG 1.0 was approved in 2001, the version SVG 1.1 in 2003. SVTG distinguishes three basic types of objects: vector objects, raster objects and text. These objects can be put together in different ways and various styles, transformations, animations and filter effects can be applied to them. For the interactive graphic there is a possibility to take advantage of Document Object Model (DOM) standard and JavaScript. SVG works with the RGBA coloured model, that is RGB model plus alpha channel, in which the degree of transparency for each point is kept. Two independent modules with limited functionality appeared within the version SVG 1.1.One of them is the standard SVG Basic destined for the applications displayed on the PDA devices, the other one is the standard SVG Tiny destined for mobile phones.

2. Practical testing

During the tests, the data from ZABAGED database were used. ZABAGED is a digital topographic model of the territory of the Czech Republic derived from the Base Map of the Czech Republic 1: 10 000 and the database is run by the Land Survey Office. During the testing, hypsometric and planimetric data in the size of map sheet have been used. As Land Survey Office has not set the structure of GML language for ZABAGED database, the data have been transferred from DGN vector format by means of trial version of the TatusGIS software.

The transformation of the data from GML language into the SVG language has been done with a help of XSL transformations. During that process, the means of SVG Basic module for PDA and the means of SVG Tiny module for mobile phones were used and consequently, the drawn map was displayed.

3. Conclusion

While using web technologies and SVG language we often encounter difficulties. The technology was somehow devised and standardized by the independent consortium, but then the implementation of the standard into the software, namely into the internet browser, should follow. And just here, at this stage, we face many problems related to its application. There is future in the use of the vector format (SVG), because in some software products that standard is supported and further developed, in the others its support is being planned.

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Scheduling Toolbox for Use with Matlab

M. Kutil

kutilm@fel.cvut.cz

Department of Control Engineering, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

TORSCHE (Time Optimisation of Resources, SCHEduling) [4] is a Matlab scheduling toolbox which proposes a background utilities for easy develop (rapid prototyping) and implementation of scheduling algorithms. Basic algorithms which are frequently used or which can be implemented as a part of complex algorithms are prepared too. The background utilities are divided into two categories. First one provides routines for classical scheduling problems implementation. Second one is intended for graph theory algorithms support. Both parts are closely related.

Classical scheduling problems utilities are described in [1]. Briefly, we can mention that main utilities are objects representing tasks and set of tasks. Task is a basic term in scheduling and describes any unit of work that is scheduled and executed by the system. The task is described by the following parameters: Name, Processing time, Release time, Deadline, Due date, Weight and Processor. Set of task is represented by taskset object which collects individual tasks and some additional parameters for example precedence constrains, user parameters, graphics representation parameters and so on. Newly, you can create taskset directly, without tasks preparing previously. This is possible by implication "dot-parentheses" syntax implementation to the object properties access. This access method is implemented for all objects in the scheduling toolbox and provides high comfort for users using Matlab console.

In new version some new scheduling algorithms are implemented and extended. Firstly, refer to the extended List scheduling algorithm. Basic idea of the algorithm is to sort tasks into list and next step by step take the task from list and assign them to processor. New modular system allows to extend the algorithm with external heuristics which order tasks in the list before releasing to the processor. Implemented heuristics are: earliest starting time (EST), earliest completion first (ECF), longest processing time (LPT) and shortest processing time (SPT). Verbose mode and unrelated processors support supplement List scheduling to be fully user friendly algorithm. Brucker's algorithm is the next one new scheduling algorithm. This one demonstrates work with precedence constrains between tasks, especially precedence constrains in "in-tree" form [2]. Except traditional scheduling algorithms [2], TORSCHE provides some modern special algorithms. One of them is an algorithm in literature called scheduling with positive and negative time-lags. This algorithm schedule tasks with release date and deadline related to the start time of another tasks. Cyclic scheduling [3] is next modern algorithm which is suitable for many activities e.g. in automated manufacturing or parallel computing. Cyclic scheduling means that tasks on machines are repeated cyclically. One repetition is usually called iteration and common objective is to find a schedule that maximizes throughput. Last two algorithms mentioned above interact with second group of background utilities – graph theory routines.

Graph theory is very important instruments in scheduling theory. Graph, a basic instance of graph theory, is represented by nodes and edges. Relations between those two items describe adjacency matrix. Size of adjacency matrix is equal to number of nodes and value on (i, j) position is equal number of edges from i-th node to j-th node. Graph object from scheduling toolbox is created from adjacency matrix. Adjacency matrix describes only graph structure, but in addition object graph consists of supplement properties with utilities

for graph manipulations. Those utilities allow supplement values to the edge, to the node, allow add graphics parameters as node position or a color. For graph manipulation functions as subgraph cute and graph merge are prepared. Moreover, we prepared some basic graphs algorithms, e.g. successors and predecessors search, or shortest path construction by Floyd's algorithm. One of toolbox routine is graph editor providing comfortable graphics user interface for graph construction. The editor allows adding or removing nodes, edges and their parameters in the graph. Each precedence constrains between tasks are described by the direct acyclic graph, where nodes of graph represents tasks, and edges are precedence constrains. From this point of view we can say that tasksets and graphs can be reciprocal transferable. For this transformation are available functions which allow user defined transfer from graph to taskset and back.

Description of all functions of TORSCHE scheduling toolbox overreaches this paper. Toolbox includes many minor functions which increase usability. Some of them are interfaces functions for integer linear programming solvers or boolean satisfiability solver and their configurations utilities. Next one is XML configuration file which describes all scheduling algorithms and allows interconnect toolbox with web interface or with prepared expert system for automatic algorithms choice. From the above point of view take this paper as preview of news from prepared version 0.1.3 for planed release in February 2006.

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Fault Tollerant Helicopter Control

S. Kroupa*, D. Pachner *, Z.Pech*,O.Spinka*, J.Rohac^

xkroupa@fel.cvut.cz

*Department of Control Engineering, ^Department of Meassurement, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This paper is focused on the Fault Tolerant Control of a helicopter model project summary. According to the proposed goals, the theory of the helicopter, especially for small rotary unmanned aircraft vehicles (RUAV) was intensively studied and several current control approaches and models were examined especially with respect to their feasibility to be applied on a real system.

The RUAV fault tolerant control task could be decomposed into several interacting sets of problems. These include the following ones: helicopter modeling, model parameters identification, the control synthesis, data validation and measurement precision enhancement, the design of a base station for tests, system configuration and visualization, fault detection and isolation. These subtasks and their results will be discussed bellow:

- **Avionics.** A new inertial measurement unit was developed at the cooperating avionics laboratory at the Department of Measurement. The Kalman filtering and data fusion methods were implemented for improvement precision of measurement. The design methodology for the real time DSP implementation based on progressive FPGA technology and Matlab Altera DSP Builder were examined.

- **The helicopter modeling and control.** A helicopter is an aerial vehicle. Its flying qualities make it an interesting subject for an autonomous platform development. The theory of the helicopter control was subject to the research of many teams. Before attempting to design a helicopter control system, the non trivial task of the helicopter model has to be solved. The theory of the helicopter flight was studied by [Proutty, Mettler], and the theory especially related to the RUAV was intensively studied by [Munziger, Alborg]. All the current approaches to the helicopter modeling and helicopter control were in the scope of our project. The helicopter is represented by a MIMO nonlinear time variant unstable system. The modeling of a helicopter is highly demanding task because the rich models contain 92 parameters. From the mathematical models published we have selected the most reliable one [Alborg] for Hirobo with respect to simulation, testing, and control design. The model will be compared with a data set recorded during a test flight when the vehicle will be controlled manually via RC.

- **The hierarchical control system.** We have chosed and verified a model to be used for the control design. The proposed fault tolerant control design is a clone of SDRE, MPC, and FDI strategies. The control consists of three level scheme. The basic level is responsible for the system augmentation and the attitude stabilization. In [Alborg] it was demonstrated that the common control methods (MPC, LQG) fail outside just a small range of the operational conditions and flight regime characteristics. Our approach combines both SDRE and MPC approaches. The idea of SDRE is based on the state space model actualization each sampling period and the feedback gain computation. The

second level of the control system is represented by an MPC is responsible for the trajectory tracking. The third level is responsible for fault detection and isolation tasks. The adequate control strategy selection depends on whether a failure and which failure type is detected.

- **Identification methods.** An existing identification and configuration tool for the system analysis and setting was extended to non-linear models, which was the main progress during the past year. The tool allows all previously developed features as were: graphical user interface for data inspection and manipulation, finding maximum likelihood probability linearizing transformation estimate, MIMO ARX model identification, model order reduction and verification on the data fitted and FDI (fault detection and isolation) testing.

- **Data validation.** Due to the lack of measured data from our control platform we have decided to test the identification and modeling approach on industrial process data to prove our current techniques are appropriate. We have chosen processes where problems similar to RUAV modeling can be found. We have examined data validation technique. Both additive and multiplicative measurements errors detection and isolation were tested.

- **Base station test design.** We have examined and tested [GeorgiaTech] RUAV base station for support control environment design.

To conclude: a considerable effort was exerted to study the helicopter behavior and control backgrounds. Although the designed control simulation couldn't be directly tested on the flying vehicle, we suppose, that this preparation phase was necessary to avoid possible helicopter damages in the future. Besides, the analysis and configuration tools improvements were realized.

Remark: *All mentioned literature references are summarized at www.cvut.iglu.cz project page to support Flight management system courses.*

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Use of Speculative Computation for Arithmetic Accelerating

T. Marek*, A. Pluháček*

marekt@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University,
Karlovo náměstí 13, 121 35, Prague 2

We are witness to a rapid growth of a general purpose processor frequency in past few years. This progression is mostly stimulated by market. Frequency sells in spite of it is not a single performance parameter. The frequency increased approximately 10 times in past seven years, but a technology improves only approximately 3 times in the same decade. This indicates that not only technology is responsible for the frequency growth. Moreover, not only frequency was increasing in past years. Also another performance parameters like a number of an instruction issued in every clock cycle or number of an in flight instructions grown. An increase of these parameters involves complex algorithms and chip area. The most common used technique for the frequency increase is a pipelining. This technique basically enables discussed high frequency increase in spite of increasing complexity of used algorithms. The number of the pipeline stages grown 9 times for the PowerPC architecture and 2.5 times for the Intel architecture in past seven years.

However, increasing number of the pipeline stages may have negative an affect. Average number of the clock cycles per instruction (CPI) and the branch misprediction can grown under the influence of increasing number of the pipeline stages [3]. We can demonstrate negative effect of the long latency on two examples. At first, instructions dependent on the executed instruction with long latency must wait in the Reservation Station until their source instruction is executed and their input operands are ready. Moreover, there are instructions that depend on the waiting instructions, etc. This dependency chain fills the whole Reservation Station and no more instructions can be issued or dispatched. The execution of instructions is stopped until the first instruction of the dependency chain with the long latency is completed. At second, if the executed instruction with the long latency is the first in-order fetched instruction from the instruction window and reaches the top of the Retire Buffer it cannot be retire, because it is still executed. Instructions after this first one cannot be retired and must wait in the Retire Buffer, because instruction must be retired in the program order. No more instructions can be executed until the first one is retired if waiting instructions fill the Retire Buffer.

Different approaches are investigated towards prevent the latency and following CPI and branch misprediction from grown. The most common techniques for the execution latency reduction are Variable Latency Pipeline (VLP), Value Reuse and Value Speculation. These techniques take advance of the value locality and reduce the latency of some instructions depending on their operands. Similar property to the spacial and the temporal locality for instruction and data addresses used in caches can define also for values. This property is called Value Locality and represents likelihood instruction will produce the similar results like in the past. Commonly used benchmark has a pretty high Value Locality. The load instruction loads the same value from the memory like previous one in approximately 50% cases. This is a good start point for the Value Prediction and the Value Reuse. The success of the previously mentioned techniques depends on used programs. However, recent researches show that the most of the programs demonstrate good Value Locality.

We can reuse a trace cache entry, block of instructions, one instruction or only execution part of an instruction for example [1]. The result of the reused part of code is stored in the Reuse Buffer together with the reuse conditions. The reuse conditions guarantee that the corresponding result can be reused without any violation of the program semantic.

We can predict instruction input operands if they are not ready. These instructions are executed in normal fashion but they cannot be retired until the speculation is verified to be correct. The retire of not verified speculatively executed instruction can violate the program semantic.

We have experimented with SimpleScalar LLC simulator in the Aplha configuration and SPEC2000 integer benchmarks bzip2, crafty, gap, gcc, gzip, mcf, parser, twolf and vortex. First, we designate a distance between multiply instruction (MULL or MULQ) and the nearest dependent instruction, which consumes its result. 56% of the dependent instructions, on average, follow immediately after the multiply instruction. Thus 56% of the dependent instructions must wait in reservation station at least for the multiplication latency. This result indicates that the multiplier latency may be the important performance parameter especially for programs containing high percentage of the multiply instructions.

We extended the multiplier with the Reuse Cache to reduce the multiplier latency. The Reuse Cache is speculatively filled with the next possible predicted operands and corresponding results. We test three types of the predictors: Last Value predictor, Stride predictor a Hybrid predictor. The Last Value predictor simply stores in the cache last operands and result. It has the lowest hardware requirements and the highest hit rate 48,23%, on average, for the fully associative cache with 16 entries. The Stride predictor predicts that the stride between the last to operands is repeated in the next multiplication. So, it stores the operands $x+(x\text{-}last\_x)$ and $x+(x\text{-}last\_x)$ and the result for these operands in the Result Cache. The result for these operands must be computed and cannot be simply reused. However, we can precompute the result in the same multiplier at the end of the last multiplication without significant performance degradation, because less than 10 instructions are between two multiply instructions only in 14.07% [4]. The stride predictor has higher hardware requirements and lower hit rate 16,48%, on average, for fully associative cache with 16 entries. The Hybrid predictor combines the Last Value and the Stride predictors. The stride prediction is added in to the cache together with last value if one of the input operands is equal to previous one and the predicted stride is less than 2^8 and dividable by 4. This restrictions decrease cache pollution by predictions, which reuse likelihood is small. The Hybrid predictor has the highest hardware requirements and the approximately same hit rate as the Last Value predictor i.e. 47,94%, on average.

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Improvement of Teaching the Data Structures and Algorithms Subject

Petr Felkel, Marko Genyk-Berezovskyj

berezovs@cslab.felk.cvut.cz

Department of Computer Science and Engineering , Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The Data Structures and Algorithms is one of the most fundamental subjects of the whole Computer Science and Engineering curriculum at our faculty. In this subject the students are taught the basic concepts of advanced data structures and their implementations along with the methods of their proper utilization. The subject can be viewed as — and to some degree it undoubtedly is — a direct continuation of the elementary programming course. The skill of programming acquired in the first semester(s) of the study is in many cases quite useless when it is not accompanied with the respective insight and understanding of the ideas implemented in the programming language and its libraries on the one hand and the abstract and general properties of the particular programming task on the other hand. When the student successfully masters the topics of the Data Structures and Algorithms subject it has a tremendous impact on his or her further study. Virtually any theme which he or she meets during his or her subsequent study of computer science is in some way tightly linked to the contents of this subject. Manipulating a particular specimen of the wide variety of the tree structures, implementation of abstract data types, searching, hashing, assessing the complexity and asymptotical complexity of any computational process — these are the tasks of profound importance to every contemporary computer engineer.

The current implementation of the Data Structures and Algorithms subject at our department suffers from the difficulty which seems to be rather unavoidable in the near future. The number of students who are studying at our department fairly exceeds the spatial and personal and thus also the pedagogical capacity of the department. The immediate drawback resulting from such an inconvenient constellation is a virtual impossibility for the teacher to get acquainted with all his or her students, with their abilities and capabilities and to react in his or her teaching to their very different needs.

One simple and obvious way how to tackle this teaching limitations is to make available as many study materials as possible and preferably the materials of various different types. Fortunately, the Internet environment with its nearly unlimited information potential, ubiquitousness and instant access may by of some significant help here.

The aim of our contribution supported by the internal CTU grant was to back the existing Data Structures and Algorithms course by various types of readily available materials mostly in electronic form.

Our priority was the creation of the subject home page where intentionally all information which a student needs in the course of the subject is collected. The home page should provide and now mostly provides the student with the following:

A) The subject overview, syllabus, timetable, the overall description of the style of the work in the subject seminaries, the list of subject participants and teachers and their e-mail addresses, shortly all the subject organizational matters and details.
B) All lecture notes in usual formats, with additional explanatory commentaries if they are necessary.
C) All seminary topics, list of seminary problems, solved examples illustrating the most typical problems, homework assignments, project themes.

D) The complete repository of the solved and commented by the teacher tests and exam questions from the previous year.
E) The complete repository of student projects with the automatic upload option (in the final stage of development now).
F) The comprehensive set of bibliography and the web links related to the subject.
G) The course grading rules.
H) Last but not least — both Czech and English versions of the home page are available.

It must be said that although the above introduced concept of web page features seems to be quite obvious and conceptually straightforward, surprisingly enough, nor a similar one neither any distantly related one has been implemented on the web pages of the majority of the subjects at the FEE CTU. Also the positive feedback we received form our students reassured us that however simple the whole idea might be, it's thorough fulfillment brings an immediate and noticeable increase in the subject quality and the home page is being exploited by the students on a daily basis.

Thanks to the internal CTU grant we were able to purchase some of the very important literature titles targeted at the elements of computer science illustrating the various approaches to the teaching of data structures and algorithms by the world most renowned authors, like Alfred V. Aho, Thomas H. Cormen, Brian W. Kernighan, Robert Sedgewick, to name only a few. Ahead of us lies the task of translating the concepts of these authors into our own curriculum. Immediately available are the problems and exercises in these books, they will be of significant use to us, the Czech literature in this branch is still far from complete

Currently we are planning to equip the Data Structures and Algorithms home page with the professional "look and feel". This we hope to achieve by the cooperation with the subject User Interface Design also taught at our department. During the upcoming calendar year 2006 we will try to add to the home page a system for the online self-check tests and to fill it with meaningful questions at the beginning of the academic year 2006/2007 when the next run of the Data Structures and Algorithms subject will start.

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CAN Laboratory Inovation

Jan Krákora

krakorj@control.felk.cvut.cz

Czech Technical University in Prague, Faculty of Electrical Engineering,
Department of Control Engineering
Karlovo náměstí 13, Prague 2, 121 35, Czech Republic

The communication protocol CAN [1] is widely used protocol in a time critical application (e.g. automotive application). It is usually used to transmit an important data among electronic control units, intelligent sensors and intelligent actuators.

This project dealt with expansion of our CAN laboratory. The aim was to obtain new equipment, to obtain a modern hardware and software and to bring to student a professional workstation with modern technologies. It also supported improvement of new methodical tutorials for students and teachers, and preparation of tutorials how to operate with the new devices and tools.

The project plan was the following:

- from January to April 2005 - Tutorials for teachers and student realization
- May 2005 - HW and SW purchasing
- from June to September 2005 - Tutorials and their including to a lesson testing
- from October to December 2005 - Workstation improvement
- February 2006 - Workshop 2006 presentation

Results and Conclusion

New software and hardware components were obtained from the project resources. The founded equipment is the following

- KVASER CAN measurement boards
  - measurement wires 251, 1051 and opto
- Workstation PC

Those components were integrated into current laboratory equipment (e.g. Vector CANalyzer tester tool).

The project supported exercises revision activities commonly used in DRS35 subject lectures - department subject “Distributed Control Systems”. The better understanding of the CAN communication principles, especially in-car process communication, is the purpose of the tutorial set.

Department students usually measure a CAN traffic at our laboratory test-bed car. The measurement had been done at the Škoda Fabia up to April 2005. Because the car was changed to the Škoda Octavia 1.9 TDi, the tutorials and lessons materials had to be revised, to meet the new car specification. The result was a tutorial set dealing with car operating and measurement using both Kvaser’s tool and Vector’s tool.

The other project activities dealt with the Motorola HC12 CAN board module tutorials. The module was designed and developed for CAN measurement at our department like measurement electronic control unit. The tutorial describes how to configure this module and how to operate it using Metrowerks Codewarior tool. For department lesson purpose the ANSI C tutorial and real-time operating system OSEK-VDX tutorial has been proposed.

Project results summary

- CAN laboratory innovation
- Škoda Octavia 1.9.TDi A5 tutorials
- Motorola HC12 tutorials for IDE Metrowerks Codewarrior
- Set of exercises dealing with CAN. HC12 development board programming, Octavia CAN measurement
- Internal report presentation and Workshop 2006 presentation

All the project results respect the aims depicted in the project application form.

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Performance Analysis of Basic Approaches to Image Filtering on GPU

M. Čadík, O. Fialka

cadikm@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

Image processing techniques that typically require a considerable amount of CPU time are becoming available for real time applications thanks to modern graphics hardware (GPU). These techniques range from blurring, sharpening or edge detection to sophisticated methods of tone mapping of high dynamic range images. Many of these techniques apply various filters in the process of image transformation. Therefore the application of filters is one of the key issues in modern computer graphics. There exist two basic approaches to image filtering - filtering in the spatial domain and filtering in the frequency domain. While in *spatial domain* we apply the filter by simple *convolution* of the image and the kernel of the filter function, in *frequency domain* we must convert the image into the frequency domain using *Fourier transform*, then apply the filter by multiplication and finally transform the result back to spatial domain using inverse transform. Both of these approaches have their pros and cons and are profitable under different conditions. In this work we concentrated on the implementation of filtering techniques on GPU and evaluated their performance in real time applications.

The Fast Fourier Transform (FFT) is a well-known technique and many slightly different FFT algorithms have been proposed in history. The issue is that most of them cannot be directly implemented on a GPU. Moreland et al. [2] described the first FFT implementation on a GPU, but their work is obsolete since they used older graphics cards (GeForce 5 series) than those available nowadays (6 and 7 series) and therefore their possibilities were limited. A very effective approach for medical images was developed by Sumamaweera and Liu [3]. Their solution adopts the decimation in time algorithm and enables the computational load to be split between the pixel and vertex shaders and the rasterizer. However, the performance speedup introduced by splitting the load is not very significant - about 10% according to their results. Most of the proposed approaches consider just grayscale images when it comes to FFT. Quaternion Fourier Transform [1] is a hypercomplex version of the standard FFT and can be used for processing of images with up to four channels. Much work has been done on applying FFT and convolution in signal processing [4]. Smith [4] compared both methods in term of performance for CPU implementations. In this work we make a similar comparison for GPU implementations, which differ in many aspects from traditional CPU algorithms.

The algorithm for FFT we have adopted for GPU is known as *decimation in frequency 2-radix* (DIF). It is easily mapped onto the GPU since it can be described by a butterfly network. The transform of a 2D image is done by applying 1D FFT's to all rows and columns consecutively. Because there are only N distinct values of the sines and cosines during the computation, they can be easily precomputed and fetched from a texture. The implementation of *convolution* on a GPU must reflect the size and type of the filter kernel. The bigger the kernel, the more operations have to be executed per pixel. This can be easily implemented using a loop but we are limited by the maximal number of instructions the shader can execute per pixel. Another aspect is the separability of the kernel. A *separable kernel* can be decomposed into two one-dimensional convolutions and can save many instructions -

quadratic complexity becomes linear. An optimized GPU implementation stores the kernel and the sampling coordinates in a uniform array, which is precomputed on the CPU.

In the performance tests we have compared the framerate of a Gaussian low pass filter applied by convolution and FFT to a simple testing scene. Three images of the sizes 256x256, 512x512 and 1024x1024 were used. The measured results show that the ratio of framerates of convolution and FFT is not the same for different image sizes. This is due to the number of elementary computation steps. The computational complexity of filtering a N by N texture with separable convolution is O ($2kN^2$), where k denotes the size of the kernel - every pixel gets convolved with the whole kernel in x and y dimensions. With FFT the time increases to $O(4N^2\log_2(N))$ - each pixel is processed in $\log_2 N$ steps that repeat four times - for both dimensions and for forward and backward transforms. Applying filters by *separable convolutions* is much faster than by the FFT for small filter kernels. The size of the kernel for which convolution is still faster than FFT depends on the size of the image. In our tests it lies between 31 and 41 pixels for monochromatic FFT. The RGBA version of FFT is slightly slower. The situation gets different for *inseparable filter kernels*. The complexity is $O(k^2N^2)$, making the convolution very slow. Another limitation is the number of instructions the pixel shader can execute. Due to this limitation, the largest odd-dimesion filter we could implement was 9 by 9 (maximum number of samples per pixel was 112). Separable convolutions are limited by this feature as well. There exist many applications that process the original scene by *multiple filters*. While convolution has to be repeated for every applied filter in this case, with FFT there is only one forward transform, and multiple backward transforms. The FFT becomes gradually more efficient with the increasing number of filters. While it is approximately as fast as convolution with a 33 pixels wide kernel for one filter, it reaches the performance of convolution with a 21 pixels wide kernel for eight filters.

In this contribution we concentrated on GPU-implementation issues for two main approaches to image filtering - the convolution and the Fourier transform. We have performed several measurements to asses the performance of these two approaches. Our results show that GPU implementations of both the convolution and the FFT clearly outperform their CPU counterparts. Convolution on GPU performs better than the FFT on GPU when we want to apply simple and small filters. Separable convolution allows more optimizations, because for kernels up to approximately 100 pixels in size all the values and texturing coordinates can be precomputed and stored in a uniform data array. This offers a significant speedup in comparison with storing the values in textures or computing them directly. However, the fast Fourier transform can outperform convolution in several cases: when applying multiple filters on the same image, for inseparable filter kernels and for very large filter kernels - more than 33 pixels for one or two channel images, more than 51 pixels for three or four channel images.

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Automotive Active Suspension Systems with Energy Recuperation

K. Hyniová, J. Honců, A. Stříbrský

hyniova@control.felk.cvut.cz

Department of Control Engineering, Faculty of Electrical Engineering,
Czech Technical University, Karlovo náměstí 13, 121 35 PRAGUE, Czech Republic

Current approaches to automotive active suspensions are limited by the accessible dynamics of the responses. Typical active actuators are based on hydraulic or pneumatic systems. Such traditional actuators can achieve the time constant about 10 ms. This time constant can be improved by feedback control of the desired damping force but the resulting time constant cannot be decreased significantly below 10 ms. Such actuators are usually applied as vehicle shock absorbers. If vehicles move by the velocity of 30 m/s then they cover the distance of at least 0.3 m before the controlled damper reacts. The consequences of this dynamics limitation on the properties of vehicle suspension are various. Therefore any alternative actuator of damping force with accessible time constant of about 1 ms is highly desirable.

From the point of view of the limitations discussed above, the application of a linear synchronous permanent magnet motor with electronic commutation is very perspective. Linear motors usage as a new way of active suspension of mechanical vibrations and improving ride comfort and handling properties of vehicles has been realized by the project research team. Vehicle suspensions in which forces are generated in response to feedback signals by active elements obviously offer increased design flexibility compared to the conventional suspensions using passive elements such as springs and dampers.

The main advantage of such a solution is the possibility to generate desired forces acting between the unsprung (wheel) and sprung (car body) masses of the car, providing good insulation of the car sprung mass from the road surface disturbances. Low friction and no backlash resulting in high accuracy, high acceleration and velocity, sufficient force, satisfactory reliability and long lifetime enable not only effective usage of modern control systems but also represent the important attributes needed to control vibration suspension efficiently.

A special attention has been focused on the robust control design of the system. Two major performance requirements of any automotive suspension system are to provide good ride and good handling characteristics when random disturbances from the environment and the driver‘s maneuvers act upon the moving vehicle. However, a trade-off exists between these two requirements. In a conventional suspension system, soft suspension components are used to improve the ride, and hard suspension components are used to improve handling. The purpose of active suspension, in terms of performance, is to simultaneously improve both of these conflicting requirements. Another important goal of the controller design was to maintain robustness of the closed-loop system. A full vehicle model with linear controlled power sources has been derived and a control system based on the H-infinity theory has been designed. Changing the system parameters, the robust performance in the closed-loop has been evaluated in shaking experiments as excellent. From experiments it has been implied that very good ride comfort - small displacement peaks and sprung mass attenuation in required frequency ranges – has been achieved. Also attenuation of pitching velocity as a car-handling indicator has been very good.

Usage of linear electromotors as actuators in the vehicle suspension systems claims specific power demands. One could object to high power demands of such a solution. But under certain circumstances using linear motors as actuators enables to transform mechanical energy of vibrations excited by the uneven road surface to electrical energy, accumulate it, and use it when needed. This way, it is possible to reduce or even eliminate the demands concerning the external power source. To outline the energy-saving strategy, two ways of energy accumulation and reusage including the main advantages and disadvantages of each of the proposed solutions has been investigated.

To demonstrate the conversion of electrical energy to mechanical energy, a Matlab-Simulink model of the linear motor including a power amplifier controlled with the help of the desired force has been done. On the base of the experiments completed on the model, the value of electric power necessary to be supplied or consumed (when the velocity and force of the motor are given) has been gained.

It results from the experiments that the designed model describes the real linear motor equipped with necessary auxiliary circuits very authentically and enables to verify control algorithms developed to control the linear motor as an actuator of the active suspension system.

The electric power consumption in standard road vehicles has increased significantly over the past 20 years (approximately four percent every year) and in the near future, even higher power demands are expected. To limit the associated increase in fuel consumption and exhaust emissions, smart strategies for generation, storage/retrieval, distributions and consumption of electric power will be used. The linear AC electromotor equipped with a storage element (super cap) with a large capacity and small energy leakage over time and used such a way mentioned above is one of the possibilities that could contribute to solve the problem.

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Inovations in Laboratory of Instrumentation of Processes

K. Hyniová

hyniova@control.felk.cvut.cz

Department of Control Engineering, Faculty of Electrical Engineering,
Czech Technical University, Karlovo náměstí 13, 121 35 PRAGUE, Czech Republic

Nowadays, it is desirable for researchers and teachers in engineering to try as much as possible to use some of their more understandable and practical work as teaching materials to give students an insight into areas of science and technology that can be still under investigation. Partial problems can be offered as mini-projects which may lead to interesting findings depending on the quality of the student undertaking the work. The work carried out as a part of the project offered can be either on a laboratory scale rig or simulation based. In the case of the former, the student gets to develop his/her practical problem solving skills as well as perhaps exploring new ways. The main goal of the project was to innovate and improve this way the quality of the form and content of the courses on Instrumentation of Processes. As the area, modern interactive autotronic circuits have been chosen. Studying modern control tools and control strategies and their variable efficiency in this attractive field in details is extremely interesting and demanding for the students. With the support of the project, four modular autotronic laboratory experimental stands have been introduced. In addition, one experimental stand demonstrating automotive active suspension system designed by the research team has been added to the learning objectives in the lab.

The autotronic modules mentioned above provide the learner with a good understanding of the operating principles of subsystems and devices found in the electrical and electronic systems of modern cars. The circuits reproduce the functions and performances of the subsystems and devices used by the leading manufacturers of automotive components. Each module comprises a set of preassembled circuits with relevant mimic diagrams, and is connected to the control unit which is common for all modules. The control unit controls fault insertion and the variations to the circuit. This configuration allows the desired learning mode to be chosen: options range from an individual unit to the fully computerized classroom with teacher control. A unique connector provides the connection to the power supply unit.

First module gives a theoretical and experimental study of the pressure and air-flow sensors used in electronic injection systems of cars. Learning objectives like characteristic features of engine load transducers, definition of characteristic parameters, electronic injection, stoichiometric air-fuel ratio, piezoelectric pressure transducer of the feeding manifold, resistive transducer of the air flow in the manifold, conditioning of sensors, electronic components, characteristic curves, linearity of transducers, position of sensors in the engine system and fault finding can be investigated on the model.

Second module gives the theoretical and experimental analysis of speed and position sensors of the engine used in electronic injection systems for cars. Here, the learning objectives are as r.p.m. measurement of the drive shaft, inductive proximity sensor for flywheel, variable reluctance, measuring/processing the engine r.p.m., Hall effect, Hall effect applied to position sensors, synchronization of ignition, position of top dead sensors, synchronization of ignitions, position of top dead center, conditioning of sensors, troubleshooting, etc.

Third module provides the theoretical and experimental analysis of the various ignition techniques and technology used in gasoline engines. Moreover, it explains the technology of Smart Power solid state relays. Operating principles of ignition, traditional

ignition, transistor-operated ignition, ignition distributors, contact-less ignition, capacitor-discharge ignition, fully electronic ignition, technology and operation of Smart Power static relays, and troubleshooting are the most important learning objectives completed on the model.

Fourth module provides the theoretical and experimental analysis of timing functions controlled by the driver, and achieved by means of electronic control. The module is equipped by a windscreen wiper with three selectable speeds, emergency with four bulbs, double frequency blinking for fault detection, timing of internal light on closing and opening of the door switch, control of dashboard luminosity by means of potentiometer, and control of two dashboard lights using a fixed frequency signal but with variable duty cycle. Learning objectives like analysis of multi-speed control techniques of windscreen wipers, directional and emergency flashers with double frequency blinking in case of fault lamp, timer controlling the internal light of the cab when closing and opening the door, control of dashboard luminosity with pulse width modulation and fault finding are the main tasks completed on this model.

As mentioned above, one experimental stand demonstrating automotive active suspension system designed by the research team [1-4] has been added to the learning objectives in the lab. As well known, the main task of a vehicle suspension is to ensure ride comfort and road holding for a variety of road conditions and vehicle maneuvers. In general, only a compromise between these two conflicting criteria can be obtained if the suspension is based on passive components, such as spring and dampers. That is why an active suspension system characterized by a built-in actuator (linear AC electromotor) which can generate control forces (calculated by a computer) to suppress roll and pitch motions and vibrations caused by road unevenness. The main learning objectives demonstrated on the model are namely new hardware solution of the suspension systems, linear motor as a modern type of actuators, robust control strategies, energy consumption optimization, and energy storage devices.

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Agent Cooperation in Competitive Environments

Jiří Bíba

biba@labe.felk.cvut.cz

Gerstner Laboratory, Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Multi-agent system (MAS) is a widely used paradigm for modelling, planning and control of various processes. Besides standard centralized planning and optimization mechanisms, the MAS supports local replanning with a minimal need of changes to the entire plan. There are several MAS implementations for production planning and for cooperation across supply chains. A modern business drives a research in the domain of Virtual Organizations that transform supply chains into dynamic cooperative networks (a cooperation with the other partners of a Virtual Organization allows an enterprise to react on incoming business opportunities that it would not be able to cover itself). Cooperation in such environment is based on a distributed negotiation of individual partners that leads to a satisfaction of individual or common goals. In case of an internal cooperation (within an enterprise), the goal is to maximize the overall profit of whole the enterprise. Changing the scope to an external cooperation (across a supply chain), the behaviour of the parties involved is more self-interested as their goals are maximizations of their own profits. Standard negotiation protocols and techniques used in MAS does not follow this course. Therefore, new negotiation mechanisms for competitive environment had to be investigated.

From the business-cooperation point of view there may be distinguished two kinds of multi-agent environments: collaborative and competitive. The most significant difference dwells in the motivations of agents towards cooperation. While the primary motivation of collaborative agents is maximization of their social welfare (i.e. the total sum of their individual utilities), the primary motivation of competitive (self-interested) agents is maximization of their individual utilities. A concept of a cooperative problem solving by means of social commitments was introduced by Wooldridge and Jennings. An eventual dropping of a social commitment (decommitment) was either both rational and beneficial for all the participants or did not even occur. Even though the authors do not restrict the provided commitment description to collaborative environments, the agents considered appear to be rather social-welfare maximizers than competitors. However, in competitive environments an agent tends to drop its commitments if it contributes to maximization of its individual utility, no matter how it may harm the others in consequence. If the self-interested agents should either to fulfil their commitments or to provide compensations for the harm to others in the case of decommitment (i.e. the agents should act responsibly), the agents have to commit themselves in this sense as well. Whereas for contracting in collaborative environments there is usually no need of any explicit metrics of the individual utility or the social welfare gained, in competitive environments an explicit expression of utility is desirable. It facilitates implementation of rewards and penalties as the utilities that the agents gain or loose. Thus, contracting in competitive environments is not only matter of negotiation about goals and plans, but about prices and penalties as well. The costs and profits (negative and positive utilities gained) differ from agent to agent with respect to contracts and resources assignments already agreed. Therefore a rational behaviour of self-interested agents is very individual and the setting of penalties and contract prices (i.e. contracting) cannot be provided centrally, neither a common knowledge among the agents that might facilitate the contracting can be assumed.

The most complete approach to commitments in a competitive environment has been presented by Sandholm and Lesser as levelled commitments. The levelled commitments include an explicit utility evaluation in a form of a contract price and penalties. They facilitate a decommitment that was not acceptable for full commitments commonly used. The levelled commitments receive several limiting assumptions that facilitate equilibrium calculations of contract settings, however, make the use of levelled commitments more difficult in domains, where such assumptions may be neither possible nor even desirable (e.g. logistics, production planning, etc.). The most significant assumptions are: (i) an agent does not want to be involved in more than one contract at the same time, (ii) all the contracts available have the same description (the only concern is the contract price) and (iii) the probability density functions of receiving the best outside offers are a common knowledge between the agents. Moreover, the concept of levelled commitments does not state explicitly whether the contract price considered introduces only a profit or if it considers also variable costs on performing activity needed. It rather seems that it introduces a total price of the contract. Fixed costs are seemingly also not considered - if an agent does not make a contract, it does not loose anything, but only does not get what it might get if the contract had been made.

A price of a contract in a real world covers at least following three items: (i) variable costs that depend on a contract size, feasibility issues, etc., (ii) fixed costs that are not related to a particular contract, but are related to the overall business and are to be covered and (iii) intended profit from the contract. A penalty in a real world seeks to cover at least a portion of fixed costs and also the profit lost. While the calculation of variable and fixed costs, resp. profit lost, is rather pragmatic, setting of the intended profit is more strategic or even speculative with dependence on many aspects (e.g. experience with the second party, various social relations, the first-party profit eagerness or “good manners”). Overall the setting of a contract price and a penalty may predetermine acceptability of such bid for the customer, i.e. fruitfulness of the contact. Although in a real business the partners often do not build explicit social and business models of a business world in order to set up their mutual contracts, they use them implicitly: their reasoning is affected by experience, non-written rules and actual business intentions. In order to provide an agent by reasoning capabilities needed for contracting (i.e. automated negotiation) we use explicit models of the other agents' social and business behaviour. Thus, the agent may determine profitabilities and risks of the incoming contract offers and may decide for the best business from its point of view.

Our work proposes means for fully distributed contracting in competitive environments. We focused on the domain of logistics as a part of supply chains and implemented a testbed for contracting as the crucial part of multi-agent cooperation in competitive environments. As a platform we chose JADE (http://jade.tilab.com) that becomes a standard in industry.

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Innovation of Subject "Data Communication Basics"

Pavel Bezpalec, Petr Hofman

[bezpalec|hofmanp2]@fel.cvut.cz

Department of Telecommunication Engineering, Czech Technical University in Prague,
Faculty of Electrical Engineering

Technicka 2, 166 27 Praha 6, Czech Republic

For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was to innovate educational process in subject "Data Communication Basics" in practical courses as well as in theoretical lectures.

1. Innovation of practical courses

Main work has been done in innovation of practical courses. Refreshed practical courses syllabus contains theoretical workshops as well as four practical tasks.

Task 1 Data channel – analog property
Task 2 Modulator – simulation and analysis
Task 3 Telegraph distortion measurement
Task 4 Basic communication protocols

1.1. Innovation of theoretical workshops

Five theoretical workshops consist of segment of theory and segment of simulation. Simulation should enrich educational process with demonstration of behavior theoretically known methods and principles.

Simulations are mainly in a manner of

- security codes
- cyclical codes
- Trellis code modulation
- detection, eye of conclusion
- telegraph distortion

All simulation has been written in Matlab Simulink.

1.2. Innovation of practical tasks

All input study materials for practical tasks have been innovated and transformed into Internet—ready form and then published to server that belongs to our department (www.comtel.cz → Předměty → 32ZDK → Materiály pro výuku) and therefore are easily accessible by students.

Innovation of Task 1 – new cables and data distribution box of data channel demonstration as well as material and tools to successful task realization (cables, connectors, pliers and punch tools) has been bought, repaired and re-measured.

Innovation of Task 2 – new TIMS (Telecommunication Learning Environment) has been bought. TIMS can simulate all stages of work process of all modulator types.

Innovation of Task 3 – new test device that realize real cables has been developed to fulfill easier method of measuring and oscilloscope displaying

Innovation of Task 4 – new simulation device for basic data communications analysis equipped by modules for detailed analysis of all basic physical and data-link level protocol (included V.24, V.28, ISO 1745, HDLC, LAB-x …) has been bought.

2. Innovation of theoretical lectures

The revised basic of telco knowledge that has been deeply studied has extended a spectrum of lectures. Mainly English written literature has been translated into new lecture base that is in form of MS PowerPoint presentation. This chosen format is able to show new concepts with animated explanation. This is more didactical. An electronic form of new lectures has been placed on Internet (www.comtel.cz → Předměty → 32ZDK → Materiály pro výuku) and therefore is easily accessible by students.

3. Conclusion

Main goals of subject innovation are:

- New knowledge implementation.
- New simulation implementation in theoretical workshops.
- Workplace innovation for practical tasks.
- Practical tasks optimization and material, tools and device complementation.
- New study material creation for theoretical lectures.
- All study material is in electronic form of presentation.
- Motivation of IT students to study modern telco technologies.

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Simple Gossip Algorithms

M. Šoch

soch@sun.felk.cvut.cz

Dept. of Computer Science and Engineering, Faculty of Electrical Engeneering, CTU,
Karlovo nám. 13, 121 35 Praha 2, Czech Republic

Parallel computing is still very modern approach for solving large and time-consuming problems. Users can use parallel computers with shared memory or machines with distributed memory. Modern and cheap systems are designed as clusters of workstations that are based on distributed memory approach. At these systems data exchange is possible by communication algorithms only.

Collective communication operations frequently occur in parallel computing, and their performance often determines the overall running time of application. One of the fundamental communication problems is gossiping (also called total exchange or all-to-all non-personalized communication). Gossiping is the problem in which every processing unit p wants to send the same packet to every other p. Said differently, initially each of the n processing units contains an amount of data of size h, and finally all processing units know the complete data set of size $n*h$. Gossiping is used in all applications in which the processing units operate autonomously for a while, and then must exchange all gathered data to update their databases. Many aspects of the problem have been investigated for all kinds of interconnection networks [2].

Complexity of gossiping algorithms strongly depends on communication model representing communication subsystem of parallel computer. We know a lot of different communication models. Very common is the telephone communication model. In this model, a processing unit can communicate with only one of its neighbors at a time, but it can both send and receive during this communication. In this paper we assume this communication model. We also assume that in one communication round two communicating processing units can exchange all available data. This is called the unit-cost model, which is considered in most theoretical papers on gossiping.

Design of gossiping algorithms also depends on type of communication network. We know a lot of networks such as hypercubes, meshes, tori, etc. One intereting network is the wrapped butterfly. Hence, we are considering wrapped butterflies, *wBF*. They form a parametrized class of networks. The k-th network has $k*2^k$ nodes of degree 4. The nodes are indexed by two-tuples (i,j), $0 \le i \le 2^k-1$ and $0 \le j \le k-1$. They are connected by straight and cross edges. Straight edges connect nodes $(i,*)$ into i lines. These lines are connected by cross edges. Nodes $(*,j)$ we call rows.

In the unit-cost telephone model we are considering, giving a gossiping schedule of length l, amounts to giving a sequence of l matchings: matching i gives the set of edges that are used in communication round i. In our case we will work with a small set of matchings M_i. To represent a long regular sequence of such matchings, we use the following notation for regular expressions. A term $[x]^k$ means that x is repeated k times. A term $\{xy..\}^k$ means that the regular expression is starting with x, is of length k, and is composed from x and y which are used alternatingly. A term $\{..xy\}^k$ means that the regular expression is ending with y, is of length k, and is composed from x and y which are used alternatingly.

Even more, for gossiping we define two following operations: Going-straight down or up means using only straight connections, moving up or down. Distance x is covered in x rounds. Braiding up or down means using alternating using straight and cross edges, moving up or down. A distance x is covered in $2*x$ rounds.

For gossiping in wBF_k we use four matching, covering all edges of wBF_k exactly once. We denote them as follows: M_0 contains all edges between *(i,2*j)* and *(i,2*j+1)*, M_1 all edges between *(i,2*j-1)* and *(i,2*j)*. Hence, together M_0 and M_1 contain all straight edges. M_2 contains all edges between *(i,2*j)* and $(i+2^i,2*j+1)$, and *(i,2*j+1)* and $(i+2^i,2*j)$, M_3 all edges between *(i,2*j-1)* and $(i+2^i,2*j)$, and *(i,2*j)* and $(i+2^i,2*j-1)$. Hence, together M_2 and M_3 contain all cross edges.

Gossiping in wBF_k, $k \geq 4$ and is even, can be done in telephone model in *5*k/2-2* rounds using $[M_0M_2M_1M_3]^{k/2-1}M_0M_2M_3\{M_1M_0..\}^{k/2-1}$ that improves result presented in [2].

Wrapped butterfly *wBF* is vertex symmetric network. It is possible to describe gossiping for any node and due to this symmetricity this description holds for every node. Without loss of generality, we describe gossiping for node *(0,0)*. Gossiping starts by braiding using sequences M_0M_2 and M_1M_3. Each of these sequences doubles number of informed nodes on every next row. After *2*k-2* rounds braiding stops. In this moment matching M_3 is used which caused that one complete one row is informed by packet from source node *(0,0)*. More exactly, all nodes at row *(*,k-1)* are informed. Going-straight operation continues. Packet is distributed by matchings M_1 and M_0 in next *k/2-1* rounds until all nodes are informed. All together we need *2*k-1+1+k/2-1=5*k/2-1* rounds.

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Concept of Web Site with Information about Geodata Sources on Internet

P. Tryhubová

p.tryhubova@sh.cvut.cz

Department of Geodesy and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

We meet GIS on Internet more frequently these days. This is mainly because of increasing number of Internet users (due to dropping prices) and the fact that data publishing on Internet allows quick availability of up-to-date GIS data usable for many users. Thanks to development of miniaturisation of electronic systems GIS data come closer to users. We can find GIS systems in communicators, mobile phones, PDAs etc. Geodata and geoinformation become available in real time anytime and anywhere. It is important to focus on processes of data mining, storing, refreshing, analysing and presenting of geodata. It is necessary to sort geodata, improve methods of searching in geodata, centralise the access to geodata. Map portal is the solution. The goal of portal is to make the searching of spatial data easy and intuitive.

Similar projects run in the world. Project that is sponsored by Office of Management and Budget – OMB runs in the United States and can be seen on web pages http://www.geodata.gov/gos. There is a portal http://eu-geoportal.jrc.it/ in Europe. European geoportal allows the access to spatial data created from initiative of INSPIRE (Infrastructure for Spatial Information in Europe). Both projects are similar. Both offer interesting solution, clear, easy to use searching of database, transparent presentation of information.

The best-known server about available geodata in the Czech Republic is system MIDAS (http://gis.vsb.cz/midas/). MIDAS contains metadata about existing information sources in the Czech Republic. Upload of data into MIDAS is so complex that the database often contains old data. Most of the web portals have the same problem with keeping data up-to-date.

From the reasons presented above I have decided to focus on problem with up-to-date information presented on server. Similar project works on department of mapping and cartography, Faculty of Civil Engineering, Czech TU Prague in Laboratory of Photogrammetry. They work on project of Database of relics that consist of photos of historical monuments. Students provide actualisation of database during their study http://lfgm.fsv.cvut.cz/photopa2003/. They keep data up-to-date and insert also new data. I want to use the same principles in my project.

Database consists of eight tables mostly connected by relation 1:N. Functional core of application is created by table with records of geodata providers and related tables with detailed information about downloadable data, databases and map application that service provider publish on his web site.

Four types of users with different rights will access the server: visitor, student, teacher and programmer. Visitor´s access is the easiest one. User can only browse the web pages, search data according to prepared criterion or define own search.

There will be an easy menu on the first page: Data categories, Search, about project, Information center, How to insert link, Entrance. There will be possibility of search on this page using the key words and graphical search in map application.

When user clicks into map, system will find web page of company that presents geodata in selected area. Searching will be enabled all over the world; detailed searching will be enabled for the Czech Republic. Map application will contain schematic maps of the whole world with contour of states and schematic map of the Czech Republic with contour of districts. User can write key word in the form in the Search part. Search will be optimized for speed by restricting of searching area by some properties e.g. searching only in selected categories, places of interest, searching according to availability, searching according to map type (map application, data, database), searching according to payment (free data, payed services), searching due to last change, searching due to date of map creation. Students will use the form for entrance into the application on the first page. They can create new links or change present links inside the system. They will log in using the user and password used in the school system KOS. System KOS is managed by Computer administration center and is primary used to support study agenda at Czech technical university in Prague.

Teacher will also use the KOS system to log into the system (using user and password that they use in the university for other services). Teacher will check links and filled forms from students and he/she will check the field authorized or unauthorized. Authorized data will be added to web and send information to student about successful finish of his/her job and possibility to pass the exam. If the page visitor adds the link, information will be sent to him/her about accepting his/her link. Teacher will approve or not approve link that was added by visitor in section Add link. If approved the system will send the link to the student's section New links and email with text:"Your link was accepted for processing" to the visitor.

Structure of presented web portal allows transparent and easy searching of information about geodata not only for the professionals, but also for user without any experience and knowledge in the area. Author analyzed the situation and created a concept of web portal that allows presenting of information, logical sorting and possibility to have all data on one place. Structure of suggested portal reflects different points of view on sharing geodata. We talk about point of view of geodata providers – commercial and free data and also point of view of users – how the data should be used and from the side of territory – what place do they need data from.

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Image Quality in Applied Multimedia Systems

M. Klíma

klima@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The subjective image quality is a critical issue in multimedia systems. The final evaluation is given by the Human Visual System (HVS) therefore technical image characteristics are of the second-order importance. There has been a long-time extensive effort to objectivise the subjective image quality measures in numerous laboratories worldwide. One of the most important applications of such a psychovisual model is the image coding field. We have experienced similar approach in the audiocoders. The psychoacoustic model allows optimizing the audiocoding procedure and evaluating a final image quality prior to the transmission. The psychovisual model is far more complex because of the information amount processed in the HVS. In terms of [1] we have studied selected aspects of subjective image quality in the applied multimedia systems such as security, visual supervision, astronomy etc. [2] including the study of HVS models suitable for the image quality evaluation [3] and our activities in this field continue further.

So far the most efficient and generally applied approach is the quality evaluation by a group of observers e.g. according to the Rec. ITU-R BT500. We have developed, equipped and tested the special observation workplace in order to get independent image quality reference evaluation and the results have been compared to the quality evaluation provided by the HVS models. The test workplace is equipped with the professional TV monitor SONY and the observation conditions are defined according the above mentioned ITU-R Rec.(background illumination, monitor peak brightness etc.).

The image quality can be seen from various aspects. The first one – mostly applied – relates to natural images (pictures) and their general quality degree. Most of image compression techniques and standards are optimized from this point of view. In applied multimedia imaging systems the quality can be defined in a different way. As an example we have tested a set of selected security images such as car-plates, faces etc. In these cases the critical issue is a correct identification of recorded alphanumeric chain. During extensive work we have demonstrated various mechanisms of image degradation esp. image compression and noise addition. The image compression has been selected as the most important tool in recent imaging systems. In order to achieve very high compression rates the lossy image compression techniques are implemented [4]. The lossy compression causes some distortion and artifacts affecting the overall image quality. Among many possible approaches we have tested selected compression techniques (DCT, WT, suboptimal KLT) and compression standards (JPEG, JPEG2000, LuraWave, MPEG-2, MPEG-4 and H.264/AVC both for still pictures and videosequences. As the image quality measures the identification threshold has been evaluated as a function of bitrate. The tested compression packages have been finally compared.

The other part of activities have been focused to the improvement of perceived subjective image quality through an introduction of specific distortions. Some of these techniques are long-time known and widely applied (edge sharpening, color saturation) but

some detailed quantitative evaluation is still missing and the correction is set intuitively. As the first step the edge enhancement is tested. The critical problem is a definition of suitable correction degree or correction measure. The image editing packages offer a wide set of possible edge enhancing tools (HP filters, unsharp mask etc.) and the expected measure could be method-dependent. In some cases the enhancement is rather complex procedure with numerous side effects affecting the final subjective image quality – e.g. the edge enhancement is accompanied with lowering of signal-to-noise ratio. The other question is a selection of suitable color space for the image representation (RGB, Lab, etc.) and selection of subjectively relevant channel (e.g. L for the edge enhancement, chrominance for the quantization noise filtering etc.).

It has been verified that the MSE or PSNR as objective measures of image quality are of limited use. The temporal and spatial filtering properties of HVS including higher-order effects such as masking affect significantly the final perception of image and much more complex criteria have to be used. So far the subjective observer tests cannot be replaced by any HVS model. If so the variety of test images and distortion mechanisms have to be strictly limited. On the other hand this very complex multiparametric interdisciplinary topic has significant impact on the final image quality and consequently QoS. Especially in the case of security images the relation between the subjective quality degree and e.g. identification threshold depends strongly on the image content (background).

Future activities will be concentrated on a study of possible and suitable combination of image-degrading (unavoidable) and image-improving (implemented) mechanisms in order to achieve an optimum system qualitative performance. From this point of view the edge enhancement seems to be one of the most important and it will be studied extensively. The critical issue is an implementation of HVS model as a part of image coder in order to assess the subjective quality in advance and to optimize the coding procedure parameters. We plan to study the impact of most of recent image codecs both for still-pictures and video sequences as JPEG2000, DIVX, WMP, QuickTime, RealPlayer etc.

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Wave Propagation in Plasma and some Aplications

V. Kaizr

Kaizr@aldebaran.cz

CTU, Faculty of Eletrical Engineering, Department of Physics, Technická 2, 166 27 Prague 6

The study of interaction between a laser beam and magnetized plasma is very important for the next use of the laser beam to improve the ignition fusion. We operate three experimental devices: Z150, S300 and PF100. Z150 is placed at the FEE CTU, its parameters are: maximal current 70 kA at the time 700 ns. S–300 device is placed in Moscow (Kurchatov institute): current 3 MA at the time 100 ns. The third experimental device marked as PF 100 is situated in Warsaw. The basic parameters are: maximum current $1{,}5 \div 1{,}8$ MA, electrical energy $600 \div 650$ kJ.

We estimated conditions for propagating of the laser beam through inhomogeneous plasma in magnetic field. The system of the Maxwell equations for homogeneous cold plasma can be reduced to an algebraic system of equations [1]:

$$\begin{pmatrix} N_{\square}^2 + N_+ N_- - \varepsilon_+ & -N_+^2 & -N_{\square} N_+ \\ -N_-^2 & N_{\square}^2 + N_+ N_- - \varepsilon_- & -N_{\square} N_- \\ -N_{\square} N_- & -N_{\square} N_+ & 2N_+ N_- - \varepsilon_{\square} \end{pmatrix} \cdot \begin{pmatrix} E_+ \\ E_- \\ E_{\square} \end{pmatrix} = 0 \quad , \tag{1.1}$$

where $\varepsilon_{\square} = 1 - \dfrac{\omega_{pe}^2}{\omega^2}$, $N_{\sigma} = \dfrac{N_x + i\sigma N_y}{\sqrt{2}}$, $\varepsilon_{\sigma} = 1 - \dfrac{\omega_{pe}^2}{\omega(\omega + \sigma\omega_e)}$,

N ... refractive index, ω_{pe} ... plasma frequency, $\sigma \equiv \pm$, ω_e ... cyclotron frequency.

Electromagnetic waves near a critical surface, it is the boundary between plasma with low and high density, are very strongly refracted. We would like find a chance how to use the laser beam as a diagnostics one or to heat up plasma in experimental devices (Z 150, S–300, and PF 1000). If we use system of equations (1.1) and make standard mathematical operation, we can obtain following dispersion relation:

$$N^2 = \varepsilon_{\sigma} - \frac{\varepsilon_{\sigma}^2}{\varepsilon_{\square}} \theta^2 \quad , \tag{1.2}$$

$$q_e = \left(\frac{\omega_{pe}}{\omega} \right)^2 , \tag{1.3}$$

where θ is an angle between wave vector and magnetic field vector. We analyze dispersion relation (1.2) for several angles θ. The dispersion relation is calculated as dependence of N^2 (1.2) on parameter q_e, for the left and right-handed polarization waves.

In the case, when the angle θ is equal zero and the cyclotron frequency is lower than the plasma frequency, the dispersion relation is relatively similar. We can find one resonant frequency (left-hand polarization wave) and two cut–off frequency (right- and left-hand polarization wave). If the cyclotron frequency is greater than the plasma frequency, the situation is a little bit complicated.

In the case the angle θ is not equal to zero the dispersion relation gives complicated solution [4]. For example, if we use angle $\theta = 0,2$ rad and the device's and plasma parameters ($I = 40\,\mathrm{kA}$, $n = 10^{23}\ \mathrm{m}^{-3}$, and radius of the load $r = 0,1$ mm, we solve the cyclotron frequency $\omega_{ce} = 1,42\times10^{13}\ \mathrm{s}^{-1}$ and the plasma frequency $\omega_{pe} = 1,42\times10^{13}\left[\mathrm{s}^{-1}\right]$**.** The solution we divided into two parts: right–handed and left–handed polarization.
Left–handed polarization wave: plasma is transparent in these ranges of laser light frequencies: $\left(0 \div 1,53\times10^{13}\right)\mathrm{s}^{-1}$, $\left(1,69\times10^{13} \div 1,79\times10^{13}\right)\mathrm{s}^{-1}$ and $\left(2,64\times10^{13} \div \infty\right)\mathrm{s}^{-1}$; plasma can be heat up at the frequencies $1,79\times10^{13}\ \mathrm{s}^{-1}$ and $1,42\times10^{13}\ \mathrm{s}^{-1}$.
Right–handed polarization wave: plasma is transparent in this range $\left(3,53\times10^{15} \div \infty\right)\mathrm{s}^{-1}$. There is no resonant frequency in this case.

The results of transparation and absorption of the laser beam were calculated for more angles and more parameters of above mentioned experimental devices in [4].

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Automatization Measuring Induction Motor "Omega - 2006"

V. Hlinovský

hlinovsk@feld.cvut.cz

Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Computerized support search examination induction motor „Omega 2006"

Measuring system is found on apparatus system Tektronix series TM5000 controlled data interface GPIB-AT from National instrument from computer PC. Whole system is managed interactive programmer „Omega 2006", which be created in environment „LabWindows CVI 7.0" in language „C++". Simple interactive in a way programmer choke database service capacity funds metering machinery and amends is record single metering search examination induction motor according to CSN 35 0300.

Programmer governs personal examination and pursues collection measured data, which subsequently evaluate to the requisite resulting tables, explicit funds and depict requisite graphic dependencies. Program output is entire search record induction motor and database resulting funds and characteristics recourse function detailing substitution diagram checking motor, applicable for resulting computerized simulation and setting movement control element v modernist a.c . drive.

Programmer is calculated for metering of those examinations search record, that are fit for automatization and supports computer. Among basic examination belong to according to CSN 35 0300 following metering:

Metering winding resistance behind cold state
Current measurement and losses no load
Current measurement and losses in short for a span
Metering range characteristics machinery solo
Metering operating characteristics – check power factor and come into operation
Metering static moment characteristics
Metering start machinery
Metering warming machinery
Calculation circular (turbojet) diagram

Other examination at lump and small-lot production is not already fit for automatization with direct supports computer, for example examination enclosed tension, insulation resistance test. These kind examinations pursue standard method; utilize modern apparatus and setting needed information on effected examination interactive in a way to the computer ori production test report.

Metering static moment characteristics:

Metering operating characteristics proceed according to CSN 35 0301, when be in at metering machinery metering static torque characteristic at decrease supply voltage U1 = 30 – 40% Un. At examination metering U1, I1, P1, f1, n, M. Number metering map point get past opt for 15 and 25 point. During metering get past several times metering machine relieve (idling cycle) and bring to all parts arose heat energy to the whole machinery, if need be him hard cool so to during whole course metering was warming machinery preferably constant. Stable equilibrium temperature is some from basic presumption for correct metering and obtaining requisite resulting funds.

Table measured and rated funds includes U1, I1, P1, M, Md, with, n and tables explicit value for check turbojet and moment overload capacity, which prescribe norm CSN.
Evaluation measured funds transaction by the help of substitution diagram, which solving by the help of power balance-sheet machinery. In contradistinction to metering operating characteristics come next metering static moment characteristics general mathematical description last two parameter substitution diagram show resistance armature winding R2' and leakage reactance X2sf' representative here part leakage reactance rotor perimeter, which depend upon frequency f2. In measuring range at slippage from 0 to the 1. Calculation proceed also iterative methods, when in first step value input in a state of outweighed machinery - idling cycle and in next steps always quantity specify and step by step pursue calculation static moment characteristics v range measured data. Computer algorithm agree bye calculate operating characteristics. At metering in solid range slippage moment characteristics it can be also mathematically describe moment auxiliary losses v rotor indoor by rote Md2. So as could auxiliary losses easily recalculating on other strength of current and angular rate, introduction we are conception referential auxiliary losses, like appreciate auxiliary losses at rated current I1 and synchronous speed w1.

$$Pd2 = Pd2ref * (1+ew) * (I2/In)2$$

This way defined auxiliary losses sheltered industry mechanical agree with our requirements for calculation of all characteristics for arbitrary tension U1, frequency f1 and temperature t metering machinery.

Metering start machinery:

Single parts search record except basic static examinations is metering start up, which it is one o'clock from basic dynamic examinations. This examination is exacting on gauging techniques. It is necessary data engagement-book for time entry metering quantity. System “Omega 2006” exploitation digital oscilloscope Tektronix TDS3014 tetra entry channel and recording size 10000 exhibits on each sewer. System set oscilloscope to the requisite recording regime and governs course examination. During metering is provided time entry course virtual value U, I, P, n. Longitude start is necessity opt for with reference to on size metering quantity during start and his rate. Is necessity take consideration, that using inverter have transient settling time after step unit on entrance straight approximately 300ms. With reference to in length start and fluent changes metering quantity are using inverter virtual value suitable.

After measured time dependence course speed mathematically make into time behavior mechanical engine moment. Calculation moment is given basic relation

$$M = J * dw/dt + Mm$$

In computer algorithm is necessity first carry out digital filtration course measured speed and only with that reckon derivative. Unwrought signal be amiss for direct evaluation

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Telecommunication Network Simulation

Lukáš Konopka, Ondřej Hudousek

konopkl@fel.cvut.cz, hudouso@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,
Czech Technical University in Prague, Technická 2, 166 27 Praha 6 – Dejvice

Telecommunication networks may be described by mathematical model of interconnected service systems. These systems may be described by mathematical equations with respect to some simplifying presumptions. In order to approach to the reality the plenty of systems are required. Unfortunately, with increasing number of systems the derivation of mathematical equations is difficult if not impossible. Then the only solution is a simulation.

Unfortunately commercial simulation programs are usually very expensive and therefore for education purposes unreachable. Main aim of this project was to establish simple universal tool that would have been useful for education and science research of students. The great emphasis would have been insisted on modularity of the program.

Telecommunication Network Simulation (TSIM) is the simulation program of interconnected service systems. Following systems according to Kendall's classification are supported: M/M/N/0, Ek/M/N/0, Hk/M/N/0, D/M/N/0 and U/M/N/0. Other service systems may be simply added. It means that user defined distribution of arrival and departure traffic is supported.

The development has been focused on modular solution with respect to future modification according to requests of a user. The program consists of following modules:

- ***TSIM***
- ***POSTPROCESS***
- ***TSIDRAW***

TSIM is an application that may be run from windows or command line. It is simulation core that provides simulation of interconnected loss service systems. By default the program uses static routing of traffic among systems but the support for routing algorithms was implemented. It means that a user can easily extend the source code with its own routing method.

The simulation is based on the Monte Carlo method. Input parameters are defined in a file. The input file has the extension *.net. The output from the simulation is the list of events that is stored in an output file. The output file extension is *.sim. Detailed information about structure of files may be found on the web pages of the project [1].

POSTPROCESS is an application that statistically utilizes the output file of TSIM. The probability characteristics like mean value, variance or confidential interval of loss and power are evaluated from the list of events for each line. The main purpose of Postprocess is to offer basic tool for statistical evaluating of results and to verify the correctness of simulation. The program may be rebuilt according to requests of a user. Evaluated results may be stored in a file.

TSIDRAW is a graph drawing tool that is useful for displaying simulated network. It supports features like user defined description of network and exporting topology to an image file. Supported formats are BMP and JPEG.

The correctness of simulation was verified on the example of two exchanges interconnected by a trunk. Let us suppose that the trunk is consisted of 10 lines. The offer of

traffic on the trunk is varying from 5 erl to 10 erl. The mean service time is equal to 120 s. The distribution of service time and the distribution of arrival time are exponential. The question is what the loss of traffic is.

In fact this topology may be described by service system M/M/N/0 where N is equal to the number of lines - N=10. With respect to previous assumption the Erlang's form may be used to determine the loss on mathematical way. It stands

$$E_{1,N}(A) = \frac{\frac{A^N}{N!}}{\sum_{i=0}^{N} \frac{A^i}{i!}}, \tag{1}$$

where $E_{1,N}(A)$ is the loss, A is the offer (mean traffic offered) and N is the number of lines [2]. The evaluation of equation (1) is time-consuming and therefore recurrent form may be used. It stands

$$E_{1,N}(A) = \frac{AE_{1,N-1}(A)}{N + AE_{1,N-1}(A)}, \tag{2}$$

where $N \geq 1$ and $E_{1,0}(A) = 1$. With respect to the equations (1) and (2) the example may be solved. Another way how to solve the example is the usage of TSIM. Results for both ways are displayed in the following table.

Table 1 Results

Dependence of Loss on Offer											
*Link Number 10, Sim. Length = 10000 hod. (1000 Sim. Runs * 10 hod.), mean time of service 120 s*											
Offer [erl]	5,0	5,5	6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0
Loss evaluated [-]	0,0184	0,0293	0,0431	0,0598	0,0787	0,0995	0,1217	0,1446	0,1680	0,1914	0,2146
Loss simulated [-]	0,0180	0,0292	0,0426	0,0595	0,0788	0,0999	0,1226	0,1443	0,1683	0,1909	0,2140
Confindential Interval [-]	0,0004	0,0005	0,0005	0,0006	0,0007	0,0007	0,0008	0,0008	0,0008	0,0008	0,0009
Confindential Interval [%]	1,94	1,57	1,22	1,06	0,88	0,72	0,61	0,56	0,49	0,44	0,40

Let us note that results of simulation and the results of analytical evaluation are with respect to the confidential interval same. This simple example has been chosen in order to verify simulation. TSIM is able to be used as optimalization and dimension tool for networks working on circuit-switching principle. It can be downloaded from the web page of project [1].

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Generating Data for Semantic Web

Martin Švihla, Ivan Jelínek

svihlm1@fel.cvut.cz, jelinek@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering
Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

To enable the semantic web vision of a universal medium of data exchange, the current web resources must be annotated by computer readable metadata. This is not a simple task, because the current web contains a huge number of resources that should be annotated by metadata.

There are many ways these resources can be semantically annotated. Since a large number of web resources are dynamic websites with database back-end, we focused our work into this area. In this paper, describing the results of the FRVŠ grant, we present *METAmorphoses*, a data transformation model that enables the generating of RDF metadata from a relational database according to a given ontology. Our proposal is a system for generating RDF (semantic web metadata format), focused on usability, while being flexible and complex as possible, so that programmers who create web presentations can compose RDF fragments of documents as easily as they compose HTML fragments using Java servlets, JSP, ASP or PHP.

We suppose the following scenario. There is a web presentation, which is grounded on data from a relational database. The semantic web metadata should be created to extend existing web resources. The metadata should be generated from the same database, their format is RDF and there is a particular ontology for this metadata. According to this, the two main prerequisites in our work are: data is stored in a relational database, and we have an OWL ontology that specifies the vocabulary and rules for RDF metadata we want to produce from the database.

In order to achieve a flexible data transformation and high usability, we divided *METAmorphoses* logic into two separate parts that we call the *mapping layer* and the *template layer*. In the mapping layer, a database schema is mapped into a structure of a given ontology. This schema mapping is described by so called *mapping document*, which is serialized in our own XML-based language. The template layer uses this mapping and produces RDF documents in the way driven by templates. Templates are serialized in another XML-based language that we developed for that purpose.

The mapping layer contains all the complexity and flexibility of mapping. On the other hand, the template layer is a simple programmer interface of our mapping model. This architecture has many common points with the MVC model, which brings many benefits to the data-transformation process, as detailed in [1].

Mapping and template documents are processed by the *METAmorphoses* processor, which is written in Java. This processor uses JDBC to connect to a database. The processor itself is a standalone Java library that transforms database content into RDF documents. However, the processor can become part of a Java servlet in order to produce metadata for the web.

According to the mapping model architecture, the processor is also divided into two logical parts - one part processes mapping documents and another one template documents. The process of the data transformation from a database to an RDF document is as follows: when a request for RDF is received, the template processor finds the proper piece of a template. Then it calls the mapping processor, which loads the corresponding mapping and prepares a database query. In the next step, a database is connected and queried for data. When a result set is obtained from the database, a set of fragments is created in the mapping

processor, and sent to the template processor. These fragments are composed according to the template document, and a resulting RDF document is returned as the response.

To make the mapping process simpler, we deployed a mapping editor, the tool that helps to create proper mapping document even for complex database schemas or ontologies.

As a test for our concept, we used the *METAmorphoses* processor in order to extend the web portal of our department with RDF metadata [2]. The web portal of our department presents information about people, publications, projects and education. Data is stored in a relational database and presented as dynamically generated HTML pages. The metadata generated by our system are published on the web. This way, we have two parallel presentations of our department - one consisting of HTML pages for human users and another consisting of RDF documents for computer applications and software agents. These presentations are created from the same data-source, so they carry equivalent information. Both presentations are linked together by references.

We use this web domain, where HTML documents are mixed with their RDF annotations, as a testing environment for further research of semantic web technologies. For example, we investigated the possibilities of a semantic enabled web information retrieval [3].

In the future we plan to make the work with our mapping processor even simpler. The programming interface in the template layer can be improved by incorporating the template document language into a JSP custom tag library.

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Traction Vehicle Control Computer Software Architecture

J.Zdenek

zdenek@fel.cvut.cz

CTU - Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Electric Drives and Traction
Technicka 2, 16627 Praha 6, Czech Republic

1. Introduction

Electric locomotive as complex of electric drives, pneumatic brakes, security devices, engine driver stands and many other parts can be seen from software design point of view as mid-range design problem. Software architecture of computer controlled systems has many modifications and depends on application size, required speed, available design time, budget size, experience of software designer and many other factors. In simple drive systems (locomotive is not the case) with sufficient number of hardware interrupt resources interrupt-background or interrupt-no background system is often used. In more complex systems selected architecture may depend on number of application tasks required. If number of task is from tenths to units of hundreds (say max 255) preemptive RTOS can be used as reliable basic layer to schedule and execute application tasks and to support user inter-task and/or inter-node communication including synchronization. As number of tasks goes high overhead of RTOS runs high extensively too and overall throughput and time response of RTOS can be unsatisfactory. In such design circumstances utilizing of coroutines (cooperating routines) may be good solution with low overhead even if there is excessive amount of application tasks [1], [4]. Such solution requires higher user programming discipline (short action task only because CPU have to be shared voluntarily, no forced preemption is possible etc.)

2. Electric locomotive structural view

Electric locomotive SKODA 93E, 6 MW / 3 kV_{dc} has been chosen as example of typical structure. Distributed control computer (DCC) of locomotive controls three main drives (bogie 1,2,3), slave chopper 3 kV_{dc} / 550 V_{dc} , three ventilator drives, compressor drive, battery charger, all logical devices (contact power switches with electro-pneumatic control), pneumatic brakes of train, pneumatic brakes of locomotive, two engine driver stands including graphic displays and several less important other parts. DCC also implements train speed regulator, cooperation of different brake types, security functions, diagnostics, etc.

3. Software modular architecture

Distributed control computer (DCC) is organized as local computer network with master-slave node access method. Nodes are connected by two serial buses with 1 Mbps speed each. The software is designed as relatively independent modules stacked in layers [2], [3]. Modules are grouped to basic system package (BIOS), network debug and run-time services package (NetBIOS) and finally user (application) software package. In majority of nodes (hw execution units with CPU and memory) application package consists of real-time operation system (RTOS) with dynamic scheduling capability and preemptive behavior and group of user tasks. In nodes which control locomotive drives is instead of RTOS used simple static executive which schedules a few tasks only with fixed time axis partitioning. Network communication services (part of RTOS) are uniformly used in all nodes to support reliable and user friendly transfer of process data.. Master node , display manager and all nodes which

control logical devices utilize RTOS. Details of partitioning of software ref. [3]. DCC has no HDD, software is stored in FLASH file system and is executed from RAM.

4. Real-time operating system (RTOS)

RTOS used is of preemptive type (commercial name TQM D2) with dynamic application tasks registration / deregistration service (Deftask(), Deltask() services). Up-to 32 users application tasks can be registered in parallel. Number of unregistered tasks is limited only by size of memory available. Registered application tasks can be planned by scheduler. Tasks can be planned statically with help of task generator or dynamically by services for manipulation of task plan counter (plan services Activate(), Xactivate(), Wake(), Wakedly(), Wakenxt()). Each task has priority distinct from priority of other tasks. Priority can by dynamically changed (not recommended practice). Task can by cyclic, such task is executed automatically with assigned period. Task can be acyclic too, such a task is executed once and to be planned again one of plan services have to be dynamically used. Task can plan itself by Wake(), Wakedly() or Wakenxt() services or it can plan other task by Activate() or Xactivate() services. Part of RTOS is communication module [3]. This module is modular and independent of scheduler and dispatcher modules, thus RTOS can be efficiently scaled up/down as necessary (e.g. drive control nodes use communication module and no standard scheduler/dispatcher modules). User task communicates with task in another node with help of mail services. Mail services transport user messages in both directions. Mail has two levels of priority in transmit direction in master node (Normal / Express) and 8 level deep FIFO (message queue) in each priority level. In receive direction master mail has 4 level queue for each connected slave. Mail in slave nodes has single priority only and 4 level deep FIFO in each transfer direction [3]. Indication of full/empty queue in both direction is available, to be message based time synchronization implemented easily.

5. Conclusion

Basic features of software architecture of DCC of electric locomotive has been presented. DCC is master slave type, with layered system software modules. RTOS used is of preemptive type with dynamic task registration / deregistration and dynamic scheduling of tasks. RTOS has communication inter-node module based on mail principle with priority message transfer and message queues in both communication directions and both master and slave sides. Sufficiently deep queues highly facilitate timing of user tasks. Presented software is in operation with good behavior and no apparent problems.

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Dimensioning of Service System for Multimedia Services

P. Hampl

hamplp@feld.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The character of the input flow changes with an increasing amount of multimedia services. The most common classical stochastic models suppose an exponential distribution of interarrival times, i. e. the Poisson input flow. This work shows the influence of probability distribution functions of interarrival times, such as the exponential, the hyperexponential, the Erlang's of the order k and the deterministic, on the loss probability of the X+...+X/M+…+M/N/0 service system Kendall's notation [4].

For calculating the analytical solution let us suppose a reliable service system that is in statistical equilibrium with:

- The Q classes of traffic sources. The qth class ($1 < q < Q$) generates traffic flow PCT1 with the intensity λ_q demands per second ($0 < \lambda_q < \infty$) requiring d_q service lines. The flows are independent and demands of each flow are mutually independent as well. The input flow q is represented by interarrival times – random variable – with distribution function $F_q(t)$ and intensity of arriving attempts λ_q.
- The distribution functions of service times are given by the exponential distribution.
- The full availability of service lines: A full availability of service lines is described as follows. If a class q call arrives at the moment when there are fewer than d_q circuits idle in the group, it is lost; otherwise it seizes d_q circuits, even if they are not adjacent.
- The N mutually independent service lines.
- The total offered traffic can be characterised by: $A_q^C = A_q d_q$, $q = 1, \ldots, Q$, where $A_q = \lambda_q / \mu_q$ is the offered traffic for class q on each line.

The analytical solution [3] can be only found for the model M+…+M/M+…+M/N/0 with exponentially distributed interarrival times and is described by stationary probabilities of states $(s_1, \ldots, s_Q)$:

$$P(s_1, \ldots, s_Q) = \prod_{q=1}^{Q} \frac{A_q^{s_q}}{s_q!} P(0, \ldots, 0),$$

where

$$P(0, \ldots, 0) = \left\{ \sum_{0 \le d_1 s_1 + \ldots + d_Q s_Q \le N} \prod_{q=1}^{Q} \frac{A_q^{s_q}}{s_q!} \right\}^{-1}.$$

The loss probability B_i of the ith input flow is given by following formula:

$$B_q = \sum_{d_1 s_1 + \ldots + d_Q s_Q \ge N - s_q + 1} P(s_1, \ldots, s_Q).$$

For systems with other types of interarrival times, such as the hyperexponential (H), the Erlang's of the order k (E_k) and the deterministic (D), the designed simulation program can be used. Results of the simulation for exponential distributed interarrival times correspond with the derived analytical solution [1].

The number of service lines needed for a given probability of loss B_i increases rapidly with increasing variance to mean ratio of the chosen distribution of interarrival times [2]. The losses B_i decrease with raising order k of the Erlang's distribution of interarrival times if the mean value A of offered traffic is constant. This trend is not influenced by the number of service lines. The lowest losses B_i are seen for the deterministic distribution of interarrival times.

The classical approach to dimensioning or determining loss B of the loss system in telecommunications is done by Erlang's theory of an M/M/N/0 service system. The aim of this work is to show significant differences between results of the X+…+X/M+…+M/N/0 service system with a renewal input flow and results of the M/M/N/0 model.

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Pitfalls of Running Error Analysis

T. Zahradnický, R. Lórencz

{zahradt|lorencz}@cslab.felk.cvut.cz

Department of Computer Science and Engineering,
Faculty of Electrical Engineering,
Czech Technical University,
Karlovo náměstí 13, 121 35, Praha 2

Many scientific computations occur in the floating-point arithmetic that maps a real number onto a floating-point number that has to fit into 32b for single precision or 64b for double precision floating-point numbers with an error less than a roundoff unit. Each of the operations during a floating-point calculation has its own error and as we perform more computations, error tends to grow. There are many floating-point errors such as discretization error, roundoff error, and more. One of the worst errors that can occur during the floating-point calculation is a critical cancellation and occurs when we subtract two, very close terms and obtain a number that is close to u. Such number's error gets greatly magnified and calculation could get completely destroyed.

A good numeric algorithm should undertake an error analysis to find out how numerically stable the algorithm is and bound its error in some way. The process of revealing the stability of algorithm can be often sophisticated and we can use a less precious yet simpler error estimates. Such kind of analysis is called Running Error Analysis (REA) [6, 7] that obtains a sharper a-posteriori error bound estimate concurrently with the run of the solution. REA comes from the following equation

$$|x \operatorname{op} y - \mathrm{fl}(x \operatorname{op} y)| \le u|\mathrm{fl}(x \operatorname{op} y)|, \tag{1}$$

where $\operatorname{op} \in \{+,-,\cdot,/\}$, and u stands for unit roundoff, which is 2^{-53} for double precision numbers and $\mathrm{fl}(x \operatorname{op} y)$ is a floating point operation with error ε defined as follows [4]:

$$\mathrm{fl}(x \operatorname{op} y) = (x \operatorname{op} y)(1+\varepsilon), \qquad |\varepsilon| \le u. \tag{2}$$

It can be observed that each algorithm that consists of basic operations can easily be extended to compute running error bound concurrently with its solution and running error bound for all four basic operations that are addition, subtraction, multiplication, and division can be derived [8]. Questionable is how do we derive such running error bound for nontrivial operations such as square root, logarithm, exponential function, sine, and more as they do not consist of basic operations. Some authors [1] assume, that it is natural to assume that (1) and (2) also hold for square root operation. Further will focus on logarithm function only.

Suppose that $\tilde{a} = a + e$, where a is the exact value and e is its error; $\tilde{y} = y + f$, y is the exact result, while f is its error. We also know that $y = \log a$. Consequently we derive:

$$\tilde{y} = \frac{\log \tilde{a}}{1+\varepsilon} \tag{3}$$

$$y + f = \frac{\log (a+e)}{1+\varepsilon} \tag{4}$$

By multiplying (4) by $1+\varepsilon$ and by subtracting and adding $\log(a)$ on the right side we obtain:

$$y + f + \tilde{y}\varepsilon = \log(a+e) - \log(a) + \log(a) \tag{5}$$

$$f + \tilde{y}\varepsilon = \log(a+e) - \log(a) \tag{6}$$

Using Taylor series expansion on the right hand side of (6) we obtain:

$$f + \tilde{y}\varepsilon = \sum_{i=1}^{\infty} (-1)^{i+1} \frac{e^i}{i \cdot a^i} \tag{7}$$

Neglecting higher orders of (7) gives the final approximation of logarithm function bound:

$$|f| \approx u\left|\log \hat{a}\right| + \left|\frac{e}{\hat{a}}\right| \tag{8}$$

An observation is that we need a value of logarithm function to calculate the error of logarithm and that is not desired. The common implementations of logarithm function found in `libm` are based on Remes theorem [5] and usually calculate logarithm bit by bit. To go around the problem without requiring the source code of logarithm function, we have approximated logarithm with minimax appromixation with Chebyshev polynomials on $(2^{-1/4}; 2^{1/4})$ and obtained a rational function that calculates a value of logarithm function in GMP [2] and its part MPFR [3]. This approach decomposes logarithm into a rational function $\log(x) = p(x)/(1+q(x))$, where *p(x)* and *q(x)* are polynomials and x gets mapped onto $(2^{-1/4}; 2^{1/4})$. Such decomposition allows calculating error in a way that it contains basic operations only and can easily derive an error bound. Similar approach could be used for other functions such as sine or exponential function. The undoubtable drawback of REA of basic functions is that we require a value of analyzed function in order to get its error. As we are working in the floating-point arithmetic, the approximation to the analyzed function can match all mantissa bits. Such approximation allows us to make the analyzed function consist only of basic operations and easily perform the REA to obtain the desired running error bound.

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Making ProTools Audio Software Accessible for Visually Impaired

T. Zahradnický, R. Lórencz

{zahradt|lorencz}@cslab.felk.cvut.cz

Department of Computer Science and Engineering,
Fac. of Electrical Engineering, Czech Technical University,
Karlovo náměstí 13, 121 35, Praha 2

ProTools [4] is professional, industry standard digital audio editing software that runs on both Mac OS X and Windows platforms. Generally, software that runs on multiple platforms is often written in a platform independent manner to keep its source code easily maintainable. Choosing such strategy and being OS independent has also its drawback that it contains platform dependent code for its graphical user interface. ProTools does not use many system widgets and prefers custom widgets to the system ones as system does not provide widgets that would match behavior and appearance of mix table widgets, and other audio related interface elements. Mac OS X has always had a support for users with disabilities through accessibility technology that got greatly enhanced with its version 10.2 and as of its version 10.4 provides VoiceOver technology [1] that extends even more the possibilities of accessibility to provide a fully spoken user interface. With the help of VoiceOver technology, visually impaired user who might be blind, color blind or have a low vision is able to navigate and control an access-enabled application without a mouse with just a keyboard. Hence ProTools uses mostly custom widgets in its windows that do not follow the accessibility protocol, VoiceOver cannot be used to navigate and/or control its windows contents, and visually impaired users are hardly able to use ProTools. To work around this problem, ProTools can be made accessible with a plug-in or external code injection such as mach_inject [5, 6] with a combination of mach_override [5, 6] if necessary. Mach_inject performs code injection and uses mach kernel APIs [3] that use virtual memory APIs to allocate memory in a task, then copy a program to be executed into that memory, follows by creating a c-thread in that task, and sets that thread's execution state including its initial settings for registers such as stack pointer. Finally, the program counter for the new thread is set to the start of the copied code and thread execution starts. With such mechanism we are able to get remote code running in target task and can perform necessary adjustments to the GUI.

Accessibility is provided by means of an assistive application which's purpose is to help the user to interact with other applications on user's computer. In order to provide this functionality, assistive application must be able to obtain essential information about widgets in application it provides access to and accessed application must provide the required information via the accessibility protocol. Each user interface element, a menu bar, a window or a button, for example is as of Mac OS X 10.2 represented with an accessibility object. The Mac OS X accessibility model represents application's user interface as a hierarchy of objects and allows one object such as a window or a view to embed another objects such as buttons, text fields, or other views. Such hierarchy allows the assistive application to easily traverse all objects in application's user interface and provide appropriate guidance to the user such as speak the name of the object that is currently focused. Accessibility objects can also perform actions specified by their name and a typical action of a button, for example, is being able to press itself and behave the same way as if the user clicked on the button with a mouse.

Since ProTools uses the system menu bar, its menu bar is automatically accessible and the problem reduces to make ProTools windows' contents accessible. Assuming that we can

safely distinguish one ProTools window from another, it is possible to provide accessibility for visually impaired users by covering each of ProTools windows with a set of rectangles that will float over ProTools widgets and provide required accessibility options, while observing the state of the real widgets that are not accessible. Covering windows by rectangles can be used to cover widgets of not only ProTools but also of their plug-ins that can use their own widgets perhaps based on the widgets provided by ProTools. Doing so does not require deep understanding of how these widgets internally work unless we need to read some state information from a particular widget. Getting into view hierarchy may be difficult as one view can embed several other views and it does not need to make sense to cover particular "container" view(s) for accessibility purposes and let VoiceOver cursor stop on such widget as such views have just embedding purposes and no other functions. The most problematic part of ProTools software from the accessibility point of view is the mixer window, and ways of changing inserts that are realized as mix table plug-ins. The rectangles in a form of system widgets, let's call them AXViews, can be subclasses of HIView [2]. HIView is an abstract class that serves as a base class for all system widgets and utter most of system widgets in Mac OS X conforms to the accessibility protocol therefore it is easy to use VoiceOver or an other assistive application to control them. AXView defines methods required by HIObject (the base class of HIView) that includes its construction, destruction, initialization, and also methods required by HIView such as control part matching, drawing, focusing, and hit testing. Note that AXView does not actually need to perform any drawing, as it is fully transparent even to mouse clicks because its purpose is to serve as a proxy widget for accessibility purposes only. Besides these methods, AXView conforms to Apple's accessibility protocol that makes it compliant with VoiceOver and responds to its queries about the structure of the widget. AXViews should also provide an action "click" which synthesizes a mouse click at itself. Either real or synthesized click on AXView, as it is transparent for mouse clicks, is expected to pass through it and reach the original ProTools widget that lies beneath and the same thing happens as if the user clicked the widget with a mouse.

Making ProTools software accessible increases its user base and enhances the overall user experience and helps visually impaired people who work in audio processing. Access-enabling an application removes the necessity of using mouse for all kind of tasks such as insert plug-in choice and may lead to a faster workflow with that application.

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Evolution and New Solution Laboratory System "Bathyscaphe"

J. Jirkovský, J. Podstata*

jaroslav.jirkovsky@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

*Department of Instrumentation and Control Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Introduction

Recently it has increased want of new laboratory models which enable practically testing all learned types of control methods and realization new methods. This article handles about development hardware (laboratory model) for education and testing as classical so higher control methods. The described system is the part of laboratory of Automatic Control on Faculty of Mechanical Engineering on Czech Technical University. The main goal for development undermentioned model was creation safe, mobile and reliable laboratory model which enables students of Automatic Control practical testing fundamental principles such as PID regulation, two-steps regulation, regulation with subsidiary regulated magnitude, etc. From above-cited reason was designed new laboratory system "Bathyscaphe".

Principle

The controlled position of float in water column is main principle of this system. It is based on Archimedes' principle. There is changed pressure inside column and volume of air is changed inside the float. Lift force is changed by volume of air. The balance of the lift force and the gravitation force is the most important for motion of the float.

History of evolution

The "Bathyscaphe" system has being developed for six years and a three thesis was made on this system. Now there is described brief history of evolution of the "Bathyscaphe" system.

In 1999 the first version of the "Bathyscaphe" system was made. It was consisted of a glass tube and a metal frame. The pressure of air was controlled by change of voltage which supplied a compressor. The pressure wasn't measured. The position of the float was measured by infrared sensor. The "Bathyscaphe" system was controlled by PC. The laboratory card was used in the PC. "Bathyscaphe" was controlled by using MATLAB-Simulink without users software.

In 2003 the second version of the "Bathyscaphe" system was made. It was consisted of a plexiglass tube and a plastic base. The pressure of air was controlled in the same way as previous version but the pressure was measured. The position of the float was measured by optical sensor. The "Bathyscaphe" system was controlled by programmable controller Tecoreg without PC.

In 2004 the third version of the "Bathyscaphe" system was made. It was consisted of a plexiglass tube and a new plastic frame. It provided easier portability because everything was

fixed at the one frame. The float was made more robust. The pressure of air from compressor was controlled by low-pressure valves which were operated by 180° servo-motors and gear with ratio 7:1. The pressure was measured. The position of the float was measured by the help of accurate ultrasonic sensor. Signals were recorded to PC by the help of serial communications interface RS 232 to MATLAB-Simulink. There is used user software for easier control.

In 2005 the fourth version of the "Bathyscaphe" system was made. The construction of this was the same as previous version. But there were some important improvements.

New solutions

By reason of more reliability was changed low-pressure valves control. The plastic gear was replaced by gear clutch. The servo-motors with turning 180° were replaced by servo-motors with turning about 2500° (i.e. about 7 turns). This solution is better than previous solution with gear because servomotor, clutch and valve have got common axis. By this was prevented existence of undesirable powers.

The older versions of “Bathyscaphe” had got stuck bottoms. It was problematic for maintenance. New solution of bottom is completely demountable. The bottom is consisted of two plastic companion parts and o-ring.

Also the user software has been modified. There has been added some functions which make possible more using for education. Software is very easy for using because there are only buttons and sliders for control. These are split to the four groups in the main window. First of them is used for setting of regulator. The next one is used for complete operating of demonstrated regulation. The third part is used for saving of results. The last part is used for graphs and visualization.

Conclusion

There were made five pieces of “Bathyscaphe” system in 2005. One of them will stay in laboratory 111 on Department of Instrumentation and Control Engineering in CTU and the next four will be sent to other four universities in Czech Republic.

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Internet Information Portal for the Nuclear Science

J. Klusoň, Z. Berka

kluson@fjfi.cvut.cz

Department of Dosimetry and Application of Ionizing Radiation, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University,
Břehová 7, 115 19 Prague 1, Czech Republic

The goal of the presented project was to form a non-profit and widely open unique internet portal for the nuclear sciences, application of the ionizing radiation and power engineering, nuclear safety and law, etc. The main portal content comprise popular and professional articles, short news, discussions, information, offer of job opportunities, educational section, etc. and serves as the source of information and the discussion platform for the public as well as professionals. Portal wants also to offer the well-arranged and commented interface to the departmental web-pages (Czech and international). Portal provides also basic services for non-profit professional associations (e.g. web-hosting). Universal conference internet interface will be available as well. Portal [1] internet address is *www.jaderne.info*. Project of the portal is fully opened for the cooperation, contributions and help of the professionals, students and public as well as schools, institutions, organizations and associations working in the portal scope scientific and technology fields.

Portals main thematical scope is oriented on the fields of the nuclear science and technology, (non)ionizing radiation and particle physics, spectrometry, dosimetry and metrology, application of ionizing radiation in the science, technology, medicine and industry, radiation biological effects and radiation protection, nuclear physics and power, nuclear safety, radioactive wastes treatment and the similar subjects. As academic project, portal makes effort to address namely the students of secondary schools and universities. Portal operation is supported by a group of volunteer co-workers and students of FNSPE. In the matter of content the portal depends on contributions from cooperating professionals and institutions working in this scientific field and portal visitors/readers. In the future we would like to attract the more participation of secondary schools and university students.

Portals primary language is the Czech, but contributions in English or other languages are welcomed as well. The special section “Foreign contributor’s window” was opened for better communication with readers and contributors from our foreign partner universities, as well as for any other foreign visitors. Also the sections of the “Contacts” and “Guest book” are available in English in this moment. Portal is ready to prepare the English versions of the selected sections in agreement with future interest of the foreign visitors.

Portals activity is based on the *statute* and is managed by the editorial and scientific board. Scientific board guarantee the professional level and general profile of the portal, is able to review contributions, moderate more special discussions, prepare answers for the sent visitor’s questions, etc. Editorial board is responsible for the portal technical operation, design and pages structure, content regular updating, basic communication with visitors and cooperating organizations, etc.

Portal offers the basic services for the non-profit subjects (government groups, interest and professional associations, students associations, etc.), currently e.g. web-hosting, based on the TYPO3 [2] content management system with user-friendly web interface access to the managed web pages. Two professional associations (SOZ and ČSFM – see cited portal [1])

use currently this services. Prepared is also the universal conference internet interface for conference registration, information distribution, abstracts/papers management, etc. The 10th European ALARA Network Workshop is currently serviced on the portal pages (see *alara06.jaderne.info*).

Technological background of the portal is based on the power PC server connected to the fast academic data communication network and operated on the Linux operating system (the Debian free distribution). Web services are supported by the free software containing the Apache web-server, the TYPO3 [2] content management system, cooperating with the MySQL database and the PHP (server-side HTML embedded scripting language processor). TYPO3 (see above) was selected for solution of this project as the powerful content management system with the web access interface, advanced users an templates management, large number of different free components, modules and applications available and simple control over the system backend and pages creation.

Portal was put into testing in the second half of the 2004, fully accessible is from November 2004 (including mentioned associations web-hosting), and after the finalizing the technical support, pages design and structure and visitors support is fully opened for public and regular operation from the September 2005.

Portal operator team invite institutions, schools and universities to participate and also welcome regular as well as occasional contributors from sphere of professionals and individuals interested in the fields of the portals scope.

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Computation of Border Array with k Substitutions in Parallel

Jan Šupol, Jan Holub and Bořivoj Melichar

{supolj | holub | melichar}@fel.cvut.cz

Department of Computer Science & Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

We present an algorithm to compute border array, which is used for computation of the fail function of a well-known Morris-Pratt algorithm [3] for pattern-matching. Since the days of presentation of the algorithm many variations has been invented, even some for approximate pattern-matching. Our algorithm can be used to compute border array using Hamming distance with at most k substitutions and the algorithm can be processed in parallel using $O(n^2/\log n)$ processors in $O(\log n)$ parallel time on EREW PRAM.

We expect the reader's knowledge of Morris-Pratt algorithm [3] and for the parallel version some basic knowledge of parallel computations [2] as well, mainly parallel prefix computation [1]. Here we provide the definitions. Set $Pref(x)$, $x \in A^*$, is a set of all *prefixes* of string x: $Pref(x)=\{y: x = yu, u, x \in A^*, y \in A^+\}$. The *proper prefix* is any element of $Pref(x)$ not equal to x. Set $Suff(x)$, $x \in A^*$, is a set of all *suffixes* of string x: $Suff(x)=\{y: x = uy, u, x \in A^*, y \in A^+\}$. *Approximate border* with at most k errors of string $x \in A^+$ is proper prefix u of x such that $D(u, v) \leq k$, where v is a suffix of x and D is some distance of two strings. The set of all approximate borders with at most k errors of string x is $abord(x) = \{u: u \in Pref(x) \setminus \{x\} \wedge v \in Suff(x), D(u, v) \leq k\}$. The *approximate border array* $A\beta[1,2,\ldots,n]$ of string $x \in A^+$ is a vector of lengths of the longest approximate borders of all prefixes of x: $A\beta[i] = \max(|abord(x[1..i])|)$ for $i = 1,2,\ldots,n$. Note that the approximate case is changed into exact one having k equal to zero. The parallel prefix computation problem is defined as follows [1]. Let $S=[s_0, s_1,\ldots, s_{n-1}]$ be an array of numbers. The prefix problem is to compute all the prefixes of the product $s_0 \otimes s_1 \otimes \ldots \otimes s_{n-1}$, where $\otimes$ is an associative operation. Now we define the algorithm.

Algorithm: Computation of approximate border array using Hamming distance with k substitutions.
Input: String $T = a_1a_2\ldots a_n$, and number of errors k.
Output: Approximate border array $A\beta[1,2,\ldots,n]$, where $n = |T|$.

1. Construct matrix $M^1 = n \times n$ such that in the first row there is string T, in the second row there is string T right-shifted by one position to the right, in the third row there is string T right-shifted by two positions to the right, etc.
2. Create matrix $M^2 = n \times n$ with elements $M^2_{ij}; 1 \leq i,j \leq n$.
3. For each row i do: {Count Hamming distances}
   a. The first element a_1 is at position M^1_{ii}. Set $j \leftarrow i$.

   b. Set counter of Hamming distance *cnt* to zero.
   c. While $j \le n$ do:
      - If symbols M^1_{1j} and M^1_{ij} are not identical, increment counter *cnt* by one.
      - Set M^2_{ij} to *cnt*.
      - Increase position *j* by one.
4. Create matrix $M^3 = n \times n$ of lengths with elements M^2_{ij}; $1 \le i,j \le n$.
5. Having Hamming distance equal to *k* do for each row *i* but the first one:
   a. The first element a_1 is at position M^1_{ii}. Set $j \leftarrow i$.
   b. Set counter of length *lng* to zero.
   c. While $j \le n$ do:
      - If $M^2_{ij} \le k$ increment counter *lng* by one otherwise set *lng* to zero.
      - Set M^3_{ij} to *lng*.
      - Increase position *j* by one.
6. Border array is a maximum from the *j*-th column $A\beta[j] \leftarrow Max\ (M^3_{2j}, M^3_{3j}, \ldots, M^3_{ij})$, $j \in \{2,3,\ldots,n\}$, $i = j$.

The parallel version of the algorithm can be performed as follows using parallel prefix computation. Step (1) of the algorithm O(1) time using $O(n^2)$ processors. Using only $O(n^2/\log n)$ processors, each processor simulates O(log n) processors. Thus it sets O(log n) numbers and the step (1) takes O(log n) parallel time. To compute step (3) we first compare two characters and we set one if there is a mismatch or zero if there is a match. This takes also O(log n) parallel time using $O(n^2/\log n)$ processors. Then we compute the sum of mismatches by parallel prefix sum. There are O(n) cost optimal parallel prefix sum algorithms that takes O(log n) parallel time using O{n/log n) processors. Therefore step (3) is computed in O(log n) time using $O(n^2/\log n)$ processors. Step (5) is computed as follows. If number of errors is equal or less then *k* for some prefix, we set one in matrix M^3 otherwise we set zero for that prefix. This also takes O(log n) parallel time using $O(n^2/\log n)$ processors. Then parallel prefix sum is computed on each row until zero is reached. This takes O(log n) parallel time using $O(n^2/\log n)$ processors too. Step (6), computing maximum of all borders is computed also with parallel prefix computation algorithm on each column, because the maximum function is also associative. This takes O(log n) parallel time using $O(n^2/\log n)$ processors. Thus the algorithm takes O(log n) parallel time using $O(n^2/\log n)$ processors. Since no concurrent write operation is needed, the EREW PRAM is used.

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Laboratory exercises in Switching systems II

David Jandera, Petr Koloros

janderd@fel.cvut.cz

Department of Telecommunications, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Telecommunication technology, as a very dynamically developing branch, require very wide and up-to-date knowledge of telecommunication specialists. It is very important to ensure this new and actual information in teaching subject as well. In our department we are lecturing two main subjects Switching systems I, II for students to obtain compact knowledge about current switching technology and designing principles of building telecommunication networks.

Thanks to successful results of our first project, that was focused on basic principles of switching systems and main building blocks of telecommunication network, we could focus our interest to following part - Designing of telecommuni-cation networks. Most significant point of our project was implementing SS7 and VoIP technologies into our existing laboratory network. Firstly was very important to revise current teaching plan in both subject to ensure sequence lectures and exercises and get students self-contained knowledge about telecommunication networks. Subject SSY I was already revised and new learning plan successfully implemented last semester. We need to innovate lectures and exercises of subject SSY II which will be focused on designing and testing telecommunication networks. For realizing our teaching plans we need to install new technology for implementing and measuring SS7 and VoIP networks, than will be integrated in our laboratory. The last step is to prepare cycle of exercises, that covers all current types of networks. Students will get knowledge about classical commuted digital networks as well as new dynamically developing VoIP networks. We need to design universal and flexible solution of laboratory network, which should be used for not only teaching, abut as well as for students to make their projects and research work.

As results of our project we successfully implemented new technologies and prepare technological back-ground for measuring and testing in laboratory conditions, which are comparable and useful in real telecommunication network.

Our Laboratory of switching systems has a very good technological background, thanks to modern telecommunication technology and measuring tools. We can provide our students background for measuring and configure technology all four generations of switching systems.

- New working place with two VoIP gateways and TTC2000 switching system for realizing heterogeneous network
- Implementing software solution of H.323 gatekeeper in Linux server to realization of plain VoIP network
- Implemented new numbering plan involving new technologies and allowed connection to real telecommunication network
- Prepared workplaces and made cycle of seminars for configuring, designing and testing telecommunication networks.

Cycle of laboratory exercises

1. *Telecommunication networks* - theoretical lecture about basic principles building different types of heterogeneous networks
2. *VoIP networks* - theoretical introduction to technologies and principles using VoIP standards H.323 and SIP
3. *SS7 signaling system* – introduction of exchange signaling messages in public network, interfaces a signaling
4. *Implementation of numbering plan* – practical realization of public and private numbering plan. Configuration of E1 PRI multiplexer with PbX TTC2000
5. *Configuration of VoIP trunk* - realization of trunk between two PbXs through VoIP network using gateways
6. *Configuration of PbX system* - configuration of PbX Hicom through terminal connection and using MML language instructions
7. *H.323 network* - practical design of plain VoIP network, using H.323 Linux software implementation of GNU Gatekeeper
8. *Least Cost Routing* – configuration of Ericsson MD110 PbX switching system to provide LCR function between private, public and GSM networks
9. *Excursion*

Interesting and important part of exercises in subject Switching systems I, II is excursion to real switching centre, which can help students make complex vision of telecommunication systems and network.

Innovated cycle of laboratory exercised, was implemented in studying program for Switching systems II and last semester students participate in this new exercise cycle. We want to continue our work with deeply participation of SS7 signaling and newly implement wireless part of VoIP network to test QoS parameters for real-time applications.

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Using of 3D Scanners in Geodesy and Historic Monuments Care

K. Pavelka

pavelka@fsv.cvut.cz

Laboratory of Photogrammetry, Dept. of Mapping and Cartography,

Czech Technical University Prague, Faculty of Civil Engineering,

Thákurova 7, 166 09, Prague 6, Czech Republic

In the framework of co-operation between the Laboratory of Photogrammetry (Faculty of Civil Engineering) and the Laboratory of Quantitative Methods of Monuments Research (Faculty of Nuclear Physics and Physical Engineering) new methods of 3D objects documentation based on 3D scanning instruments are used. There are two types of 3D scanners in this time. The first type, well known as a laser scanner, uses laser technology "time of flight". The second type uses triangulation method. In first case the laser is used only as a point or profile marker and the path of laser is processed from a digital image to 3D co-ordinates. Next type uses two digital cameras and image projector as a structured light source. Since 2003 we have in Laboratory of Photogrammetry a laser scanner Callidus. Next, various devices for 3D object co-ordinates capturing are being developed at present on the CTU in Prague. The aim of this research is to develop a technology for 3D documentation in cultural heritage documentation and special purposes. This paper is focused on experience in 3D documentation using 3D scanners and comparing this method with digital photogrammetry. 3D scanner is any device that collects 3D coordinates of a given region of an object surface. In this time, a lot of devices are used on different measuring principle:

a) Laser scanners (technical principle: time of flight of a laser pulse, phase comparison method)

b) Triangulation scanners (technical principle: one camera and laser marker, two cameras and structured light and scanned object can be static or on a rotating platform)

At our laboratory, there are two systems of laser scanners: a professional system Callidus and a school system CVUT/SICK. For large projects we use 3D Laser Measuring System CALLIDUS 1.1. The 3D Laser Measuring system measures the space geometry with a laser scanner. This scanner is located in the moving part of the measuring head on the tripod and is turned one full 360° revolution for measurement. This causes a range of 180° along the vertical to be scanned in two operations. Depending on vertical resolution (possible resolutions are 1°, 0.5° or 0.25°, i.e., one measuring value is supplied for each 1°, 0.5° and 0.25° respectively) a series of measuring points is produced for each possible horizontal position (possible horizontal resolutions are 1°, 0.5°, 0.25°, 0.125° and 0.0625°). These measuring values represent the distance of the laser to the object, which the laser hits. In this way the space around the laser is scanned. The inclination sensor (integrated in the measuring head) ensures correction when the system is out of position. An electronic compass which is also integrated in the measuring head supplies magnetic North information to allow the positioning of objects for measurement in space. The data acquired by the measuring head is processed with the 3D-Extractor® software which is supplied with the product. The result of processing is a wire mesh model of the space which can be used in CAD programs. In addition to logging the distance data, the CCD camera produces a "taped copy" of the space.

These images provide a means of verification of the calculated wire mesh model and for documentation. During the year 2004 a complete reconstruction of a historical building in Sporkova Street No.3 in Prague was done. Due to the historical importance of the building a large archaeological research was done there. There are foundations of Romanic rotunda, the first floor and some elements are in Gothic style, the second floor is Renaissance rebuilt in baroque style with classicism stucco decorations. The whole building is roofed by original unique Renaissance roof. In the neighbourhood a Romanic cemetery was found. Our department was asked to make a documentation of some interesting parts of the building such as some historical elements under uncovered facade using photogrammetry, and roof. In the case of documentation of the roof, there was a first nice opportunity to test our scanner in work experience. The first survey using laser scanner Callidus was done from five positions, each for 5 meters. We did not use control points because we expected that the measurements would be merged without any problems using an automatic function. But the accuracy was not sufficient and clouds of points did not fit each another. So, for the second survey we extended our measurements with three stations. After that the registration of clouds of points in the program 3Dipsos® ran out very well, although merging the last cloud of points took about a half an hour of processing due to the large number of points. The complete cloud of points comprised about five and half million of points.

A photogrammetric method was used too. The results of some stereoscopic models were not very good – too much invisible parts and very bad precision. In this project, about 50 stereoscopic models would be necessary for whole object and the processing would be very laborious. We can state that the photogrammetric method in this case is not advisable.

The results can be compared with one of the previous diploma project done at our department. It was focused on the documentation of a historical roof of the baroque theatre in Cesky Krumlov. The roof was surveyed by a total station with laser pointer and about 1800 construct points were measured. Processing and creation of 3D model was done in the program MicroStation®. The duration of surveying with the scanner was one day, with the total station two weeks. Processing and modeling took less than two weeks for the data from the scanner and almost some months for the total station data. The precision of both methods is similar (about 3 cm in position). From this comparison we can conclude, that the best method for documentation of the roof is to use the panorama tic 3D laser scanner and to process data in corresponding programs.

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Using of Multispectral Data and Laser Scanning for Documetation and Analysis in Environmental Monitoring

K. Pavelka*, L. Halounová **

pavelka@fsv.cvut.cz

*Laboratory of Photogrammetry, Dept. of Mapping and Cartography,

**Laboratory of Remote Sensing, Dept. of Mapping and Cartography,

Czech Technical University Prague, Faculty of Civil Engineering,

Thákurova 7, 166 09, Prague 6, Czech Republic

In the Czech Republic, there are many areas with ecological problems. Old contaminated areas, polluted areas or dumps are meant. In the case of old contaminated or polluted areas, there were old army bases at the end of the cold war polluted by oil products, heavy polluted areas due to uranium mining and large deforested areas as a consequence of air pollution produced by heavy industry during the socialism period. Brown coal mining dumps and areas used by chemical industry for many years are another example. After revolution time in 1989 and joining the European Union, the ecology activities in environmentally hazard areas are very important. The northern Bohemia is still heavily touched by mining activities – on and under the surface. Reclamation activities must follow mine closing and are included in the Czech Mining Law as a duty of mining companies. Reclamation can be divided into three phases – the technical one, the biological one and the maintaining one. The technical reclamation comprises geotechnical and hydrological arrangements and improvements of a new surface morphology to be stable (landslide resisted) and suitable for the future non-mining using. Agricultural reclamation can be characterized by changing land use detectable at least from satellite images with 4 years period. Shorter period could not distinguish agricultural plants with 3-year-old vegetation period. Land use classification is the most suitable for evaluation. The yield should be controlled by the ground truth data. Forest reclamation can be divided into deciduous and mixed forests. The deciduous forests are formed by of red oak, ash, cherry, birch, lime, maple and others. Mixed forests consist of already mentioned deciduous trees and by larch, spruce and pine in most cases. The mixture differs for individual areas. There are only exceptionally reclaimed areas with one tree type. Size of reclaimed areas varies from tenths of hectares up to tens of hectares. Good reclamation means that planted tree seedlings are sound and grow up. Their growth is the green vegetation growing. Vegetation indices are values used for characterizing of green vegetation quality and extend. NDVI (Normalized differential vegetation index) is the most often used index for evaluation of vegetation state. Water reclamation can be controlled by comparison of water surface quality in different years and by control of water basin sizes. Water basin size can be derived from water classifications in individual years. Very high-resolution multispectral data are used for monitoring and documentation of these areas. We combine old archive satellite data with aerial photos to find changes in the area. The project is focused on usage of satellite data for environmental hazard areas monitoring in mining areas and for using of new laser scanned terrain data for digital elevation model derivation.

To study changes in reclaimed areas Landsat 5 Thematic Mapper (TM) data from years 1988, 1992 and 1998 and multispectral IKONOS scene from year 2003 have been purchased. Up to now the Landsat TM data have been classified using conventional methods

of image classification in the frame of several diploma theses. The IKONOS image due to serious haze occurrence had to be carefully dehazed and then added to Landsat TM images.

Comparison of vegetation indices showed that there are differences in showing increase in VI values between NDVI and other indices. The fact is presented in project report, where the decrease occurs at other VI with the exception of NDVI. Values of PVI and DVI are very close one to another for reclaimed areas. Results comprise forest reclaimed areas whose age was up to 10 years.

Comparing of 3 years of VI values is a proof of possibility to distinguish dry and wet years from these curves. The development of reclaimed areas shown by NDVI values is not smooth. It is presented in project report where listing areas according to NDVI values in 1988 results in oscillating values in following years. Vegetation indices of reclaimed areas were compared also with tested areas. These areas were selected from close forests untouched by the mining activity. The value oscillation and therefore unsmooth development occur in both groups – reclaimed forests and "natural" forests.

Vegetation indices are very useful tools for evaluation of forest reclamation. More indices should be calculated to compare the results with usually used NDVI. Lower values of later years do not have to mean important worsening of the reclamation state. The absolute value is also important. The higher value of a previous value can only mean that the previous year measurement period was a wetter period.

Grass reclamation is seriously influenced by the previous precipitations. Information about the weather before measurement (satellite data capture) is necessary. Grass recovery after precipitations is usually very quick and successful without additional investments.

Agricultural reclamation should be controlled by determining land use changes. These changes can present changes of crops in individual years, or changes caused by crop on one year image and bare a soil after harvest on the second year image.

Water reclamation control should take into account bank stability and therefore the areas of basins should remain the same and the water quality. The water quality control can be performed by comparing green bands in individual years. The higher values mean the higher pollution.

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Secure Filesystem for Non-dedicated Workstation Clusters

M. Kačer

xkacer@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

Workstation clusters have become a very promising platform for high-performance computing, mainly because of their relatively low price. Such clusters are often used for performing CPU-intensive computations.
In [1], we have proposed Clondike, a virtual Linux cluster composed of dynamically changing set of workstations that automatically join the cluster whenever they are idle. The main innovative feature of Clondike is that the cluster administration is clearly separated from the administration of individual workstations.
The ultimate goal of Clondike is to provide so-called Single System Image (SSI), which means that the whole cluster appears to users and processes as a single powerful computer. One of the core components of SSI is a distributed network filesystem accessible from all workstations (nodes).
In this paper, a brief overview of available network filesystems is presented, with accent on their suitability and fitness for Clondike clusters. Since computer clusters are a popular topic for many researchers and developers, there are many ongoing projects that provide some kind of a distributed filesystem. In this text, only a few widely known filesystems are mentioned that are supported in the main Linux kernel branch.
Finally, a filesystem based on 9P2000 protocol is considered and its advantages described.

Network Filesystem (NFS), originally designed by Sun, became a classical filesystem for sharing data between Unix workstations. It is simple, stable, and well supported. Its main disadvantage is the lack of security mechanisms. NFS authenticates workstations, not individual users. Therefore, the user accounts must always be shared among all workstations in concern. Moreover, the authentication is based solely on the workstation IP address, which is not considered secure.
For Clondike clusters, the security limitations are crucial. The administration of workstations is separated from each other, thus, we cannot share the user accounts among them. Despite these limitations, Clondike can still operate with NFS, mainly for evaluation and comparative purposes.

Lustre is a filesystem specially designed for cluster purposes. Its main advantages are scalability, performance, and high availability. According to the authors, there are no single points of failure.
The main disadvantage is that Lustre is a young project and it is not yet as mature as it should be. For example, data formats can sometimes change slightly in new versions. Also, it took its developers a relatively long time to support Linux 2.6 kernels. In the future, it is possible that Lustre will become a powerful filesystem suitable for Clondike clusters.

Coda is a scalable, secure distributed filesystem developed at Carnegie Mellon University. It contains advanced caching mechanisms and is also able to manage replication servers to provide a high-availability support.
The main advantage for Clondike purposes is the mechanism which authenticates remote users using tokens. This is why Coda was chosen as the pilot filesystem for Clondike clusters.

Several patches and enhancements were developed to integrate Coda and Clondike [2]. Unfortunately, our experience shows that after these modifications, the filesystem performance is low and it easily becomes a bottleneck for the the whole cluster.

Plan 9 is a research operating system developed by the Computing Science Research Center of AT&T Bell Laboratories. In Plan 9, all system resources are represented as files [3]. This main principle is taken much further than in Unix: all interfaces and APIs are designed as simple operations (open, read, write, etc.) with virtual files residing on so-called synthetic filesystems.
This approach simplifies access to all system services. Moreover, by exporting such filesystems, it is possible to publish the services and call them remotely. This makes resource sharing and SSI services much easier to implement.
9P2000 is a protocol for accessing Plan 9 resources using a reliable transport mechanism, such as TCP/IP based networks. Among other operating systems, this protocol was implemented for Linux, effectively allowing to export filesystems and to mount them on other workstations, thus providing an alternative to, e.g., NFS.
The 9P2000 protocol is much less complex than NFS, which makes it easy to implement and brings performance benefits. The main advantage of 9P200 is that it is designed with remote resource access in mind, which makes it ideal for cluster purposes.
Other advantages include the possibility of exporting and mounting filesystems on a per-user basis, which makes the separated administration of workstations much easier.
The disadvantage of the 9P2000 implementation is its relative immaturity compared to NFS. Also, only basic security mechanisms are implemented in the current version. For secure operation, it is necessary to tunnel the protocol via a secure connection, e.g., SSH.

The conclusion is that 9P2000 seems to be an excellent candidate for a filesystem to be used in Clondike clusters. To fully utilize its capabilities, there is still some work to do. The work divides into the following tasks:

- Integration of the 9P2000 filesystem into Clondike.
- Authorization of remote users accessing data stored on the distributed filesystem.
- Enhancement of security mechanisms provided by the current implementation.

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Implementation of Known Heuristics into the Operation Backtrace Making Derivation of Input Vector Sets

M. Zítko, M. Šťáva

zitkom1@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague,
Karlovo Náměstí 13, 121 35 Prague 2, Czech Republic

Developing a software tool, which will derive input vectors of a combinational logical circuit from a defined output, has been our purpose. The final program will involve the base operation backtrace (it is a part of any ATPG tools) and a set of heuristics, which increase its efficiency and allow it to find an optimal result for different types of combinational circuits. Users are able to choice a method, which will be used to find results. An important quality of the tool is an easy addition of other heuristics later. A method of logical circuit description has been taken from ISCAS benchmarks.

The operation, known as backtrace, which generate test vectors for combinational circuits. At first, we have explored the well-known ATPG techniques and chose such ones that are usable for our tool. Then we have proposed a suitable skeleton for our tool and a universal data structure for internal description of a circuit. There are a lot of ATPG programs that differ in properties of generated tests (for example, in types of faults), and what way these tests are generated. So we could use some of ATPG algorithms for our tool.

Consider an ATPG program, which make a test covering of all stuck-at-faults. It systematically chooses faults, which will be tested. For the chosen fault it makes a sensitive path. This path is assembled from the location of the fault towards POs. Through this process, the operation backtrace generates the assignments of PIs (primary inputs), which justify this path. It means that the operation backtrace sets the line assignments backwards to a PI. After the successful achieving the PI a forward implication is made. There could be collisions during executing these operations when the PI assignments set some of lines to a reverse value than needed. In this case, the operation called backtrack, which makes step back and attempts to find another solution, must be executed (datiled information can be found in [1] and [2]). Notice that the operation backtrace is used to find the PI assignment, which justify required value of the chosen line. If this line is the PO, we obtain the main task of our tool.

Now for usage in our tool, there are suitable ATPGs which set a value of any line in a circuit and subsequently find the way to justify this value by using a backward coming through the circuit. The first ATPG which applied the operation backtrace was PODEM. Its principle is similar to our problem and it has been become a suitable base for our tool. By reason that PODEM was one of the first ATPG it was furthermore improved and many further ATPG coming-out of PODEM. The biggest chance to find a suitable improvement for our tool is in ATPG which arises from PODEM and breed new improvements with the maintenance need of the operation backtrace.

We have used PODEM as the base point for our tool. If PODEM needs to justify a required value of a gate output, it chooses one of gate inputs with an unspecified value and sets it. After that, PODEM tries to justify the lately set input. This way, PODEM comes to a PI and after starting, PODEM sets the next input of the gate. But if the assignment of the first input prevents an assignment of the next input, PODEM must clear the assignment of the path from the PI to the first input.

FAN brings a solution of this problem because it sets all gate inputs in one step thereby it detects collisions sooner. Further, it introduced the notion of a headline. If some part of the circuit can be separated by cutting a single line (it is a cone), this line is called headline and can defer the signal assignments to removed lines until the ATPG alg. knows the final assignment to the headline.

TOPS introduced the notion of a dominator. The dominator is the line through which every fault is propagated to a PO. With using dominators, we can effectively detect problems with propagating faults. This problem is related only to ATPG algorithms. It isn't useful for our tool.

EST creates circuit cuts during making the test, which hashes into a hash table, and looks if it is not a solution of the currently solved circuit cut in the hash table. If it finds the solution in the hash table, it uses the found one. This method is not suitable, because EST uses a different principle of assembling tests, which does not require the backtrace operation.

SOCRATES involves the notion of learning. The learning procedure explores how the assignment of a line influences the assignments to others lines in the circuit. With this information we can skip needles searching of the state space thereby increment efficiency of searching, like Recursive Learning does.

Recursive Learning uses the SOCRATES-style learning to increment the FAN algorithm efficiency. It applied learning recursively to determine more circuit signals and learnt them as circuit implications.

Among searched algorithms, only PODEM, FAN, and Recursive Learning are useful in our tool. These algorithms allow to search the state space by two ways represented by PODEM (with option possibility of a different strategy of progress) and FAN (with possibility to use Rec. Learning).

We must awake to the backtrace operation is only sub-operation of ATPG algorithms. The main operation consists of choice a fault and its propagation to POs. This operation directs the assemblage of the test vector and solves appropriate collisions. That is why it is not possible to simply copy the backtrace op. but it is necessary to create a control operation, which calls the backtrace operation and solves collisions (by backtracks). This operation calls sub-operations, which perform individual sub-steps. If there are more operations doing a same job, we can choose which one should be used by the program. It is the way to find an optimal configuration of the program which best complies with the circuit structure. This configuration also determines whether it will be found a one input vector with specific properties or a set of all inputs vectors. Finding the set of all input vectors requires an extension of the control operation so that all possible ways to justify the output vector will be tried.

Creation of sets of operations doing the same job (but different ways) enables the easy extend of our tool. We will simply add new operations into these sets. New operations do not only increase program efficiency but they can enable finding a solution, which fulfills specific requirements. This program is developed as a tool for a logical circuit analysis. Its easy expandability will allow adapting it for a particular employment.

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Optical Transfer Characteristic of Experiment BOOTES

M. Řeřábek

rerabem@fel.cvut.cz

CTU, Faculty of electrical Engineering, Dept. of Radioelectronics,
Technická 2, 166 27 Praha 6

There is described an optical transfer characteristics of systems, which makes the space variant impulse response in this paper. This thesis is focused to the BOOTES *(Burst Observer and Optical Transient Exploring Monitor)* project. The BOOTES project is a system for searching and monitoring the optical transient of GRB *(Gamma Ray Bursts)*. The system consists two parts, BOOTES 1 and BOOTES 2. Each similar systems receives a huge amount of image data. Detection of single object on image data from BOOTES system is described in e.g. [1]. The BOOTES system derives benefit from wide field cameras with visual angle (16 x 11°) to obtaining optical information about GRB.

We can assume that each of sidereal objects is point sources, because of their distance from forcing-off system. Relationship between input $f(x,y)$ (star sky sector) and output $g(x,y)$ (image data taken by wide field cameras of BOOTES system) can be expressed

$$g(x,y) = f(x,y) * h(x,y) = \int_{\mathbb{R}^2} f(\nu_x,\nu_y)\, h(x-\nu_x, y-\nu_y)\, d\nu_x d\nu_y, \tag{1}$$

where $h(x,y)$ is PSF (*Point Spread Function)* of the imaging system created by the light transfer through the earth atmosphere. Brightness profile of stars can be model by PSF also.
In the ideal possible case (of course not occurring in practice), it means using imaging system without imaging aberrations, $h(x,y) = \delta(x,y)$ and we get ideal image. In practice we have to speculate about influences of atmospheric turbulences, optical aberrations of imaging system and imperfection of tracking binocular behind the sidereal objects. These influences will cause image blurring. PSF of the imaging system have a character of an unknown low-pass filter.

The profile has circular symmetry and can be approximated by Gaussian function [2], [3]

$$I(r) = I(0)\exp\left(-\frac{r^2}{\sigma^2}\right), \tag{2}$$

where $I(r)$ is a star profile in distance r from the maximum of sidereal object and σ is width of the star profile. For the imaging systems without optical aberrations is $\sigma = \sigma_0 = konst$ for all image in visual angle. Those imaging systems we called space invariant.

If we use wide field or ultra wide field (UWFC) cameras, which portrayals a big part of sky, we can not neglect imaging aberrations like *distortion, coma, astigmatism, chromatic aberration.* Aberrations cause dependence PSF on image position. Those systems are space

variant. The biggest deformations of star profile (PSF) we can see near margins of visual angle field. In such a case is better to use for approximation of star profile 2D Gaussian function

$$I(r,\varphi) = I(0,0)\exp\left(-\frac{r^2}{\sigma^2}\right), \tag{3}$$

where $I(r,\varphi)$ is a star profile width polar coordinates r (radius) and $\varphi \in <0, 2\pi)$ (angle) and $I(0,0)$ is high of the star profile.

For imaging aberration *(coma)* is Gaussian function coming short and we have to find out better approximation for describe a star profile. The aim of next work is find out how various imaging aberrations in wide field and ultra wide field imaging systems work on star profile in marked position of image (4) and find out dependence a star profile PSF on distance to optical axis (middle of image) (5)

$$PSF_{aberation} \approx f(aberation) \tag{4}$$

$$PSF_{aberation} \approx f(l). \tag{5}$$

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High Precision Computing Based on Continued Fractions

T. Brabec, R. Lórencz

brabec1@fel.cvut.cz

Department of Computer Science and Engineering,
Faculty of Electrical Engineering, Czech Technical University in Prague,
Karlovo náměstí 13, Praha 2, 121 35

In the field of scientific numerical calculations, it is a well-known fact that computers have limited capabilities. These limits originate from properties of employed computer arithmetic and affect the accuracy of numerical results. To guarantee the accurate results, scientists may use different methods. One approach is to carry out an error analysis of a numerical algorithm and schedule arithmetic operations to minimize effects of round-off errors and cancellation. Although this method is useful for some sort of applications, it is difficult to handle by non-experienced mathematicians. It also becomes extremely complicated with increasing complexity of algorithms and thus other methods have evolved which deprive humans of this complexity and transfer it to machines. Such methods form a category of validated computer arithmetic. Each such method may be further classified to be a kind of either certified or exact arithmetic. Certified or sometimes called self-validated arithmetic methods produce numerical results together with an accuracy certificate. This certificate explicitly declares the result to be within a specified set of possible values. A typical example of certified arithmetic is an interval arithmetic paradigm, which we covered in more detail in [1]. Exact arithmetic, unlike the certified methods, does not provide any certificate since the reliability of its results follows from mathematical proofs of underlying principles. Every exact arithmetic paradigm is supposed to compute the result of a numerical algorithm up to an arbitrarily defined precision while still being accurate. There are a number of such exact arithmetic paradigms, most of which are briefly surveyed and referred to in [2]. In this paper, we are particularly interested into the paradigm based on continued fractions.

Continued fractions might be informally introduced as generalized compound fractions (e.g. fraction 3/2 has a compound fraction $1\frac{1}{2} = 1+1/2$). The generalization lies in fact that the denominator of a fractional remainder may also have a form of compound fraction. The same holds for its remainder fraction and goes on and on until end of continued fraction expansion, or to infinity. This simplified concept may be formalized through a recurrent formulation. That is, a continued fraction f_i is a number written in a form of $f_i = a_i + b_{i+1}/f_{i+1}$, where a_i and b_{i+1} are integers and f_{i+1} is a continued fraction. A full Continued Fraction (CF) expansion becomes quickly overfilled with brackets and it is thus usually expressed in a form of $(a_0, b_1/a_1, b_2/a_2,\ldots)$. Fractions b_i/a_i are usually referred to as partial fractions (or remainders) and $\{a_i\}$, $i = 0, 1, \ldots$ is a sequence of partial quotients. This form of continued fractions is too general and simplified variants are more commonly used. Especially famous has become the Euclid's form, where all b_i's in the expansion are ones and all a_i's are positive, except a_0 that may also be zero. Its CF expansion is thus usually simplified to a sequence of partial quotients, i.e. $(a_0, a_1, a_2,\ldots)$.

Euclid's continued fractions are also known as Regular Continued Fractions (RCFs). Their popularity originates from a fact that they have some better properties than general CFs, the one especially notable being their one-to-one correspondence with the positive real numbers. They are also closely related to Euclid's Greatest Common Divider (GCD) algorithm. Another interesting fact is that irrational numbers has recurrent (and thus infinite) RCF expansion. For instance, an expansion of Euler's e number is $(2, [1, 2k, 1]_{k=1,2,\ldots})$, where the sequence in square brackets is recurring with increasing k. This means that the e's number

representation itself might be very compact while still preserving an unlimited accuracy. There are even further advantages of RCFs, and CFs generally, which may be found in a famous work of Gosper [3].

In fact, Gosper was the first one who considered and advocated the use of CF arithmetic in computers. He showed that all basic arithmetic operations (i.e. +, -, *, /) could be realized in a uniform manner. His idea was to utilize a bi-linear fractional transformation, which is described by a formula $z(x,y) = (axy + bx + cy + d)/(exy + fx + gy + h)$, where a, b, c, d, e, f, g, h are integer coefficients and x, y are input arguments. Basic arithmetic operations might be then realized by specifying initial values of individual coefficients. Describing the process of evaluation of $z(x,y)$ in a case when x and y are continued fractions is beyond the scope of this paper, but an interested reader should refer to [3]. We just note here that CF arithmetic based on this principle has some exceptional properties – it is principally easy and perfectly regular. However, it would not be natural if there were not any pitfalls hiding in behind. The most obvious are performance issues. Although the CF arithmetic utilizes only operations on integers, the partial quotients of input arguments can be generally unbounded and the CFs themselves may even have a non-terminating expansion. Therefore, the coefficients of $z(x,y)$ function will continuously grow as a computation advances and it is proved that this growth can not be avoided. CF arithmetic thus relies on arithmetic over unbounded integers, which lowers its performance. Furthermore, the procedure of evaluating $z(x,y)$ requires quite a high number of division steps – actually, processing of any partial quotient (either that of input arguments or that of output result) requires several division operations. And this, compound with the need of unbounded integer arithmetic, is the true performance killer.

There are several ways how to improve this poor performance. Nonetheless, we think that the only way to yield some qualitative change goes through hardware implementation. Dedicated arithmetic units have already proven their significance with floating-point arithmetic and promising results were reported with other arithmetic paradigms [4]. CF arithmetic, unlike other exact arithmetic methods, meets most requirements for successful hardware realization. Uniformity and regularity are the necessary preconditions. Another fact that favors hardware implementation is a relatively high number of independent operations (like divisions), which might run in parallel. However, the practical realization has still to cope with other, less convenient CF properties. One of the faced problems is that of unbounded partial quotients. We are currently investigating how to overcome this problem. We are also designing a CF arithmetic unit to quantify the performance advantage of hardware implementation. We hope that we'll be able to present our research results soon.

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Running Linux on an FPGA-based Embedded Platform

M. Šimek, T. Brabec, M. Bečvář

simekm2@fel.cvut.cz

Department of Computer Science and Engineering,
Faculty of Electrical Engineering, Czech Technical University in Prague,
Karlovo náměstí 13, Praha 2, 121 35

Modern embedded systems more and more frequently resemble small computer systems. Just a few examples: PDAs, cell and smart phones, set top boxes, network and telecom systems. Even though these systems are specifically designed for a particular application, their architecture in general comprises the same components – processors, high-capacity memories, bus hierarchy and numerous I/O peripherals. As complexity of such systems increases, still more of their functionality moves into software. To ease the process of embedded software design and to meet tight time-to-market requirements the application design needs to be abstracted from its hardware dependency. These trends call for growing importance of real-time and embedded operating systems, which provide a Hardware Abstraction Layer (HAL) and some kind of standardized Application Programming Interface (API).

Motivated by similar needs, we were looking for a suitable operating system for our platform based on Xilinx FPGA devices. FPGAs are programmable integrated circuits that nowadays allow building even complete processor systems inside them. Such systems are usually called CSoCs (Configurable Systems on Chip) and we use them in a research of algorithm acceleration [1]. In a process of choosing a suitable embedded operating system, we considered the following requirements – easy portability to new hardware architecture, ultimate support for peripheral devices (especially mass-storage devices), networking capabilities, and source code availability. Costs of the OS and development tools were also of high importance. Considering these requirements and being aware of modern trends, we have got interested into Linux.

Linux has proven to be reliable operating system in both desktop and enterprise computer environment. Recently, it also started invading the field of embedded systems. After an initial skepticism and threat of licensing issues, Linux is gaining still greater acceptance among embedded system developers. Omitted royalty fees, ultimate OS features and promise of standard development platform [2] are just a few examples. Even though Linux is usually considered a general-purpose system, it can be altered to fit to almost any application. That is the purpose of miscellaneous distributions. A distribution, which we have used for our experiments, is called uClinux [3]. The original uClinux (pronounced “you-see-linux”) was a derivative of Linux 2.0 kernel intended for microcontrollers without Memory Management Units (MMUs). Today's version includes all major Linux kernel releases (i.e. 2.0, 2.4 and 2.6) as well as a collection of user applications, libraries and tool chains. It also supports a large number of processor architectures, among others also the Xilinx MicroBlaze processor. So far, uClinux is the only distribution supporting this processor, which we have been using in our CSoC systems [1]. An advantage is also a number of reference designs available that were available for our development platform (Xilinx ML401). Using such reference designs out-of-the-box, one can set up a working embedded Linux system within a while. However, to get things under our control and to be able to do application specific enhancements, we needed to dive deeper into the internals of the Linux system.

Most of the time, we were experimenting with kernel and distribution configuration. Throughout these experiments we gathered the following information. The kernel has an average footprint of 1.2 MB, but with some omitted capabilities, it can be configured down to

600 KB. An additional storage capacity is spent on add-on programs. Again, these can be configured so that they are completely removed or occupy up to 1.7 MB. These additional applications include core applications (e.g. init, agetty), flash tools (e.g. netflash, mtd utils), file system applications (e.g. fdisk, flatfsd), network applications (e.g. httpd, inetd) and other miscellaneous applications (e.g. cat, ls). There is even the microwindows Graphical User Interface (GUI), but we haven't carried any experiments with it so far. Runtime memory requirements also depend on configuration and on a number of system services running. An average memory occupation was 3.5 MB (with network services on).

Another piece of information we has been interested in is the system performance. Since there is no standard process of embedded systems benchmarking, we relied on information from a Linux kernel. During the system's boot up procedure, performance information is reported. It is given in BogoMIPS units, which stand for the number of million times per second a processor can do absolutely nothing. Although using BogoMIPS as a performance metric is questionable, it was the only way how to do a comparison with other systems whose results were published on the Internet. We personally measured two MicroBlaze systems running on Virtex-4 LX and Virtex-II Pro devices and the results showed roughly the same performance – 0.5 BogoMIPS/MHz. It is interesting that similar systems based on soft-core processors exhibit similar results – e.g. OpenRISC 1200 has performance of 0.67 BogoMIPS/MHz and Nios II running on Altera FPGAs shows almost 0.5 BogoMIPS/MHz too. A complete list of gathered results and references is given in [4].

The last thing we have paid attention to was a possibility of porting uClinux to a modified hardware platform. Simplicity of adaptation to new hardware is important for CSoC systems, which can be set up in a number of configurations. Like any other modern system, Linux relies on a HAL and thus adaptation to a new hardware is supposed to be easy. However, one needs first to now what to change and where to change it. Spending several days to gain such expertise, the porting procedure has turned out to be quite easy – a time for a basic porting procedure counts a few tens of minutes. To demonstrate the porting process practically, we have successfully created an uClinux demo for the Xilinx ML310 development kit [4].

Based on our experiences we can acknowledge Linux (namely uClinux as its derivative distribution) to be a full-featured embedded operating system. Because of an easy adaptation to the underlying hardware platform, it perfectly conforms to CSoC systems. As a future work, we plan to propose an embedded system benchmarking methodology and to compare Linux capabilities with other embedded operating systems (e.g. eCos, FreeRTOS, etc.).

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Theoretical Analysis of Routing Latency in Special Types of Networks

M. Nehéz

nehez@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

In recent years, massive growth of wide area networks has caused increasing of requirements on high throughput of networks and speed-up delivering of data. The measurement of network traffic parameters has become also of high importance. The overall network performance depends strongly on its latency, throughput, and on the traffic in the network, and all these factors are mutually closely related [1,2]. In order to design a routing protocol with fast data transmissions, it plays a key role the reduction of network latency. The network latency is defined as the delay of one packet transmission from its source to its destination. The overall network latency depends on the number of routing decisions along a routing path. In a trivial case, routing decisions are made at each intermediate node along a routing path. This means that for route of length *l,* the routing table must be accessed *l* times. It raises the main question of this work, whether there are routing schemes which allow to reduce the number of routing decisions.

The problem of elimination or reduction of routing decision is interesting mostly from the theoretical point of view. Several results are due to P. Fraigniaud, C. Gavoille, J. van Leeuwen and R. B. Tan. It was shown that for every N-node network and every positive integer $t < \log N$, there is a routing scheme that requires at most $O(t.N^{1/t})$ routing decisions for each packet, see also [G. TEL: *Introduction to Distributed Algorithms*, Cambridge University Press, 2000, Chapter 4]. It was shown in [3] that in any N-node network of diameter D, the latency is bounded by $O(D + N^{1/t}.\log N)$, for every constant $t \geq 2$. Both these upper bounds hold for routing schemes that are nonoptimal with respect to the shortest-path requirement. To obtain above results the idea of hierarchical routing is used. However, another question is whether there is a shortest-path routing scheme that allows less than the trivial upper bound of routing decisions for an N-node graph of the diameter D.

In this paper, we assume a point-to-point asynchronous communication network which is modeled by a simple unoriented graph consisting of a set of nodes (processors) and edges (communication links). Routing in communication networks is performed by a decision procedure in which each node (a processor) of a network selects the output link to forward a message on its way to destination. We can address a standard table-lookup routing algorithm or interval routing scheme as examples of routing decision procedures. The commonly used theoretical model for analysis of routing time in a node with respect to the selected routing decision procedure is random access machine (RAM) with unit or logarithm cost criterion [3]. It can be shown that the routing time in a given node depends on the number of output ports, i.e. the degree of that node. This conclusion can be verified also by experimental methods. So called trivial routing decision is performed in each node with output degree 2. In particular, the trivial routing decisions have very small time complexity both for unit and logarithm RAM complexity measures. On the other hand, the routing decisions performed in all nodes with output degree at least 3 have larger time complexity as in trivial case. This analysis leads to the observation that the degree distribution of nodes in networks plays an important role in

analysis of number and complexity of routing decisions along routing paths. We focus on two types of networks in our paper:

- random regular networks,
- scale-free networks.

Random regular networks are networks that are generalization of Erdos-Rényi random graphs [4]. The base graph is a regular graph with fixed degree Δ in each node. Each edge is present with a given probability p, $0 < p < 1$, such that the existence of each edge is independent of each other edges. The probabilistic analysis shows that the degree distribution of random regular networks attains Binomial distribution.

Scale-free networks occur in many areas of science and engineering, including the topology of web pages (where the nodes are individual web pages and the links are hyper-links), the Internet, social networks, etc. A scale-free network can be constructed by progressively adding nodes to an existing network and introducing links to existing nodes with preferential attachment so that the probability of linking to a given node is proportional to the number of existing links that node has. In scale-free networks, the number of links k originating from a given node exhibits a power law distribution $P(k) \sim k^{-\gamma}$, where γ is a constant between 2 and 3. (It depends on the specific class of the scale-free networks. In particular, $\gamma \approx 2.3$ for the web-graphs.)

The results of our research are as follows. There is a shortest-path routing scheme that allows less than the trivial upper bound of routing decisions for an N-node network, however it depends on the type of the network. In particular, such a routing scheme can be designed for the random regular networks and the scale-free networks. It can be derived from the standard table-lookup routing scheme or the interval routing scheme. The number of routing decisions is obtained from the degree distribution of the networks. From the perspective of the number and complexity of routing decisions along the routing path, the scale-free networks are more effective than the random regular networks. For the future research, we address the analysis also for other topologies with more accurate experimental results.

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Serialization of Transactions: A Graph-Theoretic Approach

M. Nehéz*, D. Chudá **

nehez@fel.cvut.cz

*Department of Computers, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

**Department of Applied Informatics, Faculty of Economic Informatics, University of Economics, Dolnozemská cesta 1, 852 35 Bratislava, Slovak Republic

One of the primary roles of large database systems is to provide data access to many users with respect to their different requirements. In such database systems, more than one program may manipulate simultaneously common stored data. We deal with multitasking database systems in this paper. They are the database systems in which at least two jobs may access the data concurrently. The main problem in multitasking database systems falls when at least two executed programs can simultaneously write a different value for the same data item. In such a case the integrity of the data must be guaranteed. There exist several slightly different approaches to solve this problem [4]. We focus on one of them in this paper - the R/W-LOCK model.

We will examine the properties of multitasking database systems, namely the serializability transaction algorithm in R/W-LOCK transaction model. This algorithm is based on the fact that given schedule of transaction is serializable only if its serialization directed graph is acyclic. We show that: (1) for each direct graph G there exist infinitively many schedules such that their serialization graph is G, and (2) almost all directed graphs are cyclic.

Now we describe the basic concept - the transaction management in the multitasking database systems. The transaction management system, to put it simply, protects the data integrity of the multitasking database system. A process is a single execution of a program. The process, which changes the database from one consistent state to another, is called the transaction. At a lower level of abstraction, the transaction is a sequence of elementary operations. At a higher level of abstraction, the transaction is considered as an indivisible entity. It means that for a given transaction either all its elementary operations are done, or none. If any operation cannot be executed, all still realized changes of the database must be returned to its initial state. Concurrent execution of at least two transactions is correct if the resulting effect is the same as in the any serial execution of the sequence of mentioned operations. A schedule for a set of transactions is an order in which the elementary operations of the transactions are executed. A schedule is serial if all the steps of each transaction occur consecutively. A schedule is serializable if its effect is equivalent to that of some serial schedule. For a given schedule of transaction, the task for the transaction management system is to construct an equivalent serial schedule and then to start its execution. A transaction may consist of several elementary operations, which access the data items. If we distinguish between read-only access and write-only access, we consider a more detailed model of transactions [4], R/W-LOCK transaction model and many transaction management systems are based on it. There are two kinds of locks in R/W-LOCK model: READ-LOCKS and WRITE-LOCKS. Both these locks are removed by an UNLOCK statement. The locking and unlocking principle is straightforward.

A serialization process for R/W-LOCK model is based on the construction of the serialization graph from a given schedule of transaction. An algorithm, which is based on the

construction of serialization graphs, was designed in order to determine that a given schedule is serializable. That is why we propose some useful notions from graph theory [1, 2]. Directed graph is an ordered pair $G = (X,A)$, where X is the set of vertices and A is the set of arcs (directed edges). The algorithm which tests the serializability of the schedules is based on the definition of the serialization graph [4]. The input of the algorithm is a schedule S of transactions $T_1, \ldots, T_n$. The output of the algorithm is a determination whether S is serializable, and if it is so, the output is an equivalent serial schedule. We study the relationship between schedules and directed graphs. It holds that for each direct graph G, there exist infinitively many schedules such that their serialization graph is G. The schedule given is serializable whenever its serialization graph is acyclic.

The results of our research are as follows. We have shown that the function, which maps each schedule of transaction to its serialization graph, is a surjection but it is not an injection. Moreover, for each direct acyclic graph G, there exist infinitively many schedules such that their serialization graph is G. Using the probabilistic argument, we have shown that almost all directed graphs are cyclic. According to the Robinson's formula [3] about the number of labeled direct acyclic graphs of the ordered n, we have enumerated that the relative number of direct acyclic graphs decreases to zero very rapidly. In particular, for the order $n \geq 5$, its number is less than 5%.

However, can we claim that "almost all" schedules in R/W-LOCK transaction model are not serializable? Such a conclusion is not so easy. We have very small information about the inner structure of transactions and about the arrangement of statements within them. Therefore, the future research may concern a detailed study on the layout of items within the transactions and other aspects of their structure.

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Caching and Streaming Underlayer of the Execution Engine VPU

M. Dráb, L. Kalvoda, S. Vratislav, M. Dlouhá

drab@kepler.fjfi.cvut.cz

Department of Solid State Engineering, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

Execution Engine VPU is a main component of a system for driving experimental devices developed within project INDECS, whose aim is to create such a software system specifically for driving and data collection and analysis of the neutron diffractometer KSN-2.

The whole system is based on proper routing of data and instruction flows among the active software components of the system.To achieve this goal mainly for project INDECS, two major subsystems were designed and implemented in form of two libraries layered upon each other, and these two layers are then used as a basis upon which the whole INDECS system including the Execution Engine VPU is based.

The lower layer is a library called Stream Cache library and as its name suggests it is an implementation of quite sophisticated caching mechanism specially designed to be able to handle variable continuous streaming data flows with relatively simple API. Simplicity, however, wasn't the only criterium for the design of the library. The design was also aiming towards achieving as little computational overhead as possible, and the ease of availability of the data within the cache, while maintaining proper data consistency and alignment.

The cache can basically operate in three different modes. The first mode is a pull-automatic cache, in which case the input end of the cache has an attached callback function wich is used to automatically fill the cache when the data is required or the cache occupancy has lowered beyond certain level. This mode is intended to be used preferably for reading of data from files or other data sources. The library also contains some predefined functions to be used for such dealing with files. The implementation even supports reading of multiple files with predefined filename conventions and is able to read it in a way that it seems as if the multiple files were actually only one continuous file. This is often needed in the data storage/processing of data collected by measuring various signals, because the amount of data is usually quite big and it is allways easier to handle them in smaller peaces.

The second mode is a push-automatic cache, which is a counterpart to the pull-automatic cache. This time it is the output of the cache that has an attached callback function which in this case is used to dump the contents of the cache to an external data storage. This is again mainly intended for storing the data streams into files. Again automatic multifile storage with predefined file size is supported and the necessary callback functions are supplied within the library.

The third and last mode of operation is the non-automatic mode, which is mostly intended for data flow connection between two data processing components, which basically means that the cache has to be explixitly written on one end and read on the other end.

As said above, the caches should be able to handle variable continuous data streams. In these cases the granularity of the access units of the data stream is often variable, unknown in advance and usually easier for the reading functions to have the access unit entirely available in one place at the same time, rather than having it scattered among multiple reads of the buffer. This poses some requirements on the actual size of the buffer as well as on the mechanism of continuouf flow of the data through the cache.

The latter is solved by the mechanism of shifting the data within the cache automatically either once the occupancy of the cache reaches certain minimal level or when data required to be accessed at the same time are greater than the current cache occupancy and there is still some room to push more data inside. This makes the stream seem fluent and continuous from the point of the data reader and when the thresholds specifying the maximal amount of data that may be shifted within the cache during one such transaction are set properly, it is done with minimal computing overhead.

The former requirement is solved by allowing the cache buffer to be growable in size. The possible growing of the cache may often be quite a complicated operation, since the grown buffer may actually reside in a different place in the memory, in which case it may actually mean quite a big memory transfer, so this mechanism is used only as a last solution in situations, that can not be resolved by any other way. Usually this means the case when the amount of data that the reader requires to access at one time is greater than the actual size of the cache buffer. The growing, when allowed, can be either unlimited, or bounded by some maximal size threshold which the buffer can not cross. A statistics of maximal amount of data required by the reader at one time is collected and can be used to tune the cache for the specific application usage.

The little overhead is also achieved by the mechanism of accessing the data within the Stream Cache. It would be pointless to have the reader just read the data into its own, possibly dynamically allocated, memory buffer. That would just mean an unnecessary copying overhead and CPU stress. Te data is available in the caching buffer, so why not to use them directly from there? The only problem may be the fact that the data can possibly be moved within the cache buffer when perhaps the input part is writing somethin to the cache or as a side-effect while wanting to extend the amount of data accessed at one time from some amount to a greater one. This is solved by the mechanism preallocating and blocking of the accessed data within the cache. The reader, in order to access some data from the beginning of the cache has to tell the library to allocate a certain amount of data available within the cache. The appropriate data is then blocked and fixed on its position within the cache (while possibly automatically adjusted before the blocking) and a pointer to its beginning is returned to the caller, who is now allowed to access the data to his needs. After the reader finishes the processing he can either releave the data from the cache, making the space available for more incomming data, or just unblock the data and possibly let some other reader to try reading the data again. This makes the possibility of reprocessing the same data without any unnecessary additional copying.

Finally I'd like to conclude, that while this mechanism was originally designed within project INDECS to support its data and instruction flows, it is not limmited to that and currently is successfully used in several other projects that involve data streaming and processing.

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A Bipartite Graph Model of Circuits

L. Vlk, M. Šťáva

vlkl1@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

We interest in combination parts of logic circuits. At first, we determine a level of gates. The level is determined from primary inputs till primary outputs. It is called starting levels. Or it can be conversed from primary outputs till primary inputs. It is called a terminative level.

If we won't to determine the starting levels, we must begin with primary inputs, which is defined to be the 0 level. For each element not yet assigned to a level, we will use $l(i) = \max l(e_j) + 1$, where *l(i)* is a level of the current element, *maxl(e$_j$)* is a maximal level of previous elements. The terminative levels are defined as opposite. It means that the maximal level minus a level of the current element, *(TerminativeLevel(i) = maximal level – StartingLevel(i))*.

We convert any combinational part of a logic circuit into a bipartite graph model. It is performed in the following way. We convert any conductors into edges, and components and fan-out stems into nodes. We distinguish these two types of nodes. Than we will note primary inputs and primary outputs. In this way, we acquire a graph model of circuits, above whereby we will next perform analysis from the theory of graphs, as are in [2].

A composition set of a gate for a current fan-out

We determine a set of gates, which are influenced by a current fan-out. It means that we add such a gate, which is passed during the circuit oriented into outputs. If we reach into a next fan-out at a passage through a circuit, we will have not to scan this part again, but we add in the set of the found nodes. Then we pass a next part for all nodes. Now we have found its set for each fan-out, $\mathbf{X} = \{x_1, x_2, \ldots, x_n\}$, where x_1 till x_n mean a detail of a gate.

A vector of a stative signal of a combinational logic circuit

We acquire a vector of a stative signal in a combinational logic circuit based on knowledge of output vectors and next limiting terms. Limiting terms are called high terms. Gates are considered as low terms.

A vector of a stative signal, $\vec{P} = (p_{x_1}, p_{x_2}, \ldots, p_{x_n})$, is sorted by levels. The higher level is sorted more right and the lower level is sorted more left. The next criterion is a number of following gates up to it. The less one is it, the more right. We aspire to have the simple ability more right.

This vector can be constructed pursuant to set an operation. At first, a set of gates is constructed for each node, $\mathbf{X} = (x_1, x_2, \ldots, x_n)$. If there are ready sets, it will be able to begin structuring and sorting.

If we perform the intersection with all sets, $\mathbf{X} = \mathbf{X}_1 \cap \mathbf{X}_2 \cap \ldots \cap \mathbf{X}_n$, we will receive a set of elements, which are dependent on all fan-outs and these elements will be most left.

High terms, whose sets contain all gates, we must position most right.

Sometimes we have two separate paths, that begin in one node, end in one common node and during the path are not divided again. That parts can reduce a value of time complexity [1], provided position this element to switch and we use in the vector only one of two. Switching is controlled by a high term.

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Microwave Optoelectronic Receiver Composed of p-i-n Photodiode and MMIC Amplifier

J. Armas, I. Hüttel*, V. Jeřábek

armasjj@gmail.com

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,
Technická 5, 166 28, Prague 6, Czech Republic

One of the most important roles of information processing is to detect optical signals, the light has to be converted into a electrical signal by an optoelectronic detector, which can then be amplified. Within hybrid or even monolithic structures, optoelectronic and electronic components are increasing their performance therefore improving the bandwidth up several GHz . This article presents an microwave optoelectronic receiver composed of p-i-n photodiode and MMIC amplifier, the device consisting of a p-i-n photodetector C30616 ECER[1] which has a 3-dB bandwidth of 3.5 GHz, an amplifier HM 396 [2] which is a GaAs InGaP Heterojunction bipolar transistor (HBT), it has a bandwidth of 8GHz. Both components were connected by a microstrip line and using the peaking effect by an inductance between the photodetector and microstrip the bandwidth of the device is increased from 3.5 GHz to 5GHz.

A microwave optoelectronic receiver plays a very important role in the technology of information processing. The performance of their components like photodetectors, amplifier, etc. is challenged by the demand of optical fiber links. This increases the need for higher bandwidth optoelectronic instruments. Optoelectronic receivers for 1.33 -1.55 μm wavelength have been widely investigated using various types of devices and growth techniques [3], actually these devices are installed in many equipments a working with a bandwidth of 3.5 GHz. We have developed the device using hybrid thin film circuit by lithography process for the bias connection and we built up the microstrip line on insulates substrate Al2O3. This one has the same impedance like the amplifier (50Ω). When we use an inductor between the photodiode and the microstrip, this one generates an effect named peaking effect; therefore we can take advantage of this characteristic and increase the bandwidth to 5 GHz.

In conventional photodetectors, the bandwidth is limited by the carrier transit time across the intrinsic region. As the transit time decreases by thinning intrinsic region, the higher roll off frequency, however, limits the device speed . On the other hand, depletion longer capacity *Cd*. And the inevitable trade off between RC-circuit and carrier transit time limits this kind of photodetector bandwidth.[4]. The 3-dB bandwidth of the device is restricted by the intrinsic capacitance of depletion longer capacity Cd and impedance of the device. The amplifier has a low resistance of 50 Ω, if we need a bandwidth of 5GHz,. On the other hand the 3-dB bandwidth of the amplifier is restricted by the capacitance of transistor but in our case it is much larger than the bandwidth of the photodetector. For real the microwave optoelectronic receiver, however there are many other factors like circuit configuration, parasitic capacitances and inductances of the amplifier, microstrip and photodiode that influence the 3-dB bandwidth.

We shall analyze and simulate the microwave optoelectronic receivers in the program MIDE where we shall represent every element like its corresponding equivalent circuit model to calculate the properties of microwave propagation and the optimum performance can be achieved at the impedance matching, performance dynamics and the low loss microwave transmission. Thus, the photodiode will be represented like a current source with its *R-L-C* elements, the amplifier will be represented by its scattering parameters (these ones were measured on the network analyzer HP 8510B). Now we have a resonant circuit where we shall apply the peaking effect incorporating an inductance between the photodetector and the input of the amplifier, thus, the intrinsic capacitance should be minimized to improve the bandwidth. The depletion longer capacity *Cd* combining with the parasitic capacitance and inductance of metallization surrounding the photodetector and amplifier forms the overall circuits. On an insulating substrate (Al_2O_3) the bias circuitry for the photodiode and amplifier will be made with their passive elements and connectors by thin film technology, where the suitable inductance is formed on the substrate plates of specific pattern of Au. Formed by deposition through masks or by deposition of a continuous sheet with subsequent selective etching. Thus, using MIDE we can simulate the p-i-n photodetector, microstrip, inductance and MMIC amplifier like a circuit formed by current source and passive elements like resistances, capacitances and inductances; the amplifier is represented like their scattering parameters obtained from the network analyzer . When we get a correct equivalent circuit we can see the variation of the gain (S_{21}) in the device changing the extra inductance between the p-i-n and amplifier and make wider the bandwidth by the peaking effect, the value of this inductance is about 2 nH, increasing the bandwidth at 5GHz.

The Microwave OE receiver model is used to optimize and design the microstrip structure. The simulation of the Microwave OE receiver results reveal that this kind of microwave circuit is limited by the carrier transit time and capacity across the intrinsic region in the photodiode. The electrical scattering (S) parameters of the amplifier of the microwave optoelectronic receivers are measured using a 20 GHZ network analyzer. The measurements will be made in three points, firstly we shall see the behavior in the photodiode, second measurement will be only the amplifier with its external circuit, finally we shall compare the scattering parameters simulated and measured in the analyzer. By increasing from 3.5GHz to 5GHz in the microwave optoelectronic receiver we can improve the speed transmission at low cost, easily and fast.

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Construction of 3D City Model from PointCloud

J. Urban, J. Hala, L. Koníček

urban@fsv.cvut.cz

Department of Informatics , Faculty of Civil Engeneering, Czech Technical University, Thákurova 7, Prague 6, Czech Republic

City models are very needed objects at present time They are useful for many urban applications such as planning, construction and visualization urban sceneries, signal radiation analysis and many other applications. This is the reason why, in order to generate city models, many of approaches have been developed during recent 10 years, using different data sources, many different methods on a different level of automatisation. Existing data models are of different geometrical resolution which is convenient for various purposes despite of fact that
there was a great emphasis on creation of multi resolution models.

This work focuses attention on several partial problems concerning city modeling. Some of them were developed in student diploma projects [3], [4]. The main objective of this project is the proposal of technology for fully automated generation of schematized city model using airborne laser scanner PointCloud. The result of this process is 3D block model that is composed of simplified geometry of buildings and of terrain. For beeing time the vegetation is neglected in model representation. Nevertheless the vegetation data in PointCloud have to be recognized.

In accordance with the modeling method classification by [1], the here suggested one is data driven method, which tries to find the planes in PointCloud. The proces of finding planes (segmentation) is carried out in several steps of clasification points of cloud. At first it is convenient to identify terrain points and building points by profil analysis. In next step the planes of buildings roof are determined and topological informations of planes adjacency are mapped. Edges and vertex can be then found as intersections of relevant planes.

Special proces has to be applied to find boarder edges of building roof. There was discussed
two methods of computing them. The first one takes in consideration only the data from PointCloud.Vertikal building faces are limited by terrain surface that could be easy constructed using PointCloud. Top limit of them is represented by roofs boarder edges. The other method uses the building ground plan from digital cadastral map [4]. Boarder roof edges are then determined as intersections of roof planes and vertical faces on ground lines. This way is more accurate but much more complicated using another data source.

In proposed data structure the 3D block model is composed of triangles and rectangles. Triangles are used for roofs and terrain surface representation. Buildings facades are represented by rectangles. This representation can be easy transformed to triangular irregular network (TIN) usually used in GIS and CAD systems. The city can be then managed as one continuous surface, known as digital surface model (DSM) that describes only shape and does not distinguish between buildings and terrain.

In contrast, the proposed data structure of 3D block model enables to pass easily to model of higher resolution. In that case the plane faces of building facades could be textured by terrestrial raster picture or replaced by micro relief, derived from terrestrial PointCloud.

Data of terrestrial PointCloud could be processed by similar way as airborne PointCloud. The relief of facade may by covered by triangular net, generated of PointCloud. Experiments were made to extract 3D primitives on the facade using data driven method [3]. Because of geometrical complexity of facades, the mentioned method needs human interaction whereas construction of 3D block city model could be fully automated.

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Removing Noise from an Imaging Data

J. Švihlík

svihlj1@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

It is generally known, that the image usually contains a noise, which induces a degradation of image. We have a lot of methods, more or less suitable, for his removing. For the first time we can divide this method like a linear and nonlinear. To linear methods mainly belongs in spatial domain, convolutions filtering and the frequency mask in spectral domain. Nowadays is popular to use Discrete Wavelet Transform (DWT), because this transform is a very good tool for denoising. Two methods will be discussed in this paper using two types of Wavelet Transform. The first of them is based on feasible thresholding (hard or soft) of wavelet coefficients on a suitable decomposition level (see [1]). This method uses Wavelet Transform, which is usually named dyadic decomposition. The second one, more sophisticated, uses special type of Wavelet Transform – the steerable pyramid, which was proposed by Simoncelli (see [2]).

As mentioned above, the principle of denoising by DWT is based on suitable thresholding of wavelet coefficients on a feasible decomposition level. These coefficients is achieved, when DWT is applied to noisy signal (image containing additive Gaussian noise). In this case, DWT can be seen as specially sampled Continuous Wavelet Transform (CWT), where the sampling is proceeded on a dyadic grid. There are two thresholding methods, the first method is called soft thresholding and the second is called hard thresholding. When is used algorithm for hard thresholding, then all coefficients under the threshold value are vanished, remaining coefficients get the same value as before. In the case of soft thresholding, the coefficients under the threshold value are similarly vanished like before and the value of remaining coefficients is computed by equation (6), which can be found in [3]. It is good to note, that the amplitude of threshold was estimated by Donoho's equation. The last step to obtain a denoised signal is to take the inverse DWT of thresholded coefficients. All of these denoising algorithms was implemented in Matlab. Implementation also including dyadic decomposition.

In items above has been showed the principles of denoising by using Discrete Wavelet Transform. We have used two algorithms for denoising; with soft and hard thresholding. From results, we can conclude, that when in this experiment are compared soft and hard thresholding, the better is hard (comparing MSE). As mentioned above, threshold was computed by equation, which was induced by Donoho and Johnston. This formula is based on probability theory, because the additive Gaussian noise has his naturalism, even when is dyadic decompoisition applied. From whence it follows that four times standard deviation contains approximately 99.99 % of the noise and than it is easy to choose suitable value of the threshold and noise romoves.

The second method for noise removing, which was mentioned above, is based on a statistical model of the coefficients of the special Wavelet Transform usually called steerable pyramid (see [4]). This form of the Wavelet Transform is redundant in comparison with dyadic decomposition.

When we want to separate the noise from an image data (degraded image), then it is necessary to know prior information about the typical description of the image and know

statistical properties of the noise (stationary, independent, additive Gaussian noise of known autocovariance). The image, which is denoised, is represented by special form of the Wavelet Transform (redundant, steerable pyramid). It is important to know, that wavelet coefficients has quite interesting properties, especially shape of the histogram (strong peak at zero) and significant correlation between neighbour coefficients (see [2]). These properties are modelled by Scale Mixtures of Gaussians. The estimation of the image is proceeded using Bayesian least square estimator. Javier Portilla from Universidad de Grenada is the scientist, who's mainly interested in methods using Scale Mixtures of Gaussians in the wavelet domain. I am also interested in these powerful denoising methods and I would like to deal with this movement of development.

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CTI Client at Telephone Exchange Avaya Definity

V. Dolecek

dolecev@fel.cvut.cz

Department of Telecommunications, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Computers and computer networks are nowadays in fast development. Because of their increasing reliability and stability, they are more and more penetrating into telecommunications. First they were used in telephone exchanges control, and now with Voice over IP technology they are replacing classical telephone lines (analog, ISDN) and even the telephone terminals. Next very promising technology is the CTI (Computer Telephony Integration).

In CTI computers are used for controlling telephones, exchanges, modems, faxes and other telecommunication devices. By interconnection of computers and telecommunications we can get new features, which were not realizable before. CTI is mostly used in call centers, but it is not limited for this use only. It could also be used for voice recording, in billing and in many other applications. CTI is mostly a server – client technology, using one telephony server and many agent workstations and telephones as clients. The telephony server is connected with the telephony exchange Definity over the Ethernet (with normal crossed-over UTP cable). In the telephony server this cable is connected to a network card, in Definity it is connected into a special device termed as MAP-D. On the telephony server there are three important programs, which have to be installed. The switch driver, CTI server and CTI client. Without the CTI client we could not use the server based applications important for the server management. On the agent workstations a CTI client must also be installed. In CTI any type of a telephone could be used. It can be an analog, ISDN, IP or system phone.

The telephony applications communicate through CTI clients with server. To program applications, standard libraries (APIs) should be used. API (Application Program Interface) is used for easier programming and for unifying interfaces. With them the programming is like "putting blocks together".
CSTA (Computer Supported Telecommunication Applications) is a standard from ECMA (European Computer Manufactures Association). Other telephony APIs are based on it.
TAPI (Telephony API) is designed by Microsoft. Adding a new telephone exchange is similar to adding a printer driver to windows.
TSAPI (Telephony Services API) is from Avaya and Novel. Although it was designed by Avaya, it is widely used by other telecommunication manufactures.
JTAPI (Java Telephony API) as the name says is used for programming applications in Java. Because I have used this API in my application, I'll focus on it.

JTAPI has three advantages: First Java is operating system independent, second it is widely supported by telecommunication manufactures and third, it is able to work with other telephony APIs.

The Java Telephony API is composed of a set of Java language packages. Each package provides a specific piece of functionality for certain aspect of computer-telephony applications. The core package is required by most JTAPI implementations. The other packages are optional.

The core package contains the core features. These features include placing a telephone call, answering a telephone call, and disconnecting a connected telephone call. Simple telephony applications will only need to use the core to accomplish their tasks, and do not need to concern themselves with the details of other packages.
The callcontrol package extends the core package by providing more advanced call-control features and a more detailed state model of telephone calls.
The callcenter package provides the ability to perform advanced features necessary for managing large call centers. Examples of these advanced features include: agent support, routing, Automated Call Distribution (ACD).
The media package provides the ability to manipulate media streams associated with calls.
The mobile package provides features required for applications running on mobile telephones or within a mobile telephone network environment.
The phone package permits applications to control the physical features of telephone hardware phone sets. Implementations may describe Terminals as collections of components, where each of these component-types has interfaces in this package.
The privatedata package enables applications to communicate data directly with the hardware switch. This data may be used to instruct the switch to perform a switch-specific action.

The Call Model used in JTAPI consists of six primary or *core* call control objects;

- Provider - the "window" through which JTAPI applications see the telephony system.
- Call - the dynamic "collection of logical and physical entities" that brings two or more endpoints together.
- Address - a logical end-point - a "phone number".
- Connection - the dynamic relationship between a Call and an Address.
- Terminal - a physical end-point - a "phone set".
- TerminalConnection - the dynamic relationship between a Connection and a Terminal.

These objects are defined using Java interfaces in the core package. Each call model object represents either a physical or a logical entity in the telephone world. The primary purpose of these call model objects is to describe telephone calls and the endpoints involved in a telephone call.

The purpose of my application wasn't to serve as a call centre. It was only a test application for proving work with JTAPI and JTAPI call model. When a change of a call object state occurs, this new state is written in a text window. This is very useful when you want to know, how the things work. With this application you can choice a controlled phone, dial a number from a computer and disconnect the call. This application is also very useful, when you are using a telephone without a display, because it can show you caller's phone number.

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CRC Simulation

J. Volf

volfj@fel.cvut.cz

Department of Telecommunications Engineering, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

A cyclic redundancy check (CRC) is a type of hash function used to produce a checksum - which is a small number of bits - against a byte or a larger block of data, such as a packet of network traffic or a block of a computer file. The checksum is used to detect and correct errors after transmission or storage. A CRC is computed and appended before transmission or storage, and verified afterwards by recipient to confirm that no changes occurred on transit. CRCs are popular because they are simple to implement in binary hardware, are easy to analyze mathematically, and are particularly good at detecting common errors caused by noise in transmission channels.

Telecommunications engineers are to understand the principles of protecting data by the use of CRC codes, so the Department of Telecommunications Engineering prepares a couple of subjects for them to become familiar with these principles. The schedule of one of these subjects, called The Basics of Data Communications, contains two practical lessons that tell them why and how to create CRC polynomials. There were prepared two web-based presentations for them. These materials are actually forms, that can be used by the students to verify their calculations when creating CRC protected data polynomials. Students put a couple of values into these forms, e.g. length of the input data sequence, (decimal) value of this input sequence, one of the CRC generating polynomials etc., and the server sends them an output.

The first form is used for counting the minimal Hamming distance of two codewords, the detecting and the correcting coefficient. These values are dependant on the size of the input data sequence and the chosen CRC polynomial, so these inputs have to be filled in. The detecting and correcting coefficients are very important when choosing the right CRC encoding polynomial.

The Hamming weight of the bit sequence is equal to the amount of 1s in this sequence. In the example sequence [0 1 1 0 1 0] three 1s can be found, so the Hamming weight of this 6-bit sequence is 3. The Hamming distance expresses the number of bit positions in which the two compared codewords differ. In most cases the Hamming distance of the two codewords is determined by adding these two words in modulo 2 arithmetic. The Hamming weight of the newly created codeword is then equal to the Hamming distance of these codewords. For the chosen length (number of bits) of the input data sequence, the finite number of valid CRC protected sequences can be produced. This finite number is equal to $2^{(\text{number of bits})}$. For example if I want to encode 4-bit long input sequences, I get 16 possible codewords protected by any CRC polynomial. The minimal Hamming distance d_0 is the minimum of Hamming distances counted between all different couples of codewords in the whole set (in this case 16) of valid CRC-protected codewords. The detecting coefficient is then counted according to Formula 1. Formula 2 tells how to get the Correcting coefficient. Table 1 shows a set of examples of CRC generating polynomials, that were chosen for this web-based educational material.

$$D = \frac{1}{2} \cdot d_0$$

Formula 1

$$K = \tfrac{1}{2}(d_0 - 1); \ldots d_0 \rightarrow odd$$
$$K = \tfrac{1}{2}(d_0 - 2); \ldots d_0 \rightarrow even$$

Formula 2

CRC-1 [1 1]	CRC-7a [1 0 0 0 0 0 1 1]
CRC-2 [1 1 1]	CRC-7b [1 0 0 0 1 0 0 1]
CRC-3a [1 0 1 1]	CRC-7c [1 0 0 1 0 0 0 1]
CRC-3b [1 1 0 1]	CRC-7d [1 1 0 0 0 0 0 1]
CRC-4a [1 0 0 1 1]	CRC-8a [1 0 1 1 0 0 0 1 1]
CRC-4b [1 1 0 0 1]	CRC-8b [1 0 0 0 1 1 1 0 1]
CRC-5a [1 0 0 1 0 1]	CRC-8c [1 1 0 0 0 1 1 0 1]
CRC-5b [1 0 1 0 0 1]	CRC-8d [1 1 1 0 0 0 0 1 1]
CRC-6a [1 0 0 0 0 1 1]	CRC-12 [1 1 0 0 0 0 0 0 0 1 1 1 1]
CRC-6b [1 1 0 0 0 0 1]	CRC-16 [1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1]
CRC-6c [1 1 1 0 0 1 1]	CRC-CCITT [1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1]
CRC-32 [1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 1 1 1 0 1 1 0 1 1 0 1 1 1]	

Table 1

The second educational web-based material is a form, too. In this example, the students are asked to fill in 4 fields. In the first one, they must specify the length of the input sequence. The value of this input sequence, expressed in the decimal system, is then put into the second field. Choosing the CRC generating polynomial is the next step in this form. In the last step, students can set the number of bits that are corrupted at the end of the transmission line. After the data is sent to the server, the new page with the output is opened. At this page are to be seen the CRC sequence, the output sequence of the CRC encoder (input sequence + CRC sequence), the error that is added to the transmitted sequence, the data sequence at the input of the CRC decoder and the detection coefficient. The last information you get from the output indicates if the transmission was error-free or not.

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Security Mechanisms in SIP

T. Vanek

vanekt1@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,

Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

SIP stands for Session Initiation Protocol. It is an application-layer signaling protocol used for establishing sessions in an IP networks. SIP is standardized by several RFCs. The most important is RFC3261. SIP is used for creating, modifying, and terminating sessions with one or more participants. It is based on HTTP protocol. HTTP is very popular and widely used protocol in the Internet. Both HTTP and SIP protocols have encode the messages headers as described in RFC822. This encoding scheme was proven to be robust and flexible over the years. SIP is not the only protocol that the communicating parties need for communication. It is not a general purpose protocol. Main purpose of SIP is ensuring communication but the communication itself must be done by another protocol. There are two other protocols that are often used with SIP: RTP (Real Time Protocol) and SDP (Session Description Protocol). RTP is used to carry the real-time multimedia data such as voice or video. The RTP encodes and splits the input data into packets and transport these packets over the IP based network. Second important protocol is SDP, which is used to describe and encode capabilities of session participants.

SIP network security includes voice-packet security, which focuses on application issues, and IP security, which focuses on a network or transport problem. Securing a digitized bit stream is an example of a transport-level problem. SIP deployments in a VoIP network are exposed to a wide range of network security threats and attacks. SIP may be deployed in relatively safe environments where the network equipment is trustworthy and physical security is agreeably sufficient, or into a potentially hostile Internet environment.

There are two kinds of possible threats to a SIP-based network – external and internal. External threats are attacks launched by someone who is not participating in the message flow during a SIP-based call. External threats usually occur when the voice and signaling packets goes through untrustworthy networks and may involve third-party networks when the call traffic is transferred from participant to participant. Internal threats are launched by a SIP call participant and so they are usually much more complex. Because a SIP call participant launches internal attacks, the trust relationship is broken. Usually communication endpoints are administratively controlled and secured behind firewall so they aren't capable of launching an attack. Once the trust relationship is broken and an endpoint acts as hostile, it is very difficult to identify the source of the attack.

Network security issues can be dividend into several categories including:

- denial-of-service (DoS) attacks - prevents access of legitimate users to a network service by flooding SIP proxy servers
- replay attacks - retransmission of a genuine messages
- eavesdropping - unauthorized monitoring of voice packets or RTP media stream and subsequent decoding of signaling messages
- packet spoofing - emulation of a legitimate user transmitting data

The fundamental network-security services required for SIP are preserving the confidentiality and integrity of messaging, preventing replay attacks or message spoofing, providing for the authentication and privacy of the participants in a session, and preventing DoS attacks.

SIP offers various security mechanisms for hop-by-hop and end-to-end encryption of sensitive header fields and the message body. Some of these mechanisms are built into the protocol itself, such as different variations of HTTP authentication or secure attachments. Network-layer security encrypts SIP signaling traffic, guaranteeing message confidentiality and integrity. IPSec is a popular network-security mechanism that provides transport layer security can be used to guarantee confidentiality, integrity and protection against replay attacks.

Authentication provides a mechanism to verify that a user or client is legitimate. In a SIP network, the authentication can be placed between the user agent and the proxy. SIP defines headers that are used for authentication. The authentication header contains a signature computed across components of the SIP message. This header does not change in transit between proxies and consists of: the nonce (a big randomly generated number, which is used only once), the realm, the request method, the request-method version and the authorization type. There is also a proxy-authorization header, which is used by a SIP user agent to identify itself to a proxy. This contains the type of authentication, credentials of the user agent, or realm of the resource being requested. Once authentication is achieved, it must be determined whether that identity is authorized to use the services it is requesting.

Confidentiality is accomplished by use of encryption. SIP itself does not consider the encryption of media data. Using the RTP encryption as defined in RFC 1889 may provide confidentiality for media data. Another option for media stream security is the use of SRTP. However, critical headers in the SIP message, such as the TO and FROM fields cannot be encrypted end-to-end because they are interpreted by intermediate devices. For this reason, lower layer security implementations (e.g. VPN) would need to be considered for global end-to-end security across an Internet.

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Comparison between Relay Method for Controller Tuning Using Linear Model of Plant and Using Non-linear Model of Plant

S. Vrána

stanislav.vrana@fs.cvut.cz

Department of Instrumentation and Control Engineering , Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

The method of Ziegler and Nichols for a PID controller setting was proposed in the 40th of last century. In the last years it has been used its new alternate called relay method. Using classic method of Ziegler and Nichols critical parameters of a plant are obtained from so called critical setting of the controller, which becomes evident outward with undamped periodical oscillation.
From the critical parameters obtained by this way controller parameters are computed.

It was described by Åström how to obtain critical parameters without exigency to reach a critical state of a plant. It is possible to obtain critical parameters using non-linear element like relay or saturation in feedback of the control loop. When the non-linear element is connected into the feedback the control loop will oscillate. The period of the oscillating is the critical period T_{krit}. Critical proportional gain r_{0krit} is defined by equivalent representation of transfer function of the inserted non-linear element. A simply relation is derived for the relay with symmetric amplitude at the output of the relay and without hysteresis. The proportional gain r_{0krit} is derived as amplitude at the output of the relay divided by amplitude at the input of the relay and multiplied by constant $4/\pi$. Similar relations can be also derived for a relay with hysteresis, relay with non-symmetric amplitude at the output of the relay, and for saturation.

Model of two-tank cascade was chosen for testing of relay method using non-linear model of plant and linearized model of plant. This model is non-linear and respects such phenomena like technological limits, accumulation stopping and changing parameters in various operation ranges. Dependence of the time constants of this model on both inputs (opening of input valve and output valve) is strong non-linear. Linearized description of this plant leads into the linear model of the second order. Model of two-tank cascade has been made in Matlab/Simulink software in the way that there is not necessary to compute initial conditions in extra program. Initial conditions are computed in the Simulink scheme that includes both non-linear model and linearized model. Because both models are contained in one Simulink scheme, it is possible to compute parameters of linearized model in this scheme too.

Some experiments has been made in different operation ranges (different desired value of a level in the second tank) and with different amplitude at the output of the relay. While the relay method using linearized model of plant has been tested, the critical parameters has changed only when desired level in the second tank was changed. It has been proved that the critical parameters were independent on the amplitude at the output of the relay. While relay method using non-linear model of plant has been tested, the critical parameters changed not only when desired level in the second tank has changed, but also when the amplitude at the output of the relay has been changed. The value of changes of critical parameters owing to changes of the amplitude at the relay output depends on the desired level in the second tank.

This is the first found difference between using non-linear and linearized model for relay method.
Verifying the controller parameters obtained using relay method was made with the PI controller in the closed control loop with the two-tank cascade. The standard relation of Ziegler and Nichols for PI controller was used for computing controller parameters from critical parameters of plant.

When controller using the settings obtained from experiments with relay method using linearized model of a plant was tested with the linearized model, there were no problems. The control performance was oscillating, but it was stable. However, when the controller using setting obtained from experiments with relay method using non-linear model of plant was tested with the non-linear model, the control performance was stable in some cases and unstable in other cases. Unstable control performance has been detected when the desired level in second tank was higher than a marginal level. In these cases a small disturbance with positive sign caused unstable control performance. When the sign of disturbance was negative, the value of disturbance could be bigger nevertheless the control performance was stable. This behaviour, dependence of stability of control performance on sign of the disturbance, is possible only when non-linear plant is controlled. Using linearized model of this plant in this case could cause significant errors.

The problem with unstable control performance in this case of model of two tank cascade was solved using modified relations between critical parameters and controller parameters where integrative time constant T_I is double in comparison with standard Ziegler and Nichols relation. This modification caused smaller integrative gain of PI controller. The control performance was oscillating, but was stable in this case. Better results could be probably obtained using another modification of relations of Ziegler and Nichols.

When the PID controller using the settings obtained from experiments with the relay method using linearized model of plant was tested with the non-linear model, the control performance was unstable in all tested cases. The found critical parameters of linearized model were different from the parameters of non-linear model, because linearized model of plant doesn't respect some properties of non-linear plant, especially changing parameters in various operation ranges. Effect of difference between nonchanging parameters and changing parameters of model is visible when comparing non-linear model step response and linearized model step response. Linearized model step response reach the final value in shorter time than non-linear model step response. It means that the critical period of linearized model is smaller in comparison with the critical period of non-linear model.

Because there is no situation where linear plant is described with non-linear model, this case was not tested.

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Conversion of Pascal Object Constructions into the C Programming Language

D. Nulíček, M. Šťáva

nulicd1@fel.cvut.cz

Dept. of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Praha 2

The fast development in computer science in the last years had as a result downfall of several software tools commonly used in the past. The Pascal language was also afflicted among programming languages. Although many good programs were surely written in it, this programming language is due to its dependency on the operating system *DOS* hardly useable today. This operating system has been replaced, e.g. by *Windows, UNIX, Linux* or *FreeBSD* and compilers for the most important dialects of Pascal language lacks (especially from *Borland Company*). However an almost platform independent C language compiler exists – *gcc*. So why not to convert programs written in the programming language Pascal into the C language and then to compile them by using the *gcc*? The advantage of this solution is in addition the fact, that a programmer unknowing the Pascal language can eventually edit the source code in the C language. A few programs that convert between given languages exist today. However none of them maintains the *Borland Pascal 7.0* dialect and the conversion of object constructions of the Pascal language.

The first premise for the successful conversion is a correctness of the source code written in the Pascal language. Further the *Borland Pascal 7.0* dialect will be thought for the Pascal language and the *gcc* compiler for the programming language C.

The next premise is ability somehow to understand and process a source code written in the Pascal language. Without that it is impossible to generate the corresponding code in the C language. It is the classic procedure that is used in conversions and compilations of any source code written in any language. First of all it is the parsing analysis executed on the basis of the given grammar. During the process, information about single parts of the source code is collected. If it is collected complete information about any part, then it is possible to begin its conversion into the C language and generate an output code.

Let's take a look at *the collecting information* phase. This effort is slightly made easy by the fact that a program written in the Pascal language is divided into several declarative parts and one statement part. The collecting information takes a place only in the declarative parts. There are six declarative parts in the Pascal language (*uses, label, const, type, var, procedure* and *function*). It is necessary to keep complete information about each declared item. So by analyzing each single declarative part, lists of variables, constants, types, labels, functions etc. are created. For better efficiency of the converter, these lists are not stored in a *linked list*, but items of the lists compose a *binary AVL tree* [2], for which the time complexity of the needed operations (insert, find and delete) is $O(log_2(n))$.

But we are interested especially in conversion of object constructions of the Pascal language. The definition of an object is in the Pascal language done in the declarative part *types*. An object is a type similar to the record type with one difference. The object besides data items (characteristics) and contains also headers of its methods. So if a definition of any object is found in the declarative part *types*, information about data items is kept in the list of characteristics, about methods in the list of methods, but also if the object has any ancestor,

the pointer to his direct ancestor is kept. In the list of types, such a way is created in the hierarchy of objects.

When the list of characteristics is created, the procedure is quite similar to a creation of a list of variables. In the creation of the list of methods, the situation is little bit more complicated. Methods are different from functions in the Pascal language by that they can be virtual, dynamic, constructor or destructor. This information is also necessary to remember.

When is the complete information collected about any object, it is possible to generate its representation in the C language. Therefore it is necessary to specify several rules [1]:

- Each object representation is written into an individual file. The filename will be same as the name of the object.
- A new type (derived from the structure) is defined and named similar to the object.
- In the new type, all data items (characteristics) of the given object are declared and at the same time, all data items of the ancestors of the given object that are not signed as *private* are declared.
- In the new type, pointers to the functions that represent methods of the given object and the public methods of the ancestors of the given object are also declared.
- The names of all private items are prefixed with word *private*.
- In generation of functions that correspond to methods of an object, it is necessary to ensure uniqueness of their names. The names of the functions are prefixed with the name of the correspondent object.
- The names of the functions can be also influenced (beside possible sign *private*) by the fact, if the correspondent method is *virtual* or *dynamic*.
- The first parameter of each function is a pointer to the correspondent instance of the correspondent object (*self*).

The appropriate function is assigned to pointers to static methods during the conversion. It is not possible to do the same for pointers to virtual or dynamic methods, because the correspondent function is known during the run of the program. So into the generated code in the C language, a data structure that exactly simulates behaviour of the virtual method table used in the Pascal language is inserted. The correspondent function is then assigned to pointers to virtual or dynamic methods, during the run of the program on the basis of a virtual method table.

Implementation of the procedure presented above makes the possibility of converting programs written in the object Pascal language into the C language. This solution is a very good base for creation of the complex converter of programs written in the *Borland Pascal 7.0* that contains a library for creation graphic user interfaces in addition, *TurboVision 2.0*, into the C programming language.

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Open Source GIS: Graphic Outputs in Various Environments

M. Bořík*, V. Honzík**

borikm@mat.fsv.cvut.cz

* Department of Mathematics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

** Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Our project at the Faculty of Civil Engineering is strictly open source system. The project solves the www visualization and analyzing the open-cast mining activities and the reclamations development in the area of North Bohemia coal basin. We fixed the problem with transformations between coordinate systems applied in Czech Republic by the help of the freeware library PROJ before now. Currently, we deal with the interconnection of the mapping server UMN MapServer and PostGIS (enhancement of relational database PostgreSQL enabling the use and manipulation of spatial objects), that can use the PROJ library. We can use complicated SQL queries using PostGIS and store them as new tables or views. Therefore using UMN MapServer or JUMP, we can display them on Internet. We need any Internet browser to this. In conclusion, we can do comparison between the both free mapping software.

PostGIS consists from the set of SQL scripts which (when executed on given database) creates necessary data types, metadata tables and functions for their manipulation. PostGIS takes advantage of GEOS library (Geospatial Engine – Open Source). After that, there is possible not only to store and display spatial data in the spatial database, but also manipulate those using spatial functions and operators in the same way we are used in the area of desktop GIS.

We have chosen PHP/MapScript interface after practical exercises and building of a test application. Therefore, we can influence practically all parameters that determinate feature of a generated map. Simultaneously, PHP language offers functions for data manipulation in database easily. In addition to PHP language at the server side, there is necessary to ensure some functions at the client side as well. We have chosen the Javascript language in consideration of the standards so that applications are not limited to the used internet browser. The result of that are several particular applications whose components will be used further.

It is necessary to create a new table or a view. They have to have correct geometry. Further we have grant privileges for user “MapServer”. The library PHP/MapScript usage in the PHTML file looks as follows:

```
        Library with MapScript is loaded:
dl('php_mapscript.so');
        Path to the map file is set up:
$map_path="./";
$map_file="test.map";
$map = ms_newMapObj($map_path.$map_file);
        Map is drawn in memory:
$image=$map->draw();
        Map is saved to the temporary folder on disc:
$image_url=$image->saveWebImage();
```

Image from the temporary folder is displayed:

...?php echo $image_url?>"

After it we can join other sections (objects) into the map file eg. SIZE, EXTENT etc. For each LAYER it is necessary to mention TYPE (polygon, line, point), CONNECTIONTYPE (postgis) and CONNECTION (user=mapserver, password, db name, host, port). DATA have to have defined geometry from the table or view. As UNIQUE key is the geometry and the concrete coordinate system (SRID) has to be mentioned.

We have been interested in applications to generating of large-scale sets of randomly generated geodata for testing purposes of the PostGIS spatial functions effectivity, and rendering speed of raster maps by Mapserver. Further, various thematic maps have been created on the basis of statistical analyses of features in tables. Hereafter, we have executed effectivity tests of the spatial database (with around millions of features), and optimation of database queries. There are documented procedures to substitute spatial operations executed in desktop systems with SQL queries. We work on the rules that decide, which operation and which maximal number of features will be executed dynamically on the basis of users demands, or statically and then their results saved as next tables into the database.

In conclusion, we are going to mention a few graphic outputs in UMN MapServer and JUMP. (1) is an example of the topological relationship usage between partial objects. There are all regions bordering upon Most region and we used the function Touches. (2) is a join of two different geometries, maps ZM10 (polygons) and seats in Czech Republic (polygons) concretely, and their intersection by means of the function Intersects. (3) There is a connection of polygons OBCE with lines SILNICE by means of the function Contains. PostGIS can work with different object types. For example we can display several furthest seats (points) from a given region (polygon).

Next map outputs are concerned with top largest regions according to their area (4) and polygons containing a “hole”. (5) There is a swamp (polygon) with a hole. We used the function nrings. Further, function Intersects can be used to destiny TM25 maps or all regions (polygons), which intersect a given main road (6, 7). We can use that function to determinate numbers of different TM maps and ZM maps (8) for a given seat (point) as well. Function Contains can be used to illustrate all regions or woods within a given country (9, 10).

We can use complicated SQL queries using PostGIS and store them as new tables or views. Therefore using UMN MapServer or JUMP, we can display them on Internet. We need any Internet browser to this.

Notice: Pictures (1) - (10) will be presented in poster section.

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Conversion Among Object Oriented Languages

M. Chalupník, M. Šťáva

chalum2@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

What is a goal and why did we choose this topic?

Our goal has been to develop an application that will allow conversion among different programming languages that are commonly used today. These days, it is possible to find some converters, but there are some disadvantages. First of them is a fact that converter usually works only for two specific languages. There is no possibility to add another language. Another disadvantage is "fixed form" – there is no way how to modify a code generated during a conversion process. For example, you may need to add some code at the beginning of some function or method, but you cannot. These applications usually have a closed source and they are not free of charge, so you are not allowed to modify their source code as you need.

Brief information about our project

In previous paragraph, there were mentioned some disadvantages of existing applications. At this paragraph, it will be described how our solution works. Application is not just "one piece of code" but it is divided into several kinds of modules, each module has its specific features.

First kind of module is used to load a source code – it is some code that we need to be converted to another language. During this process, data are stored in memory in a specific form called "internal form".

Having a internal form of a source code in memory, we can modify it. For example, it is possible to write a module that will be looking for some procedure call and replace it with a call to another procedure or function – it may be useful when function becomes obsolete.

When all modifications are completed, it is necessary to write the modified internal form to a file. Writing is handled by a module called writer. This kind of the module has rules for all supported languages, this rules tell how elements of the internal form look like in a target source code.

As you can see, conversion can be very simple and variable – you just choose some module to load a source code into memory, and some module or modules to make modifications to that code. After that, you choose a module supporting writing, and the modified code is saved to a file.

Features supported by the application can be simply extended. All you need to do is write a new module containing a class inherited from our base class and new features are available.

Current state of project

At the beginning of project, we have analyzed a situation on universities in our country and we did not found any similar project. It is possible to find some information how to parse a source code, but we have found no information about problems related to conversion among different languages. Several web sites with some converters exist on the Internet, but all of them are aimed at specific languages and have disadvantages described at the first paragraph.

At this time, we analyze features of commonly used programming languages and we suggest the internal form that will be able to cover these features.

How can be results of our work used?

There are many problems that such a application can solve. The first one is "simple" conversion among two languages. Another problem is the conversion of dependant routines – in example, a source program may contain functions dependent on one operating system but you need to port a program and compile it on another operating system.

Sometimes happens that you use one version of Development environment, upgrade to a new version and your code cannot be compiled because some data types were removed, some were renamed and so on. It is possible to change a code manually, but this problem should be solved by our application too.

In same case, it can be useful to modify a code and add something at some specified position in a code – for example, you may want to add some debug message at the beginning of methods. With such a converter, it would be very easy.

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Pair and Multi - Wire Cable Modelling

Tomáš Hubený, Jiří Vodrážka

hubenyt@fel.cvut.cz, vodrazka@fel.cvut.cz

Faculty of Electrical Engineering – Department of Telecommunication Engineering
Czech Technical University in Prague
Technická 2, Prague, Dejvice

Contemporaneousness is characteristic by rapid rising of requirements given by telecommunications network. An endeavour is the following: as the quantity of these information increases, the time necessary for delivery of the information decreases. Hence digital systems xDSL are set in the telecommunications network. The systems are suitable both for a domestic user (ADSL system) and for a business area (SHDSL, VDSL system).

However, these subscriber lines claim wider frequency ranges than the network was performed to. This bears the risk of an increment of mutual crosstalk in telecommunications cables. That is why a knowledge of the primary and secondary wire parameters is necessary. Supposing the parameters of the telecommunications network are known, it is possible to assess a real behaviour of the systems set in the network. Analogous principles of the modelling are applied in coaxial pairs used in networks of a cable television (CATV).

The transmission behaviour of lines is described by their primary parameters, which are: resistance, inductance, capacitance and conductance per unit length (for short: specific resistance, specific inductance, specific capacitance and specific conductance. These quantities are expressed in Ω/km, H/km, F/km and S/km. The secondary parameters are derived from the primary parameters: The secondary parameters are: characteristic impedance and propagation constant. Both of the secondary parameters have real and imaginary parts. The real part of the specific transmission rate is the attenuation, the imaginary part is the phase shift.

The elementary unit of the telecommunication line is generally two insulated wires twisted uniformly together to form a balanced pair. By twisting four insulated wires together, sometimes using a centre string to improve the mechanical uniformity, a quad is formed. By using the opposite wires of the cross-section as the two elements forming a pair, the overall diameter, now containing two pairs, is smaller than two individual pairs twisted together. And so is the capacitance and attenuation of the pairs for the same diameter ratio. The quad compared to the pair keeps lower values of the attenuation and capacitance. On the other hand, the quad construction embodies higher values of crosstalk compared to the pair construction. All above mentioned cable elements can be screened by aluminium foil. This step improves crosstalk between the individual elements.

The parameters of the particular transmission lines can be realized from measuring. Nevertheless the dependence obtained by this way is not suitable for simulation purposes. On the other hand the dependence given by a mathematic function with variable parameters is used. It allows a transition from frequency to time domain, impulse response of the channel. This is important for analysis of the digital signal transmission. The most known models have been designed by the British Telecom company (BT model), Deutsche Telekom AG company (DTAG model) and Royal PTT Netherlands company (KPN model). Some of these models form a part of ITU-T G.996.1 recommendation. This recommendation deals with test processes for DSL transceivers. Another possibility how to simulate the systems set in the subscriber lines, is to use a model based on physical properties and cable geometry.

Models that have been performed by the British Telecom company are designed for simulation of the primary parameters. There are two types of the models differing with numbers of parameters and applicable frequency range. The first one is a "seven parameter model" and the second one is a "thirteen parameter model". The "seven parameter model" can warrant sufficient accuracy by means of 7 parameters up to 2.5 MHz. Hence it can be used for simulation of ADSL system. The „thirteen parameter model" is designated for frequency above 2.5 MHz. In this field the "seven parameter BT model" is not accurate enough and high error appears. Hence amount of parameters increases. These added parameters set the primary parameters for higher frequency. The „13 parameter BT model" can be used for simulation up to 30 MHz. The accuracy in this field is between 0.1 – 0.5 %. This model is suitable for example for simulation of VDSL system.

A model designed by the Deutsche Telekom AG company is marked as DTAG #1. The model is acceptable rather for modelling of the secondary parameters (Zc, γ), than the primary parameters. This model can be used up to 30 MHz. For higher frequencies it is required the approaching in more steps by gradual approximation. It causes an immoderate rise in number of parameters.

Examples and results of above mentioned simulations have been published in [1].

Other simulation procedures are based on physical properties of the lines. There are distinguished two models. One of them is based on the Bessel functions and the other is based on methods of approximation. Mutual comparison of these two models has been displayed in [2]. Simulation of the primary and secondary line parameters by means of the physical properties is performed at departmental web server "MatLab Server" [3]. The parameters are figured out according to the following items: kind of the cabling element, material of insulation, material of conductor, thickness of screening, conductor diameter, insulation diameter, temperature of lines, length of twist, frequency range.

Each of the models has advantages and disadvantages hence it is necessary to choose according to specific requirements. At some time it is suitable to use the model based on physical properties of the lines (such as cable geometry, skin effect, proximity effect) and at some times it is more advantageous to come out of the basic parameters in low frequencies such as d.c. loop resistance, working capacity (BT models). During simulation of the transmission parameters, accent on the most exact approximation of the specific attenuation is put. This attenuation is accountable for a reachable bridging distance or more precisely maximum transfer speed of an information channel.

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Cars Monitoring in GSM Network

M. Krahulík, M. Orlich

krahuml@fel.cvut.cz

Department of Telecommunications Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

In the recent time, there are appearing many techniques of a localization based on different approaches. The aim of this project was to develop a system enabling monitoring of cars that would make a basis for testing of current localization methods in GSM network.

The main advantage of these methods are low costs of mobile equipment, the drawbacks are mainly low precision, high demands on the center estimating positions, and necessity of a very close cooperation with mobile provider. The purpose of this project was to collect statistical data about GSM network and verify a precision of implemented methods.

Localization techniques in GSM network can be divided into the three groups:

- Localization by the network
- Localization by the mobile station
- Hybrid techniques

Localization by network is the most widespread today. It has higher demands on the network, while it requests a bigger traffic and position estimation is centered on the server but there are not needed any modifications at client part.

In contrary, localization by the mobile station requests only small traffic, because information about network is delivered to the mobile station by a broadcast channel.

In our work we have focused on the localization by the network. There are implemented four methods. Three of them are based on empirical estimation of the distance from visible Base Transceiver Stations and following post processing, the last one uses spatial database, where there are stored coverage maps of the mobile provider.

For the post processing, there are used following techniques: Least squares, weighted algorithm, and iterative algorithm.

System architecture

In our solution, all testing cars were equipped with a GSM modules allowing communication via SMS. The module can provide different kinds of information about GSM network, i.e. identifier of serving cell, identifiers of adjacent cells, and corresponding received signal strengths.

The server part of our system consists of five independent tools and two graphical user interfaces. While some of these parts must be located in provider-protected zones, we have used with an advantage a Hessian RMI protocol to connect them. Because it is based on the HTTP protocol, it has given us a freedom in deployment and easy interchangeability of each part.

These tools are:

- SMS server – Enables to send SMS either directly over SMS module, or via UCP (SMP entity).
- Worker – Manages jobs supplied by master module (periodical and asynchronous requests for position). While UCP has only a limited capacity, the main task of this

part is scheduling of requests. There are supported three schedulers (PrimitiveScheduler, CellBasedScheduler, and RandCellBasedScheduler).

- Guestor – The core module estimating a car position according to the selected localization method.
- Master – The web server for application management. It provides administrative graphical interface and overview of measured data, resources requested by the localization graphical interface, and controls the Worker part.
- MapServer – The server purveying charts.

The application offers two graphical user interfaces:

- Administrative interface – The web portal for application management. Except administration, it provides a detailed view on the measured data.
- Localization interface – The java application dedicated for easy car localization. It provides information about cars positions and network state (BTS placement, measured signals) at given area and time.

Results

Till today, we have made 3708 measurements of GSM network using our system. In the table 1, we present average values for estimate precision and computation time, we have obtained.

Method	Estimate failure	Computation time
Least squares	2313.36[m]	216 [ms]
Weighted	694.98[m]	218[ms]
Iterative	508[m]	216[ms]
Spatial database	261[m]	20.4[ms]

Table 1. Estimates precision and computation time.

These results show that the best estimate can be obtained from coverage maps stored in spatial database. The presented computation time of this technique can be significantly influenced by the cashing of used maps in memory. The advantage of it is high precision; the drawbacks are high computation and storage demands and usage of very business-sensitive data.

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Implementation of the Backtrace Algorithm in an FPGA

M. Šťáva, O. Novák

stavam1@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Praha 2, Czech Republic

There are two approaches used for the deterministic test generation [1, 2]. In the structural approach the idea is to convert the problem of deterministic test generation into a finite space search and to operate directly on the network of gates. The D-algorithm was the first structural algorithm. The branch-and-bound based algorithm PODEM was proposed later. It makes the decision points at primary inputs applying a novel heuristic, called backtrace. The backtrace determines which of primary inputs of a circuit should be set to achieve an objective. Several improved techniques, such as RAPS, FAN and others were proposed based on PODEM further to prune the search space. RAPS uses a similar backtrace procedure, called random backtrace, to that implemented in PODEM only the selection of a gate input is random. FAN makes a decision on always-justifiable internal lines and has an improved backtrace procedure, called multiple backtrace, at the attempt to satisfy several objectives simultaneously. The second approach applies Boolean satisfiability solving algorithms. The idea is to translate the D-algorithm problem formulation into a characteristic equation and to solve the equation using a branch-and-bound search. A number of algorithms using fast SAT solvers were recently proposed. We have used methods similar to the heuristics mentioned above to shorten a test length of sequential circuits and to reduce the power consumption in the circuits containing a scan chain.

The most popular structured design-for-testability technique used for external testing is the scan design, which employs a scan chain, marked as SC. The SC divides a sequential circuit into several combinational parts. Thus any algorithm to generate test vectors for combinational circuits, such as PODEM or FAN, can be used. That is an advantage, because combinational ATPG algorithms are much simpler than sequential ones. It is assumed that a circuit to be made testable is synchronous and let any combinational part of a sequential circuit be called an *SQ-combinational circuit*. Further it is assumed to have a list of test vectors, marked as L. Consider a simple task: applying L to an SQ-combinational circuit, whose inputs and outputs are directly connected to the SC. Thus they make a feedback. And this is just an interesting task. Assume that the number of test vectors in L is t and the length of the SC is k. The simplest way to apply L is to perform the simple known procedure: selection of a vector p of the length k from L and its scanning into the SC during k clock cycles, loading a response during the $(k + 1)st$ clock cycle; it is repeated until L is empty and finally the last response is scanned out from the SC. The computing complexity of the procedure is also $\{t*(k+1)+k\}$ clock cycles. Due to reduce this complexity, the whole time to apply L and the power consumption etc. would lower. And that is why we have focused on its reduction. Reduction of the operational complexity rests in finding such a sequence of test vectors that a response to a being-processed vector will fulfil one of two following conditions: the response equals to the subsequent test vector (the optimal case) or the subsequent test vector can be achieved from the response by scanning as few values as possible in the SC.

There are two main approaches how to achieve the test length reduction. In the first approach, values kept in the SC are regarded as an input vector applied to the input signals of the SQ-combinational circuit. Responses, being obtained from the output signals of the SQ-

combinational circuit, are saved into the SC consequently. Thus, computation of the responses is provided forwards the output signals in the SQ-combinational circuit. In the second approach, values kept in the SC are regarded as an input vector applied to the output signals of the SQ-combinational circuit. Responses, being obtained from the input signals of the SQ-combinational circuit, are saved into the SC consequently as well. Thus, computation of the responses is provided backwards the input signals in the SQ-combinational circuit. We have focused on this backward computation, which is similar to the operation *backtrace* – the term used in ATPG algorithms, and its implementation into an FPGA. It is necessary to transform an SQ-combinational circuit structure into a backward-determining one.

An SQ-combinational circuit has to be converted into a corresponding structure, called a *transformed circuit*, to perform the backtrace. The transformed circuit generates one input vector by one clock cycle for an applied output vector and all possible input vectors to an applied output vector are founded. Each generated input vector can be valid or invalid. Both input and output vector consist of three-value signals, i.e. zero, one, x-val representing don't care. An SQ-combinational circuit is transformed as follows. Each gate is replaced by a corresponding block LogicElement representing a backward implication table of the being-replaced gate. Each fan-out stem has to be replaced by a block Cond, which performs a matching operation by the binary intersection operator. When a non-x-val value of one Cond input differs from non-x-val values of other Cond inputs, it means that a collision has occurred. It is signalised to a controller as a preferred condition. Let it be noted that a generated input vector is valid if and only if no collision has occurred during its generating.

The results of experiments were carried out for the ISCAS'85 benchmarks. The area overhead is expressed in the thousands of equivalent gates. A clock speed and an average number of clock cycles for generating the first valid input vector, marked as VIV, are presented. In order to determine the average number of clock cycles we have applied all of 3^m output vectors, where m denotes the number of outputs of a benchmark circuit, and observed the first occurrence of a valid input vector, if any, for each output one. As a target platform, we used the Xilinx FPGA of the Spartan 2E series, in the concrete xc2s600e. All circuits were synthesised by Xilinx XST of version 6.3i.

Each of the benchmarks was converted into a transformed circuit to use the backtrace algorithm and to perform the backward determination of input vectors. For the selected set of the benchmarks, the complexity of the area overhead is polynomial of the 6^{th} order. The maximal clock speed of the transformed circuits decreases exponentially for the selected set of the benchmarks. We can assume that these results would be accepted for any combinational circuit generally. The average time to occur the first VIV can be simply calculated as (*VIV / CLK_speed*). The backtracing unit implemented in an FPGA can be used in various applications based on automatic test pattern generation, for example: a backtracking accelerator co-operating with a software ATPG tool, a decision machine whether a given output vector can be generated from a given input vector, a computing unit for compacted test generation for sequential circuits with a scan-chain.

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Limits for Broadband Transmmision on the Twisted Pairs and Other System Co-existence

J. Vodrážka, B. Šimák

vodrazka@fel.cvut.cz

Department of Telecommunication Technology, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The main objective of this project is to carry out a study work and analysis on a cable electrical unbalances and effects they might have on a induced crosstalk levels in a cable proposing provisions for reducing influence of these negative effects on a overall transmission capacity throughput. The main focus of our research will be on problems particularly surrounding the investigation of ground cable unbalances and efficiency of shielding. The project will exploit some of the results already achieved in a previous project "The Transmission Effectivity and Rate Enhancement of a Cable Medium in an Access Networks" solved in 2000 - 2001. The research orientation will be expanded about a study of radio systems that will be integrated into a design optimalisation process of access networks design in addition to the optical and metallic transmission media. The mutual interaction, co-operation and complementation in function and coverage and even a possible negative factors resulting from cross system influence (for example xDSL, CATV and local Ethernet network) will be extensively studied. The current technical and economical conditions of Czech republic in relation to liberalized market in our country including one in other European countries will be the starting points of our study. Also the recent crises in telecom sector will be evaluated.

The original analogue telephone lines use xDSL digital systems to a lesser or greater extent. Let us focus on the trend in the metallic access networks field and the potential possibilities for further development. Apart from the evolution of ADSL (Asymmetric Digital Subscriber Line) standards the transfer methods for the very high speed VDSL (Very-high-speed Digital Subscriber Line) are being optimized.

An ADSL line transmits digital signals at various transfer speeds in opposing directions of transfer. For the connection of larger companies, especially those, which operate their own application and web servers, ADSL connection is not suitable although the SHDSL (Single-pair High-bit-rate Digital Subscriber Line) connection can be used.

Allocation of bands for transfer directions downstream and upstream and also the total width of the band is dependent on the ADSL variant given by the ITU-T standard. According to the recommendation of the ITU-T G.992.1 today's systems use a frequency band of up to 1.104 MHz. The lower part of the spectrum is of course used for telephone channels and for this reason it counts on the coexistence of ADSL in one conduit with the original analogue telephone connection (ADSL/POTS), which is preserved thanks to separation filters (adapter, splitter). Apart from this, ADSL can also coexist with the basic ISDN-BA connection (ADSL/ISDN).

Apart from the standards mentioned, a standard for second generation ADSL has also already been approved (ADSL2) ITU-T G.992.3, G.992.4. There are several paths leading to an increase in transfer speed compared to the present state. Firstly, it is possible to maximally use the reserves of existing ADSL connections. Another possibility for increasing the maximum available transfer speed of the connection is to double the extent of the frequency

band, meaning to 2.208 MHz. This is the path taken by ADSL2+ (ITU-T G.992.5), which is able to compete with VDSL connections for asymmetrical application with a level of transfer speed of 25 Mbps.

New version VDSL2 (Very-High-Bit-Rate Digital Subscriber Line 2) – ITU-T G.993.2, is the newest and most advanced standard of xDSL broadband wireline communications. It has been designed to support the wide deployment of Triple Play services such as voice, video, data, high definition television (HDTV) and interactive gaming. It allows symmetric transfer with data rates of up to 100 Mbps over short distances and ADSL-like long reach performance.

Transfer speed on ADSL and also on VDSL lines depends on many factors. On the one hand, the provider sets configuration of transfer speed for the subscriber according to the nature of the services provided and the user profile. On the other hand though, there is a physical restriction stemming from the properties of the transfer environment, where the most applicable is the inhibition seen in conduit, growing with the frequency and then the cross-talk disturbance from other systems mounted onto multi-pair cables.

Telecom carriers will benefit from offering bundled services that can successfully compete with anything cable operators can offer. In addition, with the migration towards combined ADSL2+/VDSL2 networks, a single network can be maintained to provide the entire xDSL services portfolio while reducing deployment, operating and maintenance costs. The use of physical xDSL for Ethernet transfer is a very perspective area. The IEEE 802.3ah EMF group bears the marking Ethernet in the First Mile in its name, the task of which was to create a concept and standards for the solution of high-speed access based on an Ethernet interface. EMFC plans count on the fact that at greater distances than can be spanned by VDSL, the SHDSL system will be set up. If higher transfer speed is required, a greater number of pairs can be used, among which the required digital flow will be shared. In this way it would, for example, be possible to transfer signals over a distance of 5 km with a transfer speed of 10 Mbps in both directions or at a distance of 1 km to attain a transfer speed of 100 Mbps along regular telephone lines. The concept stated is a reaction to decrease in analogue telephone connections interest and the freeing up of pairs in cables connected with this, which can then be used in a multiple manner for high-speed data transfer.

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Subtraction Free Almost Montgomery Inverse in ASIC and FPGA

J. Buček, R. Lórencz

{bucekj|lorencz}@fel.cvut.cz

Department of Computer Science and Engineering,
Faculty of Electrical Engineering, Czech Technical University in Prague,
Karlovo náměstí 13, Praha 2, 121 35

Computation of the multiplicative modular inverse is a rather complex but frequently used operation that forms a part of various cryptographic algorithms, such as the decipherment of RSA algorithm, digital signature systems and so on. Due to the time complexity of the calculation of the modular inverse, it is desirable to perform it together with the other modular arithmetic operations as effectively as possible, that is, in dedicated hardware. Another reason for hardware implementation is security.

The majority of algorithms for computing the modular inverse is derived from the Extended Euclidean Algorithm (EEA). The modular arithmetic operations are often performed in Galois Field GF(2^m) or GF(p). In the case GF(2^m) there is no carry propagation delay associated with additions and subtractions. However, this approach is not always possible or suitable and then usually computations of modular arithmetic operations in GF(p), where p is prime, are executed. An efficient "left–shifting" algorithm for computing modular inverse in GF(p) is introduced in [1]. This algorithm avoids the redundant ">" or "<" tests that are in GF(p) subject to carry propagation delays. The elementary operations in cryptographic computations are often performed in the so-called Montgomery domain [3], which is suitable for effective hardware implementation of the operations of modular multiplication and modular inverse – Montgomery modular inverse. The basic algorithm for computing Montgomery modular inverse is the so-called Almost Montgomery Inverse (AMI) [3].

The paper [2] presents a modified AMI subtraction-free algorithm suitable for hardware implementation. This subtraction-free algorithm with its hardware architecture overcomes the disadvantages of currently known methods (e.g. [4]). The ">" or "<" tests that require either extra clock cycles or extra chip area are completely eliminated. The main ideas of improvements suggested in subtraction-free algorithm are two. Firstly negative values which appear during computation are allowed (represented in two's complement code) and secondly the sign of the subtraction result is utilized to determine the target registers for computed intermediate result [2].

The subtraction-free algorithm belongs to a group of EEA algorithms using standard arithmetic with carry chain structure. For such algorithms, the length of computing word is critical because of carry chain propagation delay. A lot of approaches such as [4] divide large computing word into smaller parts – subwords with which the elementary operations are performed sequentially. These scalable techniques are very suitable for algorithms whose operation flow is independent on carry propagation. Of course, time complexity of computation grows with length of subwords and other way round overhead of scalability grows with number of subwords. There is an optimal subword length which can be found for some technological base and word length.

Since the control flow of the subtraction-free algorithm is dependent on carry evaluation, it can be used effectively only without scaling techniques. It appears that the subtraction-free algorithm is especially suitable for computing word size approximately to

200 bits depending upon technological base. Both FPGA and ASIC bases are considered. In case FPGA circuits, the size of word is limited by the structure and type of circuit. The dedicated carry propagation chain of adders/subtracters is an important feature of the structure of FPGA circuits. This fact has great influence on speedup of performance addition/subtraction using adders/subtracters on FPGA circuits. Approximately similar size of computing word can be used with implementation subtraction-free algorithm in VLSI. The reason is possibility to build special adders/subtracters effectively with respect to using VLSI technology base.

Our aim is confirm and analyze hardware implementation subtraction-free algorithm for different word length in FPGA and ASIC platform. The results will serve as design recommendations for numerical cores of some cryptosystems based on elliptic curves defined over GF(p). For such cryptosystems, word length of 200 bits is secure enough.

The first estimates resulting from our experiments with hardware architecture independent on technological base uses one subtracter less than some of previous designs show reduction of chip area by around 10%. In case the same number of adders/subtractors the average speedup by using subtraction-free algorithm instead Kaliski's algorithm [3] is 1.25. For long words, when additions/subtractions are performed in multiple clock cycles, the average speedup can reach 1.5.

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Simulations of Digital Modulations in MATLAB

V. Dolecek, J. Volf

dolecev@fel.cvut.cz

Department of Telecommunications, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Modulation is the process of varying a carrier signal, typically a sinusoidal signal, in order to use that signal to convey information. The three key parameters of a sinusoid are its amplitude, its phase and its frequency, all of which can be modified in accordance with an information signal to obtain the modulated signal. There are several reasons to modulate a signal before transmission in a medium. These include the ability of different users sharing a medium (multiple access), and making the signal properties physically compatible with the propagation medium. A device that performs modulation is known as a modulator and a device that performs the inverse operation of demodulation is known as a demodulator. A device that can do both operations is a modem (a contraction of the two terms).

In digital modulation, the changes in the signal are chosen from a fixed list (the modulation alphabet) each entry of which conveys a different possible piece of information (a symbol). The alphabet is often conveniently represented on a constellation diagram.

Digital modulation is a technique commonly used to transmit data over communication lines (metallic, fiber or wireless). Students of the subject Basics of Data Communications, which is prepared for those who attend the fourth year, need to become familiar with principles of it. So we have prepared a set of simulations that can help them to understand how the modulated signal is made and what are these modulations good for. Laboratory work based on three types of digital modulations was prepared as well.

All simulations were made using Matlab-Simulink. Most blocks, that were used to simulate communication system, were taken from the Communication Blockset. As the source of bit sequences, the Random Bernoulli Binary Generator was used. Additive White Gaussian Noise Channel (AWGN) represents the transmission line. All simulations also contain error rate calculation. The only change among all models consists of used modulator/demodulator pair.

The simplest digital modulation is Amplitude Shift Keying – ASK. In ASK, the amplitude of the signal is changed in response to information and all else is kept fixed. Bit 1 is transmitted by a signal of one particular amplitude. To transmit 0, we changed the amplitude keeping the frequency constant. On-Off Keying (OOK) is a special form of ASK, where one of the amplitudes is zero.

FSK is a technique for modulating data that use two or more frequencies to represent input data. In 2-FSK the frequency shifts between the two frequencies are generated when the binary digital level changes. So one particular frequency is used to represent a binary one, and a second frequency is used to indicate a binary zero.

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). Any digital modulation scheme uses a finite number of distinct signals to represent digital data. In the case of PSK, a finite number of phases are used. Each of these phases is assigned a unique pattern of binary bits. Usually, each phase encodes an equal number of bits. Each pattern of

bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal — such a system is termed coherent.

Type of PSK	BER		
	SNR 10 dB	SNR 7 dB	SNR 5 dB
2-PSK	$3{,}0000 \cdot 10^{-6}$	$7{,}9984 \cdot 10^{-4}$	$6{,}7986 \cdot 10^{-3}$
4-PSK	$1{,}7993 \cdot 10^{-3}$	$1{,}8992 \cdot 10^{-2}$	$6{,}9176 \cdot 10^{-2}$
8-PSK	$5{,}9788 \cdot 10^{-2}$	$1{,}3477 \cdot 10^{-1}$	$1{,}9196 \cdot 10^{-1}$

Three types of Phase Digital Modulations were prepared for the students as it is shown in the table above. From the table, there could be mentioned, that the BER (Bit Error Rate) increases as the SNR (Signal to Noise Ratio) decreases. The BER also increases with the number of states of the chosen modulation. Symbols are closer to each other when using modulation with more states, so this is the reason for the BER to be greater.

Type of PSK	BER		
	SNR 10 dB	SNR 7 dB	SNR 5 dB
16-QAM	$1{,}4000 \cdot 10^{-5}$	$9{,}9920 \cdot 10^{-4}$	$9{,}3925 \cdot 10^{-3}$
32-QAM	$7{,}9920 \cdot 10^{-4}$	$1{,}9780 \cdot 10^{-2}$	$5{,}0350 \cdot 10^{-2}$
64-QAM	$1{,}8585 \cdot 10^{-2}$	$6{,}6949 \cdot 10^{-2}$	$1{,}011 \cdot 10^{-2}$

In a QAM signal, there are two carriers, each using the same frequency band but differing in phase by 90 degrees. One signal is called the *I signal*, and the other is called the *Q signal*. Mathematically the signals can be represented by a sine and a cosine wave. The two modulated carriers are combined at the source for transmission. At the destination, the carriers are separated, the data is extracted from each, and then the data is combined into the original modulating information.

As for PSK, students were shown three models of QAM (Quadrature Amplitude Modulation). 16, 32 and 64-state modulations were chosen. The average power at the transmitter was set to 9 W for each simulation for the outputs to be comparable. The conclusion for the simulation of QAM can be the same as for PSK. The lower the SNR on transmission line is, the higher BER can be seen. Worse Bit Error Rate can be observed when the number of states of modulation grows (when not changing transmitter power).

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Borders and Finite Automata

M. Šimůnek, B. Melichar

simunem1@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University in Prague,
Technická 2, 166 27 Prague 6, Czech Republic

Border of a string is a proper prefix of string that is also its suffix. Searching for borders is one of essential tasks in stringology. Border analysis was introduced in 1970 by Morris and Pratt. A preprocessing for MP pattern matching algorithm [3] finds the longest borders of all prefixes of text in linear time. All borders of all prefixes of text can be found in linear expected and quadratic worst case time by ALL_BORDERS algorithm invented by Iliopoulos et al. [2]. Algorithm based on automata theoretical attitude was proposed by Melichar in [1] using information from *d*-subsets of determinised suffix automaton. Advantage of this attitude is that we can simply modify the algorithm to find approximate borders or borders with additional criteria as described in [1].

Straightforward implementation of algorithm from [1] constructs deterministic suffix automaton for text. We offer simplified version that finds all borders of all prefixes of text on-line without need to store even the backbone of suffix automaton. We proceed by comparison of both methods concerning their complexity.

Computation of borders using algorithm from [1] consists of four steps: 1. Construct a nondeterministic suffix automaton for text. 2. Construct deterministic suffix automaton *M* for text. 3. Find all sequences of transitions on the backbone of *M* leading from the initial state to any final state. Labeling of these sequences excluding text itself gives all borders of the text.

In the second step the backbone of deterministic suffix automaton is constructed. The backbone of deterministic suffix automaton *M* for text *T* is composed of states *q* of *M* such that there exists prefix *P* of *T* that moves *M* from the initial state to *q*. Thus the backbone of suffix automaton *M* can be constructed by simulation of the run of nondeterministic suffix automaton for *T* with *T* as an input text. After reading prefix *P* of *T* the set of active states gives the *d*-subset of the state correspondent to prefix *P*. Thus by reading whole the text T we obtain all states that form the backbone of *M* with appropriate *d*-subsets and no other states.

In the third step of the algorithm from [1] we take the backbone of *M* and analyse sequences of transitions from the initial to any final state. But this processing can be done on-line during the simulation. After each proper prefix *P* is read we analyse obtained set of active states. Let states of nondeterministic suffix automaton are marked q_i with index $i \in \{0,1,\ldots,|T|\}$ given by the topological order and word corresponding to state *q* moves automaton from the initial state to *q*. [1] shows that for suffix automaton *M* holds that whenever *d*-subset of state *q* contains q_i, occurrence of each word corresponding to q_i ends on position *i* in text. Each state on the backbone corresponds to prefix *P* of *T*. Whenever corresponding *d*-subset contains final state, *P* is also a suffix of text *T*, as an occurrence of *P* ends on the last position of *T*. If *P* is proper prefix of *T*, *P* is a border of *T*. More generally if *d*-subset contains state q_i, $i > |P|$ then *P* is a border of prefix of *T* of length *i*.

Consider we have read prefix *P*. To read the next symbol and construct the following *d*-subset it is enough to know the states that are active at the moment. Thus to compute all borders of text *T* there is no need to store previous *d*-subsets and even storing of the backbone is not necessary in the second step of the algorithm.

As follows from the previous paragraphs to find all borders of all prefixes of text *T* it is enough to: 1. construct nondeterministic suffix automaton *M* for *T*, 2. simulate run of *M* on text *T*, 3. after each proper prefix *P* of *T* is read, we output *P* as a border of $T[1\ldots i]$ whenever *i* is an index of active state and $i > |P|$.

Let us analyse the complexity of the proposed algorithm. Explicit construction of the nondeterministic suffix automaton is not necessary. All states are initial and we can proceed from state q_{i-1} to q_i by *i*-th symbol of text for each $i \in \{0,1,\ldots,|T|\}$. Step 2 needs time $O(n^2)$ in the worst case as in each step we can have $O(n)$ active states, $n = |T|$. Number of active states is never increased, thus for practical cases quick decrease of the number of active states is highly probable. In step 3 it is enough to print $|P|$ instead of *P*. *P* is a prefix of *T* and thus its length specifies it unambiguously. Length $|P|$ in binary coding can be bound by constant for reasonable size of output text. Overall time complexity of finding all borders of all prefixes of *T* is $O(n^2)$ which equals the complexity of algorithm in [2]. We need $2n$ boolean flags for activity of states in the current and in the next step, thus space complexity is $O(n)$.

To find approximate borders, we start from the nondeterministic approximate suffix automaton, and construct deterministic approximate backbone. This means that we construct the part of deterministic automaton corresponding to approximate prefixes of *T*. Both space and time complexity can grow, but as size of the backbone is smaller than size of the deterministic suffix automaton, complexity is less or equal to the algorithm from [1].

We have simplified algorithm for finding all borders of all prefixes of text from [1]. Thus we can significantly reduce the space complexity. Deterministic suffix automaton constructed in the original algorithm has at most $2n-2$ states. Moreover *d*-subsets must be stored and each *d*-subset can have up to *n* states. Thus space complexity of the algorithm from [1] is $O(n^2)$ compared to $O(n)$ for our algorithm. Time complexity is reduced by a constant factor given by the size of the alphabet. Instead of determinisation we simulate the run of nondeterministic automaton. Our algorithm is quadratic to the length of text in the worst case. Expected time complexity is close to linear for texts with small number of borders in prefixes. Deeper analysis of approximate version of algorithm remains for future work.

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Section 4

ELECTRICAL ENGINEERING
&
INSTRUMENTATION

9th International Student Conference on Electrical Engineering POSTER 2005

L. Husník, L. Lhotská, Z. Škvor, K. Müller

husnik@fel.cvut.cz

CTU, Faculty of Electrical Engineering
Technická 2, 166 27 Prague 6

Student's research activity should be integral part of the whole pedagogical process at all universities. Its main aim is to support independent creative work of students and stimulate practical application of theoretical knowledge acquired during their study. We take for necessary and very useful to organize regularly student scientific conferences, namely because of comparison of contributions to solution of a certain research problem at different domestic and foreign institutions, establishing personal contact among young researchers, development of personal skills, and development of habits of research work and its presentation.

Students' scientific conferences POSTER organized by the Faculty of Electrical Engineering of the Czech Technical University in Prague began in 1995 as an internal meeting of students from all CTU faculties interested in the field of electrical engineering. In 1997, after two-year's experience, we decided to open this event to students from other Czech and foreign universities and invite both undergraduate and postgraduate students from neighbouring countries. Seven following successful successors in 1998, 1999, 2000, 2001, 2002, 2003 and 2004 confirmed that this was a right choice.

The 9th international student conference on electrical engineering POSTER 2005 showed continuing interest in this venue. The program committee selected for presentation 163 contributions of both undergraduate and postgraduate students from 171 submitted papers. Criteria of acceptance were based namely on the scientific quality and originality of students´ contribution. Majority of contributions came from FEE CTU (98), 30 from other Czech universities and 35 from foreign countries (Germany, Poland, France, Hungary, Italy, Latvia, Portugal). The contributions were presented as posters in seven parallel sections:

Communications	44 posters
Electronics and Instrumentation	39 posters
History of Science and Technology	10 posters
Informatics and Cybernetics	21 posters
Management	9 posters
Natural Sciences	22 posters
Power Engineering	18 posters

Proceedings of the conference [1] were published in the form of the CD-ROM, which was distributed to all conference participants. The paper size was limited by 1MB of the submitted file in the .pdf format.

POSTER 2005 was sponsored by the CTU Grant Agency, FEE CTU Prague, various companies (Monster Technologies, Hensel, Siemens, Schneider Electric, Spectris, Tesla a Živnostenská banka) and scientific societies (the Czechoslovak section of IEEE, its Joint MTT/AP/ED Chapter), which provided organizers with numerous prizes (mobile phones, electronic organizers, journal subscriptions and most of all, cash prizes).

Members of evaluating committees chose winners and further rewarded contributions in individual sections. A total of 32 posters were awarded, 17 from FEE CTU Prague, 4 from other Czech universities and 11 from abroad. Winners in respective categories are listed below:

Section C: Milan Kníže: Capacity versus Outage Trade-off Inversion Adaptation Based on Reduced Eigenmode Space for MIMO Flat-Fading Rayleigh Channel, ČVUT
Section EI: Kaspar Hungar: Wafer Level Production Processes for a Wireless Retina Implant,RWTH Aachen
Section HS: Jiří Štrébl: The first steps of TV broadcasting in Czechoslovakia, ČVUT
Jana Cermanová: History of the unrealized project for the gallery building in Hořice, UK
Section IC: . Pavel Trnka, Hana Pytelová: Czech Economy Model Estimation by the Bootstrap Filter, ČVUT
Section M: Ota Drahovzál Company Value, Real Options and Financial Leverage, ČVUT
Section NS: Radoslav Bortel: EEG and EMG Pre-Processing for EEG-EMG Coherence Computation, ČVUT
Section PE: Václav Prajzler**:** Investigation of Properties of Rare Earth Doped Gallium Nitride Layers, ČVUT

Jaroslav Holiš from ČVUT received the IEEE Prize awarded by the committee of the Czechoslovakia section of IEEE, its Joint MTT/AP/ED Chapter. For his presentation Simulation of System Capacity and Quality of Coverage in UMTS Microcells

To conclude we can state that the 9th International Student Conference POSTER 2005 was very successful. This fact is substantiated by increased quality of presented posters. The program committee decided to continue in organizing this conference in the year 2005. The 10th POSTER 2005 is scheduled for May 18 2006, the first call of papers is already in circulation.

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Analysis and Implementation of Electro-acoustic Transducers with the Direct D/A Conversion

K. Motl, K. Ptáček, P. Valoušek

motlk@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Electrocoustic transducer with the direct D/A conversion is a result of effort to digitalize the whole electrocoustic chain. First work begun in the early eighties of the last century by J. L. Flanagan, who designed digital earphone.

Main advantage of digital loudspeaker is simplification of the signal chains, because electric D/A converter, power amplifier and loudspeaker are replaced by one equipment. Input digital data are transferred directly into analog acoustic signal. Digital loudspeakers convert parallel PCM signal into analogue acoustic one through acoustic pulses with amplitudes corresponding to weights of appropriate bits. Membrane of digital loudspeaker is divided into sectors with areas equal to 2^N, or corresponding number of small transducer is used. Summation of this pulses leads to pulse amplitude modulation (PAM), from which we obtain analog acoustic signal by filtration.

Distortion of output signal is the main problem of such digital loudspeaker, it depends for example on acoustic conditions for correct sum of pulses and other parameters such as path differences, parameter dispersion and other qualities of used transducers. Another problem of digital loudspeaker is the radiation impedance of transducer array, which is different in comparison with single analog transducers. Radiation impedance of the digital loudspeakers fluctuates according to the input signal and depends on array layout, so it has also influence to resulting output signal.

Driving of digital loudspeaker

A digital loudspeaker needs to be properly driven; therefore suitable driving signal must be developed. To verify the principal functionality of digital loudspeaker it is necessary to use conventional transducers and determine if they have suitable response to digital signal. Electrodynamic transducers produce both positive and negative values of acoustic pressure. Driving signal should respect this transducers bipolar behavior.

Developed driving signal is based on pulse-code modulation. Digital sample word is converted to direct code and split to single bits. Sequence of these separated bits creates single bit streams with corresponding bit weight. Bipolar character is ensured by multiplying these streams by signum bit. All streams are then amplified to level corresponding to bit weight of each stream.

Two different types of binary coding can be used. Non-return to zero coding produces wide frequency spectrum of driving signal from basic harmonic to sampling frequency. With return to zero coding, a transducer must generate acoustic pressure with sampling frequency. To simulate responses of electrodynamic transducers to digital signal, impulse responses of three transducers were obtained by MSL system. These responses were used to filter driving signals.

As a result, it is very difficult for electrodynamic transducer to reproduce digital signal. Transducer cannot handle wide spectrum in case of NRZ coding and reasonably high sampling frequency in case of RZ coding. Therefore an electro-acoustic transducer or transducers array must act as a low pass filter in direct digital to analog conversion process.

Opto-acoustic transducer

Another part of research was focused on development of electro acoustic transducer suitable for acoustic system with direct digital to analog conversion. We found that one of existing electro-acoustic systems, which can handle digital signals the way we need, is the opto-acoustic system. Unfortunately the opto-acoustic system has low efficiency and therefore it can be used only as the small earphone. The small earphone was designed and its acoustic circuits were simulated in SciLab mathematical software. Three experimental opto-acoustic systems were manufactured. Two systems were powered with power infra LED diode and the third one with red laser LED diode. The result of the simulation was compared with measured values. The acoustic circuits were adjusted according to results of measurement to provide wider frequency range response.

The results of analog signals measurement show that useful frequency response is from 1kHz up to the 63kHz (dependent on absorbing material, acoustic circuits, energy source, etc.).

The transmission of the digital signals in an opto-acoustic system was simulated in SciLab mathematical software. The simulation shows that the output signal of opto-acoustic system has poor quality when the input signal is digital. However the next simulation shows that the quality of output signal may be improved by adjusting of acoustic circuits.

Also we made basic experiments with solid-state waveguides and piezoceramic transducers. The measurement shows that we need piezoceramic transducers with better impulse response.

Conclusion

Digital loudspeakers should eliminate some problems of current analog loudspeakers. In this work we treat parameters such as amplitude and impulse response, directivity, harmonic and intermodulation distortion and other characteristics important for quality of resulting output signal. Piezoelectric, optoacoustic and electrodynamics transducer were simulated and measured. Present-day transducers represents compromises in this area, success of digital loudspeakers will depend on technology used for its parts and their miniaturization.

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Novel Methods of Local Lifetime Control in Semiconductors

J. Vobecký, P. Hazdra, V. Záhlava, D. Kolesnikov

vobecky@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

State-of-the-art local lifetime control of excess charge carriers in bipolar or combined MOS-bipolar devices is mainly based on irradiation by high-energy protons or alpha particles. In some cases, the ion irradiation is combined with that of electrons. All this allows us to adjust the lifetime locally in three dimensions in a well reproducible way after full completion of device processing. Radiation techniques provide optimal ON-state spatial distribution of the electron-hole plasma within the whole device volume that subsequently brings much wider safe operating area during turn-off. This is very important especially under the conditions of extremely high dV/dt and dI/dt during turn-off of modern fast switching devices.

In spite of a big progress in device ratings, the remaining problem is that the improvement of parameters of irradiated devices is achieved thanks to a high concentration of radiation defects forming deep levels within bandgap. As a result, the devices are subject to a high leakage current that is pronounced due to a relatively high operation temperature of power devices. This drawback is given by the fact that not all radiation defects (e.g. divacancy) possess optimal electronic parameters. The most prominent is the energetic position within the bandgap, because of exponential dependence of the leakage current on this parameter. Another practical problem consists in a relatively low annealing temperature of radiation defects. In the early days of using the radiation techniques in the field of power devices, there was a fear of potential defect annealing due to the operation at elevated temperature under overloading conditions. Fortunately, that was not acknowledged in practice. Really serious problem arose when high-power modules became widely applied, because these devices (already irradiated) are mounted by soldering above 300 ^{o}C for quite some time. This brought not only the unwanted annealing of radiation defects, but also the transformation of original defects into other ones with detrimental electronic parameters. The aim of this project, grant No.102/03/0456 from Czech Science Foundation, was to develop a method conserving the advantages of the radiation methods while eliminating the above mentioned drawbacks. The results are briefly summarized below.

The new method is based on the localization of substitutional platinum (Pt) in a desired location. The drive-in to this position is performed using low-temperature ($\approx$ 700 ^{o}C) Pt diffusion that is controlled by radiation defects from high-energy alpha particle irradiation. The result is the decoration of radiation defects by substitutional Pt with spatial distribution similar to that of the ion irradiation. Better electronic parameters of substitutional Pt give lower leakage current and, at the same time, thermal stability of created defects up to 600 ^{o}C, approx, is achieved. Compared to the works referred up to the beginning of the project, that were performed on the Czochralski grown substrate, the new approach was successfully applied on the Float Zone silicon [1] that is essential for high-power devices. The source of Pt for subsequent diffusion was created by sputtering the Pt layer at anode surface with thickness ranging from 50 to 100 nm and subsequent sintering at 450 ^{o}C. This method was successfully applied on lifetime killing in high-power diodes from Polovodiče a. s., Prague. The efficiency of lifetime killing at anode side (to promote soft recovery) was evaluated at the level corresponding

to the dose of 1 - $3 \cdot 10^{10}$ cm^{-2} of standard helium irradiation [2]. Further increase in efficiency, impeded by limited solid solubility of Pt at relatively low diffusion temperature, was not achieved yet.

Another problem, that was found, is that the sputtered Pt creates infinite source of Pt and limits the controllability of number of Pt atoms diffusing into the desired location in device. For this reason, an alternative method for the creation of source of Pt atoms was applied to. The Pt ions were implanted into chip diodes from ABB Switzerland using high-energy ion implanter (accelerator) in FZR Dresden, where the control of dose (Pt concentration) and energy (Pt range) is precise in principle. The efficiency of lifetime killing was found controllable by means of both the Pt implantation dose and additional annealing after Pt implantation prior to helium implantation [3]. The latter removes implantation defects and thus increases the number of in-diffused Pt atoms during final annealing. It was also proved that the diffusing Pt is capable to decorate quite complex profiles of radiation defects within the depths of hundreds of μm. This is important from application viewpoint, because the state-of-the-art fast recovery diodes require lifetime reduction at two different positions, namely at the anode side and deep in the base.

Beside the Pt diffusion controlled by radiation defects, we investigated the utilization of platinum silicide (PtSi) layer, left at the anode after the diffusion (annealing), for potential improvement of contact properties. It was found that thin PtSi layer improves the properties of boundary between silicon and copper contact layer so that lower contact resistance is obtained compared to that of standard aluminum. Reliability tests have showed that such layers are capable to withstand combined electro-thermal and thermo-mechanical loading, typical for power devices in press pack housing, at the level of standard aluminum. Further optimization of boundary between silicon and copper is underway in order to obtain a power diode with copper contacts providing record parameters.

On the top of platinum, the possibility of using palladium for the local lifetime control was investigated, because, up to this time, the palladium was used only for global (≈ spatially uniform) lifetime control. The full-scale diodes (2.5 kV/150 A) from Polovodiče a. s., Prague, were provided by 50 nm thick Pd layer at anode, irradiated by helium with energies of 10 and 12 MeV and annealed in the range 600 – 800 °C. The capability to localize the substitutional palladium by means of radiation defects in silicon power devices was proved. Very low leakage current and excellent ruggedness during very fast reverse recovery were found for annealing at 600 °C [4]. More detailed investigations are under way.

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Advanced Methods for Low-Temperature In-Diffusion of Platinum in Silicon

P. Hazdra, J. Vobecký

hazdra@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 16627 Prague 6, Czech Republic

Modern silicon power electronics necessitates a controllable introduction of crystal defects acting as effective centers for excess charge carrier removal to accelerate device turn-off. Radiation defects produced by irradiation with high-energy protons, alphas and electrons are being widely used for this purpose [1], but their electrical parameters are far from optimum. On the contrary, platinum atoms at substitutional position in the silicon lattice (Pt_s) are ideal recombination centers, however, the creation of an arbitrary platinum profile within a power device is difficult. Combination of both techniques, when the radiation damage produced by helium irradiation is used to guide the in-diffusion of platinum atoms, is a possible way how to get an arbitrary profile of ideal recombination centers.

We used this technique in power diodes to shape the concentration profiles of platinum diffusing from the thin platinum silicide surface layer [2], but the controllability of the amount of introduced Pt_s was low. Then, we applied implantation of platinum to control the amount of in-diffused Pt_s [3]. We showed that platinum implantation is capable to provide reproducible results, but the amount of in-diffused platinum is insufficient and does not scale with platinum dose. We supposed, that low amount of in-diffused Pt_s is caused by defects produced by platinum implantation which serve as sinks for fast diffusing platinum interstitials. In this contribution, we tried to remove this damage by introducing an additional annealing step prior to helium irradiation. We report on this effect and consequences which were studied in a wide range of doses of both the Pt and He ions.

Radiation enhanced diffusion of platinum was studied on the low-doped <100>-oriented float zone *n*-type silicon substrate forming the *n*-base of the planar p^+nn^+ diodes. The finite source for platinum diffusion was produced by implantation of 1 MeV platinum ions with doses ranging from 5×10^{11} to 3×10^{14} cm^{-2}. The diodes were then per-annealed to decrease the amount of implantation defects. We used three annealing procedures: the low-temperature long-time annealing (600°C 180 min) – under these conditions the Pt diffusion is negligible; the medium temperature short-time anneal (675°C 20 min) – this is the edge when implanted platinum atoms drive-in; and the high-temperature short-time anneal (750°C 20 min) allowing sigificant diffusion of Pt atoms into silicon bulk. Radiation defects used to enhance and shape subsequent platinum in-diffusion were then introduced by single or multiple energy implantation of helium ions with energies of 7, 9, 11 and 13 MeV and doses ranging from of 5×10^{10} to 1×10^{13} cm^{-2}. The platinum atoms were finally in-diffused by 20 minutes furnace annealing at 725°C in vacuum. Electrically active defects, namely the acceptor level of substitutional platinum at E_C-0.23eV, were then monitored by the capacitance DLTS and the high-voltage current transient spectroscopy.

Analysis of the measured Pt_s profiles showed that the radiation enhanced diffusion of platinum at 725°C for 20 min is fast enough to reach an equilibrium decoration of vacancy-related defects up to the depth of hundred micrometers. Analysis of the resulting platinum profiles indicates, that transformation of diffusing platinum interstitials to stable substitutional position is mainly given by Frank-Turnbull mechanism controlled by vacancy-related defects while the kick-out mechanism may play role at the peak of the

radiation damage and at higher doses of helium implantation (>10^{12} cm^{-2}). Results also show that a complicated Pt_s profile can be achieved by a proper distribution of radiation damage using helium irradiation with different energies and fluences. Evaluation of Pt_s profiles from samples, which were multi-fold irradiated with helium ions of different energy (7, 9,11 and 13MeV) and subsequently annealed at 725°C for 20 min, gave the evidence that platinum diffusion is fast enough to reach an equilibrium decoration of vacancy-related defect (the resulting shape of Pt_s profile corresponds to the sum of primary damage profiles given by separate He implantations), however the amount of in-diffused platinum does not scale with helium dose. Measurement on samples, where additional annealing steps were introduced prior to helium irradiation, showed that pre-annealing substantially enhances the amount of Pt_s incorporated by subsequent radiation-enhanced in-diffusion. In the reference samples (without pre-annealing), the amount of in-diffused platinum was, up to a certain limit, linearly dependent on the dose of platinum implantation and than saturated. In contrast with it, all types of pre-annealing provided a linear dependence of the Pt_s peak concentration within the applied dose range of platinum ions. However, the slope and off-set of the dependencies were different [4]. Comparison of the Pt_s profiles measured in the reference and pre-annealed diodes also showed that the removal of the damage after platinum implantation also substantially increases localization of platinum at the radiation defect maximum. Ratio of concentrations in the Pt_s profile peak and its tail (extending to the irradiated surface) increased from ~2 (constant magnitude for all reference samples) to 4. The applied pre-annealing thus allows to produce Pt_s profiles very similar to those of radiation damage caused by light ions.

In summary, we confirmed that removal of implantation defects produced by platinum implantation by an extra annealing, which preceds the helium implantation, increases the amount of in-diffused platinum atoms up to the levels typical for radiation enhanced diffusion from PtSi layers. Application of this process allows stronger localization of Pt_s at the damage peak and an accurate control of the amount of in-diffused platinum in the range of several decades. All this brings the possibility of controllable production of an arbitrary profile of ideal recombination center closer to reality.

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Optical Properties of Subnanometric InAs Structures in GaAs Grown by MOVPE

P. Hazdra, E. Hulicius*, J. Pangrác*, A. Hospodková*, J. Voves

hazdra@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic
*Institute of Physics, Academy of Sciences
Cukrovarnická 10, 162 53 Prague 6, Czech Republic

Nanometric and subnanometric InAs structures embedded as an active layer into AlGaAs/GaAs waveguide can make a basis for production of efficient and reliable near infrared lasers which can be grown on cheap GaAs substrates [1-3]. Metal-Organic Vapor Phase Epitaxy (MOVPE) is the technique suitable for mass production of advanced semiconductor lasers, but it lacks of an accurate control of the growth at an atomic level. Therefore, development of diagnostic techniques for quick and accurate characterization of MOVPE grown nanometric and subnanometric structures is necessary. In this contribution, we applied photomodulated reflectance (PR) spectroscopy in combination with X-ray diffraction (XRD) to the characterization of MOVPE grown ultrathin InAs quantum wells and modulated InGaAs layers. Ground- and excited-state transitions detected by PR were identified and used for the determination of the layer band structure. This was further compared with XRD data to provide an accurate picture of the growth at the monolayer (ML) level. Results were then used for optimization of the laser growth to extend laser's emission wavelength, increase their quantum efficiency and temperature range of operation.

Ultrathin InAs layers and modulated InGaAs structures in GaAs matrix were grown in an AIXTRON 200 MOVPE reactor. The growth was controlled by a precise setting of the growth time (GT) of both the InAs (t_{InAs}) and GaAs (t_{GaAs}) layers. Different structures were grown to calibrate the growth and to optimize optical properties: single InAs layers with variable thickness (GT 2.8 s< t_{InAs}< 45 s), coupled double quantum wells (t_{InAs}= 11.3 s) separated by GaAs spacer with a variable thickness (GT 7.9 s< t_{GaAs}< 226 s), and various types of modulated InGaAs layers (5, 7, 10, 12 times repetition of InAs and GaAs growth with GTs t_{InAs}=8.5 s and t_{GaAs}=8.5 s). Samples were analyzed by cross-sectional scanning tunneling microscopy (XSTM) and X-ray diffraction (XRD). The XRD experiments were performed using double crystal diffractometer Bede 200 and CuKα1 radiation from Rigaku 300 X-ray generator. PR spectra were measured using a setup where a 5 mW HeNe laser was used as the modulating source and a 30 W tungsten-halogen lamp filtered by a JY640 monochromator provided the monochromatic light. The reflected light was detected by a cooled Ge detector and the resulting signal was processed by PAR5210 lock-in amplifier. The interpretation of measured optical data was based on simulation of electronic states in InAs and InGaAs layers using the nextnano^3 quantum simulator.

XSTM pictures of the superlattice grown as 7 separate InAs monolayers in GaAs showed that the interface roughness of InAs "monolayers" is rather high. Total content of indium in the layer corresponded approximately to one ML of pure InAs, but the In atoms were scattered within 3-4 MLs and an exact thickness (and/or stoichiometry) of the layer could not be established. The high resolution XRD measurement revealed this superlattice as a series of 2.3 nm thick $In_{0.14}Ga_{0.86}As$ wells separated by 10.2 nm GaAs spacer, however there was a great uncertainty in InGaAs layer thickness and composition. To get more information

about In incorporation and its distribution in layers, we monitored optical transitions in the grown structures since they are highly sensitive to the thickness and In content in the layers. To identify the correct thickness/stoichiometry of the In(Ga)As layer we have simulated different band structures of these QWs. It was shown that simulation results are highly sensitive on the In content in the layer, while the QW profile has no significant influence on the energy levels due to broad spreading of the electron and hole wavefunctions outside the ultrathin well [4]. We found that the ~2.5ML thick InGaAs well with Gaussian distribution of In atoms is probably the closest to reality. In this case, the indium atoms are still strongly localized so that the relaxation of the layer can occur for short t_{InAs} (14s). Scattering of In atoms causes that superlattices transform to "digitaly" modulated InGaAs layers if t_{GaAs} decreases. This was confirmed by measurement on layers where the modulation was made by periodic 12-fold switching of the InAs and GaAs growth (GT t_{InAs}= 8.5 s, t_{GaAs}= 5.7 s). XRD and PR results showed that layers are not formed by a homogeneous InGaAs, but they keep their modulation (this was also confirmed by XSTM figures of modulated samples). The best fit of the experiment and simulation was achieved when the modulated InGaAs layer was simulated as twelve 0.39 nm thick $In_{0.43}Ga_{0.57}As$ layers separated by 0.42 nm $In_{0.23}Ga_{0.77}As$ spacers. Similar data were obtained on samples grown using the identical modulation, but with different number of modulation periods (5, 7, 10, 15).

Received structural data were used for analysis of optical properties of grown modulated QWs. We reached a good agreement between calculated and measured (PR, PL) transition energies for both the ground and excited states We found that the red shift of the dominant e1hh1 transition saturates and the mixing of the levels increases if the number of modulations exceeds 10. The optical recombination efficiency decreases and layers relax when the number of modulations approaches 15. This shows that "digitally" grown modulated InGaAs layers in GaAs have, besides their high quantum efficiency, a limited potential to shift the emission energy below 1.10 eV. Using the optimum modulated InGaAs layer as a an active layer, we fabricated lasers lasing at 1.13 eV with threshold current density of 0.3 kA/cm^2 and 37 % differential quantum efficiency, capable to operate up to 125°C.

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Real Time Video Compression

J. Štrébl

streblj@fel.cvut.cz

Department of Telecommunications, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

The compression of images is nowadays mostly proceeded with well developed methods based on block segmentation. The modern trend is represented with methods based on object segmentation, which development is in the beginning. Since the simulation on personal computers is not possible because of lack of computing power, it was crucial to build up a measurement workplace containing a signal processor with high computing power. This allows real implementation and testing of developed algorithms. The processor was chosen from the offer of Texas Instruments company.

The author's disertation thesis deals with a high compression of video signals in real time. The main goal is to find new methods of compression of picture sequences and eventually to optimize existing methods based on space and time correlation. This sphere offers a huge space to find innovative solutions. For a possibility of a real implementation and testing is necessary to use appropriate signal processor.

Realization

In accordance with a concept of project I deal during the solving of the project with practical verification of implementation of theoretical accomplishments rising up from the solving of my dissertation thesis. The proceeding is about verification of algorithms of very high compression of video sequences and compression algorithms MPEG4. After the analysis of procedures and after simulations on personal computer, which were not possible to proceed in real time due to the lack of computation speed of used personal computer, I realized an implementation of algorithms of high compression on DSK with Video Daughter Card type VDB in real time. Algorithms of high compression were applied on video sequences with picture resolution 320 x 240 picture points with frequency 50 half-pictures per second. A special observation was dedicated to detection of movement in picture area (motion detection), which makes the most demanding part of compression algorithms. And here I have performed the most of optimizations. As a subsidiary effect all findings from the solving of the project are used for demonstration purposes during an education.

The basic stone during solution of the project was a purchasing of Video Daughter Card type VDB instead of DM642 Imaging Developers Kit, which became more expensive during the time between the proposition of application and the authorization of the project. I experimentally found, that analog video cameras did not offer an enough quality image for our requirements. This was the reason for decision to buy CCD camera with digital output. During this phase I hit the problem coming up from interconnection of the Video Daughter Card with CCD camera, which has nonstandard interface. It was necessary to develop specialized interface for interconnection of those equipments. This interface was designed and realized as a special daughter card. As a basic circuits were used a semiconductor circuits TVP5150A and FPGA EP1C6 Q240 C7. For implementation of algorithms of a high

compression I choose algorithm MPEG4 ML@MP. Using the picture resolution 320 x 240 picture points I reached a frame frequency 62 Hz. It can be seen, that this way implemented method of compression could work both either in European norm PAL, or in American norm NTSC.

Main benefits from project solution

Verification of algorithm of high compression of video sequences with picture resolution 320x240 points in real time.

Building up an experimental workplace, where is possible to verify other discerning compression algorithms. We propose additional work on realized workplace leading to improvement of current algorithms.

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Implementation of the Motion Detection on the DSP

V. Štumbauer

stumbav@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, CZ-166 27 Prague 6, Czech Republic

The paper deals with the real-time implementation of the motion detection algorithms on the TI VLIW DSPs TMS320C64x. Developing embedded video applications can be an exciting and challenging task. Because video systems produce large amounts of data to record, archive, and review, data compression is a vital part of video systems. For example, even a modest 8-bit/pixel monochrome digital surveillance system with CIF resolution (352x240 pixels) running at 30 frames/second will send approximately 2.4 MB/second to a storage device. There are two primary ways to decrease the space required to store the video data: store only those video frames that have certain characteristics, such as significant motion; or store compressed representations of individual video frames. Often a simple motion-detection algorithms to automatically select individual video frames for storage is used. One of the simpler algorithms for estimating motion is to compute the difference between successive video frames. The greater the number of differences that we find, the more motion is likely to have occurred within the scene. Usually, the Sum of the Absolute value of Differences (SAD) between successive video frames, returns a useful estimate of the motion in the image area. A concern to consider when designing fixed-point systems is the effect of limited dynamic range and scaling on intermediate computations. A key intermediate result is the “absolute difference” (AD) image formed immediately prior to the final summation for the SAD output. The difference image displays ghost-like outlines of objects in motion. Only those portions of two video frames where differences are detected are revealed with high-intensity pixel values. Portions of the image where little difference occurs from one frame to the next remain dark. Artifacts in the AD image would indicate possible errors in integer processing, often due to improper scaling, leading to overflow of integer summations and premature saturation of intensity values. The proper appearance of the image is a key intermediate result. The summation of pixel intensities in the AD image leads to the SAD estimate of motion. The threshold is set via a constant. If set too high, the threshold could prevent the recording of video frames containing significant motion, perhaps even missing critical events in the surveillance data. If set too low, output video rates may grow unacceptably large, defeating the compression system. Therefore, it is imperative to enable control of this threshold parameter. In this project I have investigated two complementary methods for the detection of moving objects by a moving observer. The first is based on the fact that, in a rigid environment, the projected velocity at any point in the image is constrained to lie on a 1-D locus in velocity space, known as the constraint ray whose parameters depend only on the observer motion. If the observer motion is known, an independently moving object can, in principle, be detected because its projected velocity is unlikely to fall on this locus. This principle can be adapted to use partial information about the motion field and observer motion that can be rapidly computed from real image sequences. The second method utilizes the fact that the apparent motion of a fixed point due to smooth observer motion changes slowly, while the apparent motion of many moving objects such as animals or maneuvering vehicles may change rapidly. The motion field at a given time can thus be used to place constraints on the future motion field which, if violated, indicate the presence of an autonomously maneuvering object. In both cases, the qualitative

nature of the constraints allows the methods to be used with the inexact motion information typically available from real image sequences. My implementations of the methods run in real time on a parallel pipelined image processing system. For sake of motion recognition, I have investigated the use of robustly computable motion features. They can be used directly as a means of recognition. I have designed, implemented, and tested a general framework for detecting and recognizing both distributed motion activity on the basis of temporal texture, and complexly moving, compact objects on the basis of their activity. This recognition approach contrasts with the reconstructive approach that has typified most prior work on motion. The motivation is the observation that in many instances, it is easier to detect and identify objects when they are moving than when they are stationary. Specifically, in the case of temporal texture, the investigators extracted statistical spatial and temporal features from approximations to the motion field and use techniques analogous to those developed for gray-scale texture analysis to classify regional activities such as windblown trees, ripples on water, or chaotic fluid flow, that are characterized by complex, non-rigid motion. For action identification, I have used an independent motion detector to locate and track moving objects, and then used the spatial and temporal arrangement of motion features in conjunction with Fourier image analysis to flag and identify any objects that moved peridically. This approach was able to identify complexly moving objects such as machinery and locomoting people and animals. This work has practical applications in monitoring and surveillance, and as a component of a sophisticated visual system. Measuring target performance C6416 processor utilization is approximately 85.3% when running the surveillance algorithm at 30 CIF frames/second, owing to its low complexity and pure integer implementation. The remainder of the processor computational budget would be allocated to other sections of a complete surveillance system design, such as including image compression of each still-frame, zoom/pan/tilt control, auto-focus, and to support multiple simultaneous video-surveillance channels. The hardware used for my experiments was the combination of the Texas Instruments starter kit DSK TMS320C6416T [1] and of the Video Daughter Card VDB [2]. The Code was developed in C combined with linear assembly using the Code Composer Studio [1].

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RFID Signal Filtering

L. Vojtěch

vojtecl@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The RFID (Radio Frequency Identification Device) is one of the most popular technologies at the present. These systems are used in logistic, personalization and in other applications for identification. One of the main limits, for using of the RFID (Radio Frequency Identification Devices), is the maximum reading distance between transmitter and the reader. Maximum distance is a function of the signal quality and the electromagnetic compatibility regulations limits. Using of the signal processing methods could be an interesting way for increasing of the reading distances.

There are two main limits for the radiofrequency communications between the transceiver and the transponder. The firs one is SNR (Signal to Noise Ratio) of a communication canal. The second limit depends on EMC (Electromagnetic Compatibility) of the whole RFID system - impulse and continual interference. The filtration at the transceiver side could be effective only for the noise and some continual interference. The methods like classical FIR (Finite Impulse Response) and Adaptive filters in readers systems are not usually used at the present. The searching of the filter's coefficients is not a trivial problem in more exacting applications.

We have tested two methods for the RFID signal noise filtering. First tested method was GMDH neural network. GMDH (Group Method of Data Handling – Ivachněnko 1966) [1] is an algorithm from the neural network family for the digital signal processing. The structure is similar like the serial connection of the simple FIR filters. GMDH is a non typical neural network. Classically (like neuron network) is system working only during the training process - finding the structure and the coefficients of new filter [2]. Used type of the training method is called "with teacher". It means that we need the original (clean) signal and the received mixture signal + noise from the transceiver.

The structure of a GMDH filter is getting during a training process, when some parts of the common structure are used or not. Each active neuron has own number - one quadratic polynomial function. The theory of the coefficients finding is described in [3].

The second filtering method was based on the classical Adaptive Filters. We have compared more adaptive algorithms - LMS (Least Mean Square), SDLMS (Sign-Data LMS) and RLS (Recursive Least-Squares).

In the MATLAB software was programmed RFID signal simulator at frequency 13,56 MHz with the signal definition by ISO/IEC 15693-2 (but with more numbers of SNR) [4]. Other step was simulation of the filtering efficiency for the different filtering methods.

The best adept for an Adaptive filtering was RLS algorithm (for SNR maximum = 18 dB). Simulation with a GMDH neural network was effective for SNR max = 5 dB. The result for higher SNR was not acceptable. We obtain the signal distortion.

Final tests were made with the real signal. The real data were measured with designed antenna and stored by the digital oscilloscope Tektronix TDS 3052B. Saved data, for more

reading distance between Tradewind Technologies SDIO-RFID reader and TAG-IT transponder, were processed in MATLAB software. For the digital signal processing were used same procedures like for a simulations. The result for a real signal processing is the possibility of reading distance increasing. The discovered benefit is more than 60 % improvement for a reading distance.

An application of the digital signal processing methods in the RFID systems could obtain benefits in the economy and the expansibility of RFID technology.

On the other hand this results shows that the question about the RFID security are really actual these days. Higher reading distances (or using of signal processing methods at nowadays used systems) could represent security hazards for unsecured communication between reader and transponder. The tracing and the cloning of unsecured transponders are main problems of some RFID technology applications these days.

RFID must be secured and confidential technology at the present and in the future too. It needs careful study and the good design of secured communication protocols nowadays…

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Innovation of Laboratory for Diagnostics and Non-destructive Testing

R. Šmíd, O. Kreibich

smid@fel.cvut.cz

Department of Measurement, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

An objective of the project was the innovation of laboratory experiments in the subject Diagnostics and Technical diagnostics at the Department of measurement FEE CTU in Prague. The project was proposed with three aims:

- introduction of the problem oriented laboratory tasks,
- improvement of the learning efficiency pointed to student's ability of contemporary instruments and software usage and
- increase of the reliability of laboratory equipment.

The central part of every laboratory workplace is the Matlab software used for communication with measurement instruments, data transfer, signal preprocessing, analysis and evaluation. For control and transfer of the data from various measurement instruments serial line (RS-232) and GPIB interface directly available from the Matlab software are used. The signal processing (linear and non-linear filtering, resampling, and normalization) and analysis methods (discrete Fourier transform, wavelet transform, order analysis, time-frequency distributions) are supported by appropriate Matlab toolboxes such as Signal Processing and Wavelet toolbox. Classification and pattern recognition methods are implemented by Neural network and PRtools toolboxes. This approach integrates software part of diagnostics systems in one programming and visualizations environment.

The topic of vibrodiagnostic measurement was enhanced by realization of the machinery fault simulator capable performing fully controlled simulation of vibration of rotational mechanisms. To gain an in-depth understanding of different vibration signatures, students need to conduct controlled experiments on a device that emulates real world machinery. The simulator consists from two DC motors coupled to shafts mounted in bearings using the sleeve adapters. First motor acts as a driving unit and second as a braking unit. The bearing housings are fitted with threaded holes for proximity probe placement at 90 degrees to the input and output shafts. Surface mount vibration transducers, mainly piezoelectric accelerometers with built-in electronics and TEDS (transducers electronic data sheet) are installed on the casing by applying adhesive to mounting disks to affix them to the desired locations.

The simulator contains artificially faulted bearings to learn waveform and spectra of classic bearing defects. This enables to learn typical signal processing issues such as averaging techniques, leakage, and spectral resolution on determining bearing faults. The construction endows performing experiments with increasing the severity of defects. Students can examine how to determine why ultra-high resolution spectrum is needed to diagnose a bearing fault when fault frequencies are located close to multiples of rotation velocity, how a large signal can mask adjoining low amplitude signal due to spectra leakage, how to analyze single faults one at a time, there are many occasions when is needed to study dynamic stiffness, resonance, and speed when components interact. A thorough analysis of vibration usually requires studies of several defects simultaneously to gain an understanding of real world vibration spectra. With the simulator, students can develop the expertise required to diagnose industrial machinery problems in well-controlled experiments. The simulator stands

for an effective tool for introducing the concepts and methodologies of predictive maintenance and design considerations to engineering students.

The course “Diagnostics” offered by the Laboratory of diagnostics and non-destructive testing will give an extensive treatment of modern signal processing methods for:

- vibrodiagnostics, condition-monitoring,
- non-destructive testing (NDT) of materials and mechanical structures (eddy current, ultrasonic testing, acoustic emission NDT methods) and
- diagnostics of electrical circuits (digital and analog in-circuit testing, signature analysis, boundary scan methods).

Topics covered include: basics of physical principles of NDT methods, principles of vibration, noise and acoustical emission, processing of acquired signals by means of robust filtering, parameterization, frequency and time-frequency analysis, multiscale and multiresolution methods, signal recognition and classification. The goal is to enable students to understand the integration of efficient signal processing and classification algorithms and methods for non-destructive testing, vibrodiagnostics, condition monitoring and diagnostics of electrical circuits.

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Fiber Optic Sensor with Dielectric Annular Core for Chemical Trace Analysis

P. Solarik*, Z. Burian*, I. Kasik**

pe-tr@email.cz

*Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technicka 2, 166 27 Prague 6, Czech Republic

**Institute of Radio and Electronics, Academy of Science of the Czech Republic, Chaberska 57, 182 51 Prague, Czech Republic

Development of fiber optic chemical sensors has been a popular approach for in line control and in situ monitoring of wide range chemical or biological samples. Optical evanescent wave sensors such as waveguide and surface plasmon resonance sensors have been used so far to detect samples at the surface of the sensor in aqueous cover media. These devices are based on the phenomenon that any change in refractive index of the cover media shifts the effective refractive index of the surface mode. This change is detected through an evanescent optical field decaying exponentially from the surface of the sensor [1].

In the present paper we report special type of optical fiber for chemical sensing - annular core fiber (ACF). Capillary, where the core of doubly clad step index optical fiber is a dielectric annulus lying between two different claddings. Use of annular core fiber for chemical trace analysis is novel approach in the field of evanescent wave optical sensors. AFC waveguides are capillaries that contain a liquid or gas sample for spectroscopic analysis. It allows extending the sensitivity of conventional absorbance spectroscopy by extending optical interaction path length of evanescent wave. In such waveguides a small local part of the large annular cross section is analogous to a transversely bent planar waveguide. An analytical solution to the step index annular core fiber proposed by Sarkar [2] by solving the Helmholtz equation. This equation has Bessel and modified Bessel functions as solution, and we expect the fields in the different regions of the fiber to be the proper linear combinations of these functions. Light throughput is not a limiting analytical parameter for path lengths of this magnitude. The main problem is flow rate limitations in the capillaries [3].

To produce fibers with extremely low loss, a two-step process is usually used. First, a preform is prepared with its desired index profile and the correct core/cladding ratio. Fibers are drawn from the preform. Coating and jacket processes follow immediately. For preform production a modified chemical vapour deposition (MCVD) was used. Preform preparation by MCVD process and fiber drawing and coating of this special capillary structure have been realized in the workplace of IREE AS CR. Primary shielding of silica capillary is ultraviolet radiation activated acrylic copolymer. Polymer coating provides flexibility and strength.

We had approximately 100 meters of the flexible AFC tubing with continuous modification of diameters. Beginning of ACF with an i.d.=166 μm and an o.d.=585 μm, end of AFC with an i.d.=352 μm and an o.d.=683 μm. The mounting of the AFC tubing end cells based on standard HPLC tees, which allows both optical access and fluid transfer to the capillary, formed the optical fiber sensor. Basic optical characteristic were measured - attenuation, refractive index (RI) profile, loss spectral distribution, near field intensity distribution.

Special type of optical fiber for chemical sensing - annular core fiber has been fabricated. Benefit of this solution is possibility to use of small volume samples, long path lengths by constraining light propagation within a liquid or gas medium by evanescent wave.

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Aplication of Modern Electronic Elements in Electronic Systems Cources

M. Hlinovský, P. Němeček

hlinovsm@fel.cvut.cz

CTU, Faculty of Electrical Engineering, Department of Control Engineering
Karlovo náměstí 13, 121 35 Praha 2

The main topic of the project was to innovate and improve the quality of content and form in Electronic Systems Courses. For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was to introduce the problems „Peripheral Devices and Communication Interfaces in Microprocessors Systems“, „Power supply and DC/DC converters" and „Active filters" in the theoretical and practical part of Electronic Systems Courses. Present design and realization of the laboratory tasks in Electronic Systems Courses make possible the important modernization of teaching process and to provide simultaneously the high cost-effectiveness of invest resources for modernization of the subject.

Laboratory task „Power supply and DC/DC converters"

Laboratory task consists from two preparations and refills with indispensable measurement devices make possible to teach-in with principle of power supply. The first preparation is DC/DC converter with LM2574N-12 circuit with fixed output and the second preparation is DC/DC converter with LM2574N-ADJ circuit with adjustable output. The LM2574 series of regulators are monolithic integrated circuits that provide all the active functions for a step down (buck) switching regulator, capable of driving a 0,5A load with excellent line and load regulation. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator. The LM2574 series offers a high-efficiency replacement for popular three-terminal linear regulations. Because of its high-efficiency, the copper traces on the printed board are normally the only heat sinking needed. The features the LM2574 series:

- 3.3V, 5V, 12V, 15V and adjustable output voltage range (1,23V to 37V (57V for HV version) ± 4% max over line and load conditions)
- Guaranteed 0,5A output current
- Wide input voltage range, 40V, up to 60V for HV version
- Requires only 4 external components, uses readily available standard inductors
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode, high efficiency
- Thermal shutdown and current limit protection

Laboratory task „Peripheral Devices and Communication Interfaces in Microprocessors Systems"

The aim of this exercise is introduction in to the problematic of the peripheral devices in the microprocessor systems. There is also connection with communications interfaces, which are usually used in the digital systems. The exercise is not focused on programming of the microcontroller, but on understanding of processor systems HW. For this purpose Atmel AVR microcontroller ATMega 128 was chosen. Whole kit consists of several small units with separate PCBs, which can be connected with special cables.

Main processor unit contains except ATMega microcontroller also RTC chip with battery backup, voltage supervisor circuit, buzzer, indication LEDs, switches and IR receiver. On the border of the PCB there are connectors with address bus, data bus, universal I/O pins, memory control signals and communication interfaces (SPI, I2C, UART). For testing of students' skills, the circuit contains also multiplexers, which allow changing of order of some signals. For example SPI interface connector consist of 3 pins, but order of MISO, MOSI and SCK signal can be changed by the software in the microcontroller. The task for the students is identifying of the signals with the digital oscilloscope.

For demonstration of the typical devices used in the processor systems, some modules were designed. First one is the matrix keyboard 4x4. For SPI demonstration small graphic LCD display with the serial interface was chosen. It also shows how 5V logic can be connected to 3,3V IO. Next module contains LCD display 2x16 characters. With the processor module can be connected in the different modes – 8 bit, 4 bit or as the device in the processor memory space. Another 2 modules are used for demonstrating of the external memory connection. One module contains RAM 256 bytes and the second address latch IO. Serial EEPROM and I2C I/O expander were chosen as examples of I2C devices. Last module is TTL/RS232 converter, which can be used for connection with PC and for introduction to the asynchronous communication interfaces.

Although this kit was primary designed for the introduction of the peripheral devices and communication interfaces, it can be also used for tutoring of microcontroller low-level programming.

Laboratory task „Active filters"

Laboratory task consists from two preparations and refills with indispensable measurement devices make possible to teach-in with concrete method of design of different types the active filters and make possible correctness verification of the design. The preparations make possible to compose low-pass or high-pass Butterworth's or Bessel's filters from first to fourth order for the specific break frequency. The changes of the parameters correspond to standard possibility of the analogue technology and require the change of the value of a lot of components with guaranteeing your desiderative specificity. Those problems we can solve by means of switched capacitors filters, because the changes of the desiderative frequency properties are reached by change of clock frequency by preservation the values of all components. For teach-in with this forward-looking alternative construction of active filters three preparations for realization switched capacitors filters were made. On these preparations student can verify the properties of different types of filters (Butterworth, Bessel and Elliptic) in practical version. The work with real objects is particularly in this area extremely contributively for student in comparison with computer simulation, where the used models do not correspond to reality.

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Application of Shack-Hartmann Sensor in Optical Industry

J.Novák

novakji@fsv.cvut.cz

Department of Physics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

It is well known that aberrations affect negatively the imaging quality of optical systems. Aberrations must be well corrected in order to obtain very good imaging properties of the real optical system. The residual aberration must be reduced in the widest spectral region, especially in case of high quality imaging optical systems. A basic and very important task in optical industry is testing the quality of fabricated optical elements and systems. Experimental methods for evaluation of the image quality of optical systems can be divided into two groups, direct and indirect measurement methods. The direct methods use measurements of the intensity distribution at the image plane (measurement of the optical transfer function). The indirect methods for testing the image quality of optical systems measure the wave-front deformation with different types of techniques.

Several different measurement methods can be implemented for optical metrology systems in industrial practice. In practice, the most frequently used methods are interferometric methods that are based on interference of the tested wavefront with a defined reference wavefront (flat, spherical or aspherical). The shape of the tested wavefront is then evaluated using phase analysis of the interference field. Usually, either Twyman-Green or Fizeau interferometers are used in optical production. These measurement devices (interferometers) may obtain high measurement accuracy. However, the interferometers are very expensive and relatively very complicated measurement systems that cannot be used in most cases in industrial conditions due to their sensitivity to mechanical vibrations and environmental effects.

Other possible measurement method that is widely used in optical metrology is the Hartmann method. The Hartmann method belongs to experimental techniques that are based on measuring the wave-front gradient. The Hartmann sensor was invented more than a century ago. Nowadays, the sensors based on the Hartmann method begins to be well-adapted to a wide variety of applications including optical metrology, adaptive optics, laser beam analysis, and ophthalmology. These sensors are simpler, less expensive, do not need a coherent source of light, are practically insensitive to mechanical vibrations of the measurement environment, and have a relatively large dynamic measurement range. The wave-front shape is calculated by numerical methods from the values of the wave-front gradient. It is important to chose appropriate algorithms and wave-front sensor parameters for achieving the required accuracy of wave-front reconstruction.

In our project, we focused on the Shack-Hartmann sensor for wave-front analysis that can be used in optical testing methods in optical industry. During our project, we designed, fabricated and tested wave-front sensor that is based on the principle of the Shack-Hartmann method. This method uses the microlens array and the CCD sensor for wave-front evaluation. The sensor estimates the wave-front local slopes (wave-front gradient) at points located in a regular grid given by the dimensions and distance of microlenses. The tested wavefront is spatially sampled by the lenslet array and impinges on the CCD sensor that is placed at the

focal plane of the microlens array. From the detected intensity distribution (diffraction spots), one can calculate the values of wave-front gradient. The wavefront-shape can be numerically reconstructed from the values of displacements of diffraction spots using various mathematical procedures, e.g. by integration or by approximation using polynomials. In our work, we investigated various methods for approximation of the wavefront from a discrete set of wave-front gradients

The detailed analysis of the sensor was carried out, and appropriate evaluation algorithms were implemented in our measurement system. We have analyzed several different methods for local and global approximation of the wavefront from its gradient. The different evaluation algorithms were tested on examples of real and computer simulated wavefronts. These algorithms were compared with respect to their robustness, accuracy, number and position of grid points. Finally, the most suitable methods were chosen for implementation into the evaluation software for the wave-front sensor. Wave-front analysis software was optimized with respect to given parameters of the system (detector resolution, focal length of microlens array, source of light).

We also tested the reliability and accuracy of our sensor for the case of optical system testing in optical industry. Using our wave-front sensor, we are able to measure the imaging quality of optical systems (e.g. photographic lenses, telescopes,…). The shape of the detected wavefront is deformed due to aberrations of the tested optical system, and one can calculate wave aberration, the modulation transfer function, and other characteristics of imaging quality. The obtained accuracy is comparable to common interferometric techniques in optical industry, and it is sufficient for testing of optical elements and systems. Moreover, together with Meopta Optika, a.s., several experiments were made for testing optical systems in UV and visible light using the wave-front sensor. The presented method is relatively simple and less expensive in comparison to interferometric techniques that are mostly used for optical testing nowadays, and one can obtain a similar measurement accuracy as the common interferometric methods.

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Picosecond Timing System Development

P. Jiroušek, I. Procházka, K. Hamal, M. Kropik, M. Fedyszyn, P. Pánek*, P. Sperber, J. Kolbl**, G. Kirchner*****

prochazk@cesnet.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehova 7, 115 19 Prague 1, Czech Republic

* Institute of Radio Engineering and Electronics , Academy of Sciences of the Czech Republic, Chaberská 57, 182 51 Praha 8, Czech Republic

** University of Applied Sciences, Edlmairstrasse 6 + 8, 94469 Deggendorf, Germany

*** Observatory Graz-Lustbühel, Lustbühelstr. 46, A-8042 Graz, Austria

Satellite laser ranging is an attractive measuring technique widely applied in geodesy, geophysics, global ecology and other disciplines. The ranging accuracy has increased from meters in early seventies to one centimeter in late nineties. However, the data user's community requires the accuracy increase to a millimeter level. The ranging accuracy is limited by the ranging machine errors, the atmospheric propagation correction error, target error, and by the orbit modeling and data aggregation errors. All of these contributors consist of both random and systematic components [2].

To contribute to laser ranging we have been developing 3rd Generation of the Pico Event Timer (3G PET), consisting of two, or more, Event Timing Modules, Clock Generator Module, Input Trigger Module, Control Unit, Range Gate Generator, Microprocessor Module and the Software Package [1]. The Pico Event Timer is designed and constructed entirely for the purpose of millimeter precision laser ranging to Satellites and the Moon. It is expected that Timing Modules will provide the picosecond event timing. The Clock Generator Module supplies the precise clock frequency for timing; the Gate Generator Module maintains the smart arming and gating of the entire timing system. The Microprocessor Module equipped with a powerful operating system dedicated for parallel processing provides a real time control of the device, evaluates in a real time the gating epochs, identifies the measurements pairs and controls the data flow between the PET device and the host computer. The 3G PET will be employed at laser ranging stations for millimeter precision, two wavelength satellite laser ranging and for calibration reference purposes [3].

The 3G PET, we have been developing, will be operating on the event timing principle. Four identical Event Timing Modules are employed, which provides the timing for the laser fire event (Start) and three timing signals from three independent echo signal detectors. The precise master clock signal 200 MHz is generated in the Clock Generator Module from he 10 MHz clock signal provided by the local time base. The Range Gate Generator generates signals with programmable delays with respect to the Start events. Two independent range gate and arming signals are generated: one within the range 0 to 500 nanoseconds for the real time calibration purposes and one within the range 2 milliseconds to 10 seconds for the satellite laser ranging. The actual range gate generator delay is computed and set in a real time, as soon as the epoch of the Start event is read and the corresponding range prediction is computed. The Range Gate Generator and the Control Unit are based on the logical arrays, field programmable, if desirable. This construction ensured the device

simplicity and flexibility. There is still a significant array capacity available for future system upgrades and modifications.

The new concept of the Clock Generator Module has been designed, constructed and tested in 2005. Using especially designed harmonic generators, high gain small bandwidth filters and small bandwidth amplifiers it was possible to achieve a 200 MHz signal with a sub-harmonic suppression of better than 110 dB and rise-times of less than 35 ps. Due to the extreme low noise design the jitter of the 200 MHz signal is far better than 1 ps, therefore opening the possibility for picosecond timing accuracy and sub-millimeter ranging. The performance of the new clock generator module has been tested in a series of indoor and outdoor tests. In the laboratory tests, the content of harmonic frequencies has been measured together with the phase jitter of the 200 MHz clock markers. Both these measurements verified the capability of the module to serve as a reference for the picosecond timing system. The clock generator module has been installed in the satellite laser ranging system in Graz, Austria. It has been operating as a reference for the Epoch Timing Modules made by Thales Detexis - Dassault in the Graz Event Timing (ET) device. The laser ranging calibration tests confirmed the clock module performance: the millimeter ranging precision has been achieved using the newly developed clock module as a reference.

The new concept of the Event Timing module [4] is under development at the Czech Technical University in Prague.

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Laser Altimeter for Planetary Exploration Timing System Technology Demonstrator

P. Jiroušek, M. Kropík, M. Fedyszyn, I. Procházka, K. Hamal, J. Blažej, Yang Fumin*, Huang Peicheng*, H. Michaelis, U. Schreiber*****

prochazk@cesnet.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

* Shanghai Observatory, 80 Nandan Road, Shanghai, People Republic of China

** DLR e.V., Institute of Planetary Research, Rutherfordstraße 2, 12489 Berlin, Germany

*** Forschungseinrichtung Satellitengeodäsie der TU-München (FESG), Fundamentalstation Wettzell, D-93444 Kötzting, Germany

The European Space Agency has nominated the laser altimeter as one of the principal devices for planetary research for the next decade [1]. The first mission in view is Mercury with scheduled launch in 2010. The device should be capable to range over the distances 400 to 1000 km and to acquire the information about the probe altitude above the planet surface and about the surface terrain profile with the precision of the order of one meter. The requirements on the device are rather strict: total mass below 5 kilograms, power consumption below 10 Watts. Recently, the Technology Demonstrator of the altimeter is under development at German Air and Space Agency, Institute of Planetary Research, Germany. The altimeter Technology Demonstrator is based on the diode pumped frequency doubled Nd:YAG laser delivering 50 mJ at 532 nm in 3 nanosecond long pulses with the repetition rate of 20 Hz. The solid state echo signal detector will be used. The optical part of the altimeter is scaled down to simulate the real background count rate scenario and to reduce the energy budget link by a factor of 10^4 at the same time. The demonstrator should be capable to range objects at distances 0 – 5 kilometers in both night and day time.

We are presenting the concept, design and construction of the timing system part of the laser altimeter technology demonstrator, which has been developed at the Czech Technical University in Prague. The BTS is the timing system for the Bepi-Colombo Laser Altimeter (BELA) technology demonstrator. It is dedicated for determining the epoch of laser fire, measuring the time of flight of the laser pulse, generating the range gate pulse for the echo signal detector, data acquisition and process control. It is dedicated to measure precise time interval with sub-nanosecond resolution.

The BTS consists of the Mini Counter module, the epoch timing and range gate generator module, the control processing unit (CPU), the input / output circuits and of the power supplies. The entire control logic hardware including the epoch timing and range gate generator and the input/output board logic is based on the FPGA (ispGAL) programmable logical arrays. There is a significant array capacity still available for future functional extensions and device upgrades, the arrays are field programmable. This fact ensures the maximum device flexibility. The software for programmable arrays was prepared with the HDL programming language.

The Mini Counter has been designed and constructed in cooperation with the Shanghai Observatory, China. It is based on purely digital concept of Time to Digital Conversion. Its

main features are: sub-nanosecond resolution, high linearity, simple design and low power. The power consumption of the counter module is 200 mW.

The epoch timing and gating electronics based on programmable gate array logic determines the epoch of laser fire with the resolution 100 ns. The epoch is referred to the GPS time. The compact GPS timing and positioning sensor is included.

The range gate generator provides the gating pulse; its width and delay versus the laser fire epoch are programmable with 40 ns steps on a shot-by-shot basis. The advanced arming and gating logic permits to operate the timing system in situations, when numerous "false alarm" pulses are present on both Start and Stop inputs.

The BELA Timing System is controlled by the CPU board based on the micro-processor Zilog Z80181. It provides 2 asynchronous serial lines; the first one for communication with a master personal computer, the second one to control the Mini Counter. The connection to the gate generator is established via a parallel data interface. The microcomputer contains 128 KB Flash ROM and 128 KB RAM memory. The utilization of the Flash ROM enables a firmware upgrade via the asynchronous serial line. The microcomputer software (firmware) controls the system; it calculates the start and stop event time with the data combination from the Mini speed counter, the gate generator counter and 1 ms interrupt. The microcomputer sends data to and receives commands from the master personal computer via the asynchronous serial line. The software for the microcomputer was developed in the PRIMAS programming language that provides high level and parallel programming abilities for Zx80 class microprocessors.

The unit is interfaced to a host personal computer via a serial data link for control, two way data transfer and diagnostics. The set of programs for system set up, diagnostics, calibration and real time data acquisition have been completed and tested.

Timing system main parameters:

Interval	resolution	0.25 ns
	stability, linearity	~ 0.1 ns
Epoch	resolution, accuracy	100 ns, 1 μs
Range gate	delay range	400 ns – 12 ms, programmable in 40 ns steps
Repetition rate		0 – 20 Hz
Power, mass		DC, 9 – 38 V, 7 VA, 2.5 kg

The timing system Technology Demonstrator has been tested under various conditions; the specified performance has been verified. The device has been integrated into the laser altimeter by December 2005 for laser ranging tests.

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Single Photon Counting Detectors for Space Projects

I. Procházka, K. Hamal, L. Král, Yang Fumin*, Huang Peicheng*, E. Samain, P. Guillemot*****

prochazk@cesnet.cz

Department of Physical Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehova 7, 115 19 Prague 1, Czech Republic

* Shanghai Observatory, 80 Nandan Road, Shanghai, People Republic of China

** OCA Gémini, 2130 route de l'observatoire, 06460 Caussols, France

*** CNES, Av Edourd Belin, 71400 Toulouse, France

We are presenting the results of research and development of the Single Photon Avalanche Detector (SPAD) for space applications.

Our group has been involved in solid state photon counting detectors since early nineties [1,2]. The first detectors based on silicon have been dedicated for high precision satellite laser ranging. Several schemes permitting both single and multiple photon operation have been developed along with the schemes capable of photon number estimate. The low operating voltage, solid state design and absence of cooling are the attractive features for possible space applications. In nineties, we have constructed the first photon counting detectors for the Soviet space missions to Mars, similar device has been installed onboard the NASA Mars Polar Lander '98 [3]. Recently, numerous applications are appearing for the photon counting detectors in space. The main features required for all the space applications are: high quantum efficiency, picosecond timing resolution, low dark count rate, low mass, low power requirements, high optical signal overload tolerance and last but not least the high cosmic radiation damage threshold.

For the joint project with the Shanghai Observatory, Academy of Sciences of China, we have developed the detector package dedicated for the project of synchronizing the hydrogen masers based time scales by laser pulses. The technology demonstrator of a dual detector has been built and tested in our labs. The main parameters are: detection efficiency 10% at 532 nm, timing resolution 80 ps, and dark count rate 8 kHz, non-gated operation. The detectors active area is 25 µm in diameter. The total mass, including bias stabilizing circuit, is 2 grams; the total power consumption is below 0.5 Watt per detecting channel. The detector can be operated in a wide range of temperatures ranging from –20 ºC to +60 ºC without any additional temperature control. The ruggedness of the detector is superb: the optical power of 2 mW has been focused on a sensitive area while the detector has been biased for 8 hours. No detectable degradation has been experienced. The overload tolerance permits to avoid any mechanical Sun protection shutter in space. The recovery time from optical overload to a full functionality is below 0.1 second.

For the European project Time Transfer by a Laser Light (T2L2), the detector package capable to process optical signals of units to thousands of photons has been developed [5] on the basis of SPAD K14 structure. The timing resolution of 50 and 3 picoseconds FWHM has been achieved for optical signals of single and thousands of photons respectively. The SPAD detector is actively quenched and gated, to reduce the dark count rate it is cooled by a three stage thermoelectric cooler down to –60º C. The detector active area is 200 µm in diameter,

the quantum efficiency exceeds 20 % at 532 nm range, the effective dark count rate is below 10 kHz.

The radiation damage of the detectors has been tested. The SPAD chips without shielding have been irradiated by the total dose of 100 kRad [4]. Such a dose corresponds to more than 10 years exposition in space. The main parameters: dark count rate, sensitivity and timing resolution have beet measured prior and after irradiation. As a result, no detectable change of detector parameters has been identified. This extreme radiation resistance is in contrast to the other solid state photon counters, which exhibit many-fold increase of the dark count rates within one year in space.

Several versions of the semiconductor photon counting package have been developed and tested for the application in space projects. The main advantages of our version of the detector are: low operating voltage, wide operating temperature range, low power and low mass, very high damage threshold for space radiation. The technology demonstrators for two space missions: "LTT Mission", China and "T2L2 Mission", France have been completed. Both space missions are expected to be launched to space by the year 2008.

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Unique Features of the Silicon K14 Chips for Single Photon Avalanche Detection

I. Procházka, J. Blažej, L. Král, K. Hamal, B. Sopko*

prochazk@cesnet.cz

Department of Physical Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

* Department of Physics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6 - Dejvice, Czech Republic

We are reporting on a series of detailed characterisation procedures of the Single Photon Avalanche Diode (SPAD) fabricated on silicon using the K14 process, their particular features and their comparison to the other avalanche photon counters.

Avalanche photodiodes specifically designed for Single Photon counting devices have been developed on the basis of various semiconductor materials: Si, Ge, GaP, GaAsP, and InGaAs in our labs [1]. They have been utilised in various areas of applied physics: optical sensors, communication, quantum key distribution, optical ranging and Lidar, time resolved spectroscopy, opaque media imaging, space projects, ballistic photon identification and others. A noteworthy feature of the K14 manufacturing process of silicon SPADs is its capability to provide relatively large active area detectors without compromising the timing properties. This is in contrast to all the other structures and avalanche mechanisms described in [2], where the avalanche dynamics is explained and it is shown there, that the avalanche rise time depends significantly on the location of the avalanche seed point. In our K14 structure, the timing resolution is independent of the active area diameter.

The uniformity of the detector active area has been tested using 40 picosecond laser pulses at 747 nanometres focused on a micrometer spot in a Time Correlated Photon Counting (TCPC) experimental scheme. The SPAD active area has been scanned, the relative sensitivity, the detection delay and timing resolution has been recorded for each spot. The detection chip on silicon K14 type with the active area diameter of 200 μm has been actively quenched, gated and operated 4 Volts above its breakdown voltage. The detection delay and timing resolution variations over the entire area is below the resolution limit of the experiment: 3 ps rms. For comparison, the same parameters have been measured for the "thick SPAD" structures by EG&G and Silicon Sensors and for the "thin SPAD" as reported in [3]. For all these photon counting detectors, the detection delay changes with position over the active area by 150 and 600 ps for the "thin" and "thick" SPAD structures respectively. The detection uniformity is a key parameter for timing-critical applications of photon counters.

Additionally, we have investigated in detail the photon emission associated with the detection process: once a photon is detected and the avalanche multiplication is triggered in the semiconductor, a large number of photons are emitted by the detector. This effect causes an "optical feedback" inside the detection chain, if it consists from several independent detectors chips. Although this effect has been mentioned by several groups, no one systematic study has been reported for our type of SPAD till now. It represents serious limitation in large optical detection systems construction and in a photon counting array construction in particular. We have measured the total number of photons emitted in one detection event, the temporal and spectral properties of the emission and its radiation pattern. Both the "thick"

SPAD and "thin" SPAD structures have been tested along with active and passive quenching circuits of various configurations in an attempt to find out an optimum setup minimizing the photon emission.

For our (i.e. "thin") detector structure the average number of 370 photons/avalanche for 100 μm SPAD biased 2 V above breakdown has been measured. The temporal profile of emitted signal corresponds with the temporal profile of biasing voltage on detection diode. It has sharp rise time, with about 25 ns and fall time 16 ns for a particular active quenching circuit. It is smooth, without any internal modulation, as expected.

The photon emission radiation pattern has been recorded by a CCD and CMOS cameras integrating 10^5 events. Comparing the exposures taken trough various blocking glass filters, the spectral characteristics of the emission has been estimated in a 400 nm to 1000 nm wavelength range. The preliminary results show that the maximum of intensity is in the yellow region.

The emission intensity for "thick" detector structure (Silicon Sensors) has been investigated in similar scheme. The total number of emitted photons was about two times more for a single avalanche event in 300 μm biased 40 V above break. The higher bias has been compensated by larger area to achieve comparable multiplication condition. The temporal profile of emitted signal has a long tile in order of 100 ns.

For both detection structures the dependence of emitted signal on bias voltage has been investigated. The quenching time has been identified as a key factor determining the intensity of emitted light according effects reported currently in [4].

We have completed a series of detailed characterisation procedures of the Single Photon Avalanche Diode fabricated on silicon using the K14 process, their particular features and their comparison to the other avalanche photon counters. The uniformity of the K14 detection delay and timing resolution is one to two orders of magnitude better than for all the other available avalanche detection chips. The photon emission associated with the detection process has been characterised in detail for all the available structures in time, spatial and spectral domains.

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Time Interval Meter for Photon Number Estimate in Avalanche Detection

P. Jiroušek, M. Kropík, I. Procházka, K. Hamal, J. Blažej, Yang Fumin*

prochazk@cesnet.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

* Shanghai Observatory, 80 Nandan Road, Shanghai, People Republic of China

We are presenting the development and test of the device enabling to estimate the number of photons involved in detection by the avalanche photodiode structure. This detector, called Single Photon Avalanche Diode (SPAD), is an avalanche photodiode structure prepared using a conventional planar technology on silicon [1]. Single photon sensitivity is achieved by biasing the diode above the junction breakdown voltage. In this stage, where the first absorbed photon is capable of triggering the avalanche multiplication of carriers, a fast rise-time current pulse is generated. The leading edge of the current pulse marks the event of the photon absorption with picosecond accuracy. The current increase is terminated by an external circuit connected to the diode. The typical value of the gain achieved exceeds 1×10^9. No linear amplification or pulse forming is needed for the next pulse processing.

Our group has been involved in solid state photon counting detectors since early nineties. Avalanche photodiodes specifically designed for Single Photon counting devices have been developed on the basis of various semiconductor materials: Si, Ge, GaP, GaAsP. Recently, the photon counting detector has been developed on the basis of SiGe [3]. The existing solid state photon counting detectors have been dedicated for picosecond timing of single photon events, only. Analyzing the avalanche current pulse rise time, it has been discovered, that the shape of the leading edge depends on the number of photon detected. This effect might be used, among others, in a process of photon number estimate, which is a hot topic in photon counting detector development [2]. However, the problem is a technological one: the variations in the pulse rise time and shape are on the single picosecond level, what represents a technology challenge of picosecond timing in electronics.

This papers deals with the process of design, construction and tests of a timing device, capable to measure short time intervals with units of picosecond resolution. Recently, several techniques in electronics enable to measure time intervals with picosecond resolution. In our work, we have investigated two time interval measurement techniques: the classical one of analogue time interval stretching by means of charging and discharging a capacitor with different time constants and the technique employing the solid state transversal filtering followed by fast digitizing of the wave-front [4]. The results of the device development based on the first principle are presented below.

The time interval meter consists of the ultra-fast input sensing circuits and the arming logic, the capacitor charging and discharging circuit, the level comparator, the clock pulses counter and the microprocessor for the data acquisition, processing and communication control. The entire device has been constructed on a single two - layer PCB board using the surface mounted technology. Keeping in mind the goal - picosecond timing resolution and stability, the board and its ground plane and power lines, are divided into separate regions for individual function blocks. The communication and signal transfers between these blocks are via optical coupling, only, to overcome the problems with ground potential variations on mV

and sub-nanosecond level. Completely independent floating power supplies are used for the individual function blocks. This configuration minimizes the signal cross – talk and grounding problems when dealing with picosecond pulses. The top quality, custom designed and constructed, signal connectors and cables (SMA version) have been used within the entire instrument and related experiments. The pulse arming and signal processing is based on an extensive use of programmable gate arrays. The device is interfaced to a host computer via RS232C data line using a simple ASCII protocol.

The resulting parameters are as follows: two different measuring ranges are available. The time intervals of 0 – 3 nanoseconds may be measured with the resolution 1.6 picosecond per channel, the time intervals 0 – 6 nanoseconds may be measured with the resolution 3.5 picoseconds per channel. The timing data distribution is pretty close to normal one, with the corresponding sigma of 1.6 channels. It means that the short time intervals may be measured with the resulting resolution of 2.6 picoseconds rms. The temporal stability of the device has been measured to be better than ± 12 picoseconds per hour after 2 hour warm up period. The device is compact, rugged, and simple to operate in field conditions.

The entire measuring device has been completed tested and integrated into the photon counting experiment. Thanks to the quantum nature of photon and the pulse amplitude distribution of the dark counts of the detector, the detection chain is naturally self calibrating: the dark counts may be repeatedly used to mark "time zero reference". This way temperature and temporal drifts of the time to digital converter; signal propagation delays variations may be taken into account and the high accuracy of the reading may be maintained. The device has been tested in an indoor calibration experiment in connection with the solid state photon counter SPAD equipped with the active quenching and gating electronics with time walk compensation made by G. Kirchner and F. Koidl, Graz, Austria. In this compensation circuit, the rise-time differences are converted to time interval in the range of 0 – 200 picosecond for the dynamical range of 1 to 2000 photons. The resolution of signal strength corresponding to photon number within a factor of three has been obtained. This is in a good agreement with the previous experiments [3]. At present, the "Time interval meter for photon number estimate in avalanche detection" has been installed at the Satellite Laser Ranging station in Shanghai, China for long term tests. The results will contribute to the better understanding of the photon counting mechanisms in avalanche detection structures.

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Innovation of the Course Digital Signal Processing in Telecommunication

B. Šimák

simak@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The project deals with the education of the subject "Digital Signal Processing in Telecommunication" at the Czech Technical University in Prague. The education of the digital signal processing was substantially updated. New syllabus of the subject is presented.

The practical training in the digital signal processing in the telecommunication engineering at the Czech Technical University in Prague was traditionally based mainly on Matlab experiments in the past. Only few seminars were devoted to the old Digital Signal Processor (DSP) TMS320C50. In order to cope with the advanced of the DSP technology, the syllabus of the subject was substantially changed. The practical training is based on the Very Long Instruction Word (VLIW) DSPs, both with the floating point (320C6713) and fix point (320C6416) arithmetic in form of commercial DSP Starter Kits (DSK) [1]. In order to make the training more efficient, special in house made daughter cards for the video input and aoutput were designed and realized. The best students can design and realize their own special purpose hardware using our universal daughter cards.

Old Syllabus of the Lectures

Analog and digital signals, conversion
Integral transforms
Implementation of transformation procedures
Design of digital IIR filter
Design of digital FIR filter
Decimation and interpolation filters
Noise properties, stability of digital filters
Architectures of the digital signal processors
Adaptive filtering
Digitizing of speech
Parametric coding
Digitizing of broadcast related signals
Digitizing of images and video signals

New Syllabus of the Lectures

Analog and digital signals, conversion
Integral transforms
Implementation of transformation procedures
Design of digital IIR filter
Design of digital FIR filter
Decimation and interpolation filters
Digital Signal Processors, introduction, VLIW architecture
Noise properties, stability of digital filters

DPS TMS320C6x, instruction set, architecture
Design of systems with DSP
Adaptive algorithms in telecommunication
Digitizing of speech, parametric coding
Digitizing of broadcast related signals, images and video signals
Digital image processing, compression

Old Syllabus of the Seminars

Program tools for the analysis and synthesis of discrete systems
Matlab basics
Integral transforms (DFT, FFT, DCT)
Analysis and synthesis of a digital IIR filters
Analysis and synthesis of a digital FIR filters
Decimation and interpolation filters, signal resampling
Development tools for the realization of digital systems using digital signal processors
Instruction sets of digital signal processors
Design and simulation of discrete systems
Realization of discrete system
Speech compression
Test
Evaluation of the properties of the discrete system

New Syllabus of the Seminars

Program tools for the analysis and synthesis of discrete systems
Matlab basics
Integral transforms, decimation, interpolation, resampling
Analysis and synthesis of digital IIR and FIR filters
DSP VLIW TMS320C6x
Development tools for DSP, Code composer studio, DSK 320C6713
Implementation of convolution and correlation on DSK TMS320C6713
Implementation of echo on DSK TMS320C6713
Implementation of FFT, DFT, DCT on DSK TMS320C6713
Implementation of DTMF coding and decoding on DSK TMS320C6711
Implementation of echo cancelling on DSK TMS320C6713
Implementation of motion detection on DSK TMS320C6416
Implementation of image filtering on DSK TMS320C6416
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Rotation Stage of Optical Lithograph for Synthetic Holography

J. Svoboda*, P. Fiala, J. Zicha***

svoboda.jakub@fs.cvut.cz

*Division of Precision Mechanics and Optics, Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technicka 4, Praha 6, 166 07

**Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holesovickach 2, Praha 8, 180 00

Currently there has been an optical lithograph in operation at the Department of Physical Electronics at Faculty of Nuclear Sciences and Physical Engineering of CTU. The device serves to write synthetic holographic structures. It consists mechanical part, optical part and control unit. The mechanical part consist of x-y translation stage driven by endless screws and stepping motors. The optical part consists of a UV laser diode working in pulse mode, transparent LC display and afocal optical system. The third part is the controlling unit which cooperates with PC. The lithograph writes the elementary dots of a synthetic hologram by subsequent stepping in the two directions and exposing a micrograting into the photoresist. Recent research in the field of rotationally symmetric diffractive structures leads to the need of constructing an additional rotation stage to the current device.

Rotationally symmetric diffractive structures are being used to supply conventional optical elements. Such a structure is able to compensate the aberrations of optical systems. Since it has the negative dispersion, it enables also the compensation of the chromatic aberration. In the simpliest case, it is represented by a Fresnell diffractive plate. One of the most important features of these structures is the diffractive efficiency which means we should ensure as high energetic yield as possible. The solution for the relief diffractive structures is so-called blazing. It means that the microstructure has a well defined trapeze profile of the diffractive period or that the differential index of refraction is big enough (for the volume Bragg structures).

According to the current setup, there are these device requirements. Run-out of the stage axis at the diameter 100 mm should be less then 2 micrometers which is the depth of focus of the lithograph objective. The stage should fit the proportions of the lithograph which means the height of the stage 32 mm and diameter about 160 mm. The weight, limited by the maximum load of the x-y translation stage, is up to 5 kilograms. The revolutions of the stage should be provided by a stepping motor which would be driven by the same unit as the current two units are.

The construction results from the following conception: the rotation stage has a prismatic groove at the perimeter and it is mounted at three points with three special bearings, rollers. The rollers fit into the prismatic groove with its collar. Let us denote the diameter of the stage by "D" and the diameter of the roller by "d", the angle between the vertical axis and the axis of the stage would be α_S and the angle between the vertical axes and the axis of the roller α_r . Then we can find this relation from the triangular similarity: $\alpha_S / \alpha_r = d/D$. It is obvious that the run-out of the roller is transmitted onto the stage, decreased by the factor d/D.

The minimum run-out of the rollers is provided by its construction and mounting - the housings of the rollers contain a thrust journal. There is a pair of thrust needle roller bearings and one radial needle roller bearing inside each roller. Two housings of the rollers are pressed and the third one is eccentrically mounted into the base. The eccentricity provides adjusting

the clearance between the stage and the rollers by pressing the roller into the groove. After adjusting the clearance, the eccentric is tighten from the bottom of the base.

First design of the stage counted on placing the rollers from outside the stage and driving one of the rollers by the stepping motor. However, due to space shortage, it has been decided to make the prismatic groove from inside of the stage, move the rollers inside and provide the driving of the stage by the worm wheel and worm gear from outside of the stage. So the 160 teeth worm wheel is pressed on the stage and is driven by 3 teeth worm gear. The speed ratio (3/160) is relatively prime according to uniform wear of the teeth. The worm gear is mounted to the stepping motor by a flexible coupling. According to 200 steps per revolution for the stepping motor and speed ratio approximately 1/53, the device is able to achieve the differential angle step of 2'. The clearance between the gear and the wheel is adjusted by flexible pinning of the gear against the wheel.

The recording material is a glass plate coated with photoresist. To eliminate the inhomogenous thickness of the glass plate, it is pressed from the bottom against three pins mounted at the top of the stage. A small cone can be mounted into the stage axis. It is used for aligning the stage axis with the optical axis of the lithograph.

The device is currently being manufactured and is supposed to start working within the first half of 2006.

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A Mobile Data Acquisition System for Engineering Use

M. Galuška, V. Vacek, M. Doubrava

Michal.Galuska@fs.cvut.cz

Department of Applied Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 27 Praha 6, Czech Republic

The components being developed for measurement applications in the European laboratory for particle physics research – CERN – can be used to make a very compact and mobile data acquisition (DAQ) system for various engineering measurement needs. As a supplement to the longstanding cooperation of the Department of Applied Physics with CERN, which cooperates on the development of an evaporative cooling system for the LHC ATLAS Inner Detector, these components have been appropriately adapted and a Mobile DAQ System for engineering use has been created.

The CERN standard for most engineering measurement applications comprises, from the point of view of hardware, a personal computer or server, CAN-Bus communication architecture, and up to 64 ELMB (Embedded Local Monitor Board) units. From the point of view of software, of an OPC server for communicating via the CAN-Bus, and OPC clients on the same or networked computers to read, display, and store the measured data.

The ELMB unit comprises a 64-channel analog DC-voltage multiplexer and four flat-cable connection plugs (16 channels per cable). Each cable connection is provided with plugs for signal adaptation to enable reading not only voltage signals, but also resistance signals in either 2- or 4-wire connection modes. This provides the ability to read temperature sensors of Pt1000, Pt100, and NTC types, thermocouples, pressure sensors, flow meters, and various other electronic measurement instruments.

With the advance of processing power of notebook computers and the development of the USB interface, the opportunity arose to fit the mentioned OPC server, which administers the communication of the computer with the ELMBs, and the OPC client, which administers the user interface with the measured data, into one machine, connected to the CAN-Bus via an external USB CAN card. Together with a common AC/DC adaptor to power the ELMBs and CAN-Bus, and some cabling, a fully-functional, independent, very compact DAQ system can be created, that can fit into a single briefcase or larger notebook handbag, able to measure up to 64 channels with each ELMB unit used.

Such a Mobile DAQ System has been created at the department, along with software in the PVSS environment (OPC Client). The software allows controlling up to four ELMB units, configuring their channels, creating graphical layouts and plots for easier experiment or process visualization and control, record and store measured data, and output the data in Excel spreadsheet format, all by a user inexperienced in programming or without detailed knowledge of the PVSS and OPC environment.

The ELMB units have been adapted so as to measure 16 Pt1000-type sensors, 16 NTC-type sensors, 16 voltage-output sensors, and either 8 Pt100-type sensors in four-wire connection mode, or another 16 NTC- or Pt1000-type sensors. Therefore, with all four ELMB units connected, the system can display and record data of up to 192 temperatures and 64 pressures, flows, or other quantities measured by sensors with voltage output.

Nevertheless, this configuration can be changed simply by changing the signal adapters on the ELMB units and modifying the appropriate conversion equations within the software.

Measured data are displayed and stored about every 5 seconds. The data can be retrieved and output into an Excel spreadsheet file even at a later date, with the user choosing the time-span for which the data should be retrieved, and the interval at which the data within the time-span should be output – for example every 5, 10, 15, or 30 seconds.

The system has been successfully tested and used for experimental measurements for sensor calibrations and on cooling system prototypes.

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Advanced Source for High Resolution X-ray Diffractometry

J. Maršík

jiri.marsik@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Praha 6

Topic of this project was design of a new X-ray illuminating system for high resolution X-ray diffractometry (HRXRD). Whilst this technique has been available for over fifty years, and the basic theory for even longer, it has grown enormously in importance in last two decades for two technological reasons. First reason is massive development of X-ray sources and X-ray optics that has enabled the ideas from earlier years to be applied and extended. The second main reason is the industrial need for characterisation and control of high quality crystals and epitaxial layers that are heart of many electronic devices like integrated circuits, sensors, optoelectronic and microprocessors. Techniques such as high resolution X-ray diffractometry, that for many years were only obscure research tools, are now in daily use for industrial quality control.

Requirements on high resolution diffractometer design arise from physical principles of X-ray diffractometry. Any radiation striking material is both scattered and absorbed. Scattering is most easily approached by thinking of plane (perfectly collimated) wave. When such a wave strikes a three-dimensional atomic lattice, each scattering point (electron or nuclear particle) acts as a source of spherical wave. We usually consider an entire crystal plane as scattering entity. The addition of the amplitudes of all these waves in most directions results in almost zero intensity. Strong beams occur only in those directions, when all the wavelets add up in phase. The exact incident and diffracted angle for a certain wavelength are driven by famous Bragg law. Diffraction for a given wavelength and plane does not take place over a zero angular range defined by the Bragg law, but over a small finite range. Plot of intensity of diffracted beam versus incident angle is called the rocking curve. Small number of planes result in a broad peak, large number of planes gives narrow peak. This range is called the rocking curve width and for highly perfect crystals is only a few arc seconds wide. It is quiet clear, that dislocations, tilts or strains in crystal affect rocking curve shape. Thus interpretation of broadening, shift or division of peaks gives us useful information about crystal qualities. Measuring of rocking curve is therefore essence of diffractometry. The key problem is, that rocking curve is also broadened due to both divergence and wavelength spread of incidence beam and fine details of rocking curve are blured. Quality of incidence beam is therefore absolutely essential (divergence about 10 arc seconds, $\Delta\lambda/\lambda \approx 10^{-4}$). On the other hand, we need as high intensity as possible, because application of this method in mass production expects rapid measurements that take few minutes, not days. Beam size is also important to measure only defined area of crystal surface. All this must be very precise (tilts in arc second, translations in microns), time stable (only one servicing every six months) and extremely clean.

We see, that these requirements are very tough and diametric. Department of Precision Mechanics and Optics participated in design and we would like to introduce our solutions. Our HRXRD source consists of X-ray tube, safety shutter, X-ray mirror, vertical and horizontal slits and reference crystal. Mirror, slits and crystal are also called the beam conditioner. All these optical components are mounted to optical bench that can be translated

by special XYZ stage to align beam with center of goniometer. Every component has its own role and needs specific alignment.

X-ray tubes are very convenient and relative cheap source of X-ray radiation. We used standard tube with solid copper target and spot size about 40 microns in diameter. Copper target tubes give us characteristic $K_{\alpha 1}$ and $K_{\alpha 2}$ lines. Less intensive $K_{\alpha 2}$ should be removed by beam conditioner to obtain monochromatic radiation. Power input is approximately 80 Watts. Most of this energy transforms into heat. Unfortunately tube that is used in our system has very bad design, because it is mounted very far from target and thermal expansion could cause its movement. That would affect beam position. We therefore designed massive cooling system. However the best solution would be not to clamp the tube and let the target flow, but to clamp the target and release the tube. This solution would be of course more complicated and we didn't have enough time so it remains as one of challenges for future improvements.

Second very important feature is special multilayer X-ray mirror. This optical element has three functions. As we have already noticed, HRXRD needs plane wave. Mirror therefore transforms divergent radiation from source into ideally collimated beam of defined size. Parabolic mirror creates perfectly collimated beam only if source is infinitely small and lies exactly in focus. However real source has finite size and divergence can be improved only if increasing focal length, but that would reduce intensity. Our system therefore uses elliptical mirror. Source lies in one focus and spot in another one whilst magnification was calculated to be one. This solution gives comparable divergence as parabolic system, because aperture is very small, but spot size is much smaller and has exactly defined size. Intensity is outstanding. Mirror is mounted in six-points mount. Four points are fixed and last two allow two rotations to align Bragg angle and vertical tilt. Mirror is held in vacuum to protect its surface and to reduce absorbtion of radiation in air.

Slits are situated directly beneath the mirror. Slit size controls mirror aperture and thus divergence of the beam. Our beam conditioner can be therefore used as high intensity – low resolution our low intensity – high resolution, all in one instrument. Horizontal translation of slits is done by pair of elastic hinges. Main advantage is high stability, no backlash and very thin design. Opening is based on parallelogram mechanism that provides high sensitivity for nearly closed slits but fast opening for wide slits.

Last optical feature is reference crystal designed as two bounce channel cut crystal (CCC). Its function is to control spread of wavelengths using Bragg reflection. Crystal has more channels with different offcut angles, so each channel has different acceptance angle. This gives us similar possibility as slits – small acceptance angle gives highly monochromatic beam but extends exposure time, larger acceptance angle or even removing crystal from beampath would be useful for rapid orientation measurement. Crystal is mounted in similar way as mirror in six-points mount. This time two rotations and one translation are adjustable.

As shown above, our tool provides large variety of configurations and is designed to be universal instrument. Although X-ray tube, optics and reference crystals are extremely precise hi-tech product, only good cooperation of all these components builds successful device. We are proud, that this cooperation is provided by mechanism designed in our department.

GNSS Signals Tracking Algorithms Performance Assessment Using GRT

P. Kačmařík, P. Kovář, F. Vejražka

kacmarp@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

Contemporary GNSS (Global Navigation Satellite System) use solely Time of Arrived conception. This means, the unknown user position estimation is based on distance between satellites with known positions and user receiver. The particular satellite distance is measured from propagation time between the satellite and the receiver. The satellite distance is denoted as pseudorange in satellite navigation context. The quality of measured pseudorange is therefore significant for correct position determination.

The typical receiver process signals in two stages – first stage is responsible for the independent estimation of pseudoranges and the second stage is responsible for position determination based on these pseudoranges. The independent pseudoranges are determined in bank of DLL/PLLs, the position can be determined e.g. with Kalman filter.

The continuous pseudorange estimations are kept with signal tracking operation using mentioned DLL/PLLs bank. The characteristic of tracking algorithm therefore significantly affect own receiver performance. Since new satellite navigation system Galileo is deployed nowadays, the development of new or modification of current algorithms is carried out. The development of new tracking algorithms needs some appropriate methods which enable the algorithms verifications and coarse performance assessment. Therefore the development of GRT (GNSS Receiver Toolbox) has been started.

The GRT is a simulation tool which has a form of Matlab Simulink blockset. Since the Simulink is used as a simulation engine the high user comfort of simulations are ensured. The GRT contains a number of specialized blocks which enable simply building of a Simulink models for GNSS signal processing investigation.

The current version of GRT (version 1.1) is based on subset of embedded Simulink blocks combined together with subset of blocks from Signal Processing Blockset. The simulation performance (assessed as simulation speed) therefore solely depends on performance of these standard Simulink selected blocks. There are only a few possibilities to improve simulation performance by keeping MathWorks recommendations (for Simulink model building) which concern Simulink Accelerator. The GRT further utilize bit-true conception which enables truly modeled tracking part of receiver. Unfortunately, this brings extremely time consuming simulations. To minimize this handicap the advanced version of GRT is developing. The core of particular blocks of GRT will be overwritten in C/C++ language as Simulink s-functions. The C/C++ language enables high possibilities to optimize particular block performance. The GRT blocks written as a C/C++ s-function will be incorporated into new version of GRT (version 2).

The significant advantage of Galileo system is multifrequency signal tracking for civil (non-authorized) user. The GRT is currently capable to simulate multifrequency GNNS signal processing nevertheless we can identify two main obstacles which make this type of simulations nowadays meaningless. First obstacle consists in absence of appropriate

atmospheric model which is capable to truly modeled ionospheric effects (ionospheric scintillation). These effects could be especially significant in case of carrier phase tracking together with long integration time. The second obstacle is connected with low simulator performance (simulator speed). The important characteristics, which can assess the multifrequency signal tracking like "mean time between failures", than lead to enormous long time of simulation run and make their performing impracticable. These two obstacles should be overcome in future version of GRT.

The GRT library was used for "Code and Carrier Phase Tracking" held in frame of "Galileo Core Technologies", see [3]. The significant effort was made to the possibilities of joining of tracking loops to achieve better resulting performance. Due to mentioned lack of atmospherics model, the base of investigation lies in combination of data + pilot signal tracking (e.g. L1b together L1c).

The investigated receiver configuration was build as a Simulink model using GRT blocks and key simulated signals (like code/carrier phase error) were saved into file for consequently performance assessment. These simulations results were confronted with theoretical assumptions obtained from derived loops equivalent models.

The two methods of loops estimations merging were investigated and confronted. The first method combines the estimations of independent loops, the second method combines the filter loops output and thus forms one merged loop. The code/carrier phase tracking error in steady state was investigated as performance characteristic. The analytical solutions and also simulations results prove, that in a case of the best situation, when we merging the loops with identical configuration and thus with the identical variances of estimations, the performance of both methods are identical. In real situation we can expect that the independent loops variant brings better benefits. In case of sync failure of one loop the other can help to resynchronize the first one. It isn't possible in case of one joined loop.

The greater justification for loops merging in Galileo receiver can be found in better dynamic performance of loops. Loops merging can e.g. bring better robustness of whole tracking system in shadowing environment or in environment with multipath. Unfortunately the low simulation speed capability together with absence of appropriate atmospheric model preserves to perform this type of simulations. Both obstacles are supposed to be overcome in future version of GRT.

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Methods for Analysis of Non-ideal Switched Circuits

Jan Bičák

bicak@fel.cvut.cz

Department of Circuit Theory, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This paper informs about the project which is oriented to the analysis of switched circuits taking into account the actual properties of components. The project goal is the development of new algorithms and their following implementation in the form of function library for mathematical program MAPLE. The first part deals with the algorithms for frequency domain analysis of periodically switched linear (PSL) circuits and sensitivity calculation of PSL circuit. The next part solves issue of clock feedthrough and charge injection analysis in switched current (SI) circuits. The last part attends to the time domain analysis of switched circuits with both externally clocked and internally controlled switches.

The presented project continues the issue of GACR project with the name "Analog Filter Synthesis" solved on the workplace of project applicant in the years 2002-2004. The part of project was oriented to the optimum design of current-mode filters and their implementation by means of SI circuits. The issue of optimum design is closely associated with the issue of analysis of the actual properties of designed circuit. The proposed project also directly continues the initiation project with the name "Analysis of Real SI Circuits" solved by applicant of the post-doc project in the year 2003 in the framework of the CTU internal grant contest. The research of the known algorithms for the analysis of switched circuits was carried out here and the selected methods of analysis were tested on the base of research.

The following issues have been solved in the first year of the project:

- Evaluation of various approaches to frequency response calculation of switched circuits in Spice,
- development of PraSCAn – Maple package for analysis of real periodically switched circuits,
- development of new modified algoritm for computation of generalized transfer functions of switched circuits.

The main results reached in this field were presented in [1]-[4].

The reference [1] introduced newly developed Maple package PraSCAn which provided algoritms for analysis of real periodically switched circuits. It listed the features of the package and contained short explanation of the applied method of analysis. The usage of the package was shown on analysis of switched capacitor biquad filter. The algorithm implemented in PraSCAn package is based on generalized transfer function method GTF $K(s,z)$. The frequency response of analyzed circuit is obtained by double substitution $s=j\omega$ and $z=exp(j\omega T)$, where T is switched period. The dynamic properties are determined by pole locations of GTF in s and z domains. The PraSCAn package can be also used for symbolic analysis of ideal switched capacitor (SC) and switched current (SI) circuits and for symbolic analysis of continuous-time linear circuits. The reference [4] presented PraSCAn as an universal tool for symbolic and semisymbolic analysis of linear time-invariant circuits, SC circuits, SI circuits and switched linear circuits.

When developing new algorithm, it is always good to have a tool, which is doing the same thing in another way, to be able to compare the results. It was the reason we dealt with the evaluation of various approaches for frequency response calculation of switched circuits

in Spice (see references [2, 3]). The reason for using Spice was that it is an industry-standard circuit simulator and it can consider the common non-ideal effects occuring in switched circuits. Presented method of frequency analysis is based on transient analysis of a circuit excited by one of three input signal. Frequency response is obtained by applying fourier transformation to the computed samples of output signal. Two approaches (Discrete Fourier Tranformation and Fourier Integral Calculation) are taken into account. Circuit gain, phase and futher information such as distortion can be obtained by this method for a linear circuit or for a circuit with a small distortion. There are a number of conditions that must be kept in the course of computation to get accurate results. These conditions were mentioned in the paper. The main results are following: Circuit excitation by pulse gives some advantage in comparison with excitation by a set of sinusoidal signals. The frequency response could be easily computed for more frequencies. The computation is faster because it is not necessary to wait for periodical steady state in transient analysis. The errors of computation are comparable for both types of excitation. However it is necessary to be careful in case of real circuit (with parasitical effects) without sample and hold input circuit. There is need to use just a set of sinusoidal signals for excitation, because the analysis with pulse excitation gives different (bad) results. The reason is that there are different transfer functions for these types of excitation signals.

The work on developing of the new modified algoritm for computation of generalized transfer functions of switched circuits is not finished yet. Nevertheless the main ideas of new algorithm are likely to be presented in this year.

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Algorithms of Signal Parameters Measurement in GNSS

L. Seidl

seidl@fel.cvut.cz

Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Global Navigation Satellite Systems (GNSS) represent a commonly used positioning, navigation and localization systems. The American GPS-NAVSTAR system is the only one fully applicable global satellite position determination system on the world at present. Russian system GLONASS can be used partially for support of GPS in heavy environment, but significance of the GLONASS system is degraded due to satellite constellation incompleteness at present. European system Galileo is a new developing system, which is mentioned to replace the present systems in foreseeable future and to improve qualitative parameters of positioning, navigation and localization services in many applications including safety critical functions in civil aviation.

The GNSS position determination is based on the satellite-to-user distance measurement. GNSS satellites transmit the specially designed signal with spread spectrum modulation. The signal propagation delay is measured to obtain the distance information. Because the satellite orbital parameters are known, position and velocity of users receiver equipment is computed consecutively. Precise propagation delay measurement requires using of special high-resolution sub-nanosecond methods and construction of measurement receivers.

Modernization of the GPS and development of the new GNSS system GALILEO require new approach to investigation of the signal processing in the receiver. At the Czech Technical University in Prague the Experimental GNSS Receiver based on Software Defined Radio Architecture has been developed. The receiver is determined for research and development of new GNSS signal processing algorithms including massive parallel processing for navigation in urban area with low quality signal coverage and for the study of new forms of the GNSS signals transmitted during the early phase of the GALILEO mission.

The receiver architecture is based on the Software Defined Radio philosophy because of its versatility, easy implementation of modified algorithms and ability to fit to changes in the signal structure during the development phase of the navigation system. The receiver consists of L-band radio-frequency part and of digital signal processor (DSP). Radio-frequency frond-end is composed as a universal double-channel down-converter with wide signal dynamic range. Each channel can operate at independent frequency in the band from 1 to 2 GHz. The bandwidth of each channel is adjustable up to 36 MHz. The output immediate-frequency wide-band signal (122-158 MHz) is sampled by 8-bit A/D converter with very low jitter and samples are passed to the DSP.

The DSP unit is based on the on the FPGA Virtex-II Pro. This solution presents integration of very powerful gate array with two or more processor cores PowerPC (PPC 405E) on 300 MHz and other support circuits such as set of multipliers for parallel algorithm realization or 200 to 600 kilobytes of in-chip memory. The concentration of these circuits in one chip device allows compact solution of complicated DSP unit. The FPGA platform enables single chip integration of all digital processing parts of the GNSS receiver, i.e. correlators and signal filtering, signal tracking tasks and finally position-velocity-timing (PVT) resolving, system integrity monitoring, navigation and other related tasks. The FPGA

is fully programmable and one iteration of design procedure takes several tens of minutes only. Therefore, many variants of DSP algorithm solution can be verified and tested on the real signal in suitable time duration.

The PowerPC system in the FPGA Virtex2-Pro is used for implementation of GNSS signal acquiring and tracking algorithms. The significant numeric power if PPC-405 core is supplemented by hardware construction in FPGA and can be used for extended GNSS signal algorithm implementation – for very fast GPS/EGNOS signal acquire [1], very weak GNSS signal processing [2] or GPS+GLONASS or GPS+GALILEO system integration. Usability and efficiency of the receiver realization was tested successfully in our laboratory and in outdoor mobile experiments too. The receiver concept allows implementation of complex signal processing algorithms on multiple frequency bands.

We assume the Experimental GNSS receiver will be prepared for research and development of new GNSS signal processing algorithms including massive parallel processing for navigation in urban area with low quality signal coverage and for the study of new forms of the GNSS signals transmitted during the early phase of the European system GALILEO mission.

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Thermal Donors in Silicon Irradiated by MeV Protons and Alphas: Effect of Post-Irradiation Annealing

V. Komarnitskyy, P.Hazdra

komarv1@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University,Technická 2, 166 27 Prague 6, Czech Republic

Irradiation with high energy protons and alpha-particles is widely used for lifetime control in silicon power devices [1]. Radiation damages introduced by these ions give rise to energetic levels acting as effective recombination centers. If the irradiation is performed in a proper way, ON-state electron-hole plasma distribution within the device can be modified to speed-up device turn-off. To suppress negative-side effect of irradiation (high leakage), the post-irradiation annealing is necessary [2]. During this process, undesirable defects (generation centers) are being removed while new, more stable centers are arising. Majority of radiation defects acting as recombination centers can be removed using annealing temperatures higher than 400 ^{0}C. Simultaneously, the growth of thermal donors (TD) appearing at the depth close to ion penetration range is observed [3]. In this work, we studied introduction of thermal donors during high temperature annealing of proton and alpha-particle irradiated silicon by C-V profiling. Evolution of hydrogen related shallow donors in proton irradiated devices was correlated with concentration of radiation defects measured by deep level transient spectroscopy (DLTS) and their influence on blocking capability of the irradiated devices was also investigated.

Devices under test were commercial 100A/1700V planar p^+nn^+ chip diodes from ABB Switzerland Ltd., Semiconductors. The diodes, which were designed for use in power modules, were produced from the low-doped <100>-oriented FZ n-type silicon. The diodes were irradiated with 1.8 protons ($^1H^+$) and 7 MeV alphas ($^4He^{2+}$) using the 5 MeV tandem accelerator in FZ Rossendorf. The irradiation was carried out with fluences ranging from 1.4×10^{10} to 5×10^{12} cm^{-2} for protons and from 8.5×10^{8} to 1×10^{12} cm^{-2} for alphas. After irradiation, the diodes were isochronally annealed for 30 minutes in temperature range from 100 to 500 °C. Samples irradiated with lower fluences were studied after irradiation and subsequent annealing by DLTS (DLS-82E spectrometer) to characterize radiation defects. C-V characteristics of all samples were recorded at 85 °C in the range of reverse voltages from 100 to 0V using the HP 4280 capacitance analyzer and further used for calculation of shallow donor profiles. Blocking characteristics excited by the programmable voltage source PS350 were recorded at 30 °C by a sensitive I-V converter and HP34970A multimeter.

Free carrier profiles measured on diodes irradiated with alpha-particles showed a compensation of original shallow donor doping. This compensation is given by ionized deep acceptors originating from radiation defects and appears as a dip on the measured free carrier distribution. The magnitude of the dip increased with irradiation fluences. After isochronal annealing in the range from 100 °C to 375 °C, no substantial changes of the doping profiles were revealed excepting decrease of this dip. DLTS investigation showed, that this is given by annealing of V_2O and of VO centers. When we annealed samples irradiated with low fluences of alphas (8.5×10^{8} cm^{-2} and 5×10^{9} cm^{-2}) at 375 °C, a new peak on carrier (donor) distribution appeared in the depth slightly behind the alpha's projected range. This peak increased with annealing temperature and showed its maximum at 475 °C. Appearing of this

peak with a shape similar to the distribution of the radiation damage was attributed to formation of Shallow Thermal Donors (STD) stimulated by radiation induced defects [4] since a homogeneous formation of STD was also registered on nonirradiated samples after annealing at 400 °C. The highest concentration of STD was measured for alpha's fluence of 5×10^{10} cm^{-2} after annealing at 450 °C. For higher fluences, the STD peak related to radiation damage appeared at higher temperatures due to a stronger influence of compensation by deep acceptors. In this case, the TD distribution showed a more complex behavior. When annealing temperature increased, the peak broadened its side, which was oriented to the irradiated surface, and gradually transformed its shape to a mutli-peak distribution. Annealing at temperatures above 500 °C led to gradual decrease of all STDs. STDs in alpha-particle irradiated diodes are not detrimental since they appear only after annealing at temperatures higher than 400°C. This is well above temperatures necessary for defect stabilization or for soldering of planar devices into modules.

In contrast with alphas, we observed the increase of donor concentration in proton irradiated samples already after irradiation. This is because proton irradiation, i.e. hydrogen implantation, introduces shallow Hydrogen Donors (HD) at ion's range. In contrast with STD, the HD peak concentration is linearly dependent on proton fluence and can significantly change doping profile of the diode and deteriorate its blocking capability. To better understand process of HD evolution, DLTS spectra recorded on proton irradiated samples were analyzed after every annealing step. The highest concentration of the donors was observed after irradiation and the diode breakdown voltage was significantly reduced compared to nonirradiated sample. Annealing at 220 °C decreased donor concentration due to capturing of interstitial oxygen (O_i) by divacancy (formation of the new V_2O center) and by increasing in concentration of VOH that consumes atomic hydrogen. This recovered the breakdown voltage. However, further annealing at 350°C led to annealing out of V_2O, VOH and partially VO. This stimulated further HD and STD formation and subsequent deterioration of breakdown voltage. In this temperature region, hydrogen also started to out-diffuse from the region of maximal damage and donor distribution widened. As in alpha-irradiated samples, the distribution of shallow donors exhibited several maximums and decreased its magnitude at temperatures higher than 475°C.

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Support of Electronic Circuits Teaching Using Internet

J. Hospodka

hospodka@feld.cvut.cz

Department of Circuit Theory, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This paper presents system for electric circuit analysis through internet. The system is based on dynamical www application enables both symbolical and numerical analysis. The application – system of www interface has been done to enable analysis (using analytical programs) through internet.

Numerical analysis is solved using OpusSpice program. This program is compilation of standard Spice3 and Xspice program. It can is free and run under many operational system like Linux and MS Windows are. It disposes of analysis suitable for designed interface. Syrup package in Maple program is used for symbolic analysis of linear circuit. Maple™ program can be run in so-called batch mode which necessary for utilization in the interface where the programs are called by the PHP scripts [2,3].

Next programs are used for additional functions. GnuPlot program is used for graphs drawing, typographical system LaTeX for protocol of analysis creation, PHP scripts for proceeding of the programs, parameter passing, etc. These programs including server operational system (Linux) are free. This is the reason why the www interface is also free for use except symbolical analysis. This analysis is powered by Maple and its utilization is fixed by license for Maple program.

User interface is based on www (client-server conception). The computation and interface programs run on a server and a user uses an arbitrary graphic client i.e. standard www browser (Netscape Navigator, Internet Explorer, Firefox, Opera etc.) for results displaying only. This principle has been used also for electric filter synthesis, see [1].

The server runs under operation system Linux. The analysis of required circuit is solved using the above-mentioned programs – OpusSpice or Syrup package in the mathematical program Maple. GnuPlot program is used for drawing graphs. There is one difference: result from GnuPlot isn't a text, but it is a picture in PNG file format. Both programs are run using batch processing witch must be supported. Procedure of calling GnuPlot is analogous to a procedure of calling Maple or OpusSpice. The interface between those programs and www is built up on scripts in PHP and Bourne again shell (BASH). According to client requests the results are presented by dynamically created www pages. These pages are provided to the client by means of HTTP server Apache. The described application of circuit analysis was realized according this model.

Input requests are inserted in forms in www browser. The program in JavaScript tests the validity of these requests before sending them to the server where it is tested, too. Input files for OpusSpice or Maple computing program are generated from input requests by PHP and BASH scripts. The results are saved in separated files. The PHP scripts process these files and create the structure of dynamic www pages, which are sent to the client. It is needed to solve many other problems, for example, to distinguishing simultaneously connected users, deleting temporary files and directories. Cookies, session variables (PHP), etc. solve these problems.

The interface includes all types of basic analysis – DC, AC and transient. Operating of the interface is very easy. It is interactive system supplemented by help pages in addition. The user can use the interface without any manual and study of syntax. Specification of the circuit

and all results of analysis can be saved as a protocol of analysis. The interface is available on mentioned link [4].

Analysis of electric circuits is necessary for understanding its principles. Programs performing the analysis are needful not only for professional designers and scientists, but also for students. The described interface makes accessible the analysis for the wide range of users. The users can get benefit from the interface without any special software installation and without learning of any command syntax. It is necessary only PC with common operational system, web browser and width internet connection for using the interface. The system can by easy administrated because all used programs run on the server and configuration is protected by the server (user right).

The aim of the interface is not to create application inclusive all facilities of original Spice (OpusSpice) program. The interface should help to users to make analysis of electric and electronic circuits easy. The application has been proposed for support of education in CTU.

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Maple is trademark of Waterloo Maple Inc.

Application of The New Technical and Programming Tools in Digital Processing Education

V. Davídek, P. Máša, A. Vojáček

davidek@fel.cvut.cz

Department of Circuit Theory, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 16627 Praha 6, Czech Republic

The project has been oriented to the exploitation of new technologies, especially new families of digital signal processors and SW and HW tools in an innovation the laboratory of digital signal processing (DSP) education. Modernization of a laboratory equipment leads to the higher quality in theoretical and practical education in subjects Implementation of DSP Algorithms (31ICZ) and Using of Signal Processors in Signal Processing (31PSP).

Main topics of the project

- Design of the development equipment strategy for student's workspaces
- Marketing of the newest technologies in DSP's
- Concept of teacher's workspace (PC + SW) used to preparing of study materials, web sites, exercises for students and student's projects.
- Design of laboratory tasks and web sites.

Students will be able to work on the newest and in the present available technical tools. It will allow them to implement complicated algorithms, to program digital signal processors and to check their operation in real time. The development laboratory is turning into facility of high quality of practical education in digital filtering, digital signal processing, speech processing, spectral analysis, biological signal processing etc.

Main results of the project

- Completion of student laboratory work places using the newest boards with modern digital signal processors TMS320C6713 working with floating-point arithmetic and TMS320C5416 and TMS 320C5510 with fixed-point arithmetic.
- All student's work places are equipped by modern software tools as Code Composer Studio (CCS) for real-time implementation, containing the proposal line Assembler/Linker/Simulator.
- New laboratory tasks have been developed. This tasks will help students to practice the basic knowledge in area of digital signal processing. Attention has been paid mainly to addressing modes of processors, operation with input/output ports, moving data between program memory and data memory blocks, construction of program cycles, etc.
- Establishing the teaching work place equipped by PC and development software used to the design of laboratory exercises, completion of web sites for the DSP subjects and preparing student's projects.
- On the web site http//amber.fel.cvut.cz/icz there is in this time completed essential information which students need to the designer's work with digital signal processors:

the architecture of DSP is described, instruction set is included, HW and SW development tools, manipulation with CCS, program of lessons and exercises.

In winter-semester students have been used new development boards with modern digital signal processors in the subject 31ICZ "Implementation of DSP Algorithms". They have tested the boards and solved individual projects.

Future works

The concept of the laboratory has been developed as an open system. Quick progress on the market of DSP technologies puts big requirements on teaches, students and knowing public. From this reason it is necessary to subsequently supplement student's and teacher's work places by the newest HW and SW components. Internet sites will be regularly arranged according to requirements of students and according to newest technologies in digital signal processors.

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Modern Construction of Coronographer

L. Marek

lm.speed@seznam.cz

Department of precism Mechanics and Optics
Faculty of Mechanical Engeneering
Czech Technical University
Technická 4, 166 07 Praha 6

Observation of Solar Corona and Protuberances and their next Processing is the Aim of many Scientist Workplaces all around the World. Many Observations are to achieve only by total Eclipse of the Sun, but especially Protuberances are possible to observe by Coronagraph with Filter, in my Event Protuberance Filter (Line Hα).

First Allusions to Solar Corona are dated to old Chinese Dynasties, but systematical Observations started till second Half of XIX. Century. There started Processing of Solar Eclipse and Protuberances Observing. Over many Experiments of imaging Solar Corona without total Eclipse of the Sun was possible till 1930 to observe only Spectral line of Protuberances. Finally in 1930 made first Observation of Corona French B. Lyot in Pic du Midi Obsrevatory by Telescope of his own Construction, Coronographer.

Basic Principle of Telescope is the same since 1930, but Technical Advance allows make it better in Details. Especially is it exactitude of Manufacturing Components, using better imaging Technique and for Control and Processing better Computer technique. Today's Technology makes possible nearly everything, but its Price is nearly impossible.

I tried to joint Demand of very low Budget and Using modern Technologies in Design and Realization of one Item of this Telescope.

Next Demands are by temporary location of Telescope on one of today's Stand in Observatory done. Individual Stand for this Telescope means next Investment and the same Problem like Design of that Telescope. Just by Design turned up that Design and Construction of Individual Stand is appropriate, but it is not actual Problem.

Main Parameters determine optical Parts of Telescope, which are just made. That are main Objective, protuberance (H_α) Filter and Couple small Objectives, one Imaging and one Collimating. Applicability and Positing of this Parts and possibilities of using other commercial distributed optical Elements I must resolve in next Part.

Considerable Part of Design of whole Telescope is Design and customization of whole optical System. If I made some Mistake here, and the Mistake I find after Compilation of Telescope, it will be Problem to repair it.

First I designed and theoretical computed possible Positions of optical Elements. I selected optimal Variant from these Possibilities and that I elaborated from Way of main Rays to Experiment and final Adjustment of optical System on optical Bench.

It turned up by this Design, that it will be better to use other imaging Objective, then the one in optical Set, because it is better to use commercial distributed digital Camera. I have decided to use real Camera with good Objective focused to infinity. There is used digital Camera OLIMPUS C8080, from here is possible save Data to Computer and image it on Monitor.

I tried to abide Principle of Modularity by Design where nearly all Parts are detachable and there is limited Possibility to join other Part. It everything allows Design like photometer Bench where Body is made by 4 supporting and conducting Linkages, on it are putted in own Attachments all optical Elements. In case of Emergency is not Problem construct other Attachment for other Element and put it into System (System must be only set with new Element). For good Conducting of focusing Elements are on end of Linkage Ball Bearings from MAHR.

Conduction by four theoretical parallel Linkages practically could, providing Manufacture would not be theoretical precise, involve static Problem and it can get jammed. The Manufacturer made everything good and the Conduction works good.

Like focusing Element I will use main Objective (hold by Ball Bearings), its Working is realized by micrometric Head and over two Springs. Micrometric Head is actuated by long Linkage over whole Telescope Body from back Part of Telescope. The End of Linkage is adapted for hand Control or computer and electronic Control.

Next Part difficult to Actuation is iris Stop restrictive amount of Shine going to imaging system. I used here geared Semiproduct easy to buy, which made gear Set of actuating Gear and Gear with scale. Everything is actuated by evolvent worm-wheel, good positing to actuating Gear.

The Telescope is made only in one Copy, that's why I had to be attentive by Design. In this Time takes place Finish of Installation and Setting, it is escorted by elimination of Mistakes of Design and Manufacturing.

If the Telescope meets Demands will tell first Observations, today we know that it meets Mechanical Demands and it is modern Construction of classic Telescope.

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Section 5

MATERIALS ENGINEERING

Properties of a High Performance Concrete

E.Mňahončáková*, M.Jiřičková, R. Černý****

eva.mnahoncakova@fsv.cvut.cz

*Department of Physics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic
**Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

Nowadays, concrete belongs to the most extensively used materials in construction industry. Requirements on increasing load or on reduction of the construction thickness become highly actual. In particular, extension of concrete durability lies in focus of interest. Principal aim of this paper is to analyze basic hygric and thermal properties of cracked high-performance concrete. The obtained data can be applied as input parameters for computer simulations aimed to the prediction of concrete service life.

The high performance concrete of two basic compositions C90/105 and C60/75, marked as BI and BII, respectively, was chosen as a basic tested material. The first one, BI, was composed of cement CEM I 52.5 R, silica fume suspension, aggregate of 0-16 mm granulity, accelerant Lentan VZ33, larry Woerment FM794, and water of given proportion. The second one, BII, had the same composition as BI except for the silica fume suspension. To analyse the effect of aggregates on heat and moisture transport parameters, the cement pastes marked as PI and PII, and concretes without the aggregates of 8-16 mm granulity marked as BBI and BBII, were also studied. The experiments for measuring hygric and thermal parameters were carried out at 25 °C in usual laboratory conditions (relative humidity about 30-35%); another set of measurements was done with the various values of relative humidity. The sample sizes depended on the type of measurement. The initial state for all the measurements was dry material.

Hygrothermal behaviour of building materials is described by thermal and hygric properties. The one of the common material properties is water vapour diffusion resistance factor μ *[-]*, basically measured according to the standard ČSN 72 7031 [1]. The measurement is carried out in steady state under isothermal conditions. It is based on one-dimensional water vapour diffusion, measuring the diffusion water vapour flux through the specimen and on measuring partial water vapour pressure in the air under and above specific specimen surface. Water vapour transmission properties of a material are obtained by placing a specimen of the material on the top of a cup and sealing it. The cup should contain sorption material (desiccant, saturated salt solution or water). The sealed cup is placed in a controlled climate chamber and weighed periodically. The steady state values of mass gain or mass loss are utilized for the determination of the water vapour transfer properties.

There was also measured vacuum saturation moisture content w_{sat} *[kg m^{-3}]*, bulk density ρ *[kg m^{-3}],* and open porosity ψ_0 *[%]*. Each sample was dried in an oven to remove majority of the physically bound water. After that the samples were placed into the desiccator with deaired water. During three hours air was evacuated with vacuum pump from the desiccator, the specimen was kept under water not less than 24 hours. The so-called "Archimedes weight" was determined by weighing immersed water-saturated samples.

The simplest way, how to describe liquid water transport through a porous material, can be by way of water suction experiment. Set up for measuring the water absorption coefficient consists of tank filled with water, and the specimen, water and vapour-proof

insulated on four edges, fixed on automatic balances and immersed 1-2 mm in the water. Using automatic balance allows recording the increase of mass. The known water flux into the specimen during the suction process can be employed to the determination of apparent moisture diffusivity [2]. The constant water level in tank can be achieved by so-called "Marriott's bottle". It is water filled bottle with two capillary tubes. One of them, inside diameter 2 mm, is ducked under the water level, the second one, inside diameter 5 mm, above water level. If the water level is turned down air bubble goes inside the tube and the second tube ejects water amount needed to alignment of water level in tank. The water absorption coefficient, A, is calculated from the linear part of the dependence of the increase of tested sample's mass [$kg\ m^{-2}$] on the square root of time [$s^{1/2}$]. Then moisture diffusivity $\kappa\ [m^2\ s]$ can be calculated from the vacuum saturation moisture content and water absorption coefficient according a simple equation [3].

Among the thermal properties, the most important are thermal conductivity $\lambda\ [W\ m^{-1}\ K^{-1}]$, thermal diffusivity $a\ [m^2\ s^{-1}]$, specific heat $c\ [J\ kg^{-1}\ K^{-1}]$. They were measured using the commercial device ISOMET 2104 (Applied Precision, Ltd.), which is based on the application of impulse technique. It is equipped with various types of optional probes; needle probes are for porous, fibrous or soft materials, and surface probes are suitable for hard materials. The measurement is based on analysis of the temperature response of the analysed material to heat flow impulses. The heat flow is induced by electrical heating using resistor heater having a direct thermal contact with the surface of the sample. Calibration data in internal memory ensure interchange ability of probes without affecting the measurement accuracy. Gained data can be stored into the internal memory.

The measurements of thermal and hygric parameters of a high performance concrete were done with the primary aim to obtain the input data for computer simulation. Therefore, the different concrete components were mixed and consequently the basic parameters of the prepared samples were tested. The results show the influence of silica fume suspense addition and a great effect of aggregate granularity.

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Common Features of Fatigue Fracture Surfaces Created by Different Loading Sequences

H. Lauschmann, J. Siegl, J. Šumbera, F. Šiška, I. Nedbal

lausch@kmat.fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, Praha 2, 120 00

The **fractographic reconstitution of fatigue crack history** consists in relating crack length with time, expressed usually by the number of loading cycles or blocks. Analysis starts with laboratory fatigue experiments, which create a basis for investigation of the relation between crack growth rate (CGR) and the morphology of crack surface. Being able to estimate CGR from fracture surfaces, we can also reconstitute the history of fractures from practical service.

Although cyclic loading in practice is usually variable, the knowledge of fatigue properties of materials was generally limited to **constant cycle loading**. In fact, the conventional definition of crack growth rate itself assumes a sequence of equivalent cycles. Also a standard method of fractographic reconstitution has been developed only for cracks under constant cycle loading. Reconstitution of fractures under **variable cycle loading** from service was usually impossible. Within laboratory testing by variable cycle sequences, special cycles were inserted to create marks at fracture surface. Our long-time aim was to develop a general approach for all cases of fatigue.

The presumption of conventional fractography (valid only for constant cycle loading) is: "Crack surface morphology is unambiguously related to the (conventional) CGR." We have weakened the presumption in following manner: a) "We suppose the possibility to define the **reference crack growth rate (RCGR),** b) which is unambiguously related to **selected features** of fracture surface morphology". Constant cycle loading is expected to be a special case when RCGR=CGR.

a) RCGR must hold the general character of velocity - the ratio *increment of distance* / *increment of time*. The distance is measured by the crack length. It implies the **reference time** defined differently than the conventional. b) Although crack surfaces created by different loading sequences are more or less different, they are expected to exhibit some common morphologic features. These features should be (quantitatively – by changing shape, dimensions, counts, etc.) related to RCGR. -- The idea itself does not give any guide how the couple "RCGR; related morphological features" should be found. The solution is near at hand within textural fractography.

Textural fractography of fatigue failures [1] is a new method developed in the Dept. of Materials, FNSPE. SEM images of fracture surfaces are analyzed as image textures, being individually characterized by a set of textural parameters - a feature vector $\boldsymbol{f} = [f_1,..., f_k]$. The relation between the feature vector and CGR is expressed usually in the **multilinear form** $\log(v) = \Sigma\, c_j f_j + c_{k+1}$. The set of constants $\boldsymbol{c} = [c_1, ..., c_{k+1}]$ can be estimated by the least squares method. Statistical significance of single image features f_j is tested to select that ones predicating CGR. For the RCGR concept, textural method has been applied in two ways:

1. **Direct solution.** In stationary cases of variable cycle loading we may expect the ratio B=**RCGR/CGR** to be approximately a constant linked only to the given type of loading [2]. This presumption results into a new constant $b=\log(B)$ which, in fact, is added as an additional component to the vector $\boldsymbol{c}$ and estimated within it.

2. **Physical interpretation.** RCGR may be interpreted from a cycle-by-cycle crack growth model [2,3,4]. Crack increment in a cycle within variable cycle loading can be expressed as $\Delta a = h\, v_{cc}$, where v_{cc} is crack increment in the same cycle within constant cycle loading, and h denotes interaction effect. Then cycle's reference time increment is h (called **cycle effectivity**), instead of 1 in conventional approach. Consequently, the reference time is $\Sigma\, h_i$, i = 1,2,..N, instead of $N = \Sigma\, 1$.

The theory was applied on three sets of specimens from aluminium alloys used in aircraft industry (CT and CCT specimens from bars for cutting, bars for forging, and piston-rods). Three types of loading were applied: constant cycle, constant cycle with regulary overloading ("Z+1" with different Z), and random blocks. Crack surfaces were documented by SEM in magnification 200 x. Images were assigned mean CGR values pertinent to the center. Normalization of images was applied. The two-dimensional Fourier transformation and the Wavelet transformation were used to estimate the feature vectors.

Following conclusions may be done:

1. Some **common morphologic features** are present in all fracture surfaces, which are related to the reference crack growth rate regardless of loading conditions.

2. Results are not significantly affected by whether Fourier or Wavelet decomposition has been used. However, the Wavelet decomposition simply enables to extract and imagine common morphologic features.

3. In cases of cycle-by-cycle random loading without rare significant overloadings, the results of direct solution and physical interpretation are very close.

4. In cases of loadings "Z+1", direct solution gives smaller ratios B=RCGR/CGR than physical interpretation. The reason is that marks of overloadings split the main common morphologic structure which is oriented in crack growth direction. The correction by means of a new factor B' dependent on the density of overloading marks ("beach lines") was suggested.

The concept of reference crack growth rate brought an important improvement into the quantitative fractography of fatigue fractures.

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Material Features of Reinforced Glued Laminated Timber

L. Hluší, P. Konvalinka

lenka.hlusi@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

Timber is one of the oldest materials in the world that has always played a significant role in structural engineering. With huge promotion of steel and concrete materials in the last century timber lost its role, but there are some attempts in these days to bring this natural material back. There has been many ways how to improve the material. The first well-known method was glued laminated timber. Single lamellas are lengthened through indented joint and then glued together. It is possible to produce big cross-sections limited only with machine capabilities. Nowadays the attempts are aimed at composite materials - timber and concrete or timber with fibre reinforcement. There are many types of fibre materials, e.g. glass fibres, aramid fibres or carbon fibres. The fibres are processed into fabric layers and bond together with the epoxide resin, then are compressed and hardened.

Design and production of specimens

For reinforcement was necessary to choose the type of fibres. There were chosen the carbon fibres because of their good loading capacity, the stability to chemical attack and water attack and because of an easy way of production of the specimens. The reinforcement was made of eight layers of fabric. The upper and the bottom layer was made of bidirectional glass fibres (Interglas 90070). Between these layers there were six undirectional carbon layers (HEXCEL style 48 300). The thickness of the resultant reinforcement was 2 mm. The bond was epoxid resin (Havel LH 3000). The panel had been hardened in normal temperature in depression -90 kPa for 24 hours.

The production of timber specimens was carried out in accordance with codes ČSN EN 384, ČSN EN 408 and ČSN EN 386. Every set included three specimens and the sets were divided into four groups - natural timber, natural timber with reinforcement, glued laminated timber and glued laminated timber with reinforcement. The cross-section of the specimens was 30x30 mm and the length was 600 mm. The specimens were made of spruce timber of category SI and the reinforcement was glued with the epoxide glue.

To guarantee the best efficiency of the reinforcement was necessary to specify its place on the beam. The fibre reinforcement has much higher tensile capacity then timber so its effect in the construction is similar to the effect of steel in reinforced concrete. That was the reason why the bending test was chosen for experiments. Because of the arm of the inner forces was the reinforcement set onto the bottom side of the beam.

Before the experimental tests there were calculated the theoretical values of the loading capacity. For this purpose the theories of elasticity and plasticity were used. These values were useful for the determination of the loading forces and for later comparison with the experimental values. The specimens were loaded in bending with two symetrically arranged loads. The beam was holded as a simple beam. The sets of specimens were loaded evenly and continually until failure and the deflection was recorded with the help of the computer.

The results of the tests

There was supposed that the specimens with the reinforcement would prove the elastic-plastic behaviour, so it was necessary to calculate both limitary values. In accordance with the theoretical calculation the values of the loading capacity of the specimens were determined - the moment of loading capacity in elastic condition for natural timber with reinforcement was $M_{n,el}$ = 387,68 Nm and for reinforced glued laminated timber was $M_{l,el}$ = 521,64 Nm, the moment of loading capacity in plastic condition for natural timber with reinforcement was $M_{n,pl}$ = 699,35 Nm and for reinforced glued laminated timber was $M_{l,pl}$ = 932,50 Nm. By the real designing of the constructions there are calculated only the values in the elastic condition, but for the comparison it was necessary to have also the values in the plastic condition.

Natural specimens were destroyed in expected ways. Two specimens were damaged in a knot. Reinforced natural specimens were destroyed with a shear crack, longitudinal crack and separation of the reinforcement. Glued laminated timber showed two longitudinal cracks in one lamella and one plain crack, reinforced glued laminated timber with a longitudinal crack and the other two specimens were not failured in a common way, the reinforcement caused the crush of timber and big deflections, the specimens were not destroyed completely, but their loading capacity was very low.

There were made work diagrams for all the specimens. The average values were compared with each other and there were calculated the real moments of the loading capacity - it was M_n = 540,0 Nm for reinforced natural timber and M_l = 585,0 Nm for reinforced glued laminated timber. These values proved the elastic-plastic behaviour of the reinforced specimens (comparison with the values written in the first paragraph of this chapter).

The comparison of non-reinforced and reinforced specimens was also very important. The reinforced specimens had twice higher loading capacity than the non-reinforced specimens. This behaviour was valid for natural and also for glued laminated timber.

The experimental test proved that timber specimens with the carbon reinforcement in bending test showed a plastic behaviour. The whole capacity of reinforced glued laminated timber was only 1,1 more higher than the capacity of reinforced natural timber, but significant role played the deflection. If the beam would be used in the construction, the deflection would warn the people of the irreversible changes in the beam.

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Elastic Properties of Strongly Anisotropic Ferroelastic Crystals

P. Sedlák* **, H. Seiner* **, M.Landa**

sedlak@troja.fjfi.cvut.cz

*CTU Faculty of Nuclear Sciences and Physical Engineering, Trojanova 13, 120 00 Prague 2, Czech Republic

**Institute of Thermomechanics, Czech Academy of Sciences, Dolejskova 5,182 00 Prague 8, Czech Republic

Standard ultrasonic pulse-echo methods for elastic constants evaluation run often into difficulties in case of a strongly anisotropic media as a consequence of strong direction dependency of wave velocities. For this reason, we proposed a new experimental procedure based on pulse-echo measurement in redundant number of general crystal directions combined with resonant ultrasound spectroscopy (RUS) [1]. In RUS natural frequencies of free elastic vibrations of a small single crystal specimen are measured for a number of sample's normal modes. Elastic constants are calculated in two steps. First, the natural frequencies are calculated from the estimated elastic constants, and then nonlinear inversion procedure is employed to find the required elastic constants from the measured natural frequencies.

This new optimization method allows us to minimize uncertainties in evaluated elastic constants stemming from the experimental error in exact crystal orientation. The biggest uncertainties in the softest acoustic modes in pulse-echo measurements is reduced by RUS since these softer acoustic modes correspond to easily measurable low resonant frequencies.

RUS, well developed for the measurement on high symmetry materials, was generalized to arbitrary material symmetry by adaptation of “xyz algorithm” of the standard Ritz method for resonance frequencies calculation (this covers also disorientation of sample). Moreover, new efficient way of the identification of resonant frequencies from measured spectra was proposed.

We applied the present method to find the temperature dependence of elastic constants of CuAlNi shape memory alloy (SMA). SMAs exhibit unique thermomechanical behaviors due to thermoelastic martensitic transformations (MT) driven by the external stress or temperature. It is of essential interest to know elastic constants of the austenite and martensite phases, since they reflect the fundamental thermodynamic properties – i.e. very interesting physical information can be deduced not just from the values of elastic constants but mainly from their temperature and stress dependencies. However, due to the experimental difficulties with preparation of martensite single crystals, there exist only very few reliable experimental data concerning the elastic constants of the martensite phases in SMAs.

Temperature dependences of elastic constants of both high temperature cubic austenite and low temperature orthorhombic 2H martensite phases of CuAlNi single crystal were evaluated in the vicinity of MT. Martensitic single detwined crystal was prepared from the austenite crystal by a dedicated deformation technique [2]. This deformation technique allows mutually

converting the austenite and martensite single crystal and thus the elastic constants of both phases can be evaluated on the same single crystal piece.

The following conclusions with respect to the martensite phase transformation can be made:

i) the elastic properties change significantly with the martensitic transformation
ii) the elastic properties of the austenite phase including the soft acoustic modes are only partially inherited by the martensite phase
iii) two soft acoustic modes of 2H martensite phase were identified -<100>M(001)M and <001>M(100)M corresponding to C_{55} martensite elastic constant and soft nonbasal shears corresponding to martensite special mode (C_{MS})
iv) some elastic constants of the austenite phase (C') and martensite phase (C_{55}, C_{MS}) significantly soften when approaching transformation temperatures upon cooling and heating, respectively
v) the elastic anisotropy of the both phases significantly increases when approaching transformation temperatures.

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Analysis of Residual Stresses after Electro Discharge Machining

K. Kolařík*, N. Ganev*, J. Barcal**

kamil.kolarik@email.cz

*Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University , Trojanova 13, 120 00 Prague 2, Czech Republic

**Department of Manufacturing Technology, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

The objective of this contribution is to present the results of a comparative study of macroscopic residual stresses (RS) arising from electro discharge machining (EDM) and milling of Inconel 718 superalloy. While the surface RS were determined by an X-ray diffraction technique, the depth distribution of stresses was evaluated using a destructive method based on continual measurement of sample strain during etching of the analysed area. The results obtained affirmed that both the experimental methods used are complementary and their simultaneous employing is effective when the complex state of RS is required. Since the state of RS obtained on electro discharge machined surfaces is centrally symmetrical, milling leads to anisotropic surface field stresses.

Introduction

Technological progress in the area of transport (automotive and aircraft) industry and nuclear-power engineering is attended by constantly growing demands on construction of machine components. This development trend leads to an increase in the share of hard-to-cut materials, such as heat-resistant and high-strength materials. Unconventional methods of machining are often the only possibility for working of these materials. When using these technologies, the machinability of materials is not limited by their mechanical properties (e.g., hardness and strength). However, it is related to their physical properties, such as thermal conductivity, melting point, electrical conductivity, electro discharge endurance, etc.

Samples investigated

Residual stress analysis was completed on samples of *INCONEL 718* 718 (C 0,08%, Mg 0,35%, P 0,015%, S 0,015%, Cr 17 - 21%, Ni 50 - 55%, Mo 2,8 – 3,3%, Nb 4,75 -5,5%, Ti 0,65 – 1,15%, Al 0,2 – 0,8%, Co 1%, Ta 0,05%, B 0,06%, Cu 0,3%, Fe 19%) superalloy prepared by two methods of machining:

Electro discharge machining (EDM) was made by an *AGIE – IMPAKT 3* device equipped with automatic optimization of working conditions; the sample dimensions being 30×30×7 mm^3. Graphite and copper electrodes were used for both machining techniques: **finishing** (surface roughness Ra ≈ 0.55 μm) and **stocking**.

Parallel and up-cut milling was performed by a *HERMLE C 800* milling machine with a front cylindrical cutter (∅8), made of sintered carbide. Milling conditions were as follows: thickness of removed layer a_p = 0,35 mm, width of milled area a_e = 0,35 mm, rotations n = 1600 1/min, shift s =180 mm/min. The sample dimensions were 30×10×7 mm^3.

Analytical methods employed

An electrodissolution method [2] is based on continual measurement of sample strain during etching of the analysed area. The sign and value of strain are proportional to residual stress distribution in the removed layer.

An X-ray diffraction technique „sin$^2\psi$" [3] was realised by a Siemens ω-goniometer with CrKα radiation. The diffraction line {220} Ni was analysed. Residual stresses were evaluated provided that the state of residual stresses was biaxial.

Conclusions

When comparing the results of both the experimental methods of residual stress analysis, the fact that each method is based on different principles has to be kept in mind. Thus, these techniques are not interchangeable.

The biaxial isotropic state of residual macroscopic stresses was identified by X-ray analysis in all cut surfaces machined by electro discharge machining.

Significantly higher values of tensile stress obtained by means of the EDM method in the case of finishing by graphite electrode correspond to the higher thermal load used in the process of machining.

Anisotropic state of macroscopic residual stresses found on the surfaces of milled samples reflects the character of mechanical interaction between the tool and the workpiece.

No occurrence of subsurface thermally affected area can be observed on the micrographs of lateral polished sections of EDM samples.

The effect of surface layer plastic deformation created by mechanical interaction between the material and the tool was affirmed in the micrographs of the milled samples. This impact is more significant in the case of parallel milling and extends up to a depth of approximately 50 μm.

The results of determination of lattice parameters in surface layers of samples show that EDM leads to distinctively lower values in comparison with milling. It can be assumed that diffusion of atoms of the electrode (graphite, copper) into the surface layers of machined sample is responsible for the difference in lattice parameters. This hypothesis will be further investigated.

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Assessment of Inelastic Deformations of Cement Paste Using Nanoindentation and Atomic Force Microscope

K. Forstová – J. Němeček

katerina.forstova@fsv.cvut.cz, jiri.nemecek@fsv.cvut.cz

Czech Technical University in Prague, Department of Mechanics, Faculty of Civil Engineering, Thákurova 7, 166 29 Prague 6, Czech Republic

In this study, the elastic and inelastic properties of cement paste at microlevel were investigated. Basically, we can distinguish two types of deformations in a cement paste – elastic and inelastic ones. Inelastic deformations consist of plastic deformations, which are not recoverable and permanent, and viscoelastic deformations. All these deformations can be found and measured at macrolevel. However these permanent deformations occur already at microlevel and can be attributed mainly to hydrated cement phases. Microlevel deformations can be successfully measured using nanoindentation and AFM. Quality of specimen surface has a great influence on the determination of mechanical properties. Therefore, three types of specimen surface preparation were used and compared. Porosity is one of the important non-solid phases of the microstructure of cement paste, that has to be taken in account because it has great influence on elastic properties as well as on strength and other inelastic properties of this material. Porosity depends on initial water-cement ratio and on curing time of cement paste. That was the reason why specimens with various water-cement ratios were investigated. Specimens were measured by means of mercury porosimetry and by image analysis of ESEM images.

Nanoindentation is the only experimental technique that enables direct measuring of mechanical response of individual material phases at micrometer or nanometer scales [1]. In this process a very small diamond tip (with nanometer dimensions at the tip) is brought to the sample surface producing an imprint. Load vs. depth of penetration diagram is measured through the whole loading, holding and unloading process. Loading and holding parts of the diagram contain elastoplastic and viscous deformations whereas the unloading part is supposed to be purely elastic. Unloading part of the diagram is commonly used for assessment of elastic micromechanical properties using semi-analytical elastic solutions [2].

Identification of inelastic deformations includes the knowledge of the deformed shape of the indenter imprint. For cementitious material the shape of the permanent imprint looks like a funnel with the maximum depth measured by nanoindenter. The imprint itself and the surrounding area can be scanned with AFM. AFM provides exact three-dimensional morphological information of the material surface, (i.e. after indentation, possible fracture surfaces, cracks, etc.) Atomic force microscope uses a tip at the end of free cantilever for the specimen scanning. Force interaction between the tip and surface specimen causes a deflection of the tip. A special detector monitors the deflection during the scanning. The surface topography of specimen is created on the basis of these tip deviations. There are several forces that contribute to the deflection of the tip. The most frequent is the inter-atomic force.

Nanoindentation was used for an assessment of elastic properties (from unloading part) and for determination of permanent inelastic deformations. These deformations were successively

scanned by AFM. Three-dimensional images of indenter imprints were constructed as the result of measurements.

In this paper, four types of cement paste specimen where measured. Specimens of cement paste were produced from ordinary Portland cement CEM I – 42.5.

Experimental part of the work includes the following steps. First, the samples were prepared with the surface suitable for the described experimental methods. The sample was cut by diamond saw and then the surface was scanned by AFM to establish the surface roughness. After this, the same sample was cured by machine polishing and again scanned by AFM. Finally, the same sample was hand-polished and scanned. The surface roughness for all preparation types was established. The best quality of sample surface was reached by hand polishing.

Second, the area of investigation at each sample was marked with four large indents to specify a rectangle of approximate dimension 120 x 120 μm. This area was systematically examined by environmental scanning electron microscope (ESEM), nanoindenter and AFM.

Third, the dependence of penetration depth on time after unloading was measured to determine the viscoelastic properties of cement paste. One indent was systematically scanned by AFM at various times starting from unloading till the next day afterwards. The dependence of the depth on time was found to have a logarithmic trend.

To summarize, several novel experimental techniques were employed for the investigation of cement pastes, namely nanoindentation, ESEM and AFM. These equipments allow assessment of deformations of material. Microlevel elastic deformations and elastic properties of cement pastes were determined using nanoindentation. The mechanical response was specified using nanoindentation, too. Three-dimensional shape of inelastic deformations was assessed with AFM as the basic data for analysis of inelastic material properties. Specimens porosity and surface roughness was evaluated for different water-cement ratios. To determinate the porosity of cement paste were used ESEM images and images analysis as well as mercury intrusion porosimetry.

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Optimization of Composite Materials

S. Peskova, P. Prochazka

peskova.sarka@fsv.cz

Department of Structural mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, Thakurova 7, 166 27 Prague 6, Czech Republic

Process of debonding of fibers from matrix in composite materials plays very important role in assessment of bearing capacity of the aggregate. Couple of papers has been focused on this problem by the authors of this work. Here the problem of debonding will be concentrated on a process being brought about due to normal load applied to unit cell in periodic medium. Such an approach is a typical in the general problem describing the mechanical behavior of the interface between fibers and matrix in composite materials. The standard procedure consisting of both normal and shear influences is more complicated due to strongly non-linear behavior of the formulation.

Plenty of models have been proposed in the past. Some of them are very usable, but suffer from inaccurate formulations, numerical instability or are too robust. In this work a new approach is suggested. It consists of introducing eigenparameters in interfacial zone describing the neighborhood of fibers. Considering matrix and also fibers stiff enough, the damage will occur only in the interfacial zone. As the damage can be described by eigenparameters, the influence matrices are created in the sense of generalized Transformation field analysis to speed up the iterative solution of the nonlinear problem. It will be shown that this approach offers a new very efficient and fast algorithm, which in our case is based on finite element methods. The generalization to boundary elements seems to be simple. The matrix will obey the von Mises – Huber - Hencky ideally elasto-plastic states, while fibers remain elastic. This particular material describes especially steel-epoxy, glass-epoxy, or graphite-epoxy composites.

Micromechanical research of the past decade has produced a number of models of interface disconnection in heterogeneous solids, which often represents the main source of distributed damage in composite materials. Couple of experimental studies has been carried out. For example, experiments are reported in [1] that explore the mechanics of single pins or rods that bridge a delamination crack in a miniature model specimen. The effects of material and geometrical parameters are determined by varying the angle of the rod, its material, and the material in which it is embedded. Different tests represent mode I and mode II loading, with respect to a pre-existing delamination crack. In [2], a debonding detection technique based on fiber optic interferometry is proposed. Raman spectroscopy has been used in [3] to investigate the influence of fiber-matrix debonding on the stress situation in neighboring fibers. Sophisticated numerical or analytical models for debonding processes were published in [4-6], often in terms of local interface disconnection criteria [7]. Evolution of distributed damage in heterogeneous solids is modeled in [8] using the Transformation field analysis and selected models of interface debonding in fibrous or particulate composites. A numerical homogenization of microstructures is presented in [9]. First, linear problem is solved by BEM, then a possible debond is considered or a change of the shape of fiber–matrix interfacial boundary is observed, if the debond appears. Such a problem is strongly nonlinear. In order to simplify the computations, influence matrices are calculated, similarly as in this study. Once they are available, Uzawa's algorithm can be applied for solving the debonding process in a very efficient way. A pullout problem, frequently solved in the cracking of composite structures, is numerically treated in [10]. An example of the lag model simplifies

the geometry of the problem, and makes it possible to use highly efficient finite element procedures.

The present work develops a procedure for analysis of progressive damage in composite aggregates which incorporates the local stress. An approach for debonding is described for a single inhomogeneity from a comparison medium. Evaluation of stress and deformation fields is presented in a progressively debonding matrix-based composite material that contains a statistically homogeneous distribution of dispersed particles or fibers. The load include remotely applied tractions in equilibrium with a uniform overall stress, and piecewise uniform eigenstrains or transformation strains, such as thermal strains, in the phases. Debonding of the reinforcements from the matrix is simulated by additional damage-equivalent eigenstrains, which adjust local stresses in the affected volumes to values, implied by the selected decohesion models. Interactions of the eigenstrains and applied loads are described in terms of local field averages, with the Transformation Field Analysis (TFA) involving certain influence functions that depend on phase modules, shapes, and volume fractions. Damage evolution criteria based on local strength and energy release considerations are discussed in [8]. In a similar way the energy relations can be applied in this study with that exception that results from numerical considerations are applied.

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Surface Protection of Concrete Constructions, Its Characteristics and Possibility to Influence Them by Nanoparticles

Ing. Zdeněk Vávra*; Ing. Kateřina Zetková**

otb@klok.cvut.cz

*Klokner Institute, Czech Technical University, Solinova 7, 166 08 Prague 6

** Research III., SYNPO, a.s., S. K. Neumanna 1316, 532 07 Pardubice

The aim of this paper is to describe the research project "Surface Protection of Concrete Construction, Its Characteristics and Possibility to Influence Them by Nanoparticles. The most important characteristics for this project research are hardness (microhardness), abrasion resistance and barrier characteristics (resistance of chemical substances and resistance of CO_2 penetration).

In the first step, it was important to specify testing methods for the coats. The coats were tested two times: (1) In laboratory during the production process (2) in the field ("in situ") after the application. In the first phase of experiments were used four types of reference coats for the industrial floor. Three of them were three epoxy coats and the fourth one was polyurethane. These materials have no nanoparticle fillers.

The base plates for laboratory experiments were made of dry precast concrete mixture. Sizes of the base plates were 50 x 50 x 10 mm, 100 x 150 x 10 mm and 300 x 500 x 40 mm. In the laboratory, there were used two main methods of hardness measuring. These are Vickers microhardness (ČSN EN ISO 6507 – 1) and hardness measuring by pendulum (ČSN EN ISO 1522). For abrasion resistance measuring in lab it used mainly Taber – Abraser test (ČSN 67 3073). CO_2 barrier characteristic were measured using colourmetric tests. These tests were completed by test of ground – holding. This characteristic was tested by two methods: Pull - off test and cross – hatch test [1].

Tested coats were applied on the real concrete floor. Testing area was 1,0 x 2,0 m. For hardness testing in situ Poldi hammer test [2] was used. For abrasion resistance test an instrument was developed which is nearly simulating real load on the industrial floors. This machine was effect on the floor surface by the revolving steal balls. It allows to set the time and speed of action. The pull off test and cross – hatch test are used in situ too.

This research project has not been finished yet, but results, these are coming out, corresponds with the theoretical knowledge. In technical letters [3, 4] it is described, that the small size particle fillers are improving characteristics of the coats. First of all it is the hardness (microhardness). Using the nanoparticle fillers is more effective because they are filling the space in the coat vehicle better. Fillers used in this research are some types of clay (montmorillonit). The size of the nanoparticles is in tens of nm. Spacing of the nanoparticles is realised by the ultrasonic dispersion machine. The most important thing for correct use of the "nanofillers" in coats is to ensure the spacing of particles to the coat vehicle.

The new types of coats (with use of the nanofillers) were tested only in laboratory using the "painter tests". Laboratory tests show, that coats doped by nanoparticles in percent units can

influence its characteristics in tens of percents. In the first of all they are hardness (microhardness) and abrasion resistance. If particle distribution was ensured, then these characteristics grow according to presumptions. The barrier characteristics are going to grow, because the nanoparticles are spacing in the coat's vehicle better. During the tests of reference coats it was found, that high hardness is not the most important character. The coat with high hardness did not succeed in abrasion resistance test. The growth of all characteristics need not be the best variant. For example growing hardness can effects growth of fragility too. It means, that for right function on the real construction is necessary to coordinate all characteristics. The research is going to continue in the year 2006.

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Measurement and Calculation of Temperature Changes in Building Materials During Freeze-Thaw Cycle

T. Doležel, P. Konvalinka

tomas.dolezel@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering,
Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

This paper presents the effect of moisture content on heat transport simulation using the Delphin computer code. In this project concrete, broken-brick concrete and porous concrete (Ytong) specimens with different moisture content were loaded with freeze and thaw period. Calculated and measured data were analyzed. The greatest differences between the measured and calculated data were presumed for the wettest specimens and the lowest disagreement for the driest specimens when the freeze period was simulated.

Nine cubes (three of each material) were used as a specimen for the temperature measurement. Each cube was equipped with digital thermometer which has been manufactured by Dallas Semiconductors. Special care was taken when manufacturing the specimens. Steel rigid moulds were used for manufacturing of all concrete and broken-brick concrete specimens. Specimens made out of porous concrete were cut to the required shape with circular saw. Every cube was fitted out with one digital thermometer at the center of gravity and than weighted up. One specimen of each material had been eight hours drained in electric oven with the temperature of 150ºC. Another three cubes had been placed to the water basin for 8 days due to acquirement of the most moisture content inside the cubes. Last three cubes had been neither dried nor moistened. After that, all specimens were weighted up again and coated with epoxy resin. The epoxy coating should ensure constant moisture content inside specimens. At the end, five sides of each cube were isolated with ORSIK thermal insulation.

All loading tests were carried out at the lab of experimental center of Faculty of Civil Engineering at the Czech Technical University in Prague. Loading time was set to 40 hours for concrete specimens and 75 hours for broken-brick concrete and porous concrete. The initial temperature of concrete specimens before loading was preselect to 0^{o}C. Each specimen was loaded separately. Freezing period took place in freezing box with temperature of -40ºC, while the thawing period in thermostatic box with temperature of +40ºC. Broken-brick concrete and porous concrete specimens were loaded in a different way. All these specimens were placed into thermostatic box due to requirement of the temperature of +40ºC inside the cubes at the beginning of loading. After that, were all these cubes loaded with the freeze period in freezing box with the temperature of -40ºC.

Temperatures measured when the specimens were loaded were recorded and saved every 20s for later evaluation with personal computer. Measurement of the thermophysical parameters necessary for numerical simulation was done with ISOMET 2104 apparatus.

The numerical program DELPHIN was used for the simulation of all loading states. Program DELPHIN has been developed at the „Institute of Building climatology“ of the Technical University of Dresden in order to support the investigation of the couplet heat, air, salt and moisture transport in porous building materials. The program can be used in order to simulate transient mass and energy transport processes for arbitrary standard and natural

climatic boundary conditions (temperature, relative humidity, driving rain, wind speed, wind direction, short and long wave radiation).

Material characteristics which were used in simulation and were different for each specimen were λ[W/mK] and c[J/kgK]. All other parameters were constant for all cubes (water vapour diffusivity, conductivity exchange coefficient etc.). Ambient temperature and relative humidity was found to be dependent upon the type of loading.

After evaluation measured and calculated data was obvious that the difference between the measurement and calculation was very small for thawing simulation for concrete specimens. There was an average disagreement under the 0.25ºC for all concrete specimens. Inaccuracy of simulation is proportional to a moisture content of the specimen. The concrete cube with the lowest moisture has the average difference between measurement and calculation equals to 0.49ºC and the maximal difference of calculated and measured data corresponds to 1.39ºC. The concrete cube with normal moisture content results to the average disagreement of 1.17ºC and the maximal disagreement of calculated and measured data equals to 2.51ºC. There was a great inaccuracy found for calculated data when the wettest specimen was examined. The average difference is equal to 2.16ºC and the maximal disagreement of calculated and measured data is even 6.09ºC.

The results of broken-brick and porous concrete have the similar tendency. The difference between calculation and measurement is increasing with the moisture content of specimen. Time behaviour of temperature simulation disagrees with the reality for the wettest specimens.

Results of the measured temperature compared with the calculated temperature distribution (DELPHIN computer code) lead to the following conclusions:

- Numerical model of temperature distribution leads to the reliable results when the ambient temperature is above zero or the moisture content of the specimen is very low. The difference of calculated data increases with the increased moisture content of specimens especially when the ambient temperature bellow zero is simulated.
- The biggest difference between measured and calculated data was found for the wettest specimen when freezing period was simulated. It was evoked with the computer code which has not take into account a change of phase of water.

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Microplane Model Parameters Identification from Different Types of Loading Experiments

A. Kučerová

anicka@cml.fsv.cvut.cz

Department of Mecanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

A numerical simulation of response of complex concrete structures still remains a very challenging and demanding topic in engineering computational modeling. One of the most promising approaches to modeling of concrete behavior is based on the microplane concept, see [1]. It is a fully three-dimensional material law that incorporates tensional and compressive softening, damage of the material, supports different combinations of loading, unloading and cyclic loading along with the development of damage-induced anisotropy of the material. As a result, the material model M4 presented in [1] is fully capable of predicting behavior of realworld concrete structures once provided with proper input data, see [2] for more details. The major disadvantages of this model are, however, a large number of phenomenological material parameters (Young's modulus, Poisson's ratio and six other parameters without simple physical meaning) and a high computational cost associated with structural analysis even in a parallel implementation. Although the authors of the model proposed a heuristic calibration procedure [1], it is based on the trial-and-error method and provides a guide to determination of selected material parameters. Therefore, a reliable and inexpensive procedure for identification of these parameters is on demand.

The main goal of this project was examination of the possibility to create a simple and not time-demanding tool, which could be able to provide a reliable estimation of microplane model parameters from the load-deflection curves. In the view of potential improvements proposed in a recent work on soft computing methods [3], a novel procedure based on artificial neural networks (ANNs) is used. Particulary, a feed-forward layered neural networks, which are known for their good capability to approximate non-linear relations, were used to represent the functional dependence of microplane parameters values and the shape of load-deflections curves.

As it is proposed by authors of microplane model in [1], a several load-deflection curves from different types of loading test are necessary to calibrate all model parameters. Based on this proposition we used the uniaxial compression test for Young's modulus, Poisson's ratio and parameters k_1 and c_{20} identification, the hydrostatic compression test for k_3 and k_4 parameters identification and finally triaxial compression test for k_2 parameter identification. The Pearson product moment correlation coefficient evaluated for the set of load-deflection curves in twenty steps of deformation reveal the influence of the chosen parameter to a structural response. Especially, the big importance of Young's modulus and Poisson's ratio during the starting stage of the uniaxial loading could be observed, same as the importance of k_1 parameter in the post-peak stage, but only weak important of c_{20} parameter at the end of this loading. For the hydrostatic compression test, the analysis reveals a certain importance of k_3 parameter in the loading stage and also certain importance of k_4 parameters in the unloading stage. However, there was shown only very weak importance of k_2 parameter during the triaxial compression test.

Because of high non-linearity of the identification problem, independent ANN were prepared for identify each parameter. Results from the stochastic sensitivity analysis served also for the choice of appropriate points of load-deflection curves for predicting particular

parameters. Then the deformation values in these points are used as the input values for k_3 and k_4 parameters identification and the stress values for all other parameters. Three-layered fully connected feed-forward neural networks with bias neurons (see, e.g, [4]) were used.

When the topology of the ANN is established, the last step is the training process to find the appropriate values of the ANN's synaptic weights. For this training the set of known input-output values is needed. Each microplane parameter is assumed to be uniformly distributed on a specified interval. Thirty training sets of microplane parameters are chosen from the prescribed intervals using Latin Hypercube Sampling method to get maximal diversity among the sets. For each set of parameters, the simulation of the loading tests were realized using the microplane model implementation in OOFEM software on the cylinders represented by 2688 microplane cubic elements. The resulting load-deflection curves were used together with corresponding microplane parameters for preparing the set of known input-output data for neural networks training. Data of ten other simulations were prepared for testing the network predicting capability. The training process itself could be considered as the minimization of the least square errors between the known values of microplane parameters and their prediction by ANN. This minimization was governed by evolutionary algorithm GRADE (see [4] for more details).

Results of ANN training correspond to the results of sensitivity analysis. Trained ANNs give good predictions of Young's modulus (max. error 1.79%), k_1 parameter (max. error 2.76%) and Poison's ratio (max. error 4,72%) and not so bad prediction of k_4 parameter (max. error 9.54%), but parameters k_3, c_3 and c_{20} wasn't identified with satisfying precision. For that reason the resulting neural network were successively used to predict the microplane parameters from the real experiment in uniaxial compression. There are still a lot of possible modifications to ameliorate the quality of microplane parameters predictions. Especially the intern topology of ANN is still purely heuristic. Also the nonlinearity of the proposed problem could be so high, that thirty sets for ANN training couldn't be sufficient. For that reason, other training set containing sixty input-output pairs were tested, but the result didn't change significantly. New improvements of proposed methods will be the subject of future work.

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The Effect of Solution Annealing on Properties of Microalloyed Low Carbon Cast Steels

K. Macek, J. Cejp, Ganwarich Pluphrach

karel.macek@fs.cvut.cz

CTU,Faculty of Mechanical Engineering,Dept. of Materials Engineering
Karlovo nám.13,121035 Praha 2

The solution annealing is the first stage during treatment of microalloyed low carbon (MLC) *wrought* steels which are then in the second stage subjected to hot deformation, most frequently by hot rolling. This technology enables to choose high temperatures of solution annealing for beneficial solution of coarse carbides, nitrides and carbonitrides in austenite originating during crystallization or/and in course of ingot cooling. This possibility does not exist for MLC *cast* steels which are in the first stage of heat treatment usually normalized. Temperatures of normalizing are 30 – 60 °C higher then temperatures Ac_3, so being too low for sufficient solution of above mentioned secondary phase particles in austenite. Therefore also precipitation potential [1, 2], needed for precipitation strengthening of MLC cast steel, is rather low. In order to maximize precipitation strengthening in those steels by increasing the temperature of austenitization, one has take into account the risk of austenite grain size coarsening that is for every cast steel irreversible process. Furthermore, during cooling by blowed air from high temperatures, both acicular ferrite and higher volume fraction of pearlite might arise, what will decrease the toughness of steel.

Before experimental studies of the topic on steels microalloyed with vanadium (0,09 wt. %) and niobium (0,05 – 0,07 wt. %) have begun, temperatures of solution annealing were computed considering the solubility products for carbonitrides of elements concerned. The temperatures (table 1 and 2) had to comply with condition that approximately one third or one half of the total content of V, or Nb was soluted in austenite of given steel.

Table 1 Effect of solution annealing temperature on microstructural characteristics

Steel grade	Temperature [°C]	Grain size [μm]			Volume fraction [%]		
		F_p	F_a	P	F_p	F_a	P
16MnV6	1000	9,1	–	5,9	84	–	16
	1070	9,2	3,7	6,2	61	8	31
19MnNb6	1050	7,1	3,5	5,3	56	10	34
	1150	9,4	5,0	7,3	57	17	26
22MnVNb6	1000	7,3	–	4,7	61	–	39
	1070	8,3	3,7	6,5	54	8	38

Notes : F_p = ferrite polyhedral, F_a = ferrite acicular, P = pearlite

Brief description of chemical composition of steels is as follows : contents of carbon and manganese are given in standardized EU designation for steels (tab. 1 and 2) which also contained 0,35 – 0,40 % Si, 0,14 – 0,19 % Ni, 0,14 – 0,22 % Cu, 0,013 – 0,017 % P, 0,010 – 0,015 % S and 0,009 – 0,018 % N.

The steels were sand - casted into plates with dimensions 30x250x350 mm and cooled down to ambient temperature during 16 h [3]. The procedure of tensile tests and toughness

tests comply with standards CSN EN 10002−1 and CSN EN ISO 14556. Stereological measurements in quantitative metallography respected CSN EN ISO 643.

Results of microstructural analyses are presented in tab. 1, whereas change of mechanical properties are gathered in tab. 2.

Table 2 Effect of solution annealing temperature on change in mechanical properties related to those after normalizing (930 °C, 2 h)

Steel grade	Temperature [°C]	ΔR_e [MPa]	ΔR_m [MPa]	ΔA [%]	ΔZ [%]	ΔKV [J]
16MnV6	1000	+8	+11	−2	−4	+1
	1070	+15	+21	−4	−10	−5
19MnNb6	1050	+2	−2	+4	+5	+30
	1150	+21	+32	−4	−10	−11
22MnVNb6	1000	+26	+11	+3	+2	+4
	1070	+52	+48	−1	+4	−14

Notes : R_e = yield strength, R_m = ultimate strength, A = elongation, Z = reduction of area
KV = impact energy

Obtained experimental results yield following conclusions concerning microstructure and mechanical properties of MLC cast steels with vanadium or/and niobium after isochronal (2 h) solution annealing in temperature range 1000 – 1150 °C and air cooling

(a) Microstructure consists from fine grained polyhedral ferrite and pearlite if the temperature is fairly low and vanadium is present; niobium supports the transformation of austenite into acicular ferrite.
(b) Optimum temperature of solution annealing that increase the contribution of precipitation strengthening and do not diminish plasticity and toughness by grain size coarsening can be find out.
(c) Combined microalloying with vanadium and niobium is most effective for both precipitation strengthening and grain size refining. Single microalloying with niobium might prove to be promising for toughness increase if optimum temperature of solution annealing is discovered.

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Cast Steels with Improved Mechanical Properties

J.Cejp, K.Macek

Jiri.Cejp@fs.cvut.cz

CTU,Faculty of Mechanical Engineering,Dept. of Materials Engineering
Karlovo nám.13,121035 Praha 2

The contribution gives information about ways and means to enhancement of strength properties of low carbon cast steels when the toughness and the transition temperature to brittle fracture are sufficient. Addition of alloying elements and suited heat treatment are traditional ways to increasing of mechanical properties. In the case of cast steels for thin-walled castings it is possible in contrast to steels for thick-walled works [1] put to use for strength improvement of austenitic transformation to bainite , martensite or sorbite.

The material used in the experimental work was low carbon manganese steel S1 (0,17wt.%C-1,47wt% Mn- V,Nb,Ti≤0,01wt.%-0,009wt.%N) which was modified by microalloying elements V,Nb and Ti to five following types steels:

S2- 0,16 wt.%C-1,54 wt.%Mn- 0,09 wt.%V -0,006 wt.%N
S3- 0,19 wt.%C-1,40 wt.%Mn-0,07 wt.%Nb-0,018 wt.%N
S3- 0,22 wt.%C-1,39 wt.%Mn-0,09 wt.%V-0,05 wt.%Nb-0,017 wt.%N
S4- 0,17 wt.%C-1,43 wt.%Mn-0,03 wt.%Ti-0.010 wt.%N
S5 -0,18 wt.%C-1,49 wt.%Mn-0,09 wt.%V-0,03 wt.%Ti-0,011 wt.%N

Effect of microalloying on mechanical properties was assessed after normalizing (NT) – (930^{o}C/2hours/air cooling) resp.(1000^{o}C/2hours/air cooling) using the tension test performed on INSTRON 5582 and impact test of Charpy type specimen. Results testified the best combination strength and toughness for microalloying V+Nb, steel S3.

Another interest was devoted only on steel S3 and was focused on improvement of strength this steel with suitable heat treatments. Experimental program beside normalizing included following procedure :

HT1 - solution annealing + tempering
(1000^{o}C/2hours/ water + 600^{o}C/4hours/air cooling)
HT2 - normalizing + intercritical quenching
(1000^{o}C/2hours/air cooling) + (780^{o}C/2hours/water)
HT3 - normalizing + intercritical quenching + tempering
(1000^{o}C/2hours/air cooling) + (780^{o}C/2hours/water) + (600^{o}C/4hours/air cooling)

Assessment of influence both microalloying and heat treatment procedures on properties was carried out with respect to original steel S1 which offered yield strength YS=374 MPa , elongation A=32%, area reduction Z=66% and notch toughness $KV_{20^{o}C}$ = 85 J .

Positive influence of microalloying elements vanadium and niobium on strength was testified even after normalizing (accession 50MPa) when carbides, nitrides and carbonitrides form and control grain size.

Maximum strength increase was expectably detected after heat treatment HT1 because microstructure after aplication this procedure consist from bainite and tempering martensite and yield strength reached level 700MPa which means profit 300 MPa.

Another two process HT2 and HT3 contain intercritical quenching which has beneficial influence on mechanical properties [2,3].HT2 improved the yield strength up to 584MPa and procedure HT3 to level 477 MPa.

Relating plastic properties and toughness , ductility was expressed quantitatively as a elongation A or area reduction Z and toughness was assessed by using an impact test to measure impact energy KV . It is clear that will increasing strength the ductility and toughness are reduced and we must search optimal falling with respect to ductile –to-brittle transition temperature. This characteristic transition was defined as $FATT_{50}$,fracture appearance transition temperature when specimens exhibit 50% of brittle fracture.

Ductility and toughness were dramatically reduced after HT2.Elongation assigned only 7%, impact energy at room temperature was lowest 6J,transition temperature correspond to this state ($FATT_{50}$= + 160^{o}C) and steel was completely brittle.

Plastic properties were significantly higher when the procedure HT2 was completed by tempering (HT3). This three steps procedure produced not only high yield strength but outstanding toughness as well, so that following conclusion can be drawn:

Steel microalloyed with vanadium and niobium (steel S3) after normalizing , intercritical quenching and tempering (heat treatment HT3) exhibited optimal mechanical properties with respect to practical application to thin-walled castings with the wall thickness of up to 30mm : yield strength YS = 477 MPa , elongation A = 22,3% , impact energy $KV_{20^{o}C}$ =43 J , transition temperature $FATT_{50}$= – 5 ^{o}C .

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Dependence of the Pyrolitic Graphite Biocompatibility on the Surface Roughness

M. Douděrová, L. Bačáková*, V. Starý

margita.douderova@centrum.cz

Department of Materials Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Karlovo Náměstí 13, 121 35 Praha 2, Czech Republic

*Institute of Physiology, Academy of Sciences of the Czech Republic, Vídeňská 1083 14220 Praha 4, Czech Republic

The material which should come into the contact with cells has to be biocompatible. The biocompatibility means, that the material must not have a negative influence on to cells and cells must not degrade the material. Chemical and morphological properties of the surface are important especially during clinical application as well as at in vitro examinations of the material. The roughness is one of the important morphological property of the surface. The purpose of this study is to evaluate the dependence of cell areas on surface roughness parameters.

In general the biocompatibility (individual factors) are dependent on following parameters: kind of cells (TYPE), chemical state of surface, surface energy Φ, free bonds R1,…, R1n, functional groups (e.g. carbonyl, carboxyl, hydroxyl with surface concentration c1,…,cm), etc. and on the surface morphology. Surface morphology represents roughness (e.g. parameters Ra, Rq, S, Rku, Rsk), porosity etc.

Biocompatibility can be taken as a function of (N1,DT,A,...). N1 is a factor usefull for evaluation of the cell adhesion. It is number of cells adhered on the surface after 1 day cultivation. DT is a factor referring about the cell proliferation. DT is an abbreviation for the doubling time, which is time of doubled number of cells. A is another factor which can help to determine the biocompatibility by the cell spreading. A is an average area of adhered cells. We can pretend for example A = A(TYPE; Φ, R1,...,Rn, c1,..., cm, etc.; Ra, $\overline{\vartheta}$, S, etc.)

Our experiment is based on the two directional (2D) carbon-carbon composite which consists from plain weave fabric (T800 carbon fibers, Torayca, Ltd. Japan) and the phenol-formaldehyde resin "UMAFORM" (SYNPO, Pardubice, ČR). This composite was prepared by the carbonization in N_2 at the temperature of 1000°C and preassure of 100MPa, followed by the graphitization in Ar at the temperature of 2200°C for 1h at the atmospheric pressure. Than after the composite was cut onto bars by diamond saw. The surface was treated mechanically by grinding and polishing with metallographic paper (grade 4000).

The pyrolytic layer of graphite was prepared in TESLA Vršovice, a.s., Prague by dissociation of butane in the mixture of N_2 at the temperature of 1900°C with duration 300 – 400 min at low preassure of 4Pa. The arose layer had thickness in range 0,25 – 0,7 mm. The surface was than after successively ground and polished. We could finally measure the surface roughness. The Talysurf - Rank Taylor Hobson Ltd., England was at our disposal. Measured parameter were Ra, Rq, Rsk, Rku, S and $\Delta\vartheta$.

The preparation of cell for scanning electron microscop observation was done by the sterilization in 96% ethanol plus washing in distilled deionized water. We used human osteosarcoma-derived MG63 cells at density 17000 cells/cm^2 (European Collection of Cell Cultures, Salisbury, UK) and seeded them in to the bottom of plastic dish (Nunclon Multidishes). Cells were cultured in 1,5 ml Dublecco-modified Eagle Minimum Essential Medium (SEVAC, Prague, CR) supplemented with 10% of fetal calf serum and 40 μg/ml gentamicin. After the cells proliferation and the particular time (24 hours) were cells counted in the Burker haemocytometer. For the SEM observation cells had to be dried. We used for it the Critical Point Method. Images made by the microscop could help us to evaluate especially cell areas. Areas were measured manually by tracing theirs perimeters in the Olympus DP Soft equipment.

Achieved results are following. Parameters Ra and Rq are proving the influence on the cell spreading up till the optimal maximum of the surface roughness. Ra and Rq correspond very closely together. The skewness (Rsk), describing the asymmetry of the profile, showed a tendency to be in negative values. The kurtosis (Rku) has tendency to have pointy character of the distribution. It means that the profile which represents the best cell spreading would have pointy and negative distribution. Successive grinding and polishing caused decrease of $\Delta\vartheta$. The mean spacing of adjacent local peaks (S) has proved influence on cell spreading. The optimum is around 80 μm. The maximum of S parameter appears at the beginning of PyG grinding (120 μm). By achieving of the optimal value following polishing cause decreas of S parameter again.

We have reached conclusions which are described in this paragraph. The dependence of osteoblast cell areas on differently modified surface was prooved. Cells react preferentially on the mechanically treated surface. There is the dependence of cell areas on some parameters of the surface roughness. By the successive grinding is achieved better cell spreading. This hold true just to some extent. Cells can integrate only to the material which seems them to be closed to the original one, the natural one. The chemical composition is not the only important parameter. This study has proved that cells promote different behavior on the same material with differently mechanically modified surface. Particular parameters of the surface roughness could allow us to find out which morphology would be the most suitable for cell spreading.

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New Technologies for Passive and Active Planar Structures on Carbon Base and Organic Materials for Active Structures for Integrated Optics

V. Prajzler, I. Hüttel*, J. Špirková*, J. Oswald, V. Peřina***, H. Boldyryeva***, V. Machovič*, Z. Burian, V. Jeřábek**

Vasek.Prajzler@email.cz

Department of Microelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,
Technická 5, 166 28, Prague 6, Czech Republic

** Institute of Physics, Academy of Sciences,
Cukrovarnická 10, Prague 6, Czech Republic

*** Institute of Nuclear Physics, Academy of Sciences,
Řež near Prague, Czech Republic

The amorphous carbon layers have excellent properties such as hardness, high resistivity and low friction coefficient. These properties make carbon layers very interesting materials for a wide variety of applications such as cutting tools, wear resistance, and hard barrier against corrosion [1]. It was also shown that it is possible to fabricate carbon layers with high optical quality. Hüttel has already shown that it is possible to fabricate carbon thin films with low optical losses [2]. Therefore we may consider carbon thin films suitable materials for fabrication of passive planar structures. Our research was focused to check whether it is possible to deposit carbon layers which can be used as active optical structures. In our case that means to investigate optical properties of carbon layers containing Rare-Earth (RE) ions. The most extensively studied RE ions have been Erbium (Er^{3+}), Ytterbium (Yb^{3+}), Praseodymium (Pr^{3+}) and Neodymium (Nd^{3+}). In the last decade have been intensively studied optical materials containing others RE ions such as Thulium (Tm^{3+}), Europium (Eu^{3+}), Terbium (Tb^{3+}) etc. as well. Optical materials doped with the RE such as Er^{3+} ions can lase or amplify at 1 550 nm, the wavelength of minimum loss in silica fibers [3]. Such optical amplifiers might replace the currently used electronic amplifiers because of their advantages for increased link distance, higher operating speed, and the elimination of the need for signal regeneration. Er^{3+} performs in a three level system which means lower efficiency comparing with the four level systems. High concentration of Er^{3+} ions is required for sufficient amplification, but Er^{3+} ion tends to cluster even at moderate concentrations. To overcome this problem co-doping with Yb^{3+} ions is applied [4]. Pr^{3+} doped materials are suitable for construction of active waveguides components operating at 1 300 nm. Utilization of such systems becomes widespread because the signal at this wavelength has zero dispersion for single mode silica fibers. Optical materials containing Eu^{3+}, Er^{3+}, and Tm^{3+} have emission of pure red, green and blue colors and that is used for construction of new types of full color displays.

We fabricated carbon thin films doped with erbium and ytterbium ions by using RF magnetron sputtering (*Balzers Pfeiffer PLS 160*). We used a carbon target, partially covered by erbium and ytterbium small pieces. Deposition was done under argon or argon + methane gas mixture atmosphere. Growing time ranged from 30 min to 4 hrs at power from 50 W to 150 W (13.56 MHz) and total gas pressure from 1 to 4 Pa. The carbon films were deposited on silicon and Corning glass substrates.

The structure of carbon layers were investigated by Raman spectroscopy. The compositions of the fabricated samples were determined by nuclear chemical analysis as Rutherford Backscattering Spectroscopy (RBS) and Elastic Recoil Detection Analysis (ERDA). The evaluations of RBS and ERDA spectra were done by GISA3 and SIMNRA code, respectively. Transmission spectra of the samples in the spectral region from 400 nm to 600 nm at room temperature were taken as well. The photoluminescence measurement was carried out at two excitation wavelengths: Ar ion lasers operating at λ_{ex} = 514.5 nm, E_{ex}= 300 mW, Semiconductor laser P4300 operating at λ_{ex} = 980 nm, E_{ex}= 500 mW. The FEU62 photocell was used for detection of the wavelength from 500 to 1 000 nm, while the Ge detector was used for the wavelength from 1 000 nm to 1 600 nm. The reference chopper frequency was 75 Hz. All the luminescence measurements were performed at the room temperature.

The RBS and ERDA analysis proved that the samples contained carbon, nitrogen, oxygen and hydrogen, and the pertinent RE ions. The amount of the incorporated RE ions differed depending on the area of the target covered by the RE co-dopant as well as on the erosion area represented by the part of the surface covered by the RE powder. Er^{3+}/Yb^{3+} doped carbon layers exhibited weak photoluminescence peak at 1 530 nm. The peak was attributed to the $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition and was observed under both excitations 514.5 nm and 980 nm. The main advantage of the doping processes presented in this paper is that the RE doping can be easily carried out in the course of the sputtering process. Also sputter deposition is relatively inexpensive method comparing with other techniques used for fabrication thin films containing RE ions. The next research will be focused on improving photoluminescence properties.

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Polymethylmethacrylate Optical Planar Waveguides

V. Prajzler, I. Hüttel*, J. Špirková*, M. Myslík,
O. Hlaváč, L. Oleksiy* Z. Burian, V. Jeřábek

Vasek.Prajzler@email.cz

Department of Microelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,*
Technická 5, 166 28, Prague 6, Czech Republic

In recent years, passive optical waveguides are widely used for production of optical components such as optical couplers, switches, multiplexers, modulators, polarization converters, wavelength filters, attenuators and also optical sensors. There are many optical materials used for that optical devices such as semiconductor materials (Si, GaAs, GaN, GaP, InP, AlGaAs etc.) and dielectric materials (Al_2O_3, $LiNb0_3$, $LiTaO_3$, $BaTiO_3$, YAG, TiO_2, Ta_2O_5, or glasses) [1]. Thought the above mentioned materials have suitable properties the fabrication process of the optical devices in them is not simple and is also relative expensive. Therefore nowadays many photonics devices are based on new materials such as organics and polymers like Polymethylmethacrylate (PMMA), Polysthyrene (PS), polyfluoromethacrylate (PFMA), polydimethylsiloxane (PDMS) and etc. [2]. Optical components based on polymers are attractive due to simple fabrication process and low cost. Polymer materials have also been investigated due to their advantages such as, e.g. low dielectric constants and there is also flexibility in the sense that polymers are used as spun-on layers that are compatible with many substrates like glass, silicon and so on.

Our polymer optical waveguides were theoretically designed by using mathematical modification of the dispersion equation. We determined the number of guided modes and critical thickness of the waveguides. After that the polymer layers were fabricated by spin coating on silicon and silica-on silica substrates. Present experiments were performed on Polymethylmethacrylate (PMMA) doped with 3-(1,2-dimethyl imidazole)-borane. The drawing of the spin-coating set-up and designed optical waveguides were previously described in [3]. For the coating the small pieces of PMMA (Goodfellow) were melting in chloroform for few days. Obtaining solutions with different PMMA concentrations the solution was droped onto the substrate from a pipette, then the substrate was let to spin round, the PMMA drop covered the substrate surface and partially evaporated out. The PMMA layers were prepared with or without the assistance of an external electrical field. The electrical field from 2 to 8 kV/cm was applied during the fabrication process.

Properties of the fabricated layers were analyzed by various methods. Refractive indices of the samples were determined using refractometer at wavelength range from 200 to 800 nm and by prism coupling method at 632.8 nm. Optical losses were evaluated by scanning the light scattered from the waveguides by the CCD camera. The absorption spectra were taken at wavelength range from 300 to 600 nm. The film thickness was measured by a profilmeter Talystep (Taylor&Hobson).

Al the samples deposited onto the silica-on-silicon substrate had waveguiding properties. The number of propagating modes varied from 1 to 12 depending on the thickness of the deposited layers. The measured thickness of the waveguide corresponded well with the calculated values and thickness of PMMA layers depended on deposition conditions. The measured thickness of the waveguides corresponded well with the theoretical design described in [3].

Typical spectral dependences of refractive index in the wavelength interval from 280 nm to 730 nm were already shown in [4]. The PMMA waveguides had refractive index 1,482 ± 0,001 (PMMA waveguides fabricated without using electrical field) and 1,492 ± 0,007 (PMMA waveguides fabricated by using electrical field 8 kV/cm) at 632.8 nm. The PMMA waveguides fabricated under electromagnetic field had higher refractive index. So we fabricated optical waveguides on silicon substrate without silica layer. The waveguides consisted of PMMA cladding layer (PMMA layers deposited without using electrical field) and waveguide layer of PMMA films fabricated by using electrical field.

Optical losses of PMMA waveguides were less than 1 dB/cm when electrical field was not applied. The best sample had optical losses below 0.1 dB/cm. The PMMA waveguides fabricated by using electrical field had the optical losses lower than 3 dB/cm. The best sample has optical losses less than 1.5 dB/cm.

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Rare Earth Doped Gallium Nitride Layers

V. Prajzler, I. Hüttel*, E. Alves, Ch. Buchal ***, J. Špirková*, J. Oswald****, V. Peřina *****, H. Boldyryeva*****, V. Machovič*, Z. Burian**

Vasek.Prajzler@email.cz

Department of Microelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,
Technická 5, 166 28, Prague 6, Czech Republic

** Instituto Tecnológico e Nuclear, EN10, 2686-953 Sacavém, Portugal

*** Institut für Schichten und Grenzflächen (ISG1), Forschungszentrum Jülich,
D-52425, Julich, Germany

**** Institute of Physics, Academy of Sciences,
Cukrovarnická 10, Prague 6, Czech Republic

***** Institute of Nuclear Physics, Academy of Sciences,
Řež near Prague, Czech Republic

Rare-Earth (RE) doping of Gallium Nitride (GaN) is still a very new area, and as yet there are only a small number of groups active in this field (for example: Steckl, Bishop, Zavada, and Abernathy of the universities of Cincinnati, Urbana-Champaign, and Florida, Gainesville). The most extensively studied RE ions have been erbium (Er^{3+}), ytterbium (Yb^{3+}), praseodymium (Pr^{3+}) and neodymium (Nd^{3+}).

Optical materials doped with Er^{3+} and Yb^{3+} are interesting due to the fact that they can be used as optical sources or optical amplifiers with operating wavelength at 1 550 nm (this wavelength corresponds to a low loss window of silica based optical fibres) [1]. Pr^{3+} and Nd^{3+} doped materials are suitable for construction of active waveguides components operating at 1 300 nm. Utilization of these systems becomes widespread because the signal at this wavelength has zero dispersion for single mode silica fibers [2].

In the last decade optical materials containing others RE ions such as Thulium (Tm^{3+}), Europium (Eu^{3+}), Terbium (Tb^{3+}), Holmium (Ho^{3+}), Thulium (Tm^{3+}) and so on have been intensively studied as well. The materials co-doped with Tm^{3+}, Eu^{3+} and Er^{3+} ions can be used for fabrication of optical storage devices and displays [3].

Gallium nitride is a wide band gaps direct semiconductor material (3.4 eV) and it is known that the thermal quenching in the RE-doped semiconductors decreases with increasing width of the band gap [4]. Therefore, wide bandgaps materials, such as GaN, are suitable hosts for the RE elements.

Our research is mainly focused on investigation of optical properties of the Gallium Nitride layers doped with Er^{3+} and Yb^{3+} ions. The GaN layers were fabricated by Metal Organic Chemical Vapor Deposition (MOCVD) on sapphire substrate and Er^{3+} and Yb^{3+} ions were incorporated into GaN by using ion beam implantation.

The structure of the GaN layers was studied by the XRD (X-ray diffraction) and Raman spectroscopy. The compositions of the fabricated samples were determined by nuclear chemical analysis as Rutherford Backscattering Spectroscopy (RBS) and Elastic Recoil Detection Analysis (ERDA). The evaluations of RBS and ERDA spectra were done by GISA3 and SIMNRA code, respectively. The refractive indices of the deposited thin films were determined by dark mode spectroscopy. Transmission spectra of the samples in the spectral region from 400 nm to 1 000 nm at room temperature were taken as well. For that the tungsten lamp and monochromator MDR 23 were used as the light source and the light transmitted through the samples was detected by the pyro-detector. The photoluminescence measurement was carried out at three excitation wavelengths:

- Ar laser ILA-120 operating at λ_{ex} = 488 nm, E_{ex}= 100 mW,
- Ar ion lasers operating at λ_{ex} = 514.5 nm, E_{ex}= 300 mW,
- Semiconductor laser P4300 operating at λ_{ex} = 980 nm, E_{ex}= 500 mW.

The FEU62 photocell was used for detection of the wavelength from 500 to 1 000 nm, while the Ge detector was used for the wavelength from 1 000 nm to 1 600 nm. The reference chopper frequency was 75 Hz. All the luminescence measurements were performed at the room temperature.

The GaN layers have mono-crystalline structure and we do not observed crystalline damage after Er^{3+}/Yb^{3+} implantation. Some Er^{3+}:GaN samples exhibited weak emission at 1 550 nm at room temperature. Better results were achieved with GaN layers containing Er^{3+} and Yb^{3+} ions. All these layers exhibited the typical emission at 1 550 nm due to the Er^{3+} intra-4f $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition.

Next research will be focused on improving photoluminescence by high temperature annealing.

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Fracture of Pearlitic Steel for Railway Applications

P. Haušild*, B. Strnadel**

Petr.Hausild@fjfi.cvut.cz

*Department of Materials, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, 120 00 Praha 2, Czech Republic

**Technical University of Ostrava, Department of Materials Engineering,
17. listopadu 15, 708 33 Ostrava, Czech Republic

Hypo eutectoid steels with predominantly pearlitic structure and minor amount of ferrite having reasonable strength and wear resistance can suffer from poor ductility and toughness. Their use for railway wheel sets production demands to ensure a low risk of fracture initiation at both quasistatic and dynamic loading conditions. Although the mechanical properties of pearlite have been studied for many years, extensive discussion continues regarding the microstructural parameters controlling its yield and fracture. Since pearlite tends to promote brittle fracture, physical-metallurgical parameters and geometrical characteristics of its microstructure play an important role in design of production and heat treatment. The microstructural parameters which have been identified as affecting deformation process in pearlite include the pearlite interlamellar spacing, the pearlite colony size, the cementite thickness and the prior austenite size.

The dynamic and quasi-static fracture behavior of the R7T steel [1] was measured at room temperature on standard Charpy V-notched (CVN) specimens and CT fracture toughness specimens. The CT specimens were $B = 30$ mm thick equipped with chevron notch and fatigue pre-crack with the length Δa in the interval from 30.10 to 31.92 mm. The fracture toughness K_Q was assessed from the dependence of load on crack displacement according to standard of ASTM E 1820-99a [2]. The set of six experimental K_Q values was treated according to ASTM E1921 standard [3].

Visual examination of fractured specimens showed that the fracture surfaces of the both type samples were quite rough and that fracture proceeded straight across the samples with no shear lips at the edges and almost no lateral contraction along the fracture plane. The roughness of fracture surfaces increased with the measured fracture toughness, and/or Charpy impact energy.

More detailed examination of fractured CT samples in scanning electron microscope showed transgranular cleavage. There were occasionally small areas of ductile tearing, typically about 20 – 30 μm in extent along the fatigue pre crack tip. In CT specimens, multiple initiations occurred along the pre-crack front. Two types of cleavage origins were observed in CT specimens. The first ones are associated with inclusions, which were found by energy dispersive X-ray analysis to contain S, Ti, Cr, Mn and V. However in some cases, inclusion triggering the cleavage was presumably dislodged during the rapid fracture event and it is not visible. The second type of cleavage origin was a narrow featureless zone. Cleavage initiation occurred probably on boundary of pearlite colony. Cleavage in pearlite could be also triggered by shear cracking of cementite lamellae induced by shear strain of ferrite according to Miller–Smith mechanism [4].

It has been observed that a crack very often traversed across several pearlite with similar crystallographic orientation colonies forming a single cleavage facet and needed not necessarily change direction at pearlite colony boundaries. The size of individual large facets

was often greater than the size of largest pearlite colony. Small single cleavage facets correspond to the cracking of single pearlitic colonies highly disorientated with regard to their neighbors. Since a propagating cleavage crack must alter direction at mismatch boundaries and the unfavorable orientation of cleavage planes induce the local failure is by ductile tearing it seems that the number of these mismatches contribute to higher toughness of steel.

There were no visible differences in morphology of cleavage facets on fracture surfaces of CVN and CT specimens. Comparing fracture surface features of CVN and CT specimens also no differences in the cleavage initiation micro-mechanisms were found. On fracture surfaces of broken CT specimens a number of cleavage initiation sites were observed. However, fracture in CVN specimens is generally initiated only by one main primary initiation site. This site is situated in the center-line of specimen, frequently close to the front of the ductile crack which preceded the cleavage initiation.

Results of presented study can be summarized as follows:

1. Cleavage in hypo eutectoid steel R7T has been found to be initiated on pearlite colony boundaries or triggered by stress concentration around cracked inclusions and also by shear cracking of cementite lamellae induced by shear strain of ferrite.
2. Crystalographical orientation of the ferrite lamellae in pearlite is the crucial parameter controlling cleavage facets formation, probably influencing toughness of high carbon hypo eutectoid steels.
3. Cleavage fracture in quasi-statically loaded CT specimens is triggered by multiple cleavage initiation, however in dynamically loaded CVN specimens cleavage initiates in only one site in proximity of the notch root, and/or actual ductile crack tip. This finding suggests that cleavage fracture in steels with dominant pearlitic structure is controlled by critical tensile stress.
4. The relationship between the fracture toughness and Charpy impact energy falls into two distinctive domains. The first one accounts to very low values of K_{Ic} which grow slowly with increasing Charpy impact energy KV. In the second one the dependence of K_{Ic} on KV is steeper. The transition from one domain to another is probably caused by the ductile crack formation and its growth in CVN specimens.

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Influence of Microstructure on Fracture Energy of Low-Alloy Steels

Š. Válek, P. Haušild

Petr.Hausild@fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Praha 2, Czech Republic

The aim of this study is to contribute to deeper knowledge of mechanisms of brittle fracture and influence of microstructures parameters, such as grain size, size of bainitic packet and interlamellar spacing, on ductile to brittle transition of low-alloy steels. In our study we investigated two bainitic steels A508 [1] (used for production pressure vessels of nuclear reactor PWR) and 15Ch2MFA [2] (which are used for pressure vessels of nuclear reactor VVR 440) and feritic-pearlitic steel R73 [3] used for rail wheels.

To determine the microstructure parameters optical metallography was used. The specimens for metallographic cuts were taken from Charpy specimens in all three directions and enrobed by resin. Methallographic cuts were grinded, polished and etched in nital. The mean bainitic packet size of 15Ch2MFA and A508 steels and the mean grain size of R73 steel are given in Table 1. From comparison of differently oriented cuts we concluded that microstructure is not dependent on orientation. For all three steels, which we have studied, the values of microstructural parameters were similar in all three metallographic cuts. For the steel R73 the interlamellar spacing was measured using scanning electron microscopy (SEM) and was determined to be 0.12 μm. For the steel 15Ch2MFA the distribution of particles was determined with assistance of program for image analyzes from SEM micrographs. The mean value of particle diameter was found to be 0.1 μm.

The fracture energy was measured on the instrumented impact pendulum device on the Charpy V-notch specimens. Carrying out the measurement at different temperatures we obtained transition curves for each steels. The upper shelf energy of 15Ch2MFA steel reaches 120J, A508 reaches 160J and R73 reaches only 60J. The transition temperature was determined to be 3.5°C for 15Ch2MFA, -20°C for A508 and 44.5°C for R73 steel. The R73 steel had higher transition temperature from ductile to brittle fracture, and the transition range was wider. The instrumented Charpy test [4] gives us not only the fracture impact toughness, but also the dependence of force on striker displacement. So we can obtain through integration the energies, which were absorbed in respective stages of fracture process and correlate them with other quantity, such as temperature. The fracture energy KV was correlated with displacement at the initiation of unstable crack propagation s_{iu} (initiation of cleavage fracture) and was found linearly dependent. In a similar way the crack initiation energy W_{iu} is linearly dependent on crack initiation displacement s_{iu}.

Table 1. Grain size, upper shelf energy and transition temperature of investigated steels.

	Mean grain/bainitic packet size (μm)	Upper shelf energy (J)	Transition temperature (°C)
15Ch2MFA	30	120	3.5
A508	18	160	-20
R73	10	60	44.5

The fractographic analysis of fracture surfaces of broken Charpy specimen at room temperature was done for R73 steel. The fracture surfaces of all specimens were covered by cleavage facets. All ruptured specimens contain small area of dimpled fracture in the vicinity of notch, which was wider with greater fracture impact toughness (especially good correlation was with crack initiation energy W_{iu}). The specimens were broken in the transition region by transgranular cleavage fracture, which were preceded by ductile dimpled fracture. The initiation of cleavage fracture occurred always in the vicinity of ductile crack tip front. From quantitative fractographic analysis it is obvious, that absorbed energy is dependent on complete area of ductile fracture. The different areas of ductile fracture were correlated with energies obtained from instrumented Charpy test record. The investigation was done for specimens ruptured at room temperature and at temperatures in the transition region. The best correlation is for the crack initiation energy W_{iu} on the size of ductile area adjacent to the notch of Charpy specimen (linear dependency).

The metallographic observation enabled us to characterize the influence of microstructure on mechanical properties. Smaller bainitic packets cause higher impact fracture energy (similarly to the grain size in Hall–Petch equation). The R73 steel has higher transition temperature, and the transition range is wider. The value of the fracture impact energy of R73 steel is half of the value obtained for the bainitic steels; even though the grain size is lower than the size of bainitic packets. The difference in fracture impact toughness between bainitic and perlitic structure is therefore due to smaller microstructural parameters, such as fine carbides, dislocation structure inside bainitic lamellae, interlamellar spacing and the thickness of pearlitic lamellae.

It is obvious from the record of instrumented Charpy tests, that the most of the absorbed energy belongs to the stage preceding the cleavage crack initiation (energy W_{iu}). Crack initiation energy W_{iu} is linearly dependent on crack initiation displacement and on the ductile area adjacent to the notch.

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Transmat-S: A Computer Simulation Tool for Modeling Coupled Water and Salt Transport in Porous Materials

Jiří Maděra, Robert Černý

madera@fsv.cvut.cz

Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The computer simulation tool TRANSMAT-S was developed in the Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague for the simulation of coupled water and salt transport in building materials in 1D and 2D.

The modeling of transport phenomena leads into a system of non-linear partial differential equations. The construction of the code is based on the application of the general finite element computer simulation tool SIFEL (SImple Finite ELements) developed in the Department of Structural Mechanics, FCE CTU. The basic state variables (moisture content, relative humidity, salt concentration) can be obtained as functions of space and time. A particular advantage of the numerical simulation program is the possibility of investigation of different constructions, different materials and different climatic loads. Constructive details of buildings and building materials can be optimized using the numerical simulation, and the reliability of constructions for different given indoor and outdoor climates can be assessed.

In the analysis of coupled water and salt transport, the diffusion-advection equation is applied for salt transport description [1],

$$\frac{\partial (wC_f)}{\partial t} = div(wD\ grad C_f) - div(C_f \vec{v}) - \frac{\partial C_b}{\partial t}, \tag{1}$$

where w is the volumetric water content [m^3/m^3], C_f the concentration of free ions in water [kg/m^3], C_b the concentration of bonded ions in the whole porous body [kg/m^3], D the ion diffusivity [m^2/s] and $\vec{v}$ the Darcy's velocity of the liquid phase [m/s].

The water mass balance equation is assumed in the basic form [2]

$$\frac{d\rho_v}{d\varphi}\frac{\partial \varphi}{\partial t} = div\left[D_\varphi grad\varphi + \delta_p grad(\varphi p_s)\right], \tag{2}$$

where ρ_v is the partial moisture density [kg/m^3], $\rho_v = \rho_w w$, ρ_w the water density [kg/m^3], φ the relative humidity, δ_p the water vapor permeability [s], p_s the partial pressure of saturated water vapor in the air [Pa], and the liquid water transport coefficient is defined as

$$D_\varphi = \kappa \frac{d\rho_v}{d\varphi} \tag{3}$$

where κ is the moisture diffusivity [m^2/s].

Assuming the Darcy's velocity in the diffusion form,

$$\vec{v} = -\kappa\, grad\, w, \tag{4}$$

and the water accumulation function in the form

$$\rho_v = \rho_v(\varphi), \tag{5}$$

we arrive at a system of two parabolic equations with two unknowns variables w, C_f.

The computer simulation tool TRANSMAT-S consists of several parts for data input, initialization and output, numerical calculation and data representation. The user interface of the program TRANSMAT-S has been developed for PC - Windows 2000/XP in order to facilitate the input data handling. Using TRANSMAT-S, the input files can be edited for SIFEL, and the user has access to the databases of materials, climatic data and construction details. In order to enable changes in the input files, the information about projects is stored in a user-friendly format.

The time required for simulations depends strongly on several factors: the discretization, the material properties, the initial conditions, the climatic or constant boundary conditions and the output properties.

The water and salt transport and storage coefficients coming into the system of partial differential equations describing coupled water and salt transport are dependent on the variables of state. Therefore, the material properties are described by material functions (analytical functions with parameters and/or interpolation and approximation of measured data). The available material specifications are contained in the material database, which was created in the form of an internet application.

The conditions of simulation problems are defined by "Conditions" part. Available conditions types are initial and boundary conditions. The initial conditions to be specified are salt concentration and moisture content/relative humidity. The following boundary conditions can be used: „Dirichlet conditions", „Newton conditions", „Neumann conditions".

SIFEL allows to define various output file formats, for example GID, Open_DX and clasical data outputs. The formats of SIFEL output files depend on their data presentation type and their specific settings according to the output data records contained in the input file. SIFEL distinguishes three data presentation types:

- 2D-Presentations, a single time dependent variable
- 3D-Presentations, a variable dependent on time and one spatial coordinate (x or y)
- 4D-Presentations, a variable dependent on time and two spatial coordinates (x and y).

For the graphical representation of simulation results in TRANSMAT-S, the TransGraph code can be used. TransGraph is an external program, which can present 2D and 3D graphs. The usage of other external programs is also possible as the output files are easily readable.

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Characterization of Water and Salt Transport Properties of Mšené Sandstone

R. Černý, Z. Pavlík, P. Michálek

cernyr@fsv.cvut.cz

Czech Technical University, Faculty of Civil Engineering, Department of Mechanics
Thákurova 7, 166 29 Praha 6

Historical masonry often contains significant amount of various salts. They can originate from several sources. One of them is underground soil with water-soluble salts. As in most historical buildings horizontal water-proof insulation is missing, salt solutions can be transported into materials of load bearing structures by capillary forces. Another source of salts in masonry is sodium and calcium chlorides used for winter maintenance of pavements and footways. They can diffuse either into underground soil or directly into the masonry. Salts can also be formed by reactions of acid-forming gases in the air with basic components of building materials. Some salts can be formed by actions of living organisms and microorganisms. Water-soluble salts in the form of hydrated ions capable of transport in the porous system can also be presented in masonry materials themselves.

Prediction of water and salt movement and salt crystallization in the walls of historical buildings can be done effectively by means of mathematical and computational modeling. In this way, the time development of water and salt concentration fields can be obtained which is crucial for a proper assessment of possible future damage. However, the accuracy of simulated water and salt concentration fields critically depends on the availability of all input parameters. There are two types of these parameters which have to be known in advance. The first are initial and boundary conditions. Initial conditions can be determined using on site analysis of water and salt concentration fields in the walls. Boundary conditions are of two types. The first of them are meteorological data for temperatures, relative humidities, rainfall and solar radiation, possibly also concentration of acid-forming gases in the atmosphere. This type of data can be obtained from meteorologists in the form of so-called TRY (Test Reference Year) data which present certain average values over a sufficiently long time period. The second type of boundary conditions involves water content and salt concentration in the underground soil close to the studied building. These data can be obtained again by on site analysis. The second type of input parameters are water and salt transport and storage parameters of the materials of the wall which appear in water and salt mass balance equations. For the studied problem of coupled water and salt transport, these parameters include moisture diffusivity and water vapor diffusion resistance factor as water transport parameters, sorption isotherms and water retention curves as water storage parameters, ion binding isotherms as salt storage parameters and salt dispersion coefficients as salt transport parameters. These parameters can be determined by common laboratory methods. Samples for the determination of water and salt transport and storage parameters can be obtained most easily from the walls of the analyzed historical building. If this is not possible, stone samples can be taken from the original quarries which are usually known for a particular building.

In this paper, salt solution transport parameters of sandstone from the Mšené-lázně quarry are determined using a series of salt solution absorption experiments with various NaCl concentrations. The main aim of this experimental work is to obtain input data for the computational model of water and salt transport which is to be used for damage assessment of historical buildings built from the Mšené sandstone.

The experimental setup for salt solution absorption experiment we used was quite common (see, e.g., [1]). The specimens having the form of a plate were water and vapor-proof insulated on all lateral sides (i.e. the sides parallel to the main direction of water transport) using an epoxy resin. The specimens were then located in such a manner that the lower surface was placed in contact with water. The mass of the specimen was recorded automatically as a function of time (a part of the measurements was performed in a manual way as well, for the sake of comparison). In this way, the cumulative mass of water i in the specimen as a function of time was determined. The salt solution absorption coefficient A was then calculated from the linear part of the $i=i(t^{1/2})$ function.

Table 1 Salt solution absorption coefficients A of sandstone depending on the NaCl concentration of the penetrating solution in kg $m^{-2}s^{-1/2}$

NaCl concentration	0	0.05 M	0.2 M	0.5 M	0.8 M	1 M
A (manual)	1.14	-	1.36	-	-	0.85
A (automatic)	1.41	1.51	1.38	1.43	1.50	1.42

Table 2 Apparent salt solution diffusivity κ of sandstone depending on the NaCl concentration of the penetrating solution in 10^{-5} m^2s^{-1}

NaCl concentration	0	0.05 M	0.2 M	0.5 M	0.8 M	1 M
κ (manual)	1.3	-	2.5	-	-	0.75
κ (automatic)	2.1	3.1	2.5	2.9	2.9	2.4

Table 1 shows the salt solution absorption coefficients of sandstone depending on the NaCl concentration of the penetrating solution, Table 2 the corresponding apparent salt solution diffusivities The results obtained by automatic recording of mass during water penetration are higher in all cases which is due to the higher accuracy of the method (during a manual measurement some water can drop from the sample removed from water bath). The differences between salt solution absorption coefficients due to the different NaCl concentrations in the penetrating solution are very low, typically about 5% which is within the error range of the measuring method. Similar situation can be observed for apparent salt solution diffusivities. Therefore, it can be concluded that the dependence of the velocity of liquid water transport on the NaCl concentration in the penetrating solution up to 1M was not evidenced.

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Effect of High Temperatures on Hygric and Thermal Properties of Alkali Activated Slag

J. Toman*, J. Drchalová*, L. Zuda, R. Černý

cernyr@fsv.cvut.cz

*Czech Technical University, Faculty of Civil Engineering, Department of Physics, Thákurova 7, 166 29 Praha 6, Czech Republic
Czech Technical University, Faculty of Civil Engineering, Department of Mechanics, Thákurova 7, 166 29 Praha 6, Czech Republic

For the alkali activation, any aluminosilicate material with pozzolanic, hydraulic or potentially hydraulic properties can be used. The most appropriate and most studied option is alkali activation of granulated blast furnace slag and kaolinite [1]. Alkali-activated materials have many benefits. They have high strength, high corrosion resistance, they are also partially resistive to high temperatures. Therefore, there is a high potential for their increasing use in practice as building materials.

In this paper, basic hygric and thermal properties of a slag-based material alkali-activated using water-glass solution with a composition given in Table 1 are determined in both the reference state and after thermal load up to 1200^0C.

Table 1 Composition of the alkali activated slag material

Sand aggregates [g]			Slag [g]	Alkali-activation silicate admixture [g]	Water [ml]
PG1	PG2	PG3			
450	450	450	450	90	190

The measurements of basic characteristics of the studied aluminosilicate material determined by water vacuum saturation method showed that the porosity began to increase significantly after heating to 600^0C, achieved its maximum at 800^0C, and at 1000^0C and 1200^0C it was not changed significantly.

Table 2 Thermal properties of dry material in dependence on thermal load

Thermal load [^{0}C]	Thermal conductivity [W/mK]	Specific heat capacity [J/kgK]	Thermal diffusivity [10^{-6}m^2/s]
25	1.59	798	0.92
200	1.60	781	0.99
400	1.67	743	1.04
600	1.09	754	0.70
800	0.94	777	0.59
1000	1.10	789	0.67
1200	1.16	738	0.77

The effect of heating temperature on thermal conductivity of the studied aluminosilicate material in dry state is presented in Table 2. Similarly as with the porosity, the first remarkable change was observed for the heating to 600^0C. The thermal conductivity decreased here by about 30% in comparison with the reference material and the decrease continued at 800^0C where it achieved about 40%. For higher heating temperatures, the thermal conductivity was stabilized approximately on the values measured for 600^0C heating. The changes in specific heat capacity were much less important than the changes in thermal conductivity. The typical differences were less than 5% which is on the edge of the error range of the measuring method. Therefore, we can conclude that the heating process did not lead to any detectable changes in specific heat capacity.

Table 3 Water vapor diffusion resistance factor of the studied material

Thermal load [0C]	Water vapor diffusion resistance factor [-]	
	Dry cup	Wet cup
25	47	17
200	33	14
400	25	14
600	22	10
800	17	4.4
1000	19	5.7
1200	19	6.2

The water vapor diffusion resistance factor of the reference material was in the dry cup measurements relatively high as it is presented in Table 3. Its value was comparable with common concrete. However, its wet-cup value was almost three times lower. This is most probably a consequence of inclusion of a part of liquid water transport into the wet-cup measurements. For the specimens exposed to thermal load before the measurement, the water vapor diffusion resistance factor decreased with the increasing load temperature up to 800^0C. Then, it was stabilized and even began to increase slowly. This character of changes of water vapor diffusion resistance factor with the load temperature is in a very good qualitative agreement with the results of porosity and thermal conductivity.

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Salt Solution Transport in Hydrophilic Mineral Wool

P. Michálek, R. Černý

petr.michalek@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Hydrophilic additives are used only seldom in mineral wool products. Practically the only notable application of hydrophilic mineral wool is in the form of synthetic soils for plant growing where water saturation of the material is necessary for its proper function. However, the capability of a fibrous material with hydrophilic substances to transport rapidly liquid water makes very good prerequisites for a variety of other applications such as interior thermal insulation, desalination of old buildings, drying out of flooded buildings where such favorable hygric properties could be conveniently employed. In building structures, salts can be potentially present, which can influence water transport properties of various materials in different way. Therefore, in this paper we analyze the effect of salts on liquid moisture transport properties of several hydrophilic mineral wool materials intended for using in building structures.

Mineral wool materials analyzed in this paper were produced specifically for testing purposes by Rockwool CZ, SA. The first material consisted of two mineral wool layers with different bulk density. The layer about 7 cm thick was formed by lower bulk density mineral wool (soft layer – INS) and this layer was during production bound together to a higher bulk density 2 cm thick layer (hard layer – INH). The fiber orientation of the INH layer was parallel to the board surface, and within the INS layer the fibers were oriented in multiple directions. The second material with fiber orientation perpendicular to board surface was PRG. The fiber surface of studied materials was covered by a hydrophilic admixture.

The specimens were cut from the material boards delivered by the producer. The size of the specimens was 50 x 50 x 20-50 mm. The specimens of INH and INS materials were prepared in such a way that the effect of fiber orientation on salt solution transport could be analyzed. Four or five specimens were used for every measurement.

The experimental setup for water (or salt solution) absorption experiment we used was quite common [1]. The specimens having the form of a plate were water and vapor-proof insulated on all lateral sides (i.e. the sides parallel to the main direction of water transport) using silicon elastic resin. The specimens were then located in such a manner that the lower surface was placed in contact with water or salt solution. This was achieved by suspending the specimens above a water or salt solution reservoir allowing them to suck water or the solution from free surface. The mass of the specimen was recorded automatically as a function of time. In this way, the cumulative mass of water/solution i in the specimen as a function of time was determined. The water/solution absorption coefficient A was calculated from the linear part of the $i=i(t^{1/2})$ function.

Tables 1a and 1b present the water/salt solution absorption coefficient A in dependence on solution concentration. Five different NaCl solution concentrations were used, namely 0.05/0.1 M, 0,2 M, 0,5 M, 0,8 M and 1 M NaCl. We can see that for the material INH with highest density the effect of salt concentration was not a very important factor in the studied range of NaCl concentration. The A values were in some cases higher, in some lower than for distilled water which indicates random errors. For the material INS we observed decreasing A values with NaCl concentration increase for fiber orientation perpendicular to

moisture flux but for parallel fiber orientation similar behavior as for INH. The material PRG with fiber orientation parallel to moisture flux exhibited a decrease of *A* values with NaCl concentration increase.

Table 1a Water and sodium chloride solution transport parameters, fiber orientation perpendicular to moisture flux

Material	Saturation moisture content	Absorption coefficient A					
	[kg m^{-3}]	[kg m^{-2}s$^{-1/2}$]					
		water	0.05M NaCl	0.2M NaCl	0.5 M NaCl	0.8 M NaCl	1M NaCl
INH	864.2	3.48	5.22	4.78	4.82	4.54	4.37
INS	872.7	3.72	3.22	2.42	1.72	2.00	2.01

Table 1b Water and sodium chloride solution transport parameters, fiber orientation parallel to moisture flux

Material	Saturation moisture content	Absorption coefficient A					
	[kg m^{-3}]	[kg m^{-2}s$^{-1/2}$]					
		water	0.1M* NaCl	0.2M NaCl	0.5 M NaCl	0.8 M NaCl	1M NaCl
INH	816.0	4.06	4.09	3.29	3.72	3.27	3.83
INS	863.3	2.09	3.14	2.94	2.23	1.98	2.03
PRG	844.7	3.24	2.94	2.28	2.14	2.77	2.33

* for INH 0.05 M NaCl solution has been used

Therefore, we can conclude that the concentration of sodium chloride up to 1M is not likely a very significant factor affecting liquid moisture transport in the analyzed hydrophilic mineral wool materials. The ambivalent results indicating in some cases increase of liquid water flux into the material with the increase of NaCl concentration, in other cases a decrease, are most probably a consequence of sodium and chlorine ions bonding to the hydrophilic admixture on the surface on the fibers which competed with the bonding of water molecules.

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Properties of High-Density Glass Fiber Reinforced Cement Composite Produced by Unicret-Mix Technology

E. Mňahončáková, P. Tesárek, P. Padevět, L. Kopecký, J. Němeček, R. Černý

cernyr@fsv.cvut.cz

*Czech Technical University, Faculty of Civil Engineering, Department of Physics, Thákurova 7, 166 29 Praha 6, Czech Republic

Czech Technical University, Faculty of Civil Engineering, Department of Mechanics, Thákurova 7, 166 29 Praha 6, Czech Republic

Glass fiber reinforced cement composites (GFC) are frequently applied in wall systems, utilized in form work, pipework, used for surface bonding and rendering, see e.g. [1]-[3]. The use of GFC in different technical areas requires specific design principles to be employed. However, one condition is common for all applications. A designer should be provided by an exact knowledge of mechanical, thermal and hygric properties of the particular GFC. Otherwise, the assessment of mechanical and hygrothermal performance of GFC in the particular application cannot be done in a serious way. In this paper, basic properties of high-density glass-fiber reinforced cement composite are determined as functions of thermal load.

The specimens of the glass fiber reinforced cement composite were produced in the laboratories of VUSTAH Brno. The composition of the material was as follows (calculated among the dry substances only): Portland cement CEM I 52.5 54%, sand 0-1 mm 40%, microsilica 3%, alkali-proof glass fiber 12 mm long 3%. Water in the amount corresponding to the w/c ratio of 0.33 was added to the mixture. The samples were produced using a successive homogenization procedure. First, sand and microsilica were homogenized in a mixing device, then cement was added and the dry mixture was homogenized again. The dry well homogenized mixture was thoroughly mixed with water. Finally, the glass fibers were added and the mixture shortly mixed again. The prepared mixture was cast into the molds and vibrated. After the time period of 28 days after mixing, the samples were prepared for testing. In the experimental measurements, four various sample pre-treatment conditions were tested: reference specimen not exposed to any load (denoted as UM in what follows), specimen exposed to a gradual temperature increase up to 600, 800 and 1000^{o}C during two hours, then left for another 2 hours at the final temperature and slowly cooled (denoted as UM-600, UM-800 and UM-1000 according to the loading temperature).

The measurements of basic physical parameters showed that the most important change in porosity and saturated water content occurred between the unloaded state and the loading temperature of 600^{0}C where the increase of porosity was as high as 40%. Later porosity changes were lower than 10%. This is in accordance with the behavior of most Portland cement based composite materials where the most important chemical reaction in the high temperature range is decomposition of calcium hydroxide at about 460-480^{0}C.

The changes of the internal structure and composition due to the temperature changes were analyzed using the environmental scanning electron microscope Phillips XL30 equipped with the EDX (element X-ray) device. In the first phase, both physically and chemically bonded water was released and the C-S-H bonds were decomposed through a series of intermediate phases (CS, CA, $CaCO_3$, CaO, clay minerals) to the final products β-C_2S, mullite, C_2A, Fe_2O_3. The glass fibers were softened at about 900 ^{0}C and subsequently melted.

Mechanical properties were tested using the MTS Aliance TR 30 device. The tensile strength of the basic UM specimens achieved 0.931-3.449 MPa, for the UM-600 it decreased to 0.486- 1.189 MPa, and for UM-800 to 0.044-0.443 MPa. The bending strength of the basic UM material was in the range of 11.95-20.37 MPa, UM-600 specimens achieved 3.95-5.31 MPa, and UM-800 only 2.0 – 2.88 MPa. UM-1000 specimens were destructed already before the measurements and their strengths were equal effectively to zero. Fatigue tests were performed for 6000 cycles. The basic UM material exhibited very low fatigue resistance, when 8 of 12 specimens were destructed already during the load increase phase. Therefore, the thermally loaded specimens were not tested.

Micromechanical tests were done using the Nanotest nanoindenter. However, the analysis of the UM specimens was not successful, basically because it was not possible to achieve such a flatness of the surface that indents under 1 μm could be realized and evaluated. Even bigger indents exhibited very large scattering of data due to the high phase heterogeneity and rough surface. High aggregate space density was another negative factor for the nanoindentation because the small distance between the particular grains did not make it possible to find a place with homogeneous properties. The nanoindentation data evaluation did not show any logical trend but random scattering due to the above negative effects, for instance the elasticity modulus was in the range of 22-61 GPa, hardness in the range of 1.1-4.3 GPa which is not realistic.

The analysis of water vapor transport properties revealed that water vapor diffusion coefficient increased very rapidly with the increasing load temperature, the most important being the change between the unloaded state and the loading temperature of 600^0C. The water absorption coefficient increased with the increasing loading temperature also very fast with the same basic features. This is in basic agreement with the porosity data. The water vapor adsorption capacity of the studied material decreased with increasing loading temperature, the most dramatic decrease being observed between the unloaded state and the loading temperature of 600^0C again.

The results of measurements of thermal parameters showed that thermal conductivity in dry state significantly decreased after high temperature loading. This is in qualitative agreement with the increase of porosity due to decomposition reactions in high temperature range leading to an increase of significance of the low thermal conductivity of air in the cement matrix-air system. The principal loading temperature was again 600^0C where occurred the most dramatic change and thermal conductivity decreased to about one half of the value for unloaded specimens. Further changes were within a 10% range. The volumetric specific heat capacity was affected in much lower range. The changes were only up to 5%, which may reflect the mass loss due to the decomposition reactions. Thermal diffusivity then logically followed the changes of thermal conductivity which were more remarkable than changes of volumetric specific heat capacity.

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Properties of FGD Gypsum with Different Fillers

P. Tesárek, R. Černý

tesarek@fsv.cvut.cz

Czech Technical University, Faculty of Civil Engineering, Department of Structural Mechanics, Thákurova 7, 166 29 Praha 6, Czech Republic

Flue gas desulfurization (FGD) gypsum is a waste material produced in desulfurization of flue gases in power stations and heating plants in high amounts. However, the industrial use of FGD gypsum is insufficient considering the amount of its production. Nowadays, it is mostly used for the production of gypsum plasterboards only, and the rest is deposited at waste disposal sites. Calcined gypsum as a low-energy material can be produced with advantage from the waste FGD gypsum by its dehydration at the temperatures of 110 to 150°C. The solid structure of calcined gypsum can then be created by reverse hydration. Due to the very low price and large availability of FGD gypsum, the material has a good potential for applications in building structures, possibly also as a material of load-bearing structures. One of the reasons for the neglect of the material by building industry is the almost complete lack of knowledge of its properties.

Table 1 Composition of measured materials

Material	Additive	Amount of additive [g]	Amount of gypsum [g]	Amount of water [g]
S0	-	-	1000	627
S8	Standard sand	300	1000	627
S9	Fly ash	300	700	627
S10	Gypsum	300	700	627
S11	PP fibers	90	1000	627

The material, which was used for measurements, was β-form of calcined gypsum with purity higher than 98% of FGD gypsum, produced at the electric power station Počerady, Czech Republic. The water/gypsum ratio was 0.627 (normal consistence according to the Czech standard ČSN 72 2301 [1]). Three different types of fillers were used, two of them being secondary raw materials. The first filler was standard sand of the types I and II (in a ratio of 1:1) produced by FILTRAČNÍ PÍSEK, spol. s.r.o, Dubá (the material with this filler will be denoted as S8 in what follows), the second was fly ash (S9) and the third gypsum from Počerady electric power plant (S10). Also, the effect of PP fibers (FIBREXCRETE, thickness of 18 μm, length of 4 mm, produced by STACHEMA Kolín s.r.o.) on the properties of FGD gypsum was studied (S11). The exact composition of the particular gypsum mixtures is given in Table 1.

As for the basic properties of studied materials (see Table 2), the bulk density was significantly decreased due to the application of fly ash and increased due to the sand addition. The open porosity followed an opposite trend.

Table 2 Basic properties

Material	Bulk density [kgm^{-3}]	Matrix density [kgm^{-3}]	Open porosity [% by volume]
S0	1180	1800	38
S8	1330	1810	30
S9	1076	1777	39
S10	1160	1815	36
S11	1225	1800	32

The water transport properties shown in Table 3 are in good agreement with the basic properties, water absorption coefficient and apparent moisture diffusivity being highest for the material with fly ash and lowest for that with sand and PP fibers.

Table 3 Water transport properties

Material	Water absorption coefficient [$kgm^{-2}s^{-1/2}$]	Apparent moisture diffusivity [m^2s^{-1}]
S0	0.30	7.13 E-07
S8	0.23	6.00 E-07
S9	0.42	1.10 E-06
S10	0.32	7.00 E-07
S11	0.22	4.70 E-07

Thermal properties of the analyzed gypsum-based materials followed the basic trend given by the bulk density. The material S8 with sand filler exhibited an about 25% increase of thermal conductivity compared to the basic FGD gypsum material S0. On the other hand, the addition of fly ash (S9) and gypsum (S10) led to a 20% decrease of thermal conductivity. The application of PP fibers did not lead to any significant change in thermal conductivity.

On the basis of obtained experimental results it can be concluded that basically all the studied fillers were found applicable in practice, and their further, more detailed analysis, can be recommended.

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Calibration of TDR Technique for Evaluation of Moisture Content of Hygroscopic Building Materials

L. Fiala

fialal@fsv.cvut.cz

Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In this paper, application of time-domain reflectometry (TDR) measuring technique for monitoring moisture content in hygroscopic building materials is studied. The main attention is paid to the calibration accuracy. The practical example of the measuring technology is given on measurements of moisture profiles in flue gas desulphurization (FGD) gypsum.

A device based on TDR principle launches electromagnetic waves, and then measures the amplitudes of the reflections of waves together with the time intervals between launching the waves and detecting the reflections. From the measured time intervals in the range of picoseconds, the static relative permittivity, having clear relation to the amount of moisture in material, can be determined utilizing basic equations of electromagnetism.

In the experimental part of this work, the cable tester LOM/RS/6/mps produced by Easy Test was used [1, 2]. The apparatus is based on the TDR technology with $\sin^2$-like needle pulse having rise-time of about 200ps. For the measurement of relative permittivity, two-rod miniprobes LP/ms (Easy Test) were used. The experiment was arranged in the form of vertical suction [3] of water into naturally dried samples of FGD gypsum in air-conditioned laboratory at 23 ±1°C and 30 ± 2% relative humidity. The sample was prepared by casting. The material, which was used for sample preparation, was β-form of calcined gypsum with purity higher than 98 % of FGD gypsum. The water/gypsum ratio was 0.627. The size of the specimens was 70x50x330 mm. Sixteen TDR probes were installed into each sample during the process of casting and connected through multiplexers with the TDR device. The moisture profiles were continuously monitored, and the experiment was stopped before the water front reached the end of the measured sample.

There are three basic approaches to the determination of moisture content from measured relative permittivity. The first possibility is utilization of empirical conversion functions generalized for a certain class of materials, which, however, are always limited for specific groups of materials only, for which they were proposed. The second possibility is application of dielectric mixing models, which assumes knowledge of the relative permittivities of the material matrix, water, air and other parameters, that can not be measured directly but have to be determined by empirical calibration of the model. The third method for consists in empirical calibration for the particular material using a reference method, such as the gravimetric method. This method is the most reliable until now but the most time consuming one.

In the presented work, the empirical calibration was done using the final moisture profiles of all analyzed specimens. After finishing each experiment, the sample was cut to 1 cm wide pieces, and the relative permittivity data obtained by the TDR device were assigned to the moisture content of the particular 1 cm segments determined by the gravimetric method. The empirical calibration curve was then used for the assessment of two other empirical conversion functions frequently used is soil science and of several calibration functions based on dielectric mixing models. Among the empirical calibration curves, the conversion functions proposed by Topp and Malicki [4] were tested. The first dielectric

mixing model analyzed in this paper was the 4-phase α-model proposed by Dobson. The Maxwell-De Loor mixing model was the second formula which was tested for the application with the studied gypsum material.

The shape of the $\varepsilon(w)$ function assessed by empirical calibration is rather unusual, with practically no dependence of ε on w in a wide range of moisture content. This appearance I assign to the high hygroscopicity of the material. Both Topp's and Malicki's empirical functions that proved to be very useful for many soils clearly failed for FGD gypsum. This is, however, not very surprising result. The empirical and semi-empirical formulas for evaluation of moisture content from measured permittivity originally designed for application in soil science cannot be universal. As most soils exhibit a very low hygroscopicity, the application of soil-science formulas for highly hygroscopic building materials is not straightforward and should always be done with care. On the other hand, the formulas derived on the basis of dielectric mixing models should be more universal. Their derivation is not confined specially to soils, and they also contain free parameters which can be fitted to match the experimental data. However, the results of extensive parametric studies performed for Dobson 4-phase a model and the Maxwell-De Loor model were not very successful as well. As both the empirical conversion functions used in soil science as well as the tested dielectric mixing models clearly failed in the application to the calibration curve of FGD gypsum, an empirical 4-th order polynomial formula for the calculation of moisture dependent relative permittivity was proposed. It was proofed that its agreement with experimental data is much better than for all other analyzed models. However, it should be noted that at this stage of research this formula can be considered just as a conversion function valid for FGD gypsum and no generalizations can be done.

The results obtained in this work can be considered as another step towards the application of TDR technique for monitoring moisture content in hygroscopic building materials. It was found that methods for calculation of moisture content from measured relative permittivity used in soil science are not applicable for building materials in general. The verification of commonly used conversion functions and mixing formulas by a reference method is necessary case by case.

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Experimental Setup for Monitoring Salt Transport Induced by External Electric Field

M. Jiřičková, L. Fiala, R. Černý

jiricko@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Chloride transport in porous matrix of building materials has drawn much attention due to problem of chloride-induced corrosion of reinforcement in concrete structures and materials carbonation caused by CO_2 from surrounding atmosphere. The basic steps to determine salt transport through the porous matrix are the estimation of ion binding capacity and the evaluation of transport coefficient. The most of mathematical models applied for description of ion transport through the porous structure of materials are based on the Fick´s diffusion equation. As input data for these models, salt transport and salt storage parameters are used. The basic suction experiment of salt solution is often used to measure transport parameter. However, it is rather difficult to recognize share of free and bound ions in the determined salt transport coefficient. On that score it is indispensable to know ion binding isotherms, which are key parameters for salt transport simulation and transport parameter determination.

It is common to measure salt transport using so called simple diffusion test, but it is extremely slow process. On that account it was made suggestion to apply external electric field. At the beginning of 1980s, there was designed experimental set-up for salt diffusion coefficient measuring in concrete called „Rapid Chloride Permeability Test“ or „Migration Test“ [1,2]. Measuring apparatus consisted of two boxes separated with tested sample, which was fitted with measuring electrodes. There was sodium chloride solution in the first box and the same concentration of sodium hydroxide solution in the second one. Thus, the arranged experiment was limited to following conditions. The first condition was that ion movement is higher in the solution than in the measured material, it means the ion transport took place only inside the sample. The second one was that mass transport due to convection was neglected. The next one said that Fick´s diffusion was not accounted for because of its negligibility compared with ion migration in the electric field. The last condition required linear electric field changes crosswise the sample. The migration experiment reliability was often discussed in literature, because measured data were systematically higher compared with data measured with simple diffusion test.

The other way how to determine salt diffusion coefficient can be inverse mathematical analysis of measured salt concentration profiles. Up to the present it is not known sophisticated method for salt diffusion coefficient measuring depending on salt concentration. Calculation of salt diffusion coefficient in dependence on varying salt concentration can be done using methods currently applied for evaluation of moisture diffusivity depending on moisture and heat conductivity depending on temperature according to Černý and Toman [3].

Presently a database of salt transport and salt storage parameters does not exist and the amount of measured data is insufficient. The only source of experimental data are papers of some investigators, see for example Tang [4].

In this work, firstly was analysed the problem of migration experiment and then new experimental set-up for measuring ion diffusion through the sample accelerated using electric field was arranged. The experimental device consists of plastic vessel divided into two separate boxes with the tested sample. The sample is water and water vapour proof insulated

with epoxy resin. Specially designed corrosion-resisting steel plate electrodes can be placed at a different distance of sample surface. The applied electric field is horizontal and it is produced with exactly defined electric voltage. There is salt solution of known high molar concentration in the first box and salt solution of known very low molar concentration in the second one. At the first, it is necessary to calibrate the LP/ms miniaturized probes for measuring electrical conductivity. These probes are LOM/RS/6/mpts device (EASY TEST, Poland) component, which periodically records the instantaneous profiles of moisture and water electrical conductivity in chosen time intervals. LP/ms probe is designed for monitoring changes in water and salt distribution in material. The sensor is made of two 53 mm long parallel stainless steel rods, having 0.8 mm in diameter and separated by 5 mm. The probe cable length from the sensor to the multiplexer is 1 m and cable feeder length from the multiplexer to LOM is 3m. From the measured data was found out that the sphere of probe influence creates the cylinder having diameter about 7 mm and height about 60 mm, circumference around the rods of sensor. Therefore, the probe is placed in the middle of each box.

The probe calibration is done with help of pH/ION 740 measuring device and electrochemical (ISE) cell, which is formed by reference and ion selective electrode. Chloride ion selective electrode is equipped with silver chloride membrane and Ag/AgCl electrode. The main component of the electroactive membrane is a neutral compound which is able to convert the complex ions and to transfer them through the membrane. The reference electrode consists of silver chloride membrane, sleeve diaphragm and Ag/AgCl electrode. It is filled with internal and bridge electrolyte solutions. The most important step is to calibrate ion selective electrode with NaCl standard solution. Then the ISE cell is immersed into measured solution and chloride concentration in mg/l solution is shown on the display of the pH/ION 740 measuring device.

The experimental device allows recording changes of electrical conductivity in each box separately and continually in chosen time intervals. These values are consistent with calibrated chloride ions concentrations in mg/l solution. Concentration depending salt profiles are then calculated according to the method of Černý and Toman [3]. The migration experiment accelerated using electric field will be used for measuring salt transport parameters of most porous building materials exactly in a short time period.

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Experimental Assesment of Hygrothermal Function of Building Envelope on the Basis of Thermally Cracked High Performance Concrete

L. Fiala

fialal@fsv.cvut.cz

Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Application of "semi-scale" technology for monitoring hygrothermal function of building envelope based on thermally cracked high performance concrete is presented in the paper. The performed experiment is done using the monitoring and simulating system called NONSTAT [1]. The NOSTAT system makes use of two climatic chambers for simulation of difference climate conditions very close to reality. Between climatic chambers, the testing tunnel of 700/700/900 mm dimensions for placing the studied structure is fixed. In the investigated structure, there are placed particular sensors according to demands on measured quantities. In the presented experiment, the simultaneous monitoring of capillary pressure, relative humidity, liquid moisture content and temperature was carried out. For measuring moisture content, special sophisticated devices working on the TDR methodology are used. The precision of the TDR sensors in moisture content reading is ± 2 % in the range of relative moisture content 0-100 %. The measurement of capillary pressure is done by minitensometers with accuracy 15% in the pressure range of 0-900 mbar. For monitoring relative humidity and temperature, the measuring technique from Ahlborn is applied. The accuracy of particular sensors is as follows: capacitive relative humidity sensors are applicable in the range of humidities 5-98 % with accuracy ±2 %, temperature sensors have accuracy ± 0.4 °C in the temperature range from –20 °C to 0 °C and ± 0.1 °C in the range from 0 °C to 70 °C. The whole measuring system is operated by a computer, including the climatic data entry into the exterior climatic chamber.

The investigative work was done on fragment of building envelope on the basis of high performance concrete C90/105 containing silica fume water suspension, plasticizer FM 794 based on polycarboxylateether and hydration retarder Lentan VZ 33 on the saccharose basis. The silica fume water suspension consisted of 88-95% of SiO_2 and small amounts of calcium oxide, magnesium oxide and nitrogen oxide. The water/cement ratio was 0.36. The fresh concrete mixture was cast into the mould, after one day the sample was unmoulded and then treated using curing solution. After the hardening period of 28 days the sample was heated up to 600°C in an oven to induce cracks. The concrete structure 200 mm thick was in the second part of the experiment provided by exterior thermal insulation system consisting of the cement glue layer 3-5 mm thick, mineral wool thermal insulation boards INROCK h 80 mm thick and exterior cement plaster KAM 5-7 mm thick.

The experiment was performed in several steps. At first it was necessary to calibrate sensors for monitoring moisture content. The calibration was done by means of procedure proposed in [2]. The sensors for measurement of relative humidity and temperature are calibrated by producer, therefore we have only roughly tested their proper function by measurement in desiccators with salt solution corresponding to specific relative humidity. The accuracy of resistive temperature sensors was verified using thermocouples. After the calibration, the sensors were placed into the studied structure in accordance with specific principles and methodology designed in [3, 4]. In the installation of the specimen into the connecting tunnel, its thermal and hygric insulation from the tunnel walls performed for the

sake of simulation of one-dimensional heat and moisture transport in the envelope belongs to the main tasks. For that reason, the specimen was insulated using the boards from extruded polystyrene in combination with mineral wool, the front sides of the insulation were covered by polyurethane foam. Finally the tunnel was connected with the climatic chambers. Since the presented experiment should simulate the hygrothermal processes in stucture in conditions close to the reality, the simulated climatic conditions in the particular climatic chambers have to be realistic. We employed hourly reference-year based data for temperatures and relative humidities for Prague in the chamber simulating external climate and proper constant temperature and relative humidity data in the chamber simulating the internal conditions. Reference-year data were constructed according to generally recognized international methodology. The measurement was first performed on non-insulated wall, and after 110 days the designed insulation system was installed. The climatic loading of the building envelope began with the climatic data for October 1 and was finished with the climatic data for the March 3. Hence, the whole winter period which is considered to be the most critical part of the year from the point of view of water condensation was simulated.

Pursuant to measured results we obtained rather detailed view of hygric and thermal behavior of the studied structure during the simulated winter period. The function of the insulated structure can be rated as good in general because the appearance of overhygroscopic moisture was not observed. The higher values of relative humidity were found out only in non-insulated concrete wall. This moisture arose probably as an effect of application of unfavourable climatic conditions on relatively freshly cast concrete structure with high amount of gaseous moisture what led to its condensation. However, the amount of condensed water was not extremely high, because the measured values of capillary pressure were systematically higher than 900 mbar. On top of that the structure was gradually dried out. After the application of thermal insulation, there was observed marked shift of temperature in the concrete structure. The temperature steadied subsequently at constant value 19°C. Owing to exterior thermal insulation system the possibility of appropriate water condensation was strictly limited. The increase of temperature of interior surface is another positive effect of applied insulation system.

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Nondestructive Detection of Intensity of Sensitizing to Intergranular Corrosion of Stainless Steels

V.Ovesná, J.Hořejší*, J.Cejp, J.Pitter*, J.Horník

v.ovesna@email.cz

CTU,Faculty of Mechanical Engineering,Dept. of Materials Engineering
Karlovo nám.13,121035 Praha 2
*ATG,s.r.o.Beranových 65,199 02 Praha

Various non-destructive techniques are used for characterization of ferrous engineering materials and their inspection and specially eddy current testing (ECT) in spite of its simplicity and low cost was very often used in practice for assessing structural integrity which is affected by various types of degradation processes including intergranular corrosion [1-3].

This study evaluates the applicability of eddy current method to detection of structural changes mainly precipitation of secondary phases in wrought austenitic steel.

Microstructure changes were monitored on thermally aged AISI type 304 and AISI type 316 stainless austenitic steels:

AISI 304 – 0,06wt.%C – 0,95 wt.%Si – 1,70 wt.%Mn – 18,7 wt.%Cr -9,4 wt.%Ni

AISI 316 - 0,07 wt.%C -0,92 wt.%Si - 1,65 wt.%Mn - 17,9 wt.%Cr -13,4 wt.%Ni - 2,4 wt.%Mo

Both materials were exposed at following conditions:

Temperature [°C] : 550, 600, 650, 750, 800, 850

Endurance in time [min] : 20, 60

On these samples was measured conductivity using a uniform eddy current probe MIZ-21SR driven at frequencies 60kHz and 120kHz. Before measuring was gently wore out oxide layer from surface of the samples. It was because of more exact measuring of conductivity.

For estimate of sensitivity (by measuring of conductivity on a change of composition) is the change related to decrease of concentration of iron. In case of steel AISI 304 and AISI 316 (after dissolving burning) is the whole change of conductivity imputed to the influence of composition of rigid dilution (austenite), because it was not found out presence of other phases. Experiment with using of method ECT was replenished with metallographic analyse with help of lighting microscopy. Analyse of results showed increase of carbides by different temperatures and time of sensitizing. In the both cases of the materials is microstructure formed of austenitic matrix without presence of precipitate or another particles on the grain boundary. Measured data exhibited that eddy currents is possible to use for detection.

Continuous chains of carbide precipitate which occupied almost whole grain boundary were detect by material AISI 304 at temperature 750**°C** and time of sensitizing 20 min while another increasing of temperature led to precipitation inside of the grains. By sensitizing of the same material in time of 60 min was structure similar and displayed increase of precipitated particles and their incidence inside of grains.

By material AISI 316 with increasing of temperature 800°C/20 min (850°C/20 min) was recorded intensive precipitation inside of grain, with simultaneously forming of continuous chains of carbide particles on grain boundary. By lower temperatures (less than 650°C/60 min) was not marked precipitation of carbides.

Incidence of precipitation on grain boundary was not appeared before temperature 750°C/60 min. Another increasing of temperature led on to more expressive precipitation of carbides inside of grains and to growth of size of carbide particles on grain boundary.

From mutual comparison of measuring values of conductivity of material AISI 304 (by frequency 60kHz in time of sensitizing 20min, temperatures 550-850°C) is possible to record complicated progression. The sensitizing in interval 550°C means expressive increase of conductivity in comparison with actual status. In other increasing of temperature led to slight decrease of conductivity, but temperature of 750°C means vehement increase. After this local maximum conductivity decreases with another increasing of temperatures. Depletion of chromium means increase of conductivity and also originating carbides reduce effective conducting section of material and these carbides also decrease measured conductivity. By frequency of 120 kHz of the same material were found out very similar dependences as in case of frequency of 60 kHz. Sequential decrease of conductivity is not too expressive. That is because in case of this frequency is very important surface area of the samples. By material AISI 316 in measuring of conductivity with frequency 60kHz is possible to record positive influence of molybdenum on resistance to sensitizing to intergranular corrosion. The local maximum of conductivity we can see with temperature 800°C(850°C) With using of frequency 120kHz is the situation very similar as by steel AISI 304.

AISI type 304 and AISI type 316 stainless steels aged between temperature 550^{o}C and 850^{o}C produce sensitisation and when this steel is exposed to a corrosive environment intergranular corrosion occurs. The results of eddy current technique correlated well with metallographic analyse and confirmed applicability this method to assess sensitisation of stainless steels first of all in welding or during isothermal exposure steels during service.

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The Influence of Forming and Heat Treatment on the Mechanical Properties of Tungsten Alloys

J. Siegl*, K. Dalíková*

klara.dalikova@fjfi.cvut.cz

*Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

The research dealing with the study of fractographical aspects of failure mechanisms in relation to the chemical composition of tungsten alloys and on the technological processes of their preparation (i.e., cold working reduction ratio and consequential heat treatment) has been carried out at Department of Materials at Faculty of Nuclear Sciences and Physical Engineering at CTU in Prague in cooperation with UJP Prague [1].

Three sets of damaged test specimens with different chemical composition were subjected to the experimental programme (Tab. 1). All specimens were prepared by the method of powder metallurgy. They were made by compression of homogenized powder of appropriate composition to obtain density 11 g/cm^3; the compressed specimens were sintered in the hydrogen atmosphere. The alloying elements Fe, Ni, Co fused and created the matrix containing about 30% of tungsten. Almost pure tungsten created spherical particles; their size grew during the sintering. Then annealing in vacuum at 1200 °C followed and rapid water quenching which had to avoid the segregation of intermetallic phases and ensure good cold workability. The test specimens in each set differed, on the one hand, by the reduction ratio of cold working in the range from 24.8% to 70.4% (see Tab.1), and, on the other hand, by the heat treatment (the original state and state after annealing at 500 °C/2h). Cold working led to the hardening of both W-particles and matrix which came out by decrease of ductility and increase of hardness and strength with increasing reduction ratio (with the exception of alloy TRC where a decrease of strength values was found at a higher reduction ratio). Consequential heat treatment led to further increase in strength at relatively good ductility for alloy TZ but to a decrease of tensile strength at a higher reduction ratio for alloys TRC and TK.

Table 1 – List of investigated specimen sets

Specimen set	Chemical composition				Number of specimens	Range of cold working ratio
	Fe (wt %)	Co (wt %)	Ni (wt %)	W (wt %)		
TRC	0.50	1.00	2.50	96.5	8	29.5% ÷ 70.4
TK	1.15	1.50	4.85	92.5	6	29.5% ÷ 70.4
TZ	1.40	1.80	5.80	91.0	12	24.8% ÷ 61%

The detailed study of fracture micromorphology and character of longitudinal metallographic sections was made by two scanning electron microscopes, namely JSM 840A and JSM 5510LV. During the research, it was repeatedly verified whether the found changes of microstructure characteristics and mechanical properties had not been due to the local changes of chemical composition. The monitoring of chemical composition was carried out by the energy dispersive X-ray microanalyzer IXRF 500 [2, 3].

Only with TK alloy specimens in the original state, the results of tensile tests were comparable with the results obtained for TZ alloy, i.e., the tensile strength increased with increasing reduction during forming, and the ductility did not decrease below 1.8%. In other

cases, a sharp fall of the tensile strength was observed as well as the ductility at reduction values above 42%. Nevertheless, HV10 hardness of alloys TRC and TK increased with the increasing reduction during forming, both in state before and after annealing.

For alloy TZ, the obtained results have shown that the chemical composition of particles and matrix have not changed after annealing (500 °C/2h). The chemical composition of the tungsten particles is practically the same for all the investigated alloys. However, it has been found that the chemical composition of the matrix for TRC a TK alloys has been relatively different. Especially, with TRC the increase of tungsten content to 96%, which is connected to the decrease of Fe and Ni content (to about one half against the content in TK alloy), leads to significant changes in matrix chemical composition. The influence of annealing on the chemical composition of structural components of alloys TRC and TK has not been proved. From the above results, it follows that the changes of nominal chemical composition of TRC and TK (the increasing content of W, and decreasing content of Fe, Co and Ni) lead not only to the decrease of the matrix volume but also to the changes of its chemical composition. These changes are possible to consider by reason of the different mechanical behaviour, first of all, for all TRC specimens.

By the study of the longitudinal sections it has been found that the orderliness of the structural components (W-particles and matrix) increases with the increasing reduction ratio during forming. The tungsten particles become longer in the direction of forming and even the size of the area of contact between particles simultaneously increases. The metallographic observations have revealed in alloys TK and especially TRC a markedly lower volume fraction of the matrix which can carry the plastic deformation (in comparison with TZ alloy). With respect to very low amount of the ductile matrix between the tungsten particles, the tensile stress can induce rapid development of a defect and creation of a major crack, which results in the final failure of the carrying cross-section rest of test specimen.

The main results of this research can be summarised as follow:

- The failure of specimens proceeded due to the combination of three partial mechanisms – the ductile failure of matrix, the cleavage failure, and a decohesion of tungsten particles.
- The nominal chemical composition influenced the geometry and the ordering of structural components, and, above all, the distance of tungsten particles. The volume ratio of the matrix between the particles decreases with increasing tungsten content.
- The local electron microanalysis has shown that the change of nominal chemical composition of an alloy may influence the chemical composition of matrix.
- The decrease of tensile strength of TK and TRC alloys with increasing reduction ratio is, above all, the result of the decrease of the matrix volume. Also the influence of different chemical composition of the matrix can be significant.

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Structure Parameters of Chemisorbed Faujasite Zeolites by Powder Neutron Diffraction

S. Vratislav, M. Dlouhá, V. Bosáček*,

vratisla@troja.fjfi.cvut.cz
CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Solid State Engineering
Břehová 7, 115 19 Praha 1
*CAS, J. Heyrovský Institute of Physical Chemistry
Dolejškova 4, 182 23 Praha 8

Microporous materials such as zeolites are of enormous importance in a wide variety of chemical process e.g. catalysis or molecular separation. Aluminosilicate faujasite-type zeolites have been widely studied in the past few years. There is a great deal of fundamental interest in understanding how zeolites function at the atomic or molecular level. This knowledge will provide the means to design novel catalyst materials. The building blocks of zeolites are SiO_4 and AlO_4 –tetrahedra, which can be assembled to form a wide variety of crystal structure with pores and channels of varying dimensions. These are important candidates for different types of catalysts and many laboratories try therefore to „tailor“zeolitic catalysts of requested properties. Cations and especially extra-framework cations play an important role in determining the adsorption, separation and catalytic properties of zeolites. The positive charge of the cations produces electric fields within the zeolite pores, which can strongly influence absorptive behavior and catalytic activity. The locations of the extra-framework cations in the dehydrated faujasite zeolites such as NaY, NaX and NaLSX have been determined by powder neutron diffraction. Sites I and I´ are located in the hexagonal prism and the sodalite cage, respectively, while the site II and the site III positions are in the supercage. The knowledge of the position and the occupancy of these cations after chemisorption processes are very important for understanding in controlling and catalytic properties. Therefore, the careful structural studies of these faujasite type of zeolites under as real as possible conditions (the sorption or catalytic environments) are needed.

Well-developed crystals of NaY, NaX and NaLSX with high content of sodium cations and with low content of defects and decationation were used in our study. Chemisorbed methyl groups were prepared in the structure skelet by chemical reaction of methyl iodide with reactive sodium cations available in SII and SIII positions of faujasites. Methyl cations CH_3^+, evolved in the reaction, react immediately with the lattice oxygen forming surface bonded methyl groups in bridging configuration.

Neutron powder diffraction patterns were collected at temperature of 298 and 7 K on the KSN-2 diffractometer, which is placed at the LVR-15 research reactor in Řež near Prague. The wavelength of 0.1362 nm was used and the resolution $\delta d/d=0.00075$ was achieved (d is the interplanar spacing). The structure analysis was proved by Rietveld analysis of powder neutron diffraction data using the GSAS package and a difference Fourier maps. Some features of samples (NaX and NaLSX), experimental and refinement are given in Table 1. Our structure parameters for the initial dehydrated NaX, NaY and NaLSX samples are in agreement with results refined in the Fd3 space group given by other authors (e.g. Olson [1]).

The full description of crystal structure of NaY, NaX and NaLSX zeolites with chemisorbed methyl groups has been determined by powder neutron diffraction and by high resolution solid state ^{13}C MAS NMR. The complete sets of structure parameters of our chemisorbed samples were published at [2] for NaY and at [3, 4] for NaX and NaLSX.

Table 1. Some features of samples, experimental data collection and Rietveld refinement

zeolitic catalyst	Si/Al	T /K/	CD_3I^* mol/u.c	R_p	R_{wp}	χ^2	a /nm/
NaX	1.33	7	15.3	0.0597	0.0486	2.062	2.5049(6)
NaX (+Ar)	1.33	7	14.6	0.0573	0.0456	2.065	2.5042(5)
NaLSX	1.00	7	26.4	0.0571	0.0473	2.054	2.4981(4)
NaLSX	1.00	298	24.8	0.0569	0.0459	2.037	2.4936(4)

Remarks: *Adsorbed molecules per unit cell [a]Rietveld refinement was used to minimize $\Sigma w_i (I_{o,i} - I_{c,i})^2$ where $I_{o,i}$ and $I_{c,i}$ are the observed and calculated powder diffraction intensities for the *i*th point, respectively. Weights w_i are $1 / I_{o,i}$. Weighted and unweighted profile *R* factors are defined as $R_{wp} = \{[\Sigma w_i (I_{o,i} - I_{c,i})^2] / [\Sigma w_i (I_{o,i})^2]\}^{1/2}$ and $R_p = \Sigma |I_{o,i} - I_{c,i}| / \Sigma I_{o,i}$. χ^2 was calculated from $(R_{wp} / R_e)^2$.

If we take into consideration our results than we can do following remarks:

- We observed serious changes in the distribution and in the coordinates of Na^+ cations after chemisorption of methyl ions [4]. Typical example was found for NaX and NaLSX in the cases without and with chemisorbed species where is demonstrated a splitting of the position SI' into two sites Na2 and Na3. These positions are separated at helium temperature but fused together at room temperature. Cations in SII positions are represented after chemisorption only with fully occupied Na4 site (32 per unit cell).
- Methyl ions are located in X faujasite at the O4 and the O1 lattice oxygen [3,4] and in Y faujasite at the O1 lattice oxygen [2] only in α-supercavity. It is clear shown that the distances observed by us in microporous crystals are longer then the C-O bond length estimated in nonporous crystals. The O-C distance lengthening may be associated with the interaction of the considered chemisorbed CH_3 or CD_3 group with other species. Further lengthening of O-C bonds could be connected with strong intermolecular interactions or with the influence of force field gradients in zeolitic supercavities.

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X-ray Diffraction Analysis of Zr-based Alloys Oxidized under Temperature Transient Conditions

G.Gosmanová, I.Kraus, V.Vrtílková*

gosmanov@troja.fjfi.cvut.cz

CTU, Faculty of Nuclear and Physical Engineering, Dept.of Solid State Engineering, Trojanova 13, 120 00 Prague 2, Czech Republic

*UJP Praha Inc., Nad Kamínkou 1345, 156 10 Prague – Zbraslav, Czech Republic

Zirconium alloys are currently used as cladding materials of fuel elements of water-cooled reactors. However, their behavior under extreme conditions is still the object of extensive research.

The aim of this contribution is to present the results of X-ray diffraction analysis of Zr1Nb (Russia) and Zircaloy-4 (Zry-4 Sandvik) alloys oxidized under so called temperature transient conditions. Residual stresses σ and microstructure characteristics (crystallite size D and lattice strains ε) of oxide layers were evaluated by means of analyzing a selected diffraction line of oxide. The underlying metal was investigated as well.

Transition oxidation in water steam at 500 °C (1 day for Zr1Nb and 0,003 day for Zry-4S) was applied on unoxidized specimens and on a specimen preoxidized in water at 360 °C for 21 days. All the specimens were further oxidized in pure water at 360 °C for various times up to 170 days. The specimens of both the alloys which had not undergone the temperature transition were also studied. The kinetics of oxidation of the alloys under investigation were represented by weight gain (or T_{ox}) being measured after each exposure.

The „sum of the surface principal stresses" technique with a reference substance [1] was used to determine the stresses in oxide layers and metal underlying. The method is based on the determination of lattice strains ε^{hkl} from which, subsequently, the stresses were calculated by using appropriate macroscopic Young's moduli. The evaluation of the crystallite size and lattice strains was performed by using a „single-line" method with the Pearson VII approximation of the profiles´ shape [2].

An ω - goniometer SIEMENS with Cr Kα radiation was used to measure diffraction patterns. In oxide layers of the samples investigated the measurements were performed on the {10-4} planes with $2\theta = 119.5°$ for CrKα radiation.

Four partially overlapping diffraction lines were recorded within the 2θ range of measurement: (10-4) of ZrO_2 and (112), (201), (004) of α-Zr; thus, the fitting procedure had to be used to obtain the accurate profile characteristics such as peak position 2θ, .integral breadth W_{int}, integral intensity I_{int}.

The same procedure was applied on standard samples of both the alloys under investigation.

As it followed from the experimental values of I_{int} , the texture in oxide layers strongly varied in quantity at almost each exposure. Consequently the plots of W_{int}, D and ε vs oxide thickness have had quite inhomogeneous character. This phenomenon has been established in the earlier research which was concerned with the short-time oxidation of Zr1Nb alloy under temperature transient conditions [3].

Therefore, the behavior of the two alloys oxidized under transient conditions can be qualitatively examined using average values of oxide thickness T_{ox}, stresses σ, and integral breadth W_{int}. These values for oxide layers including crystallite size D and lattice strains ε are given in Table 1.

Table 1
Average values of oxide thickness T_{ox}, macroscopic stresses σ, integral breadth W_{int}, crystallite size D and lattice strains ε determined for oxide layers of the alloys under investigation

alloy	oxidation conditions	T_{ox}(μm)	σ(MPa)	W_{int}(2θ)	D(nm)	ε
Zr1Nb	pure water 360 °C	3.33	-846	3.87	10	0.004
	steam 500 °C + water 360 °C	5,32	-806	3.26	14	0.005
	w. 360 °C + s. 500 °C + w. 360°C	3.74	-993	3.89	8	0.002
Zry-4S	pure water 360 °C	3.27	-668	3.70	13	0.005
	steam 500 °C + water 360 °C	6.71	-539	2.90	12	0.003
	w. 360 °C + s. 500 °C + w. 360°C	5.63	-923	3.82	9	0.004

It follows from the data tabulated that:
- oxidation of both the alloys under transient conditions leads to a rapid increase in weight gain (or T_{ox}). The largest increase in Tox occurs for Zry-4 S alloy,
- macroscopic stresses in oxide layers of Zry-4S alloy are significantly lower than those of Zr1Nb oxide layers in all the cases of oxidation. The greatest stresses in the oxide layers of both the alloys occur for oxidation in water + steam + water,
- smaller values of W_{int} occur during oxidation in steam + water for both the alloys,
- an unambiguous conclusion from D and ε average values cannot be made, probably because of high quantitative variability of texture of the oxide layers,
- if we suppose that oxidation is controlled by diffusion of oxygen via oxide grain boundaries and pores, there may be another easy paths (or another mechanism) in the case of temperature transient oxidation,
- residual stresses can be considered as a reliable XRD characteristic of different behavior of the alloys under investigation.

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Experimental Study of Salt Transport and Storage Parameters of Concrete

M. Jiřičková, R. Černý

jiricko@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The protecting function of a biochemically modified silicate layer against water penetration was studied for fine grained concrete substrates with and without superplasticizer addition. Firstly material characteristics, water and salt solution transport and storage parameters of fine grained concrete were analysed, to obtain information about behavior and properties of the tested basic substrates. To protect concrete surface against aggressive substances the biochemically modified silicate layer was proposed. This cheap damp proofing can preserve concrete construction during the whole service life. It is based on formation of hydrated calcium silicates in pores and cracks to the 20 mm depth. This silicate layer can seal cracks up to 2 mm width. In the case of secondary cracks formation in treated concrete surface the silicate layer can react again with water and reactive products fill in new cracks up to 1 mm width. This phenomenon is called autogenous treatment. The biochemically modified silicate layer can be apply in the most cases, like as sealing of roofs, parking places, surfaces of roads, railway bridges, docks and water proofing constructions [1].

It was tested fine grained concrete charges with and without superplasticizer addition. One set of basic charge was treated with biochemically modified silicate layer to analyse its protecting function against aggressive solutions penetration. Tested samples were mould in the form standard prisms sizes of 100x100x400 mm or 40x40x160 mm. Prisms were stored in water during 28 day period and then 7 days at 50% relative humidity. The experimental specimens were cut to required sizes. Silicate damp proofing was painted on the sample surface, which was ground off firstly to open surface pores. After that, surface was sprayed with water three times to form hydrated calcium silicates in silicate layer.

The experiments for measuring transport and storage parameters were carried out at 25±2°C in laboratory conditions (relative humidity about 30-35%). The sample sizes depended on the laboratory test type. The initial state for all the measurements was dry material. Firstly, bulk density, vacuum saturation moisture content, and open porosity were determined. Each sample was dried in an oven to remove majority of the physically bound water. After that the samples were placed into the desiccator with deaired water. During three hours air was evacuated with vacuum pump from the desiccator, the specimen was kept under water not less than 24 hours. The so-called "Archimedes weight" was determined by weighing immersed water-saturated samples.

The basic tested methods for determining concrete transport and storage parameters can be used also for investigation double-layered systems. The simplest way, how to describe liquid water transport through a porous material is realization of suction experiment. The water sorptivity was measured using a standard experimental setup. The specimen was water and vapour-proof insulated on four edges and the face side was immersed 1-2 mm in the water, constant water level in tank was achieved by a Mariott´s bottle with two capillary tubes. One of them, inside diameter 2 mm, was ducked under the water level, second one, inside diameter 5 mm, and was above water level. The automatic balance allowed recording the increase of mass. The known water flux into the specimen during the suction process can be employed to the determination of apparent moisture diffusivity. The water absorption

coefficient was calculated from the linear part of the dependence of the increase of tested sample's mass on the square root of time. Then moisture diffusivity can be calculated from the vacuum saturation moisture content and water absorption coefficient according a simple equation [3]. The salt transport parameters were obtained from a one-dimensional free imbibition experiment. Specimens were water and vapour-proof insulated on four edges after drying in an oven. The face site of each sample was immersed 1-2 mm in the salt solution on top of a saturated sponge. The sample mass was weighing according to the weighing regime. The water absorption coefficient and moisture diffusivity were then calculated from the measured data.

Salts can originate from several sources. One of them is underground soil with water-soluble salts. The salt solution can be then transported into materials of load bearing structure by capillary forces. Another source of salts in building materials are sodium and calcium chlorides used for winter maintenance of pavements and footways. In concrete, cement mortar and cement paste, the determination of ion binding isotherm is chiefly concerned with chlorides. It was used a slight modification of the Tang and Nilsson adsorption method, taking into account the above considerations on the problems associated with the original version of the method and using the specimens of more realistic dimensions, for the determination of chloride binding isotherms. As the transport medium NaCl solution was used and some basic cement mixtures were explored. The measured samples were placed into the cups with 200 ml chloride solutions with different concentrations. Then they were stored in laboratory at the temperature of 25±2°C to reach equilibrium. The inside solutions were analyzed after several months to obtain the bound chloride content and chloride binding isotherms were plotted. The amount of chloride ions in liquid samples was easily and rapidly determined using chloride selective electrodes. The chloride electrode responds directly to the activity of chloride ions. The measuring apparatus consists of pH/Ion measuring device and electrochemical (ISE) cell, which is formed by reference and ion selective electrode. Chloride ion selective electrode is equipped with silver chloride membrane and Ag/AgCl electrode. The main component of the electroactive membrane is a neutral compound which is able to convert the complex ions and to transfer them through the membrane. The reference electrode consists of silver chloride membrane, sleeve diaphragm and Ag/AgCl electrode. It is filled with internal and bridge electrolyte solutions. The most important step is to calibrate ion selective electrode with NaCl standard solution. Then the ISE cell is immersed into measured solution and chloride concentration in mg/l solution is shown on the display of the pH/Ion measuring device. The measuring error in the determination of ion concentration can be considered in our experiments as about 10 % in the case of ion selective electrode.

The measured data showed that biochemically modified silicate layer could protect concrete surface against water and aggressive solutions penetration.

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Fatigue Properties of Bodies with Composite Ceramic Coatings

J. Bensch, O. Kovářík, J. Siegl

jan.bensch@fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Materials

Trojanova 13, 120 00 Praha 2

Thermal spray coatings can be the answer to increasing demands of industry for better mechanical and thermal properties of construction materials while saving weight and costs [1]. Substantial anisotropy and inhomogeneity of thermally sprayed coatings cause significant differences between properties the coating and bulk material of the same composition [2]. Classical mechanical characteristics, e.g., Young's modulus, strength, hardness, fracture toughness, adhesion, or wear resistance of various types of coatings are studied and measured for many years. At the same time, fatigue properties of coated bodies are gaining importance due to the increasing number of aeronautical, medical, transportation, and other applications.

Almost every kind of material can serve as coating, but mainly are used ceramics, metals or the mixtures of both. Certain distinct features are common when using a ceramic coating as well as a metallic one. Also the combination of two materials with different properties, e.g., the thermal expansion coefficient or elastic properties, can lead to interesting characteristics and performance of the resulting composites [3].

Our research was focused on investigation of fatigue behaviour of flat steel bodies with various ceramic-metal coatings. Low-carbon steel 4 mm in thickness was used as the substrate material. Prior to coating, each bone-shaped sample was grit blasted using alumina grit. All samples were then coated using a gas stabilized plasma spray torch (GSP) at the State University of New York (SUNY) in Stony Brook, USA. Four kinds of material were deposited – pure white alumina, pure Ni-5wt%Al, and two mechanical mixtures of alumina and Ni-5wt%Al powders (80wt%Al_2O_3 + 20wt%Ni5Al and 20wt%Al_2O_3 + 80wt%Ni5Al).

Fatigue tests were carried out on an electromagnetic computer controlled testing device "SF-Test". The flat fatigue specimens were loaded by symmetrical cyclical bending (as a cantilever beam) at room temperature with the loading frequency corresponding to the resonance frequency of the specimens, usually around 80 Hz. Deflection amplitude of the free end was kept constant at 4 mm, which corresponds to tensile load about ~ 270 MPa in the crack initiation area. The mean values of the fatigue lives corresponding to all five sets of specimens (including one reference set with no surface treatment) are presented in Table 1. Also the relative value of the average of fatigue lives compared to the reference set and relative value of the average of natural logarithms of fatigue lives are included.

Obtained results clearly indicate that all types of coatings led to decrease of fatigue lives compared to the fatigue lives of specimens without any coatings. The specimens with Ni-5wt%Al coatings showed the lowest fatigue lives, while specimens coated by alumina had the longest fatigue lives from all coated specimens. The specimens coated by the mixtures, i.e., sets 80Al_2O_3 + 20Ni5Al and 20Al_2O_3 + 80Ni5Al, showed fatigue lives ranging from below Ni-5wt%Al to alumina. Surprisingly, it seems that the metal-rich composite coating works better than the ceramic-rich one, despite of the above fact, that the pure metallic coating showed the worst fatigue properties at all. The discrepancy of fatigue tests results can indicate that the used mixtures of two different powders were not truly in proportion specified. This could be caused due to the separation of powders of different densities during spraying [3].

Table 1: The fatigue test results (average fatigue lives of coated specimens are related to average fatigue life of reference set) [2].

Set code	Number of samples	Average fatigue live		
		[cycle]	[%]	[%]*
No surface treatment	9	317,154	100	100
Al_2O_3	8	178,889	56.4	95.7
$80Al_2O_3 + 20Ni5Al$	8	162,060	35.0	89.4
$20Al_2O_3 + 80Ni5Al$	8	110,876	51.1	94.5
Ni-5wt%Al	8	62,901	19.8	87.7

** relative value of the average of natural logarithms of fatigue lives.*

Moreover, in the past research, it was unambiguously proved that alumina coatings deposited using WSP® 160 water stabilized plasma system lead to the significant increase of average fatigue lives, minimally 1.6 times compared to the specimens without coatings, e.g. [4]. It was also found that GSP sprayed Ni-5wt%Al leads to average fatigue lives decrease by approximately 4 times. The main reason for observed fatigue life difference of bodies with alumina coatings is the change of spraying system from the WSP® to the GSP. The lower flame temperature of GSP and shorter spray distance used for GSP deposition might have influenced the stress field in the coating [2].

It is necessary to take into account also the relation between the resulting local residual stress field in the area of fatigue crack initiation and the local composition (either Al_2O_3 or Ni-5wt%Al) of individual splats adjacent to the substrate interface (respectively the first layers of splats). As a result of powders separation, the composition may change locally along the specimen as a result of position and orientation of specimen in the spraying equipment.

It is obvious, that besides the coating material also the spraying method and parameters used will strongly influence the fatigue properties of created coatings. Though, presented investigation indicates that fatigue behaviour of coated specimens can be controlled also by choice of multicomponent coatings composition. This conclusion will be used in the following experiments oriented towards study of functionally graded materials.

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Multiparametric Fractal Analysis in Fractography

Z. Sekerešová, H. Lauschmann

lausch@kmat.fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, Praha 2, 120 00

Fractals [1] are geometrical objects of hierarchic structure having full scale independence i.e. they are characterised by self-similarity within the scale changes. This means that elements visible in a magnification appear in the same order after magnification has been decreased or increased. The selection of magnification is restricted to a particular range of interest and needs.

Fracture surfaces usually hold fractal character in a certain range of magnifications. Therefore, fractal analysis is suitable for fractographic applications. SEM image of a fracture surface is a 3D object: Lateral coordinates in the plane of the image define two dimensions, while the third dimension is defined by the value of brightness. For both lateral coordinates in the plane of the image, the pixel size is taken as the measuring unit. As the basic measure for the third dimension - brightness - the 8-bit scale (the range of 256 brightness levels) may be taken. However, with respect to the inhomogeneity of the set of dimensions, the ratio size unit / brightness unit is not obvious, and its effect should be investigated.

Fractal character of three-dimensional objects may be studied by the box-counting method. The object is covered with cubes of the side length r, and their number $N(r)$ is recorded. For 3D, fractal dimension D is given by formula $D = 3 - \log N(r)/\log(1/r)$, where $1/r$ is called factor of scaling. Fractal dimension is estimated as the slope of the interlacing line of the dependence between factor of scaling and the number of cubes, both in logarithmic scale.

Four specimens of the stainless steel AISI 304L were loaded [2] by a constant cycle in tension with $P_{min} = 1450$ N, $P_{max} = 4850$ N (coefficient of cycle asymmetry $R = 0.3$), at frequencies $0.5 \div 10$ Hz, at running temperature 20°C in a corrosive aggressive aqueous solution, denoted as B-water. The status of the process of crack growth was regularly recorded during the loading in the form of pairs [number of cycles N, size of crack a]. Crack size was calculated from the measurements by the potential method.

Fatigue crack surfaces were documented using SEM with magnification 200x. The sequence of images was located in the middle of the crack surface; the images were distanced by 0.4 mm. The direction of the crack growth in images was bottom-up. The real area of one image was about 0.6 x 0.45 mm. Digital representation in 1200 x 1600 pixels and 256 brightness levels was used. The total number of images was 165. Crack rates were assigned to single images form laboratory records mentioned above.

Images went through processing by many different methods and the result was that a single feature of any type for each image is not sufficient to be representative for crack growth rate. We decided to use the box-counting method for estimating the vector of fractal features. The fractal feature vector of a crack surface image [2,3] was composed of 24 $N(r)$ values, corresponding to the set of r = {5,7,9,11,…,50} pixels. In fact, this feature vector involves fractal dimension as an implicit parameter. However, it contains also all fine deviations of data from the line, from which fractal dimension is calculated.

Multilinear regression is usually used for modeling of the dependence between feature vectors and known crack growth rates [3]. It is defined by the matrix equation **Y** = **FC**, where **Y** is logarithm of crack growth rates assigned to single images, **F** is feature matrix and **C** is vector of unknown coefficients to be estimated. An overdetermined system is required: The number of unknown constants (number of features +1) must be significantly smaller than the number of equations (which equals number of images). The test of zero *c* values is used to eliminate features which do not contribute within the model. Input (experimental) and output (estimated from the model) crack rates are compared to judge the quality of the model – its ability to express the relation between image features and crack growth rate.

To optimize the relation between dimensions, we focused on the third dimension - brightness. *Brightness ratio* [2] was defined as p_j = number of brightness levels assumed / 256. For example, let us compare selections $p_j = 0.25$ (6-bit brightness range corresponding with human eye sensitivity) and $p_j = 1$ (standard 8-bit brightness range). The spatial and brightness intervals are paired differently - the "cube height" in the second case is a quarter. The effect of brightness ratio was investigated in the interval $p_j \in \langle 0.25;\ 4 \rangle$. Primary images $p_j = 1$ were re-calculated into another brightness ratio by multiplying the brightness with the requested value p_j. The correlation coefficient between input and output crack growth rates was used as the quality criterion.

The best results were achieved for brightness ratios from 1.95 to 2.2 (for separate evaluation of single specimens and all data together, respectively) [2,4]. Within these computations, 8-11 features from the total number of 24 passed the test of significance under test criterion $t = 0.05$. The dependences of model quality on brightness ratio are slight and a little chaotic, giving only a rough guide for the selection of this parameter. According to hitherto results, the value of $p_j = 2$ could be recommended.

The final plots comparing crack growth rates estimated from the images of fracture surfaces (fractal feature vectors) and the values known from the experiment show a narrow confidence belt in the area of ideal agreement. This method gives valuable results and therefore it will be further developed and used within routine fractographic analyses .

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Fractal Analysis of the Relation Between Fatigue Crack Rate and 3D Reconstruction of Fracture Surface

Z. Sekerešová, I. Karovičová, H. Lauschmann

lausch@kmat.fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, Praha 2, 120 00

Fractal analysis [4] is a mathematical method for the description of natural and artificial structures. The main characteristic of fractal structure is self-similarity. This means that the element of fractal structure is repeated regularly in different magnitudes. Our 3D reconstruction of fracture morphology is a suitable case for application of fractal methods because of the character of the surfaces. However, the self-similarity with respect to the scale ratio is not totally valid; we used this presumption in the past as the first step before looking for a more proper method.

The box-counting method is convenient for this case [2]. The method is based on continuous covering of the fractal object (surface) with cubes of side r, while the size of the cube side is changed in each step. The number of cubes $N(r)$ necessary for the coverage of the object surface is recorded. The relation between the number of cubes and the size of the cube side r determines the value of the fractal dimension D according to the relationship: $D = 3 - \log N(r)/\log(1/r)$. Here $1/r$ is called factor of scaling. However, we do not calculate the fractal dimension, because a single feature cannot characterize the fracture surface entirely. Therefore, we need a feature vector. It can be simply composed of values of $N(r_i)$ – numbers of cubes covering the surface – for a constant set of values r_i.

A specimen of aluminium alloy AlCu4Mg1 was loaded by a constant cycle in tension with a defined mean load and frequency. Testing was made at operational temperature 20°C. During the loading, the status of the crack growth process was regularly recorded in the form of couples [number of loading cycles, crack length]. The size of the crack was calculated from the measurements using the potential method.

Fatigue crack surface was documented using optical metallographic microscopy (microscope NEOPHOT 32 + camera Olympus DP 50) with magnification 100x. The direction of the crack growth in images is bottom-up. We used digital representation in 2776 x 2074 pixels and 256 brightness levels. As input for the 3D reconstruction of fracture surface, 17 crack localities of crack surface were documented. In each locality, a sets of images was ordered in equidistant focus levels distanced by 2 μm. All images were more or less blurred.

Reconstruction of the surface from the set of images is based on image focus analysis [3]. The focus measure is given by the energy of the image of Laplacian, which is given by the relation: $FM = \iint \left(\partial^2 g(x,y)/\partial x^2 + \partial^2 g(x,y)/\partial y^2\right)^2 dxdy$, [3]. Focus curve is constructed from the vector of focus measure (FM) values. Adaptive size of the window which we use for focusing is defined by criterion $\sum_i |FM_{i+1} - FM_i| / \max_i(FM_i) \le T$, [3]. The approximation of the focus curve enabled better precision in height levels. A focused image may be composed of details corresponding to maxima of the focus curve. However, each point of the focus curve corresponds to a height level. Therefore, the main output is a 3D reconstruction of

fracture surface as the matrix *m* by *n*. It may also be imaged as a grayscale image, where the brightness is proportional to the height level.

3D reconstructions of fracture surface may be related to fatigue crack growth rate by methods used in textural fractography [1]. Feature vectors for all 17 localities of fracture surface were constructed by the box-counting method as described above. We began with a cube of a 5 pixel side, and then we increased the side by 2 pixels in each step up to a cube of 50 pixel side, which gave a feature vector of 23 components. Then we used the principal component analysis and removed 13 correlated features. It resulted in a vector formed of 10 uncorrelated features for each of the 17 localities.

For modeling of the dependence between feature vectors and known crack growth rates [1] we usually use multilinear regression. It is defined by the matrix equation $\mathbf{Y} = \mathbf{FC}$, where **Y** is logarithm of crack growth rates assigned to single localities evaluated, **F** is feature matrix and **C** is vector of unknown coefficients to be estimated. The regression requires an overdetermined system. It means that number of unknown constants (the number of features +1) is significantly smaller then number of equations (which equals number of localities evaluated). In our case, we had 17 equations for 11 unknown constants. This ratio is barely sufficient for application of the method, and will be increased for calculations in future by adding further experimental inputs.

Crack growth rates estimated from the 3D feature matrix are close to corresponding values known from experiment. Of course – this is only re-estimating of input values. However, the result undoubtedly shows that the 3D reconstruction of fracture morphology reflects crack fatigue growth rate, and that we are able to express their dependence by a mathematical model.

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Structure and Texture of PVC Foils Investigated by Neutron Ddiffraction

L. Kalvoda, M. Dlouhá, P. Sedlák, S. Vratislav

ladislav.kalvoda@fjfi.cvut.cz

Department of Solid State Physics, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

The contribution links to our precedent reports and presents the recent results achieved in investigation of poly (vinyl chloride) (PVC) foils' structural order by means of wide angle neutron diffraction (WAND) and wide angle X-ray diffraction (WAXD) method.

Our results obtained so far [1-3] on samples of foils stretched uniaxially and biaxially with the main deformation directions oriented along the foil plane can be summarized as follows:

(1) The deformation process leads to orientation of polymer main chains parallel with the foil plane. The tendency is more pronounced for the equally biaxially stretched sheets. The conclusion results from the analysis of "cumulative" inverted pole figures calculated from the collected WAND patterns. The optical birefringence (OB) measurements showed that the overall level of the main chains' in-plane orientation is rising up with the total deformation ratio (ε_A).

(2) The preferential alignment of polymer chains within foil plane exists for the samples with $\varepsilon_A \geq 2.8$, as follows from OB measurements. The average direction of chains declines increasingly from the stretching direction (SD) with the ε_A ascending, even for the case of biaxially stretched samples. The maximal declination ($\alpha_0 = 25^o$) has been observed for the foil stretched with $\varepsilon_A = 2.2 \times 2.2$. The later effect likely follows from the non-uniformity of the local deformation field in the positions far from the stretched sheet center (the samples were cut out of square sheets having original size 10 x 10 cm^2).

(3) An unusually strong and sharp Bragg reflection at $d = 0.52$ nm appears in diffraction patterns of the equally biaxially stretched samples. The gross reflection intensity is observed in symmetrical reflection position; the low half-width suggests the corresponding crystalline domains' size is in range 50 - 100 nm along the scattering direction; the isolated character of the reflection speaks for the restricted dimensionality of the domains. The reflection period 0.52 nm is compatible with the two perpendicular packing periods of the PVC chains in frame of the PVC crystalline structure model, i.e. it can be interpreted as either (200) or (010) Bragg reflection.

Our further research was focused on the elucidation of the enigmatic reflection mentioned under the point 3. At first, reflection WAXD measurements were performed (Co-Kα, Siemens C56-X-A3 goniometer, Bragg-Brentano arrangement, scintillation counter, $\Theta/2\Theta$ step scan, $\Delta 2\Theta = 0.05^o$, exposition time per point $t = 5$ s) on equally biaxially stretched foil ($\varepsilon_A = 1.7 \times 1.7$, sample thickness ~ 0.35 mm). The obtained patterns did not contain any sharp Bragg maxima, but were dominated by two broad amorphous peaks at $d = 0.46$ nm and 0.35 nm related to the average distance of atomic groups and polymeric main chains, respectively. The result might suggest that the crystalline regions are more developed within the foil bulk then at the surface (which is preferentially probed in this case), but the

conclusion has to be taken with caution considering the much lower sensitivity of X-rays to positions of light elements and much higher absorption compared to thermal neutrons.

With the aim to obtain further information about the nature of objects responsible for the presence of the Bragg reflection with d = 0.52 nm in WAND patterns, the distribution of the WAND diffraction pole density (pole figure, PF) was recorded. The position of sample (ε_A = 1.7 x 1.7, stacked specimen with the total thickness ~ 3.5 mm) varied within the orientation quadrant defined by the scattering vector (κ) of the reflection set to be gradually parallel with the normal direction (ND), and the two principal stretching directions (SD1, SD2). As expected, the principal maximum of PF intensity appears at κ || ND, but there is also a weaker population of domains with the orientation spread between κ || ND and the κ || SD [3].

Our interpretation of the obtained results has to start from the character of the applied deformation and the well known rules restricting the plastic behavior of linear polymers. The equally biaxial stretching applied in-plane of foil is in an ideal case equivalent to the uniform compression deformation leading to the same foil thickness reduction. Thus, it is to be expected that either the polymer main chains (when isolated) or the whole lamellar crystals will orient themselves with their long axis perpendicular to the compression direction, i.e. the ND. But, in case of lamellar crystal (considered in the recent structural models as the largest coherent crystalline domains present in PVC, with the main chains folded perpendicular to the lamella plane), such orientation is contradictory to the observed PF distribution, no matter whether the puzzling reflection is (200) or (010). Thus, in our opinion, the collective behavior of the polymeric chains' network has to be taken in account.

At first, we can consider the recently commonly accepted micro-domain model introduced by Summers. It is based on the idea of two crystalline domain types existing within the amorphous PVC matrix: the type A, folded lamellar platelets, weakly interconnected with the surrounding matrix, and the type B, fringed micelles, interconnected much strongly by tie chains and being part of the 3D physically bound network. It has to be assumed that the network action under deformation is not only preventing the lamellas to orient perpendicular to the pressure direction, but it is orienting them along it. The supposed weak bound of lamellas to the surrounding network is in such case doubtful. The other possibility is to suppose that the lamellas are forming part of the chain network. Similar situation is known from polyethylene (PE). The composite entities created during crystallization under strain are called shish-kebab and combine lamellar plates (kebab) with the fibrillated part (shish). The orientation behavior of shish-kebab domains would be conformal with our results. On the other hand, the parallel between PE and PVC suffer from the fact that PE is highly crystalline polymer, oppose to the PVC situation. Thus, the so-called "PVC crystallinity enigma" discussed by Hobson and Windle seems to remain still unresolved and opened for further research.

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Characterization of Thin Polymer Coatings by Optical Reflection Spectroscopy

L. Kalvoda, J. Černý

ladislav.kalvoda@fjfi.cvut.cz

Department of Solid State Physics, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

Polymeric photo-resists layers are widely used in conjunction with the recent procedures of micro- and nano-patterns fabrication used e.g. in the fields of micro-electronics, opto-electronics and sensorics. The desired changes of micro-structural order taking place during the patterning process (leading to polymer solubility and complex refractive index changes) are accomplished by various photo-initiated cross-linking reactions enhancing the material density, thus leading to the remarkable shrinkage of the illuminated layer thickness, too. Combination of surface-scanning method with the standard reflection elipsometry measurement is usually applied to simultaneously analyze geometrical and optical parameters of such films. However, the approach is hardly applicable in cases when repeated exposition occurring at the same fixed spot of the layer is required. In such case, application of a fully non-destructive approach is necessary.

The contribution reports on one possible solution of the problem based on combination of attenuated total reflection (ATR) spectroscopy and reflection spectroscopy (RS) methods. The theoretical reasons for applicability of the combined ATR/RS method, as shown by set of computer simulations [1], lie undoubtedly in the different sample examination geometry used within the methods. In both cases, the identical sample structure is examined. It consists of glass support, Au layer and polymer coating. In case of ATR spectroscopy, the modified Kretchmann arrangement of total internal reflection is used with the sample optically adjoined to the basal plane of glass cylinder. Sample properties are then probed by monochromatic transversal electro-magnetic (TEM) plane wave incident from the side of the glass substrate and polymer film in case of the ATR and RS method, respectively. The minima observed in angularly-resolved ATR patterns result from successive resonant excitation of asymmetric waveguide modes within the polymeric layer. On the other hand, the broad RS patterns are mainly governed by the mutual interference of the waves reflected from the air/polymer and polymer/Au interfaces.

To demonstrate the different sensitivity of the ATR and RS methods towards the variation of thickness (D) and relative dielectric permittivity (ε) of the polymer layer, we have numerically simulated the reflectivity $R(\Theta, \varepsilon, D)$ for the both methods within the practically applicable intervals of the instrumental and material parameters [2]: $0 \leq \Theta \leq \pi/2$, $2 \leq \varepsilon \leq .3$, $0.5\mu m \leq D \leq 2.5\mu m$. The optional birefringence of the polymer material was neglected. Further structure parameters were as follows: $\varepsilon(\text{glass}) = 2.3$, $\varepsilon(\text{Au})\} = -12.3 + 1.35i$, $D(\text{Au}) = 500$ nm, $\varepsilon(\text{air}) = 1$. The character of the calculated patterns clearly differs for the two methods in question. In the ATR case, the patterns vary similarly when ε and D are changing - the influence of the both parameters is difficult to distinguish. Conversely, for the RS method, the sensitivity of the reflectance patterns to D-changes is much more pronounced. Thus, simultaneous fit of the both ATR and RS patterns by theoretical patterns obtained as solution of the corresponding Fresnel relations can help us to disassemble the ε*D dependence.

The applicability of the outlined ATR/RS method has been tested on sample of polymeric photo-resin coating successively exposed to UV-irradiation. The polymer LIRON-EO was obtained from LIR ltd, Czech Republic. Microscopic glass slide (20 x 20 x 1 mm) was used as the sample substrate. At first, 50 nm thick Au-film was vapour-deposited in vacuum. The polymer layer was then prepared by spinning from nitrobenzene solution and let to dry overnight in vacuum oven (2 Pa, 100^o C). The sample was fixed at goniometer head and successively cured with mercury lamp (Wotan BHO 200W, the total light intensity at sample surface 0.4 W/cm^2, 3.4 per cents of the power within the wavelength interval 200 - 450 nm) in 5 steps with the exposition time: 160 s, 460 s, 220 s, 210 s, and 750 s. The ATR and RS spectra were recorded after the each UV exposition.

The experimental setup used for the measurements consisted of He-Ne laser (Uniphase, 10 mW, 632,8 nm, polarization ratio 500:1) providing the primary beam. The light polarization was adjusted by combination of Fresnel rhombus and linear polarizer, the beam let to reflect on sample, and the intensity analyzed and registered by Si PIN detector. The later was placed on moving arm of goniometer (Siemens C56-X-A3, $\Theta/2\Theta$-scan, $\Delta 2\Theta = 0.05^o$). The standard lock-in detection scheme was employed (SRS DSP lock-in amplifier SR830, SR540 optical chopper). The sample re-positioning from ATR to RS arrangement and back was easily achieved by the sample 180^o rotation around the vertical axis of the goniometer. The usage of cylinder instead of prism in the Kretchmann ATR arrangement prevented the undesirable drift of the beam spot over sample surface. The beam defocusing was compensated by the cylindrical lens placed in the incident beam.

The collected data were fitted by theoretical reflection curves $R(\Theta)$ using the Newton-Raphson method. Optical absorption within the polymer layer was neglected. The following fitting strategy was applied: In the first step, the D-value was estimated from the RS spectrum (ε constant), and ε-value from the ATR spectrum (D constant). In the second step, the approximate values were simultaneously refined using both data sets. The other parameters of the substrate structure were calculated using ATR spectra recorded before the polymer deposition, and kept constant during the calculations: $\varepsilon^{glass} = 2.31$, $\varepsilon^{Au} = -9.80 + 1.26\ I$, $D^{Au} = 55$ nm. The parameters of the polymer coating obtained before irradiation (step 0) and after the successive exposures (step 1 – 5) were as follows [1]: $\varepsilon^0 = 3.0$, $D^0 = 754$ nm, $\varepsilon^1 = 2.995$, $D^1 = 748$ nm, $\varepsilon^2 = 2.953$, $D^2 = 737$ nm, $\varepsilon^3 = 2.951$, $D^3 = 732$ nm, $\varepsilon^4 = 2.92$, $D^4 = 724$ nm, $\varepsilon^5 = 2.915$, $D^5 = 689$ nm.

As expected from the exposition dozes, the calculated data shows that both the thickness and permittivity value descends approx. linearly with the exposition time. More detailed analysis of the ATR/RS data reflecting the photo-curing process is already under progress including the presumable polymer birefringence and inhomogeneous light absorption and cross-linking spatial distribution features.

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The Effect of 100 C Steam Exposure on Fracture Morphology of Zr Alloy Cladding of Fuel Rods

J. Adámek, J. Siegl, O. Kovářík

ondrej.kovarik@fjfi.cvut.cz

Faculty of Nuclear Sciences and Physical Engineering, Department of Materials, Prague, Czech Republic

The LWR fuel rod cladding is one of the primary barriers acting against the fission products release into the reactor coolant. Major structural materials employed within the fuel cladding are zirconium alloys containing of about 2 wt. % of alloying elements (Nb, Sn, Cr, Fe). These Zr-alloys are characterized with low neutron capture cross section, high resistance to corrosion in high temperature water and relatively high mechanical properties (R_m ~ 480 MPa, $R_p02 \approx 460$ MPa) [1], [2]. The mechanical behavior of Zircaloy fuel cladding degrades during nuclear reactor operation due to a combination of oxidation, hydriding, and radiation damage [3].

Under normal operation the cladding temperature is below 400 °C and the cladding alloy reacts with water forming ZrO_2 corrosion layer on the surface. At the same time the remaining hydrogen forms many different hydrides. The thickness of corrosion layer grows very slowly under these conditions (low-temperature corrosion) – a 50 μm oxide layer needs around 5 years of growth. During the loss of coolant accident (LOCA) the steam temperature rises above 1000 °C. However in a short time (given by the emergency cooling system design) the emergency cooling system is activated and the fuel cells are rapidly cooled. Under these conditions both intensive corrosion and temperature induced structural changes of the cladding material take place. For both normal and LOCA conditions, the cladding undergoes oxidation with the associated hydrogen pickup. As the total amount of hydrogen increases, hydride precipitates form preferentially near the outer (cooler) surface of the cladding, usually in the form of a continuous layer/rim containing a high concentration of discrete hydrided particles [1],[3].

The presented research is a part of extensive research programme conducted by UJP Praha, a.s. This part of the research covers the influence of 1 000 °C steam exposure on failure processes taking place in Zr-Nb alloy. The research was performed for both preoxidized cladding (simulating period of normal operation before the LOCA accident) and as-received cladding.

The specimens were prepared from reactor grade Zr-Nb alloy tubing (outer diameter 10.7 mm, wall thickness 0.75 mm). The corrosion tests were performed on 30 mm tube segments (both inner and outer surface was exposed to steam), 7 mm segments were used for ring-compression tests. Both preoxidized and as-received specimens were subjected to LOCA conditions (1 000 °C steam exposure of different duration). After the exposure, the hydrogen content was measured and ring-compression test was performed to evaluate the oxidized cladding ductility. The measurement results were related to the results of fractographic analysis. It was unambiguously proved that with increased time of exposure in 1 000 °C steam the amount of hydrogen absorbed in the alloy increased, whereas the mechanical properties of the alloy degraded significantly.

The fracture surface of cladding tube after ring-compression test consists of several morphologically different areas. Corrosion oxide layers at the outer and inner surface are

followed by layers of α-Zr[O] (oxygen stabilized α-phase), while central part of the cladding wall corresponds to transformed β-phase (β-phase formed by the high temperature during 1 000 C steam exposure and transformed back to α-phase during rapid cooling). The surface layer of α-Zr[O] phase grows immediately after exposing the specimen to 1 000 °C steam. Both α-Zr[O] grain size and thickness of α-Zr[O] layer increase with increasing time of exposure in overheated steam. The α-Zr[O] fails mostly by transgranular cleavage mechanism and/or intergranular decohesion. The primary material fracture micromorphology is characterized by ductile dimples in cases of low hydrogen contents (i.e., either before 1 000 °C steam exposure or after very short exposure). With increasing exposure time, the share of ductile fracture of transformed β-phase decreases and fracture micromorphology corresponds increasingly better to failure processes without any plastic deformation. It can be concluded, that the observed changes of failure mechanism of transformed β-phase result from the microstructure changes. The microstructure changes of transformed β-phase are a consequence of many factors, among which the influence of absorbed hydrogen amount is generally believed to be the most important. The changes of failure mechanisms of transformed β-phase together with α-Zr[O] layer growth (i.e., with increasing share of intergranular decohesion) result in gradual decrease of ductility of claddings.

The preoxidized specimens generally showed lower mechanical property degradation than the as-received specimens due to hydrogen and oxygen absorption rate limited by the oxide layer. For both types of specimens the changes of mechanical properties took place during the first 60 minutes of 1 000 °C steam exposure. Beyond this point, no significant changes of mechanical properties were detected.

The oxide layer generated during normal operation protects the fuel rod cladding against the LOCA accident conditions i.e. against the exposure to high temperature steam (over 1 000 °C). The positive effect of the oxide layer is noticeable especially during short time exposure to 1 000 °C steam.

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High-Temperature Characteristics Degradation of Modified High-Temperature Steel T23

M. Svobodová*, J. Kudrman, J. Douda****

M.Svobodova@sh.cvut.cz

*Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

**UJP PRAHA a.s., Nad Kamínkou 1345, 156 10 Prague - Zbraslav, Czech Republic

Materials "ageing" presents chemical and physical changes that sooner or later occur in a material during its process exploitation, if not a part of a process, as, e.g. hardening. These changes are time-dependent, like brittleness and the change of yield and breaking strength, being followed by impairing processes like fatigue and creep failure, corrosion drop, corrosion cracking, and wear. Then "controlled ageing" presents a general system of operation parameters monitoring and archiving, material characteristics and their changes during process monitoring, and material failure monitoring (small cracks, corrosion, wear, etc.). An integral part of this is then systematic processing of these data by difficult predictive computations. To make full use of these computations, which should show the real condition of the monitoring appliance, a sufficient number of input data is necessary. The output then is the optimal operational regime and inspection system (i.e., the planned outage) of the device during its long-time process. The use of predictive computing results could mean savings due to over fulfilment of the rated structural service life or a possibility of preventing damage creation.

This research was performed within a wide researching program focusing on creating a material database by simulation of the operating-degradation processes induced by temperature and the ambient atmosphere effects. The main attention was focused on monitoring the structural and mechanical characteristics changes, and on measuring the growth kinetics of oxidation and decarburization layer. Steel T23 was compared with another alloyed structural CrMo(V) steels.

In all the engineering metal materials there are generally under way some changes of the inner structure due to diffusion processes; these changes also induce changes of mechanical characteristics. Therefore, the structure processes are conditioned by a specific minimal temperature and they concern, first of all, the machinery and components operating at elevated temperatures. The basic heat-activated process is the well-known diffusion, and the basic degradation process is the gradual coarsening of the hardening phase particles. The latter leads to change of the free interparticle distance. With its growth, the slip dislocation motion resistance generally decreases, and, thereby, the alloy strength. Also, an oxide production at higher temperatures has degradation effects leading to thinning the wall of operating pieces, to the creation of notches, etc. The oxidation in steels is often attended by surface decarburization.

When monitoring the oxidation, we can, in principle, choose between two basically equivalent models of the oxidation layer growth kinetics under isothermal conditions. The first one, the logarithmic law, is used to describe the low-temperature oxidation; the second one, the parabolic law, of the evaluated temperature oxidation (the logarithmic law has two mathematical modifications) [1].

T23 (modification of steel 15 313 alloyed with W 1.45 – 1.75, V 0.20 – 0.30, Nb 0.02 – 0.08, N max.0.03 w.%) is a new kind of promising high-quality structural steel. Thanks to this percentage of W, V and Nb, steel T23 in comparison with steel 15 313 is useful at higher operating temperatures, and it has better creep characteristics. Therefore, it presents a suitable material for, e.g., boiling pipeline or superheater components.

Within our research, the specimens were prepared and the long-time annealing was started. Cut specimens from the steel tubes were exposed in ovens to temperatures of 600°C, 650°C, and 700°C for periods of 10h, 30h, 100h, 300h, 1 000h and 3 000h. After the annealing the scantlings were axially cut. On this cut there was prepared a scratch pattern, where the measurements of oxidation, decarburization layer thickness, and hardness were taken, and the microstructure was observed. For the decarburization measurement etching was necessary.

After the initial treatment steel T23 has the tempered bainitic microstructure. Long-time annealing leads to gradual coarsening of the separated carbidic particles on grain boundaries and to precipitation of new carbides inside the grains [2]. This leads to a change of the average free interparticle distance and the hardness, and two cooperative processes are involved: precipitation of stable carbides (mainly W) and coincident coarsening of Cr carbides precipitated earlier. The changes of mechanical characteristics then depend on the temperature, i.e., the dominant mechanism.

At first, the results can be used to classify the degradation grade on structural parts in service. Due to mechanical characteristics measurement of the material in the actual condition implicit information about the structural degradation state can be obtained, and thus the global degradation state of the material. The following analysis determines the part's structural life, and, alternatively, the planned inspection program. At second, the possibility was demonstrated of using the empirical relations, obtained by regression analysis of measured kinetics relations, in oxidation and decarburization kinetics prediction of popular heat-resistant steels.

This research has indicated the necessity of a complex approach to the way of alloying high-quality structural heat-resistant CrMo(V) steels, to the choice of the chemical composition for the new steel to be developed. Also, it has confirmed the significant role of chemical composition in general, e.g., alloying with wolfram improves the creep behaviour.

The results of this study can be included in the database of the material degradation simulation in a process. The determined time and temperature relations can be decisive for the operating life.

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Determination of Water and Salt Transport Parameters of Porous Building Materials Using Measured Water and Salt Concentration Profiles

Z.. Pavlík, M. Jiřičková, R. Černý

pavlikz@fsv.cvut.cz

Department of Sttructural Mechanics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

One of the most severe durability problems in civil engineering is the deterioration of reinforced concrete structures through corrosion of the reinforcing steel. This process is accelerated by the presence of chloride ions which may be transported from the concrete surface to the reinforcing steel. Therefore, for estimation of the durability of structures, it is highly desirable to quantify and simulate the chloride diffusion process in concrete.

In this work, an inverse analysis of coupled water and salt transport in material on the cement basis in order to identify parameters driving the process of salt solution transport through the porous structure is presented.

The mechanism of salt solution transport is described by Bear and Bachmat diffusion-advection model [1] taking into account not only the influence of moisture flow on salt transport but also the effect of bonded salt on pore walls. System of two parabolic equations describing the salt and water mass balance is subjected to an inverse analysis in a similar way as for one parabolic equation, provided the initial and boundary conditions are simply enough, and the material parameters (moisture diffusivity, salt diffusion coefficient) are identified as functions of water content and salt concentration. The simplest possibility of such an inverse analysis is an extension of the Boltzmann-Matano treatment [2] under the same assumptions of constant initial conditions and Dirichlet boundary conditions on both ends of the specimen for both moisture content and salt concentration where one of the Dirichlet boundary conditions is equal to the initial condition.

For the laboratory experiments, the samples of cement mortar were used. The composition of the mixture of cement mortar for one charge was the following: Portland cement CEM I 52.5 R – 450 g, natural quartz sand with continuous granulometry I, II, III (the total screen residue on 1.6 mm 2%, on 1.0 mm 35%, on 0.50 mm 66%, on 0.16 mm 85%, on 0.08 mm 99.3% - according to the Czech standard ČSN 72 1208) - 1350 g, water – 225 g. For the realization of suction experiments, the freshly blended mixture was put into 40 x 40 x 160 mm moulds and compacted by ten impacts of the compactor. After one day the samples were unmoulded and stored in a 100% relative humidity environment for 27 days. Then, the samples were dried, left for several weeks freely in the laboratory (relative humidity 45%, temperature between 20 and 22°C) so that they achieved equilibrium moisture content, and finally all their lateral sides were water and vapor-proof insulated by an epoxy varnish. The samples for ion binding isotherm measurement were cut from cast beams, the samples dimension was 40 x 40 x 10 mm.

The arrangement of the experiment for determination of salt concentration profiles and water suction curves was analogous with standard water suction experiments. The samples were exposed by their 40 x 40 mm face to the penetrating medium (NaCl solution with the concentration of 18.195 g Cl^- in one liter of the solution or distilled water). Duration of the experiment was 1 hour, 24 hours and 7 days for three different groups of samples. After this time, the samples were cut into 8 pieces and in each piece water content and chloride concentration were measured. Moisture content was determined by the gravimetric method

using weighing the moist and dried specimens. In the determination of chloride concentration, the particular samples were after drying first ground by a vibration mill so that grains smaller than 0.063 mm were obtained. Then 10 g of the ground sample was leached 30 minutes in 180 ml of 80°C warm distilled water, a magnetic stirrer was used to speed up the leaching process. The content of chlorides in the leach was determined by a turbidity method, i.e. titration of the volumetric solution of mercuric nitrate on the sodium nitroprusside indicator. The first turbidity indicated the equivalence point. On the basis of consumption of mercuric nitrate, the total amount of watersoluble chlorides in the sample was determined and related to the mass of the hardened mortar.

A slight modification of the Tang and Nilsson adsorption method [3] using the specimens of more realistic dimensions, was chosen for the determination of ion binding isotherms [4]. From the standard 1M-NaCl solution, other diluted solutions, with the concentrations between 0.005M and 0.8M, were prepared. The exact concentration of chlorides in the solution was determined with ion selective electrodes (ISE). The samples were placed into the cups with 200 ml chloride solution. Then they were stored in laboratory at the temperature of 22±2°C to achieve equilibrium. The solutions were analyzed after 6 months. The concentration of ions in the solution after equilibration was determined again with an ion selective electrode (ISE).

Experimentally determined NaCl concentration profiles and moisture profiles were used for identification of salt diffusion coefficient and moisture diffusivity on the basis of inverse analysis.

The obtained results have proved that water transport was affected by the presence of salt in water in a relatively low extent in our case. This was clearly a consequence of the relatively low salt concentration in the solution which did not lead yet to a significant change in the viscosity of the liquid phase. The calculated salt diffusion coefficients were quite high, typically three orders of magnitude higher than the diffusion coefficients of most ions in free water. Therefore, the common diffusion mechanism was probably not the only driving force for the salt transport within the liquid phase and some other driving forces were taking place here. The electromigration could be considered as one of them.

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Development of Fiber Optic Sensor of Alkali Ions in Water

R. Klepáček, L. Kalvoda

rudolf.klepacek@seznam.cz

Department of Solid State Engineering, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2

The presented research is focused on development of novel fibre optic sensor suitable for detection of alkali metal ions (Na^+, K^+, Ca^{2+}, Mg^{2+}) in various water-based solutions. The physical principle of the detection system under development utilizes the light-guiding properties of optical fibre. The later is a dielectric waveguide which consists of two parts – core and cover. The guided light is propagating in form of discrete electromagnetic (EM) modes trough the fibre core by series of total reflections occurring at the core/cover interface. The internal reflection events are accompanied by creation of special non-propagating evanescent electro-magnetic field components spreading through interface into the fibre cover. The field creates an optical link between the core and the cover of the fibre. Continuity conditions have to be fulfilled at the interface, and the electromagnetic modes propagating through the core are influenced by the "status" of the evanescent field existing inside the cover matrix. So, for instance, if the spectral distribution of guided electromagnetic modes is measured, the optional changes of light absorption inside the fibre cover can be also deduced.

The upper described scheme is used as the working principle of the so-called intrinsic absorption-based fibre optic sensors. In such systems, the cover has to be permeable for the target substance (analyte), and, when present, it has to show selective, reversible, concentration dependent spectral absorption changes. The simplest way how such cover properties can be ensured is to incorporate a proper doping agent (reagent) into the cover matrix. This reagent has to posses the desired initial light absorption spectrum, as well as the capability to (selectively, reversibly) chemically react with the analyte (the selected alkali-metal ion type in our case) giving rise to a reaction product with different spectral absorption band structure. Concentration-driven reaction between the analyte and reagent moiety is optimal from the point of subsequent analyte concentration analyses. In such case, calibration curve can be obtained measuring changes of monochromatic light intensity (with the properly selected wavelength λ) in presence of precisely defined concentration of analyte. The sensor system calibrated in such way then allows for conversion of "chemical information" (analyte concentration) onto the information optical.

The mentioned requirements imply that the suitable reagent structure applicable for alkali ion detection (M^+) has to combine ionophore (reaction selectivity) and chromophore (spectral changes in the VIS-NIR region suitable for fibre optic detection) functionality. The reaction scheme may look as:

$$\begin{aligned} \text{Reagent-H} + M^+ &\leftrightarrow (\text{Reagent- M}) + H^+, \\ A(\lambda) + M &\rightarrow A'(\lambda). \end{aligned} \qquad (1)$$

Here, A and A' is the absorption of the original and resulting chromoionophore, respectively. The exchange of M^+ and H^+ ions occurs at the coating/water interface.

Unfortunatelly, such combination is difficult to achieve in case of alkali ions used as the target group, mainly because of the highly restricted capability of the later to form complex compounds. Proper chromo-functionalization of existing ionophores, such as crowns, calixarenes, or cryptands is considered as the very complicated chemical task, for their complex-forming ability is closely related to their geometrical structure.

The drawback can be overcome applying the sensor system architecture proposed by Morf and coworkers [1]. The scheme chains together the primary reaction of the analyte with ionophore and the secondary proton-assisted conversion of a pH-sensitive chromophore (B):

$$\text{Reagent} + M^+ + BH \leftrightarrow (\text{reagent-}\ M)^+ + B^- + H^+. \qquad (2)$$

The proton peeling reaction of the chromophore (pH-indicator) depends on the internal pH-value of the coating membrane, which must be carefully tuned by presence of suitable lipophilic anion agent to ensure the proper sensing function.

Recently, we have reported on the results of our experiments focused on characterization of complex-forming properties of p-tert-butyl calix[4]arene ethylester (TBCE) in presence of alkali ions [2, 3, 4]. The observed reaction suggest that some combination of (1) and (2) is also possible with TBCE ($M^+ = Na^+, K^+$):

$$\text{TBCE-H} + M^+ + B^- \xleftrightarrow{H^+, OH^-} \text{TBCE-M} + HB \qquad (3)$$

The reaction (3) proceeds at basic conditions compatible with the de-protonated form of the indicator B. Diffusion of analyte moieties into the coating membrane has to be again compensated by the flow of other positive ions in the opposite direction to preserve the total electrostatic equilibrium of the system.

Selection of the pH-indicator with the proper threshold point is crucial for the optimal function of the reaction scheme (3). We have tested four different pH-sensitive dyes: acid green (AG), bromocresole purple (BCP), nile blue (NB) and methylthymol blue (MTB), from the point of miscibility with and reactivity within PVC membrane matrix used as fibre coating. The measurements were performed on short fibre sections (12 cm long, 500 μm core diameter, coated by dipping and removal of the sample fibre from PVC/dye mixed solution in THF) exposed to series of pH-buffers (Britton-Robinson mixtures). The absorption spectra were recorded with Ocean Optics S1000 fibre optic spectrometer. Two of the dyes, AG and MTB, showed only very limited spectral reaction on the pH-changes (reflecting the restricted reactivity within the PVC matrix). In opposite, the reaction of BCP and NB was pronounced and the observed threshold point (pH_T) matched closely with those reported for the ethanol solution of dye. The observed values were: $pH_T^{BCP} = 6.0$, $pH_T^{NB} = 10.5$. Thus, regarding the reaction (3), especially the NB indicator seems to be promising candidate for our system.

The forthcoming research will be directed towards tailoring the full co-operative reaction scheme (3) to smoothly run within solid PVC matrix. Other possible ionophores will be tested, too.

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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

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Section 6

MECHANICS
&
THERMODYNAMICS

Monolens 3-D Imaging and Measurement System

J. Hošek

Jan.Hosek@fs.cvut.cz

Department of Instrumentation and Control Engineering, Division of Precision Mechanics and Optics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech

Determination of spherical object in space is very important in many technical or production applications. The spherical objects of the interest may consist of solid particles, spray of the liquid droplets or spherical bubbles of gas in liquid or solid phase in general. Observation and determination of dimension and position of these objects can affect or be the bases for optimization of the technological processes like chemical reactors, where homogeneous distribution of bubbles is often demanded in multiphase reacting systems. On the other hand, there are technologies where the presence of multiphase system can indicate a technological problem, for example in hydrodynamic systems or in glass production industry. Different experimental systems, which allow to determination of the position and radius of the spherical object in 3D space, are still under development. They are based on the two-camera system in the simplest setting, for example like stereo PIV systems, but there are still in development another more sophisticated system like laser light scattering method [1], holographic method [2]. The possibility of utilization of these methods is limited caused by complicated set-up adjustment in multi-instrument system or the price of the system parts like lasers, high speed or high resolution cameras. It is reason of recent new experimental and measurement methods development, which are able to measure objects in 3D space with only single camera and common polychromatic light source. Determination of 3D coordination information is there for example calculated from time [3] or optical [4] parameters taken from single camera set-up.

This paper presents a new optical system, which allow to determinate radius and position of a number of spherical shape objects in 3D-observation space using the only one monolens camera system. The principle of the system is based on anamorphotic optical system and appropriate data processing algorithm. The goal of the presented work was to develop the first experimental and measurement set-up of this method, which confirm the theoretical expectation and allow to perform the first experimental measurement and experiences. It is necessary, especially, to verify the precision and repeatability of the proposed system and to find optimal illumination and imagination condition, for the next development and presentation of the system.

A special experimental vessel was design, construct and mounted for presented experimental method testing. This experimental bottle uses like anamorphotic part of the camera optical system consists of standard camera lens and cylinder meniscus glass-liquid lens. Experimental vessel was design to minimize unwonted illumination of the camera pictures caused by total reflection on the spheres objects of main illumination source rays. It is possible to use direct or side-indirect illumination scheme of the observed 3D space too. The experimental vessel was design like top and bottom open in order it was possible to locate any kind of spherical object inside there.

Special precise x, y, z, movable support was design for the precision and repeatability measurement as an auxiliary system of the experimental vessel. The possibility of precision and repeatability of the system position determinations was tested by measurement of a glass

and steel sphere mounted on x, y, z movable support. Images of the measured volume with spherical object were taken with different camera systems. We used B/W CCD camera, C-B/W high sensitive CCD camera, and digital camera Olympus C-50 ZOOM and Olympus E-300 high resolution 8Mpix camera. Captured images was corrected to image distortion and processed with special software for determination X, Y position parameters of each spherical object in the image. The radius and position of objects in 3D space then was computed with another algorithm written in Matlab system.

The first measurement and data processing are demonstrated in multiphase bubble-liquid system with different bubble density. We expect the presented system will be able to use for the determination of the objects velocity as well as dimension change in the case of application of time-resolved photography.

Due to the fact that presented method has been never published in any publication before, it was applied for patent for future licensing of this experimental method.

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Laboratory Model of a Mechatronic Beam with Controllable Stiffness

M. Nečas, M. Valášek*

m.necas@fs.cvut.cz

* Department of Mechanics, Faculty of Mechanical Engineering, Czech Technical University, Karlovo nám. 13, 12135 Prague 2, Czech Republic

The research of active vibration control in areas of machine tools chatter reduction has mainly been driven by an advancement in solid state actuators technology and associated power electronics, namely switched power amplifiers. The placement of discrete solid state actuators to control vibration of typically lightly damped structures (e.g. welded machine tool frames) along with linear motor technology presents the current state of the art and is the first step to a development of composite materials with distributed sensing and force actuation capabilities.

In the near future magnetic and solid state technologies will be determinant factors for the further improvement of machining productivity and precision.

The most predominantly used solid state actuation technology in active vibration control today is based on a Lead(Pb)-Zincornium(Zr)-Titanate(Ti) oxide ceramic (PZT) piesostacks. In principle these behave as "moving condensators" where stacked piezo rings make use of the increase of the ceramic thickness in direction of the applied electrical field (d33 effect). The maximum strain achievable today is about (1-2 ‰) and up to recently, large force (50000 N), limited stroke actuators were available (typically 30-150 μm). The most recently developed actuators achieve a stroke of 1000 μm with forces ranging up to 70000 N and with a corresponding actuator length of 500 mm. Shortly achievable power output of such actuators can be up to 0.1 MW in 50 μs pulse [1] .

The piezoelectric technology opens up the whole range of important applications. A very good example related to piezo active chatter reduction can be found in a work of Erdal Unver et al. [2]. In this DARPA co-founded project they developed an active boring bar clamp and achieved an improvement in manufactured surface roughness finish (boring bars 8-10 length-to-diameter) to go from 632.2 μm down to 20.5 μm in controlled case. A.Woronko et al. [3] developed a piezoelectric tool actuator for precision machining on conventional CNC lathes. Utilizing a sliding mode controller they achieve position tracking bandwidth up to 200Hz and disturbance rejection X/Fd in orders of 5nm/N.

In our research project we propose an active piezoactuator beam structure that is potentially able to resist end-point disturbance forces (e.g. from a milling process) and effectively lower susceptibility to chatter vibrations. The structure consists of two beams (primary and secondary). The main idea is based on a possibility to derive additional structural stiffness of the primary beam by permitting the secondary beam to deform while the piezoactuator counter-compensates the force disturbance acting on the first beam. This way it is possible to dramatically improve the stiffness of the first beam.

The prepared lab model is in the stage of a build-up. It comprises of a steel structure (primary and secondary beam) rigidly attached to the foundation and the piezoactuator PI 843.40 (actuation stroke 60 μm, max. force 800 N) connected in between the primary and the secondary beam. The piezoactuator contains internal displacement sensor and the deflection

of the secondary beam is also measured. Disturbance force is to be generated by a magneto-dynamic disturbance actuator acting on the controlled structure (first beam).

The control strategy is based on a compensation principle. However, the robustness of such control, especially the possible instability with respect to phase and magnitude discrepancies in measured and real force disturbances has to be investigated. The planned approach to improve the robustness will be based on the work of C. Brecher et al. [4], where disturbance observer and LMS adaptive filter concepts led to a significant improvement of the control robustness.

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Traversing System for Use in Hydrodynamic Analogy

M. Schmirler, H. Netřebská, J. Ježek

michal.schmirler@centrum.cz

Department of Fluid Dynamics and Power Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

Hydrodynamic analogy is very old analogy between 2D supersonic gas flow and flow of liquid in a thin layer over horizontal canal ground. As an experiment liquid we usually use water, because of her price and physical qualities. On principle we can use any other liquid, because the results are not depended on liquid density.

Water canal, called Hydrodynamic analogon too, was built and put into operation during diploma work solution, by author of this project. Now this gauging machinery is working in laboratory hall of Department of Fluid Dynamics and Power Engineering.

Basic principle of hydrodynamic analogy consists in water surface wave speed, which is equal to

$$a = \sqrt{gh}, \qquad \begin{array}{l} g \ldots gravitational\ cons. \\ h \ldots water\ depth \end{array}$$

With hydrodynamic analogy we can investigate only 2D flow, because the wave distribution on water surface is only 2D too. As next limitation factor we can take reality, that this analogy is valid only for hypothetical gases with adiabatic exponent $\kappa = 2$. So in air flow modeling we have to expect some measurement errors. For Mach number up to 2, we can ignore this errors, for $Ma > 2$ is hydrodynamic analogy rather question of wave shapes and flow structure.

There are results of gauging machinery innovation and of some measuring with new blade cascade models presented in this paper, by the help of new traversing system. So we can solve flow between stator and rotor turbine blades, as well as pressure distribution and Mach number evolution along the blades. Especially blade cascades NT 1050 and SE 1050.

Models

Our models for use in hydrodynamic analogy have in order a chord size of 20 centimeters. Experimental model set consists of 5 blades in stator blade cascade and 5 blades in turbine blade cascade. Blades were made of balsa wooden and covered of PVC thin layer.

The stator blade cascade, with the profile NT 1050, was still fixed to the water canal with stagger angle of 46° and pitch to chord ratio of 0,56. Then the turbine blades SE 1050 were mounted to the traversing system's support. SE 1050 has a inlet angle of 70° and stagger angle of 37°. So we can to realize the flow between both of this blade cascades and investigate the interactions between them.

Experiment

The main experiment was divided into follow steps. In the first step was realized the measuring in the stator blade cascade separately and some results were compared with dates outgoing from real supersonic tunnel and with numerical results. All for gases with $\kappa = 2$ off course. In the next step the similar measurements in the turbine blade cascade were made and results compared with other methods as well. After that, both of this blade cascades were measured together. Thanks to the new traversing system we could realize measuring in the hydrodynamic analogon of the third type, thus the analogon with flowing water and with moving models too. This traversing system is designed for PC controlling.

Experiment results

Most of results of this method have a graphical character, which isn't possible to show in this abstract. Complete blade cascades were measured with inlet Mach number of 0, 3.

Comparison the method of hydrodynamic analogy and other methods on the same blade cascade gave us very credit agreements.

Graphical results will be presented in the Workshop poster form.

Conclusion

During the solution of this project was engineered the complete traversing system for use in hydrodynamic analogy and in other experimental methods. By the help of this traversing system could be solved the question of interaction between static (NT 1050) and turbine (SE 1050) blade cascade.

Experiment results give us very good agreements with other methods. In the next time will be realize the pressure and Mach number investigation along both of blades in this blade cascade.

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Piercer Transducer for in Vivo of Bone Displacement Measurement

K. Vítek

karel.vitek@fs.cvut.cz

Department of Mechanics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technicka 4, 166 07 Prague 6, Czech Republic

Experimental assessment of forces exerted in the bones inside the living human organism is rather complicated since the exact structure, material properties and shape of a concrete bone are time variable and therefore the bone is more or less unknown object. Elastic constants of the living, and subsequently, dead bone vary even for one particular person. The Young's modulus of elasticity $E(z, y)$ in the bone axial direction, distributed over the bone cross-section from 6 to 10 GPa, see [1]. When modeling the bone as a thick shell, the modulus of elasticity is mainly influenced by the size of specimen, which elastic constants were to be measured.

The measurement principle of the axially loaded bone is implemented by the several piercer gauges which, similarly to a needle, pass through the soft tissue and stick into the bone surface. This is a type of a semi destructive application of the gauges, because the bone is only slightly damaged by the piercer gauges. Measuring points, which are created all around the perimeter of the bone, induct the coordinate system of the oriented gauge and can be used for better estimation of the real cross-section shape. In the measured points, axial strains of the bone surface were supposed to be measured by the pierced gauges. Over the bone cross-section, in the measured points, a regress surface $\varepsilon(z, y)$ was defined by the measured axial strains. It was supposed that Hook's Law could be applied for the bone material which resulted in the axial normal stress expression by

$$\sigma(z, y) = E(z, y) \cdot \varepsilon(z, y) .$$

Further integration of the axial strain (the axial normal stress, respectively) over the bone cross-section A yielded the normal force

$$N = \int_A \sigma(y, z) \cdot dA$$

and two bending moment components

$$M_y = \int_A \sigma(z, y) \cdot z \cdot dA \ldots\ldots\ldots M_z = \int_A \sigma(z, y) \cdot y \cdot dA$$

distributions in the bone examined.

The piercing gauge structure was composed of two parallel needles fixed to the prick. Close to the needles clamping, sets of strain gauges were installed, which were calibrated for

the axial strain measurement after their application into the bone. The needle gauge prototypes was made and it has a linear characteristic, see[3], [4].

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Identification of Force Transducers

T. Vítek*, K. Doubrava, T. Mareš**, M. Španiel**, K. Vítek****

karel.vitek@fs.cvut.cz

* Department of Control Engineering, Faculty of Electrical Engineering, CTU in Prague, Technicka 2, 166 07 Prague, Czech Republic

** Department of Mechanics, Faculty of Mechanical Engineering, CTU in Prague, Technicka 4, 166 07 Prague, Czech Republic

Demands on more complex sensors - multiaxial force transducers are usually matter of custom design and manufacturing and their price is generally substantially higher and much. Design of multiaxial transducers leads towards optimization techniques, because the necessary criteria, which have to be fulfilled, have various features. High-strength steel with low material hysteresis, closely fitting the Hooke's law, are mostly used for bodies of sensors.

Further it is supposed that an identification of a force vector F that loads a reference place is realized through measuring of a strain ε on the transducer using strain gages. A force vector F is composed of three force F_x, F_y, F_z and three momentum M_x, M_y, M_z components who are mutually independent. Ordering of directions of the strain gages that are used for measuring on the beam is analyzed in [1].

Each of the sensors reflects every kind of load that is measuring device exposed to. Device can be practically exposed to six independent kinds of load. We further assume that the final value of the sensor ε_i is a linear combination of individual contributions that are done by the individual loads¨. The F_k denotes a force in the direction of the coordinates, M_k denotes a momentum to axis x, y and z and finally c_{ik} marks the sensitivity of i-th sensor to the k-th variable. Supposing m measuring sensors there are m linear equations in matrix form like one that contain $m\times 6$ unknown coefficients c_{ik} $\quad [C]\cdot[F]=[\varepsilon]$.

The sensitivities c_{ik} are constant time invariant values that need to be identified by an experiment. To identify these values we need to load a measuring device by well-known forces and moments independently one by one. Suppose we have an independent loading force $\overline{F}_y$ and all other influencing powers and moments are zero. In that case we measure a value on all the sensors denoted like $\varepsilon_{\overline{F}_y}$. Putting this case into equation yields

$$\begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} & c_{15} & c_{16} \\ \vdots & & & & & \vdots \\ c_{m1} & c_{m2} & c_{m3} & c_{m4} & c_{m5} & c_{m6} \end{bmatrix} \begin{bmatrix} 0 \\ \overline{F}_y \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \varepsilon_{\overline{F}_y} \quad \text{and then} \quad \begin{bmatrix} c_{12} \\ \vdots \\ c_{m2} \end{bmatrix} \overline{F}_y = \varepsilon_{\overline{F}_y}.$$

The magnitude of load $\overline{F}_y$ is known with its relative error $\delta_{\overline{F}_y}$. Sensors values $\varepsilon_{\overline{F}_y}$ evoked by load $\overline{F}_y$ are known with their relative error $\delta_{\varepsilon_{\overline{F}_y}}$. When dividing, we have to find relative error δ_{i2} of c_{i2} from relative errors of the dividend and divider like $\delta_{i2} = \sqrt{\left(\delta_{\varepsilon_i}\right)^2 + \left(\delta_{\overline{F}}\right)^2}$.

To get all the coefficients of matrix $\mathbf{C}$, we have to make six measurements, caused each time just by one isolated force or momentum. Product of this is a sensitivity matrix together with vector δ of the relative uncertainty of individual matrix components. Values of components of matrix $\mathbf{C}$ belong to interval $\hat{c}_{ij} \in \left(c_{ij}\left(1-\delta_{ij}\right), c_{ij}\left(1+\delta_{ij}\right)\right)$.

If we impose the specimen to the unknown combination of forces and applied moments it evokes a sensor reaction denoted by ε_u with relative uncertainty δ_ε. Unknown forces vector and moments F, which has n components, must fulfill the equation $\mathbf{C} \cdot F = \varepsilon_u$. To provide all the unknown forces we have to have at least n identified sensors. To test the existence of solution, the rank of matrix $\mathbf{C}$ must be equal $rank(\mathbf{C}) = n$.

On the other hand number of sensors m can be larger than n. In that case we have more equations than variables. As all the sensitivities are produced by the identification its clear that the Frobenius law $rank(\mathbf{C}) = rank([\mathbf{C}, \varepsilon_u])$ is not fulfilled as the vector ε_u is linearly independent on columns of matrix $\mathbf{C}$. As the components of matrix $\mathbf{C}$ and components of vector ε_u are all known imprecisely, we should solve the problem using the Total Least Squares algorithm (TLS) formulated like $\min_{\forall[\hat{\mathbf{C}},\hat{\boldsymbol{\varepsilon}}]\in\Re^{m\times(n+1)}} \left\{ \left\| [\mathbf{C}, \varepsilon_u] - [\hat{\mathbf{C}}, \hat{\varepsilon}] \right\|_F : \hat{\varepsilon} \in R(\hat{\mathbf{C}}) \right\}$, where $\hat{\mathbf{C}}$ is more concrete matrix $\mathbf{C}$ and $\hat{\varepsilon}$ are more appropriate measured values, that fulfills a Frobenius law. If we find a matrices $\hat{\mathbf{C}}$ and $\hat{\varepsilon}$ than unknown vector F^* can be found by solving a equation system $\hat{\mathbf{C}} \cdot F^* = \hat{\varepsilon}$. Solution of the problem can be found in [2].

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Capillary Flow Models and their Experimental Verification within the Cooling Circuit working with Fluiroineret Refrigerant

V. Vinš*, V. Vacek*

vaclav.vacek@cern.ch

*Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Capillaries are tubes of the small inner diameter mostly between 0.5 - 1.5 mm and with the length about 1.5 - 5 m. Due to their simple design and low cost they are widely used in small cooling systems such as household refrigerants and freezers. Capillary usually substitutes more expensive and complex thermostatic valve. High pressure of the liquid refrigerant at the condenser side is reduced through the capillary tube to the low pressure of evaporation.

The Department of Physics has been participating in design of the vapor cooling systems for Pixel and SCT detectors at the International nuclear research center (CERN). Many measurements of several prototype parts, such as the heat exchangers, evaporators and capillary tubes, have been performed during several past years. Most of these circuits use the combination of the capillary tube and the pressure reduction valve. The cooling circuits work mostly with fluoroinert refrigerants ($C_n F_{(2n+2)}$).

The main goal of this study was to provide deeper knowledge of the two-phase capillary flow. A set of experimental measurements were performed at CERN on a real circuit working with the fluoroinert C_3F_8 in a completely dry oil-free mode. All measured capillaries were insulated with Armaflex material to be assumed as adiabatic devices in most cases.

Theoretical part of our activity was aimed to improve capillary flow models, some of them described in [1]. The study comprises certain modifications of previous models presented in the literature (mainly [2] and [3]). The model assumes steady state capillary flow inside two equilibrium regions. Obtained solution describes all main flow characteristics along capillary tube (pressure, temperature, vapor quality, etc.). Both homogeneous and separated flow through adiabatic or non-adiabatic capillary tube is possible to solve via simulation. Various optional correlations of empirical coefficients were implemented into the model algorithm (two-phase viscosity, friction factor, slip ratio, frictional pressure gradient).

The simplified numerical model of the capillary flow with both homogeneous sub-cooled liquid and two-phase regions presented in [4] has been modified. The model allows us to solve both the critical length of the capillary tube and the critical mass flow of the refrigerant at given inner diameter of the capillary with all standard parameters being fixed.

There were considered two different experimental strategies for the capillary flow measurement.

a) Two, in-house made, copper capillaries were divided into uneven length sections. The temperatures at the end of each capillary section were measured with calibrated mini Pt1000 and NTC sensors inserted at the level of the inner surface of the capillary tube. Pressure drops were monitored across the section and three extra absolute pressure sensors were also installed for the reference. The length of the sections enlarged in the expected liquid

phase flow region and at further sections shortened due to the expected two-phase flow region. Such measurements provided clear understanding of the pressure and temperature profile over the real capillary. Length of the investigated two-phase flow region increased with higher temperature and lower pressure at the capillary inlet. The metastable phenomenon inside the liquid region was detected in several measured cases. A very good agreement was achieved between the pressure drop measured inside the two-phase region and the theoretical pressure prediction calculated from the measured temperatures through the refrigerant saturation properties.

b) Set of measurements considered non-divided capillaries of different length and inner diameter. Consequently, the absolute pressure sensors could have been installed only at the inlet and outlet of the capillary. The temperature sensors, mostly NTCs, were attached just at the capillary outer surface. Such approach brought almost negligible error into the measurement accuracy inside the two-phase region due to the evaporation of the flowing refrigerant and thin capillary wall (wall thickness ~ 200 μm). Obtained results help to better understand the influence of all main capillary flow characteristics (the inlet and outlet pressure and the inlet temperature) on the refrigerant flow.

The experimental measurements were compared with theoretical results of the numerical models. Fairly good agreement was obtained in most studied cases, except the one with strongly sub-cooled refrigerant at the capillary inlet, where the ambient conditions inside the laboratory caused non-negligible difference between the modeled temperature development and the real data. At the end of this study the general influence of changes applied to the three main parameters of the capillary behavior was studied: mass flow of the refrigerant, capillary inner diameter and the refrigerant temperature at the capillary inlet.

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Sources of Noise -Thermostatic Valves

M. Kučera, R. Nový

miroslav.kucera@fs.cvut.cz

Department of Environmental Engineering, Czech Technical University in Prague,

Technická 4, 166 07, Prague 6, Czech Republic

The control of the performance of heating radiators is performed by regulating the flow of heating water. By fitting a thermostatic valve at the entry to a heating radiator the process of regulation of the flow of water (closing of valve) is accompanied by an increase of local losses, occurrence of cavitations and subsequent production of noise and its transfer to the heating radiator. The radiator due to its large surface area is an ideal medium for the transmission of noise into dwelling spaces.

In recent years owners of residential buildings are able to refurbish their heating equipment with an aim to improve its efficiency, to limit emissions into outdoor space and mainly to ensure that the produced thermal energy is used in the heated buildings on a level usual in advanced countries. Various alternatives of refurbishment are offered leading to energy savings, adjustment of the room temperature according to customers´ requirements and mainly to detectable measurement of the energy actually consumed. One of the most often recommended measures is the application of thermostatic valves. Experience with this application however shows that this measure is accompanied with an unusually high increase of noise from the heating equipment.

Sources of noise can either be mechanical or aerodynamic (hydrodynamic). The noise generated by thermostatic valves belongs to the latter group for which it is typical that the sound power is a function of the velocity of the flowing fluid.

Mechanical emitters - and from the viewpoint of users valves are considered as such - are with respect to the frequency spectrum of emitted noise characterized by two zones. In the sub critical zone the emitter emits with a low efficiency. If $k . R = 1$, $R = 0{,}02$ m, $f = 2705{,}7$ Hz.

For the sound power of a zero-grade source is obvious that a valve by itself cannot generate noise from its surface into the surrounding environment. Therefore the noise of thermostatic valves must be evaluated in context with radiators in the vicinity of which they are installed. Only very large radiator surfaces can be considered as actual generators of noise into the surrounding environment.

From analyses is is apparent that by doubling the flow velocity the emitted sound power increases 64 times. In the logarithmic scale used in technical acoustics this is equivalent to an increase of the level of sound power by 18 dB.

If the flowing medium were air the sound power would propagate from the source to the auditor without further complications. However if noise from thermostatic valves is considered, we must be aware of the fact that in this case the sound power is generated in water flowing inside a closed central heating water piping system with radiators included. In any case all these parts of the central heating system directly affect the noise emitted into air. Basically this is a case of the secondary emission of sound power from water via a steel

structure into the air. This of course complicates the whole problem. And the effect of the fixing of pipes and radiators to the steel structure only adds to it.

The design of thermostatic valves is strongly affected by the sensor and its ability to react to temperature changes of ambient air by changes of the size of an active element (dilation) in the thermostatic valve. For a normal temperature range these changes are approximately in tenths of millimetres. The flow velocities of water between the valve cone and the valve seat are consequently very high, particularly in the phase immediately before closing. The hydraulic resistances of thermostatic valves in dependence on their adjustment lie in the range from approx. 1 to 7 kPa.

As an example is a diagram describing the dependence of the pressure loss of a valve produced by … on the water flow. The diagram also shows the lines of constant levels of sound pressure A. This information about the noise of the given valve could be easily queried since it is not clear for what temperature of water and what type of radiator were the data on noise obtained from. In this respect extensive experimental work is at present proceeding at the laboratories of the Department of Environmental Engineering.

In response to requirements for the measurement of the noise of thermostatic valves an experimental heating system was built in the noise laboratory and adjoining technical support base. The source of heat in the heating system is a 12 kW wall electric boiler hung on a mobile stand. A 300 litter accumulator tank is inserted in the system. The travelling pressure is supplied to the system by a circulating-water pump with a continuously variable lift.

The heating system is designed according to the principle of real equipment. The system is located in such a way that the measured radiator with the valve is situated in the noise laboratory and the source of heat with the pumps in a separate room in order to suppress the noise they generate.

It is notoriously known that older warm-water heating systems were calculated for a 90/70° temperature gradient. However by measurement it can be shown that pressure losses in the circuits were overestimated and the actual heating-water flow is much higher at a temperature gradient of 5 K. If thermostatic valves are inserted into such a piping system instead of ordinary valves or even instead of cocks the points of pressure losses are displaced towards radiators in the protected room. An even worse situation can occur if the designer of the refurbishment project inserts a circulating-water pump into the circuit. The working point of the thermostatic valve is then displaced into the right upper part of the diagram which indicates the highest values of noise.

Inappropriate design of the heating system and therefore also setting of the thermostatic valve to a higher closing grade result in undesirable generation of noise.

A frequently asked question is how the designer should proceed in such cases. Primarily he should deal in detail with hydraulic losses along the entire central heating system and not only rely on data available from the original project.

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Temperature Fields of Radiators

R. Vavřička, J.Bašta

Roman.Vavricka@fs.cvut.cz

Department of Environment, Czech Technical University in Prague, Faculty of Mechanical Engineering, Technická 4, 166 07 Prague 6 - Dejvice, Czech Republic

At contemporary trend cost reduction on heating it is important, to proposal heating body answer needs on heated space. Economy running of heating body is so integral part of proposal heating system. On running of heating body has direct influence way his proposal, whose integral part of is also proposal way connecting of heating body on heating system.
In experiment we were located on behaviour panel radiator at single-side top and diagonal top inosculation. Experimental arrangement consists of mobile source of heat. The measuring was conducted on four panel radiators type 10 – 500 x 500, 500 x 1000, 500 x 2000 and 300 x 2000, always for temperature gradient 75/65 °C. To both manners of connection (single-side top and diagonal top) was adjusted nominal flow. After opening measuring track will get to close of spherical cocks before panel radiators and heating water circulates only in circuit ultra thermostat, where the waters is warm excepting 75 °C. After warming - up waters on appropriate temperature will close cut off and open spherical cocks before panel radiator. At the same time the themrographic camera ThermaCAM PM695 will be start individual working order of radiator.
By single-side top inosculation of panel radiator is perceptible expressive warming - through left upper incoming corner of heating body. Thanks subdued fluxion in top distributing chamber, like expressive fall of dynamic pressure longwise upper distributing chambers, the warm water push at once first sluiceways back to returnable chamber on same side of radiator. Better hydraulic inosculation, i. e. diagonal top inosculation, offers more favourable lay of pressures in radiator. Warm water spill out longwise heating body, i. e. the water largely flowing first longwise upper distributing chambers. After the water flowing sluiceways against direction gravitation for help inner underpressure incurred reverse branch, which is interface overleaf bottom. Warming up of warm-exchange surface is more regular longwise of radiator.
After 4 minutes from opening input fixture is by single-side top inosculation perceptible sharp triangle of high temperatures, which is stretches upper distributing chamber after her almost complete length and only upside of channels. But by diagonal top inosculation the area of high temperature is a trapezoid, i. e. high temperature no cover only upper distributing chamber, namely all over its length, but in all of length radiator the area stretches also sluiceways. From lay intensities colours are perceptible even lay temperatures after radiator by diagonal top inosculation. As well middle surface temperature is higher, consequently the heat output of radiator must be higher. It proves and record measuring of heat output. Marked difference of heat output by radiators single-side and diagonal top inosculation are by radiators so - called long radiators.
In light of dynamics of start by radiators the diagonal top inosculation of long radiators have the time to reach of inertia start T_{90} [min.] lower than by single – side top inosculation. It can be established even by short radiators.
For type 10 – 500 x 1000 the difference of thermal profile between single – side and diagonal top inosculation after stable isn't so striking like for example by type 10 – 500 x 2000. Nevertheless achieved middle surface temperature in steady state behind explicit flow is by

diagonal top inosculation 70,5 °C and by single – side top inosculation is 69 °C. This difference shows higher heat output by diagonal top inosculation of radiator.

The next measuring contains evaluation of „long" radiators (L/H ≥ 4), exactly type 10 – 500 x 2000. By these radiators is already at first sight perceptible difference between single – side and diagonal top inosculation. At look on figure of temperature field of single – side top inosculation is perceptible cooler area created at the bottom part of radiator and stretches almost complete his length. Cause is hydraulic conditions in radiator. Reduction of speed fluxion of waters in this area causes marked drop of temperature of heating waters. After steady of temperatures the contactless thermometer was register minimum temperature 55,3 °C in the right bottom corner of radiator. There is a 20 K different between the inlet temperature (75 °C) and the minimum temperature of radiator (55,3 °C). At comparison single – side and diagonal top inosculation is higher heat potential by diagonal top inosculation. After standstill temperatures the difference between single – side and diagonal top inosculation is approximately 5 K (by single - side top inosculation t_{st} = 64,7 °C, diagonal top inosculation t_{st} = 70,2 °C), whence follows lower heat output at single – side top inosculation of long radiators.

For comparison was also measured panel radiator type 10 – 300 x 2000. This radiator is so „long" radiator, because its rate is L/H ≥ 4. But after measuring this radiator showed, that difference between middle surface temperature by single – side and diagonal top inosculation is almost zero (by single - side t_{st} = 69,8 °C and diagonal top inosculation t_{st} = 70,1 °C).

The last measuring warn us, that the condition L/H ≥ 4 for inosculation of long radiator, either single – side top inosculation or diagonal top inosculation, is not sufficient. The condition would have been extended far influence of natural buoyancy in form reference to height of radiator, like major parameter pull of natural buoyancy.

By „long" heating body happens namely at wrong way of inosculation to undesirable decrease heat output of radiator. This decrease of heat output can be 10 even 20 %. The diagonal top inosculation of radiators afforded possibility achievement higher surface temperatures of radiator thereby better usage of warm-exchange rate surface. The condition which would be defined conception „longer" or „long" radiator is fixed in term L/H ≥ 4. The measuring proved truth this condition however in recommendation is necessary specified this condition on L/H ≥ 3 and at the same time is necessary take into account height of radiator. It means, that we would design for inosculation of „long" radiators only diagonal top. And „long" radiators are such as this radiators, which accomplish the conditions L/H ≥ 3 and at the same time H ≥ 300 mm.

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A Study of Transition Flow and Separated Boundary Layer

V. Jakubec*, M. Matějka*, L. Popelka**

Milan.Matejka@fs.cvut.cz

* Deparment of Fluid Dynamics and Power Engeering, U12107
Faculty of Machanical Engineerig
Czech Technical University in Prague
Technická 4, 166 07 Praha 6
Czech Republic
** Institute of Termomechanics
Academy of Science of the Czech Republic
Dolejškova 1402/5, 182 00 Praha 8
Czech Republic

Nowadays, the experimental research of shear layer and transition to turbulence is still on one of the first places of scientific interest. This study of influences of inlet flow parameters is new direction at world research.

Our project was directed to the boundary layer control and to refine numerical solution of its transition. These points at issue are one of the research lines solved at department 12107. Three wind tunnels can be used for the experimental research – one with closed 1200 x 400 mm cross section Eiffel type wind tunnel and two with open cross-section first 750 x 550 mm closed-circuit wind tunnel and second 300 x 300 mm Eiffel type wind tunnel (blade cascade measurement). From our point of view the flow visualization was found to be best of available measurement techniques to record changes in the boundary layer.

There were made three experiments. First was aimed at the visualization of the boundary layer transition and its passive control. It has been designed and manufactured airfoil PW212-163 (L. Popelka) with chord c=400 mm, where the influence of position turbulator to the separation bubble dimension and position were investigated. Smoke visualization recorded by the camera in condition Re=210 000 and Tu=1.3% was used. The position and dimension of separation bubble obtained from experiment were compared with numerical simulation by solver Xfoil. Both of them pointed to the significant influences of intensity of turbulence and position or design of turbulator to the extent and position of separation bubble or transition.

Second experiment was focused to the boundary layer transition and separation on the blade inside blade cascade. Measurement has been carried out by PIV method visualization. For more accurate results of PIV measurement the area of interest was divided to the three or five parts and the adaptive correlation with interrogation area 32x32 was used. The conditions were given by the operation range of the experimental device: $Re = 1.5 \cdot 10^5$, the input angles of the blade cascade were $\alpha = 5°$, 11.5° and 20°. The considerable influence to the quality of acquired flow field had size and number of shielded parts and reflection of the laser sheet from the surface of the blade. At these parts it is not possible to obtain velocity profile. Static pressure on the surface of the blade was also measured by switch Scanivalve and pressure transducer to reveal the changes of the boundary layer and compare it with the PIV measurements.

The last experiment was concentrate on the possibility of active boundary layer control application of synthetic jet. Measurement was carried out on the model with flap and three position of actuator by PIV method. Amplitude-frequency of actuators of synthetic jets was measured by HW. Synchronized and unsynchronized flow field were taken. The significant effect of synthetic jet to the boundary layer separation and its character was confirmed. Substantial influence to the operation of synthetic jet has its frequency and intensity and also the direction and position of it to the surface of the model.

Design features of the airfoil using numerical solutions and measurement were presented [3]. General application of numerical method in feasibility studies of experimental research is written [2]. Methodology of PIV measurement and limits of evaluation of turbulence properties was studied [1]. Interaction of synthetic jet with free shear layer and its usage for boundary layer thickness control was introduced [4].

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Optimization of the Wind Tunnel Diffuser Elbow Blade Cascade

K. Vališová, A. Sládek

Katerina.Valisova@fs.cvut.cz

Department of Fluid Dynamics and Power Engineering, Division of Fluid Mechanics and Thermodynamics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

The design of guiding vanes in closed-circuit wind tunnel is a complex aerodynamical problem, which strongly influences the efficiency of the wind tunnel and the quality of the flow in the test section. In the literature, we can find some basic recommendations on the design of guiding vanes, but the applicability is dependent on the wind tunnel configuration. In most of the cases, especially for design of guiding vanes in the diffuser elbow, where the band of flow is combined with the change of cross section area, numerical simulation or experiment is needed.
In order to obtain good flow conditions with low turbulence level in the test section, we have to care about several things in the design of small closed-circuit wind tunnel. We have to ensure that the flow in the bends is not separated and that the vibrations from the propulsion unit are not transmited by the construction of the wind tunnel to the test section area. At the same time we have to lower energy losses as much as possible. All modifications and improvements in the wind tunnel are limited by both the configuration and the dimensions.

In our case, we are interested in the part of closed-circuit wind tunnel from the exit of the test section to the part with the propulsion unit, where we can expect the main sources of energy losses. First diffuser bend with guiding vanes is designed to produce minimal energy losses, second diffuser bend is optimized to lower dynamical load on the propeller of propulsion unit. Both diffuser bends are designed with area ratio AR=1.3, straight diffuser behind the test section has AR=3.
The solution of the problem consists of both the numerical optimization, where the optimal number of vanes and its position was found, the experimental solution, where the parameters of flow behind the second diffuser elbow were obtained, and the consistency of the numerical and the experimental data.

For the numerical simulation, commercial code FLUENT 6.1 was used with the realizable k-ε turbulence model and with the non-equilibrium wall function. The second order upwind scheme discretization and SIMPLE algorithm for pressure coupling was applied in the simulation. At the inlet, the pressure and velocity field was determined from the supposed working conditions in the test section, at the outlet the Outflow boundary condition was applied. Flow was considered as incompressible.
As it would be extremely time consuming to optimize the whole part of wind tunnel from the test section to the propulsion unit (complex mesh with enormous number of cells), it was decided to split the problem in two parts.
First diffuser was designed from the data available in the literature to produce minimal loss of kinetic energy. 3D numerical simulation was carried out for relevant part of the wind tunnel without blading in the second bend to obtain boundary conditions for optimization of guiding vanes distribution in the second diffuser bend. The second stage was the own optimization of guiding vanes distribution in the second diffuser bend.

Using the designed optimization algorithm the optimum for number of vanes and its distribution for uniform static pressure and uniform velocity profile was found. Owing to supposed position of the second diffuser bend in front of propulsion unit the solution for uniform static pressure was chosen to minimize its dynamical load.

For obtaining of experimental data, the experimental device consisting of the same parts like the numerical model (i.e. the diffuser, first diffuser elbow, straight sector and second diffuser elbow) was used. The diffuser was connected to fan and the outlet was open to the atmosphere to allow the access for measurements.
In uniformly distributed points of outlet cross-section the total pressure was measured by alcohol manometer and determined velocity of outlet flow by measuring of vane anemometer and by calculations from measured pressure.
The velocity field was mapped in more detail by PIV (Particle Image Velocimetry) method, which elaborated and confirmed previous measurements.

Experimentally obtained parameters are in very good correspondence with numerical results so that the inlets of optimization algorithm were not necessary to be subject to revaluation and the determined number and position of vanes correspond to the optimal solution.

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The Improvement of PIV Laboratory

J. Nožička*

Jiri.Nozicka@fs.cvut.cz

*Inst. of Fluid Dynamics and Power Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

Since 2001 a new PIV (Particle Image Velocimetry) system has been introduced in the aerodynamic laboratory of Institute of Fluid Dynamics and Power Engineering, FME CTU in Prague. This system serves not only to a research activities of institute mentioned, but it is used by students as a powerful device for their semester or final projects, diploma or PhD theses. Moreover, the system allows demonstrating many aerodynamic effects within a student's practical training.

This leads to such intensive exploitation of PIV laboratory, that a lot of interesting projects couldn't be solved in time. To overcome this problem, an improvement of laboratory equipment supported by a FRVŠ project has been mastered during 2005.

Following critical spots has been found:

1) limited capacity of wind tunnels,
2) a system of flow seeding
3) possibility of an data post processing,
4) a comparison of a PIV and CFD results.

These problems have been solved as follows:

1) A new circulating wind tunnel with an exchangeable test section has been designed and built. The wind tunnel is powered by a AC motor of 25 kW output. The dimensions of test section are 200 x 360 mm, the outer dimensions 8 x 4 m allows to place the wind tunnel into a closed room, where the security rules for laser handling are ensured.
2) A new seeding particles generator SAI has been purchased, producing a He_2 bubbles with a life time of ca 15 s. This system allows to investigate large areas and so to improve the test efficiency.
3) For typical aerodynamic test the time for data processing is 3 to 5 times longer than that one used for the entire measurement. Three new working stations with data processing software Dantec FlowManager have been installed. Today the actual configuration of PIV system allows to proceed three data evaluating processes parallel to a wind tunnel measurement.
4) For a computer aided data comparison of PIV tests and numerical simulation Dantec FlowMatch software has been introduced. This system allows not only the experimental and CFD data comparison, moreover various enhanced tools for data visualization are available, as well.

Due to the realization of a project described the capacity of PIV laboratory from the point of view of students' research activities could be doubled.

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The Combination of PIV and Schlieren Method

J. Slanec*, M. Knob**

Jan.Slanec@fs.cvut.cz

*Institute of Fluid Dynamics and Power Engineering, Czech Technical University in Prague, Technická 4, 166 07 Praha 6

**Institute of Thermomechanics Academy of Sciences of the Czech Republic, Dolejškova 1402/5, 182 00 Praha 8

The paper discusses the possibility of flow field analysis in high-speed measurements by combination of different measurement techniques. The information about velocity field is obtained by means of Particle Image Velocimetry, which is supported by the schlieren method.

Particle Image Velocimetry (PIV) is a very popular technique, which is being used with success in low-speed measurements. The quality of the measured data depends on the ability of seeding particles to follow the flowing fluid. However, this ability decreases with increasing gradients of velocity. If the PIV method is to be used in compressible flow with shock-waves (with abrupt changes of velocity) the question how the movement of seeding particles corresponds to movement of fluid arises. Therefore, it is needed to verify such data from PIV by some different technique. One way how to verify PIV data is a comparison with schlieren photographs.

All tests have been performed in a small high-speed wind tunnel of the laboratory of the institute of Fluid Dynamics and Power Engineering at CTU in Prague. The tunnel consists of test section with model and vacuum tank, the volume of which is $10m^3$. Due to the limited volume of vacuum tank, time of measurement has been less then 10 seconds. As the tested model a turbine blade cascade has been used. Flow conditions in this model are apparently distinguished by large areas with significant dissipative processes.

As the first step for obtaining information about flow field, the visualization by Particle Image Velocimetry was used. Type of seeding particles was important for obtaining good results by this method. To avoid problems of fouling of vacuum tank, solid particles couldn't be utilized and therefore water droplets have been used instead. The choice of these seeding particles wasn't ideal because of high density of water, but only water droplets have sufficient size for investigated area.

Measurement has been carried out by PIV system produced by Dantec which consists of:

- two Nd –YAG lasers - New Wave Gemini 15 Hz , 120mJ
- CCD camera Dantec HiSence PIV, 1280 x 1024 pixel
- PIV processor Dantec FlowMap1500, 1GB buffer

The schlieren photographs for comparison with PIV data have been done by Carl Zeiss schlieren device. Visible area of this device has been a circular one of 80mm in diameter and Mercury discharge lamp of 500 W has served as a source of light.

Although only the simple configuration of PIV tests has been used, the PIV visualization has been able to give basic information about velocity distribution. From the comparison with

schlieren photographs it is visible, that it's possible to find information about shock-waves from these data, too.

These experiments have been done to obtain basic quantitative information about flow field that could be used to preparation of more detailed and accurate (and heavy on time and money) measurements. For this purpose the simple performance of experiments has been fully sufficient and the comparison with schlieren photographs has been very useful for correct interpretation of PIV data.

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Section 7

MECHANICAL ENGINEERING

Development of Equipment for operating Parameters Testing of Drive Parts and its Application for Teaching

Z.Češpíro

Zdenek.Cespiro@fs.cvut.cz

Department of Production Machines and Mechanisms, Division of Machine Parts and Mechanisms,
Faculty of Mechanical Engineering, Czech Technical University,
Technická 4, 166 07 Prague 6, Czech Republic

Industrial brakes are used in machine drives, where they serve as a safety device. Their purpose is to secure device stopping time after motor turn-off and to secure device fixing after device stop. Stopping time is given by secure requirement. These brakes should be use for devices with high inertia moment, high revolution and long stopping time without using brakes. Run-out controlled by brake must be gradual with aspect for possibility of device damage by beats. High inertia moment and high accumulated energy cause of release big amount of heat in full brake application and brake is strongly heated-up. Therefore heat conditions in running markedly affect brake dependability and life-time. Temperature of brakes in running can't exceed maximum permissible value which in first depends on thermal endurance of brake control mechanism. Thermal conditions are probed during brake operation with repeated process cycles. These cycles are arranged of run-up, specified running, braked run-out and stationary delay before next run-up. Measured parameter is temperature of brake in one or more places. Theirs placements depend on designated location of critical places which are the most endangered by brake overheat. In some places is difficult to secure measure of heat. Therefore is necessary to describe heat field in brake mechanism and temperature dependence in various places in order to be possible to specify temperature in other brake mechanism area. Temperature specification is made by measuring in easy accessible places.

The goal of heat conditions measurements in brake running is to designate basic heat parameter of brake. It means amount of temperature rise after one brake application in dependence on amount of brake inertia moment load and time behaviour of next cooling. Amount of temperature rise is given by thermal variation of elected measuring place at start and end of brake running-out. Initial temperature corresponds with steady condition where thermal variations are low and theirs changes are proceeding slowly. Temperature after full brake application is given by maximum value after brake stop. After brake stop follow lag for single brake parts temperature equalization and cooling to steady condition which makes possible next brake operation cycle. During this lag is measured temperature fall behaviour in elected point. Brake cooling speed depends on immediate brake temperature measurement and decline from maximum speed after brake stop to minimum when single brake parts temperature are equalized and are like ambient temperature. Main purpose of temperature parameter values investigation is acquisition of data for medium-term testing mode chooses for determination of permissible operating brake mode. This permissible mode is determined by possible amount of repeatable full brake applications during time unit. In this time brake can't be overheated over permissible value and/or damaged. On base of verified medium-term testing mode is possible to carry out long-term testing which verify brake dependability and life-time in continuous working. Brake is being loaded by repeated operating cycles during these testing. These operating cycles follows successively. Every working cycle is arranged of run-up to specified revolutions, specified constant speed running, run-out where motional energy is exploited in brake and stationary delay. During testing is being watched temperature

in elected measure places or possibly thermal field in mechanism of brake. Brake temperature can't exceed permissible value. In right selection of operating cycle parameter is being maximal reached temperature ´s value in single cooling cycles after initial fast growing make stable. Size of this stable value depends on amount of brake loading and process cycles parameters. Right operating cycle selection parameter must secure sufficient cooling after every brake stop.

Next determined work parameters are static and dynamic brake moment, size of beam disk and brake shoe and its change during brake activity. Static brake moment is being determined as an amount of brake load moment in standstill in moment of brake slip. Dynamic brake moment is being measured during brake run-out. Purposeful brake gap is being measured in standstill and its size has an effect for dependability and functionality of brake. Testing process, running cycle control and saving measured data provides a personal computer which includes measuring card and programme LabWindows. Brake is loaded by circular weight unit. Additional brake loading is possible to imitate by control motor run-out. Motor controlled by electric converter is decreasing revolution smoothly using specified function in parallel with brake function.

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Solar Collector Optimization for Combined Heating and Cooling Systems

T. Matuska

tomas.matuska@fs.cvut.cz

Department of Environmental Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Transition to sustainable development with renewable energy sources exploitation requires high fraction of solar energy utilized in systems for heating and cooling energy supply in building sector. This trend results in demand for advanced combined solar systems for domestic hot water preparation (whole year), space heating (winter season) and cooling (summer season). Associated higher operation temperature level and need for efficient solar energy utilization in such systems assume solar thermal collectors with high solar conversion factors, low heat loss and operation energy demands (pumping energy associated with pressure loss of collector absorber) kept in reasonably low levels. Further, architectural barriers should be overcome with collector integration into building envelope thus eliminating the disturbing visual impact of collector fields. There is a huge potential for traditional flat-plate solar collectors in buildings [1].

Solar thermal flat-plate collector efficiency depends mainly on optical and thermal properties of glazing and absorber. Usual solar flat-plate collectors available on the market today consist of single cover glazing and spectrally selective absorber. Front heat loss through glazing gives about 80 % of total collector heat loss in such configuration. This leads to development of the advanced glazings, like transparent thermal insulations (honeycomb structures, foams, etc.) with good both optical and thermal properties. One of the most promising material is an aerogel [2], porous silica structure with extremely small pore size (2 to 50 nm) and high porosity (95 % of air). Due to special structure, excellent optical and thermal properties are achieved: solar energy transmittance 0,85 – 0,95 (according to thickness of aerogel layer) and thermal conductivity 0,015 – 0,020 W/m.K (at 20 °C). For solar collector applications, transparent monolithic aerogel in the form of sheets could be used.

In the project, development of slim solar collector with maximum thickness of 35 mm at standard small size 1 x 2 m intended for building envelope integration has been initiated. The slim collector consists of hydrophobic aerogel layer (th. 15 mm) with glass cover (5 mm) and hydraulically and thermally optimized pipe grid as absorber (max. 15 mm). Aerogel glazing with non-selective absorber gives the front U-value around 1 $W/m^2.K$ and optical efficiency above 0,75. All collector components are assembled in one tight construction. Back and edge insulation should be provided by insulation layer of the building envelope.

Slim solar collector with aerogel glazing has a large potential in middle temperature applications (solar heating and cooling, 80-120 °C) even with non-selective absorber. Efficiency above 50 % is achieved at temperature difference 80 K between absorber and ambient. High thermal resistance of the glazing results in compensation of front heat loss and appropriate insulation of collector frame should be considered. Advantageous solution is the integration of aerogel collector into insulation layer of building envelope, which provide sufficient insulation level for back and edge part of collector. On the other side, aerogel

glazing doesn't act as a thermal bridge in the envelope construction compared with usual single glazing with air gap.
Hydraulic design of slim collector absorber pipe grid has been analyzed. Hydraulic configuration of collector absorber piping influences the heat transfer from absorber to anti-freeze liquid and pressure loss. Use of anti-freeze liquid (propylen-glycol – water mixture) and given mass flow through collector results in laminar flow in pipes of wide dimension range. Under slim collector principle, the pipes dimension was minimized with respect to pressure losses and hydraulic balance of pipe grid. Convection heat transfer for laminar flow in pipes results in constant Nusselt number independent on pipe dimension. Influence of heat transfer coefficient on overall collector efficiency is not strong, it changes within ± 1 % in wide range of pipes dimension. The infulence decreases with lower collector heat loss coefficient [3].

Much stronger is impact of dimension on pressure loss of absorber piping grid. While determination of friction pressure loss in pipes in laminar flow is known problem, determination of local pressure loss of realistic connections is not a simple problem. Local loss coefficient in laminar regime is not a constant value even for known ideal cases (bend, elbow, T-connection, etc.). There should be done a lot of experimental work and CFD modeling to analyze usual practical (unideal) connection types in future.

For further experimental investigation of aerogel slim solar collector, several experimental devices will be used in continuing research for characterization of individual elements (absorber, glazing) and the whole collector. New test circuit for determination of pressure loss was built. It allows the testing of slim collector absorber with optimised hydraulics of pipe grid. An existing apparatus for solar transmittance measurement of sheet materials according ASTM E 1084-86 was reconstructed. It will be used for aerogel glazing optical characterization (solar energy transmittance). Finally, test-bed for solar collector thermal performance testing according EN 12975-2 was retrofitted. Now, the standard efficiency curve could be experimentally obtained in two clear days with uncertainty about 5 %.

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The Telescope for the Sun Corona Detection

Š. Němcová, J. Zicha, E. Marková*

sarka.nemcova@fs.cvut.cz

Department of Instrumentation and Control Engineering, Div. of Precision Mechanics and Optics, Faculty of Mechanical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic
*Observatory Úpice, U Lipek 160, 542 32 Úpice

The solar corona plays a fundamental role as a mediator between solar activity near the solar surface and space weather outside. Beside its function as an energetic converter which transfers imprints of photospheric and chromospheric conditions to the interplanetary space, there are plenty of coronal formations in the solar atmosphere (such as coronal streamers, coronal holes, loops, cavities and so on), which reflect the topology of solar magnetic field.

We can note a growing interest in terrestrial total solar eclipse observations at present time. The main interest is directed to the observation of lower coronal dynamics. Although specialized solar satellites play an important role in observation, ground-based observations are nevertheless indispensable. The main reasons are namely the calibration troubles, insufficient spatial resolution and unavailability of low solar corona detection in white light by satellite observations, as well as financial accessibility and fast operational variability of ground-based observations.

Strong interests insist to new methods of visualization of solar corona in pictures obtained during total solar eclipses. The very high dynamic solar corona intensity range complicates to obtain an eventual picture without degradation by over and/or underexposure. This trouble is solved by different ways with various results. Using of a radial filter, which compensates a high decrease of intensity, has instrument troubles. Some other methods use a mathematical composite of individual frames and detail enhancements. The main disadvantage of most of these methods is a preference of one direction in the picture (radial or tangential), which disallows valuable visualization of faint details and allows the origin of image artifacts. However, especially the visualization and identification of very faint coronal structures play an important role in study and understanding of processes of coronal heating, refilling of coronal matter and other questions.

The observers from Observatory Úpice have got unique series of corona observations of total solar eclipses during last 15 years. Obtained data were processed by a new unique numerical method, based on adaptive filters. This method was developed in cooperation with the Institute of Mathematics at Brno University of Technology. These techniques enable visualization of coronal structures, which is quite reproducible and reduces occurrences of unreal artifacts caused by secondary effects of both digitizing and numerical processing of a picture. Coronal pictures obtained by this process are probably the best views of inner parts of solar corona in the world nowadays. They are in an excellent coincidence with the data of coronagraphs on the SOHO satellite. In addition, they exhibit a more precise display of image details.

The telescope for the solar corona detection is a part of a future project “The Seven-Head Dragon”. This is a name for a new instrument, which will allow to observers from Observatory Úpice to improve their work and to obtain even better views of solar corona. The method of processing data needs to obtain a big amount of pictures of white light corona with different exposure times. This new telescope will allow on parallel pathway to obtain pictures of inner and outer corona at different exposure times (seven pictures at a time). This is further

necessary for study of fast changes in the low part of corona. It is crucial to get the pictures of corona with different exposure times practically at the same moment for recording of inner, middle and outer parts of corona simultaneously. This is very important especially for the process of composing the realistic picture of the whole corona without secondary effects caused by composing of time-remote pictures.

The designed telescope is one “head of the dragon”. The aim of the project was to design and produce the telescope and proof its function and its cooperation with a camera. There was used a Canon D20 camera with CMOS detector with 8 millions pixels.

The optical part of the telescope was designed and produced at VOD Turnov. The focal length is 500mm, f = 5.6. The telescope consists of two non-cemented doublets. The spherical aberration and chromatic aberration were corrected. The mechanical part – the body tube – is designed as a bipartite, with material combination of a duralumin and a brass. The camera is connected to the body tube by a helical focuser Borg, that enables perfect focusing.

The telescope will be tested at total solar eclipse on March 29, which can be observe in Turkey and Libya. There the correct operation of the telescope will be prooved. Also the instrument’s behavior in various temperatures will be checked. No special mount was costructed, there will be used camera stand Manfrotto. Obtained data will be processed by the mentioned method of visualization and mathematical processing of images.

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Using Convential Digital Camera for Near IR Photography

J. Hošek

Jan.Hosek@fs.cvut.cz

Department of Instrumentation and Control Engineering, Division of Precision Mechanics and Optics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech

The goal of the presented work was to use the standard CCD photographic camera for visualization of near IR spectral source. Almost every standard CCD camera chip is usually sensitive not only in visible spectral range but the maximum of spectral sensitometric characteristics of CCD chip is around wavelength 800 nm. In order to be possible take snapshots with standard CCD photographic camera without color distortion caused by near IR illumination the sensitivity of the camera chip is artificially decreased.

One of the most usual methods of decreasing near IR sensitivity of the cameras is to deposit an interference short pass filter system to the chip cover glass. We decided to try to remove chip cover glass and performed camera spectral sensitometry measurement.

The standard CCD photographic camera Olympus C-750 UZ was chosen as an experimental object. At first we performed spectral sensitometry measurement of the original camera without any modification in each color canal. Spectral sensitometry was measured using laboratory monochromator Karl Zeiss SPM 2 calibrated with compact spectrometer LASP in range 600 – 1160 nm. Measured camera spectral sensitivity shown expected RGB characteristic for visible spectral range and very low equal level of sensitivity for all RGB canals in range above 820 nm. But there was still detectable camera signal till 1280nm. It means that CCD chip used in this kind of camera is near IR sensitive and its sensitivity is artificially decreased in this spectral range [1]. Next we tried to estimate near IR illumination level using IR LEDs necessary for optimal image quality taken with unmodified camera. The optimal illumination level in near IR range should be too high in case of original camera set-up, so it was decided to modify Olympus C-750 UZ camera system and increase the sensitivity of the camera in near IR spectral range.

We had let to perform chip cover glass extraction in the Lavet s.r.o. company. Then we made the next measurement of the modified camera system. It was performed camera sensitivity measurement again in the same experimental set-up based on the using monochromator Karl Zeiss SPM 2. Due to the fact, that every RGB canals appears the same level of spectral sensitivity in spectral range above the wavelength 800 nm, the sensitivity measurement was performed only for RED camera color canal [2]. It was finding-out that camera interference filter extraction caused intensification of the integral sensitivity of the RED canal in range of wavelengths 600-1100 nm approximately four times. It dramatically decreases near IR illumination demanding necessary for IR photography.

The performed camera chip cover glass extraction caused camera near IR sensitivity increase, but it is accomplished with different complications. The first complication was found out the impossibility of the camera focusing. This is caused by absence of chip cover glass in camera optical system. The presence of the glass prism in the uncolimated light beam of the optical imagination system causes the change of the system total focal length. The change of the camera focal length after the chip cover glass extraction caused, that neither

automatic nor manual focusing system of the camera was to able to focused. In order to correct this problem, a new transparent glass the same thickness was placed instead of the extracted chip cover glass with interference filter.

The second complication caused by the original interference filter extraction was the chromatic distortion of the taken images in the case of day light illumination. Due to the presence the red, green and blue color filters in front of the each CCD photo detector cell, the integral sensitivity of each color canal in visible spectral range are different in the case of visible and near IR spectral range. This affects the original expectation of the color evaluation algorithm used by camera and caused referred chromatic distortion.

There are two possibilities for images chromatic correction. The first possibility is to place near IR filter in front of the camera lens again in case of the day light photography and to take it off in the case of using IR illumination. This possibility has disadvantage - the price of necessary filter. The diameter of the used filter has to be around 50 mm and the price of the appropriate interference low-pass filter is about $400.

We have used the second solution and we developed a numerical algorithm for image chromatic correction. The algorithm uses values of the integral camera sensitivity ratios for the red and blue color canal in case of no intensity change green color canal. It was find out, the higher ration for red color canal. The ratio of the blue canal color change was only 30 % of average value of red color canal. The amplification of the red canal sensitivity is not constant, but it appears the power function dependence on the image pixel intensity level. The chromatic correction algorithm was written in Matlab and gives a very good image chromatic correction [3].

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Driving Linear Guided Motion of a Telescopic Arm with Non-conventional Roller Chain and Synchronisation of a Telescopic Full-Stroke

P. Jurda, V. Andrlík , J. Talácko *

pavel.jurda@fs.cvut.cz

Department of Production Machines and Mechanisms, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

* Department of Production Machines and Mechanisms, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 03 Prague 2, Czech Republic

Linear motions issue is very wide and solves linear movement in many various kinds from several liquid mechanisms, through screw mechanisms with sliding or rolling parts, mechanisms with cogged belts using push or pull components to linear electro motors for very fast and precise moves. Analysis of particular linear motion systems should be necessarily connected to a category of relevant mechanisms, working conditions, used frequency etc. and would get over this topic. During analysis of all existing linear motion devices a blank space of a missing drive appears. This device should solve these relevant problems in a very simple way, using as many conventional parts as possible, with a possibility of working in extreme conditions and with extreme loads, creating the same strain conditions for both directions – ejection and insertion, with a possibility of using telescopic guides by acquiring long extrusion with minimal requirement of an operating area of such motion device. The answer for this solution gives this newly designed linear motion drive with non-conventional push-pull roller chain patented according to the patent application number 2004-35 from 8th January 2004.

The invention applies to the driving motion of a telescopic arm. This special module uses a modified conventional roller chain for transferring axial forces for insertion and extrusion of the telescopic arm. The chain is guided by telescopic supported construction, which allows to strain the chain by push forces.

The basic idea of this invention is in creating a limited area by ejecting a telescopic arm in which the push-pull roller chain will be placed. This limited surrounding area does not allow this roller chain to go out of bounds to sides, especially in push forces of the chain. For this purpose is possible to create a grading telescopic tube with an inside area where the roller chain will be placed. Solitary grading of tubes brings step changes of the inside cross section. Against cranking of the chain in the tube with larger cross section, the chain is also step by step composed for corresponding lengths of sections filling the appropriate stage in the telescopic tubes.

The chain is constructed of a conventional roller chain and completed with appropriate supporting rollers, which have to centre the chain in particular parts of the telescopic tubes and do not allow cranking it.

The roller chain is pushed and pulled inside the tubes by a motor-driven roller chain wheel, which is equipped with double-sided guide of the roller chain. The drive of the roller chain wheel can be provided by any type of motor device. In this case a Harmonic Drive motor was used. It is a compact drive with harmonic gear, position control, option of program control and with favourable torque characteristic.

The assembly made in that way is able to create push or a pull forces for ejection given by the used number and lengths of steps of the telescope. Carrying of forces - bend and torsion

torques and shear forces must be provided by an exterior part of the drive. Using square or rectangular profiles joined together into telescopic construction with linear rolling guides seems to be very favourable. Dimensional coupling of this construction corresponds with coupling of the telescopic tubes with the roller chain.

Experimental position accuracy measurement in the lab of the designed motion device was necessary. The position inaccuracy of the stroke of 450 mm is 15,75 mm. This value is not the smallest, but for lot of applications suitable. For finest position controlling the software tuning or decreasing the clearance among shafts and parts of the chain is possible.

This report solves issue of a linear drive with non-conventional push-pull roller chain according to the invention. The obtained drive fills the blank space in drives of existing category in an easy and original way. The report contains analysis of construction and very short view of experimental verification of position accuracy. From information mentioned above it arises that the drive came up to expectation and showed its possibility to be viable.

Existing applications solving problems of full-strokes are based on using non-synchronized telescopic guides working with mechanical, hydraulic or pneumatic motion drives. In these cases the full-stroke in general is not possible to position and control reliably.

One of disadvantage of non-synchronized full-strokes using especially double-sided full-stroke is uncontrollable movement of extending parts, which can stagnate in various positions during the working cycle.

Creating of a synchronized full-stroke using mechanical kinematic structure between particular components of the telescopic unit can solve these problems mentioned above. The basic idea of this invention is creating a mechanical kinematic structure using cogged belts with driving and tightening pulleys to achieve a synchronized movement of extending parts. According to described design concept the prototype of this double-sided full-stroked telescopic unit was made. Designed synchronized double-sided telescopic unit solves reliably positioning and controlling of full-strokes and provides high rigidity in bend and torsion. This unit can be parallel connected to synchronous shaft and be driving with only one motorized driving unit and seems to have a great usage in various fields in all kinds of industry.

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LPGs in Singlemode Optical Fibers Prepared by a CO_2 Laser

F. Todorov *, J. Dunovsky **, L. Kolarik *, P. Cisarovsky *, M. Chomat *, D. Berkova ***, V. Matejec ***, I. Kasik *****

filip.todorov@fs.cvut.cz

* Department of Manufacturing Technology, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

** Department of Transportation Technology, Faculty of Transportation Sciences, Czech Technical University in Prague, Horská 3, 128 03 Prague 2, Czech Republic

*** Institute of Radio Engineering and Electronics, Academy of Science of the Czech Republic, Chaberská 57, 182 51 Prague 8, Czech Republic

Fiber long-period gratings (LPGs) formed as axially periodic variations of the refractive index inscribed in the core of optical fibers are attracting increasing interest for possible applications in optical sensors and telecommunications. LPG-based sensors have many advantages such as the ease of fabrication, low insertion loss and back reflection, higher temperature, torsion, bend and load sensitivity than in-fiber Bragg gratings. LPG's refractive-index variations have usually a period of a few hundred micrometers and length of less than 50 millimeters. The most of LPGs reported are written into commercial fibers with Ge-doped core by UV laser light through an amplitude mask. However, the UV exposure method has some constraints in practical applications, including the use of expensive lasers with high running costs and relatively poor long-term stability, if annealing is improper.

An inverted graded-index (IGI) optical fiber drawn from a preform prepared by the MCVD method was used in this work. The diameter of the optical fiber was 125 μm and the fiber was covered with a UV-curable acrylate jacket. The LPGs were fabricated by releasing the residual stress in the fibers by exposing them to a CO_2 laser radiation [1]. For the LPG inscription, the fiber was fixed into a V-groove fiber holder and the acrylate jacket was removed from the fiber in a length of approx. 50 mm. The fiber holder was placed on a platform which was used for the LPG fabrication and transmission spectra measurements as well.

Two lasers with a wavelength of 10,600 nm were used. The first one was an air-cooled CO_2 laser ILS-III, produced by Laser Tools&Technics Corp. with an output power of max. 50 W and a speed of beam scanning up to 1524 mm/s (60 inch/s). The second one was an air-cooled CO_2 laser Synrad 48-1S with an output power of max. 10 W and a speed of X-Y stages up to 12 mm/s. During the LPG inscription the fiber was scanned at both the X and Y axes in a programmable manner. The inscribing process was controlled and regulated by changing the output power and scanning speed of the laser beam.

The prepared LPGs were characterized in situ by measuring their transmission spectra in a range of 1400-1700 nm using an LED-1550 optical source with a central wavelength of 1550 nm and an Ocean Optics NIR512 spectrometer. LPGs with a length of 35 mm and various periods were inscribed under different inscription conditions. LPGs with periods of 170 up to 980 μm were characterized in a range of 1400-1700 nm.

The reproducibility of the LPG's inscription process was tested by repeated inscription under the same conditions into an experimental noncommercial IGI optical fiber. A not very good reproducibility and a small dip in the transmission spectra of the LPGs with periods of 170 and 190 μm were observed. The probable reason for that was the laser beam spot diameter of 100 μm, which was close to the period of the LPGs. There were no major difficulties with the reproducibility with the rest of the LPGs.

An experiment with multiple inscription of LPGs was made. The inscription process was repeated ten times at the same conditions over the same part of the fiber. The wavelength of the dip in the transmission spectra shifted to lower values as a result of a change of the mean refractive index of the fiber core caused by repeated laser irradiation. In some cases of the LPG fabrication, preheating with a low-energy laser beam was used. A lower level of the average power and no change of the beam speed was used. No dip in the transmission spectra was observed after the preheating process. This low-energy irradiation was without any observable influence on the depth or width of the final dip.

LPGs with different periods were inscribed into an experimental noncommercial IGI optical fiber under variety of conditions. There were observed dips in the transmission spectra deeper than 10 dB with a very good reproducibility. Two different CO_2 lasers were successfully used for the fabrication of the LPGs, but the results obtained were not similar. There was always a need to find out the right inscription conditions for the given laser. Such an extreme manufacturing method like ten-times repeated irradiation of the fiber is not necessary, because an LPG with a strong dip can be fabricated just at one or two runs under proper conditions. The influence of preheating with a low-energy laser beam on the transmission spectra of the inscribed LPGs has to be examined in more details.

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Corporate Entity - Analysis of Credibility Factor

Petr Kocour

petr.kocour@sec.cz

Czech Securities Commission, Washingtonova 7, 111 21 Prague 1, Czech Republic

The creditworthiness of a corporate entity can be calculated by using the credit risk definition.

The credit risk represents the risk of loss that is associated with the failure of a debtor and his inability to repay his debts. The failure is mostly defined as a bankruptcy, insolvency and or debt restructure.

The credit risk makes it possible to search a risk for two partial components – inherent risk and loss risk.

The inherent risk determines the amount, which can be lost by a creditor due to the failure of a debtor. This amount can be easily calculated in the case of typical credit exposures such as a loan or a bond, because it is equal to the nominal value including claim attribution

The loss risk specifies the probability of the failure from a loan portfolio, which contains the credit risk.

In all cases, quantification of the credit risk begins with its decomposition into components, whereas the starting component is the default risk or the probability of the debtor defaulting.

To assess the probability of defaulting (failure), there are several methods used, which can be divided into the three following groups.

Firstly, there are approaches which are based on judgement. These methods combine an internal experience of evaluating subjects with a theory and its judgement. Such assessment is often based on examination of the debtor´s historical financial statements and their financial analysis.

The second group of methods represents approaches based on statistical analysis. These methods study not only historical figures and data, but also their connections between parameters of the evaluative subject and its follow-up default. Consequently these methods measure the relations, as well as the similarities, of various companies and provide us with some generalizing conclusions. However, these methods measure are concerned with no particular events of default. Therefore, suitability of their utilization is possible for only certain groups of subjects, industrial branches according to statistical codebook etc.

The third approach consists of a probability determination of default from the market figures, for instance from credit spread determined with bonds. These methods are consistent with requirements on a higher accuracy of credit risk measurement and suffer from no problems like the other methods (i.e. the dependence on historical financial statements and their evaluation according to internal experience, unfavourable sampling etc.). Such an approach based on the market figures has two significant advantages. Firstly, it is a forward-looking method, because the market figures involve certain expectation from the side of capital market participants, each of them are surely subjective. However, through an interaction on the market they reach a level, which fairly reflects expectations of the all capital market participants. Therefore, it becomes a better indicator than any approach based on the financial analysis of historical figures with their subjective evaluation included. Secondly, the market indicators which leave no doubt for a regulatory arbitration. It is important to mention, that only statistically insignificant parts of our domestic companies solves its finance requirements through the capital market. This represents a huge difference compared to the common situation in Anglo-Saxon countries.

It is important to mention rating too. Rating is a traditional and widely used instrument to assess a corporate debtor´s creditworthiness. Over the years many rating agencies have developed various scales that make easier orientation for creditors, as well as preparation for financial analyses. The debtors are rated within the discrete rating categories, which correspond with an estimated default rate for them. A final rating grade is the result of the fundamental analysis of historical figures and the internal opinion about the debtor´s business development in the future. That means except for the evaluation of particular corporate financial health an analyst is also engaged in the assessment of relevant industrial branches and the corporate entity´s ranking within named industry. A lot of rating systems result from quantitative and qualitative assessments, whereas the final decision is entirely reached in a normative way and as result of that, the rating systems are based on internal experience (know-how) and are not based on mathematical modelling.

For my future thesis I have been monitoring and collecting suitable information and data, which is available because of the mandatory implementation process of rules Basel II in the banking sector. Mainly, I will focuse on advanced analytical-rating approaches used for corporate assessment including the appropriate corporate database for statistical evaluation.

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Applications of the High-pressure Membranes in Design of Elements of Mechanisms

J. Talácko, M. Jalová, M. Jalový

Miroslav.Jalovy@fs.cvut.cz

Department of Production Machines and Mechanisms, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

This project is oriented to the experimental research on the structure of composite membranes based on polymer matrix with kevlar fibre support, which are applied to the high-pressure membranes in hydraulic mechanism design, gripper elements of manipulators.

The main advantages of composite material are: we can influence and adapt their properties to the required properties (by the suitable combination – a ratio of mass or volume of the used materials) and we can dimension them according to the required loading. The properties become optimized (their strength and their stiffness gets improved) and the mass of material is minimized parallel. The corrosion of material eliminates. Despite the use of modern method (finite element method) there is one disadvantage – a rather complicated calculation of these materials. It is always necessary to verify experimentally the most of applications at least at their basic properties of the designed composite material.

Six types of kevlar textile fabrics are used for producing experimental samples (membranes). The kevlar fabrics are differed in their weave, their thickness and their areal density of fibres. There are used: plain weave which has a thickness 0,06 mm and an areal density of fibres 61 g/m^2, plain weave which has a thickness 0,07 mm and an areal density of fibres 80 g/m^2, twill weave which has a thickness 0,11 mm and an areal density of fibres 110 g/m^2, plain weave which has a thickness 0,19 mm and an areal density of fibres 173 g/m^2, twill weave which has a thickness 0,27 mm and an areal density of fibres 275 g/m^2 and sateen weave which has a thickness 0,38 mm and an areal density of fibres 326 g/m^2.

There was designed and realized an experimental stand for this purpose which consists of a hydraulic circuit (maximal value of working pressure is 32 MPa) with numerical control of the relationship between time and pressure and an experimental chamber. It is possible to carry out static or dynamic tests which are ended by destroying of tested membrane. There are obtained the strength of membrane and the vibration fatigue limit. There is measured the maximal sag of membrane under the load.

The experimental stand is universal. It is possible to add new components to hydraulic circuit, to add new sensors or new types of the experimental chambers. Wide possibilities are given in control software Matlab, Simulink and Real Time Toolbox (LabView) and in modern measuring and control analog-digital cards.

Membrane elements are used very often in pneumatic systems. It is not possible to use these elements in hydraulic systems due to the working pressure. Maximal working pressure of membrane elements in pneumatic systems are 1,6 MPa. Therefore there has been developed a high-pressure membrane. The static strength of membrane, which is made of kevlar fabric with areal density of fibres as far as 110 g/m^2 is maximal 5 MPa. The static strength of membrane of kevlar fabric with plain weave and areal density of fibres 173 g/m^2 is 10,5 MPa, membrane of kevlar fabric with twill weave and areal density of fibres 275 g/m^2 is 14,5 MPa, membrane of kevlar fabric with sateen weave and areal density of fibres 326 g/m^2 is 16 MPa. If better isotropic property is applied strength can increase nearly twice. The strength of the best membrane can reach as much as 28 MPa.

The areal density of fibres and thickness of membrane increase and its strength increases too. This results, which were obtained experimentally, were verify analytic calculation (mechanics of composite materials and theory of thin planks which are geometric nonlinear).

The membrane was designed for a membrane hydraulic motor with low stroke. The membrane hydraulic motor consists of an upper and a lower flange which are used for gripping of membrane, a piston rod, a spring, a spacer ring, screws and o-rings. Six screws (size M12) support required gripping. Two O-rings are used for sealing of working area. These O-rings were designed for this application. When hydraulic oil is get to the working area to membrane, membrane is deformed and piston rod is moved to spacer ring at the same time. This is stroke of membrane hydraulic motor. Spring is used for doing a back stroke.

The main parameters of the membrane hydraulic motor are: the outside diameter of motor which is 145 mm, the optimal stroke of piston rod is 4,5 mm, the diameter of membrane is 90 mm, the maximal force which is made out of piston rod is 11,7 kN. The weight of whole membrane hydraulic motor is 5,9 kg. The working pressure is 10 MPa.

Membrane hydraulic motor is used also in design of robot gripper. In this case the membrane hydraulic motor is used as an actuating unit. Robot gripper consists of membrane hydraulic motor, a piston rod with a cross head and three rotary arms. When piston rod does stroke robot gripper is opened and when piston rod does back stroke robot gripper is closed. High values of the force, which is made out of piston rod, makes possible to get high values of the force of gripping of robot gripper throughout stroke of rotary arms, which is 15 mm. Rotary arms are used partly as a lever and partly as a multiplier of stroke.

Detailed FEM calculation of membrane and experimental measurements of other parameters of membrane, membrane hydraulic motor and robot gripper are made at present days.

Application of composite material in mechanisms design supports the use of principles which have simple conceptions and are experimentally and practically verified and the creation of new principles in design.

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Thermal Stabilization of Machine Tools

O. Horejš*

O.horejs@rcmt.cvut.cz

*Department of Fluid Dynamics and Power Engineering, Faculty of Mechanical Engineering, Czech Technical University,Technická 4, 166 07 Prague 6, Czech Republic

Accuracy, productivity, economical efficiency and low costs are the main trends under development of modern high speed machine tools. Especially the development of high-speed feed systems has been a major issue in the machine tool industry for the past few decades. A ball screw system is widely used for rapid translating precise motion because of its high efficiency and long lifetime. However, a high-speed ball screw drive system naturally produces heat through friction at contact areas, which thereby causes thermal expansion which adversely affects machining accuracy. In order to achieve high accuracy and great stiffness, the ball screw preload is common solution of removing the backlash of the ball screw. Consequently the applied preload on screw shaft produces more heat through friction. Mainly two heat sources occur in ball screw drive system - friction heat generated between ball screw and the nut and friction heat in supporting bearings.

The main goal of this work was to investigate the thermal characteristics of a ball screw system in special test bed. The other objective was to evaluate an influence of cooling, two heat sources mentioned above upon ball screw thermal stabilization. On the one hand the obtained experimental data should determine boundary conditions of finite element model; on the other hand data should be used for validation of numerical model using finite element method.
The test bed represents standard machine tool. The rotational speed is possible to change in range of (0 – 800) rpm. The table repeatedly (70 cycles then the test bed is stopped due to measuring ball screw temperature and photography by thermo-camera) moved the axis x of test bed with a stroke of 600 mm. The test bed is also equipped with mechanism generating breaking force. The maximum potential braking force F_b is 5000 N. The configuration of ball screw drive system was: rotating screw shaft (driven by servomotor) and fixed nut. A diameter of screw shaft is a D = 50 mm, lead is an h = 20 mm/rpm and a length of screw is an Ls = 1330 mm. Experiments with standard ball-screw and also with internally cooled ball screw and cooled nut were carried out. A cooling medium is water with synergizing agent (2 - 5 %). The external cooling circuit consists of reservoir for cooling medium, pumps, fittings and tubes connecting reservoir with ball screw and nut. The connection of cooling circuit with rotating ball screw was enabled through the rotating union placed at the one end of the ball screw. Cooled ball screw is hollow with inner diameter d = 18 mm. Both cooling of screw shaft (first sub-circuit) and cooling of nut is possible (second sub-circuit). Flow rates in each sub-circuit are regulated by valves. Both flow rates are measured by flow indicators. The cooling medium inside the reservoir is maintained in constant temperature by cooler. The one end of the ball screw is fixed in chucking device; the other one is seated in bearing with backlash. This configuration is chosen due to elimination of heat production in supporting bearings. Thus thermal stabilization effect of different factors can be investigated separately. First the single source of heat (friction heat generated between ball screw and the nut is evaluated). The cooling of ball screw is added in the next step. In this manner is possible to debug numerical model.

The temperature increase was measured using thermocouples. Three thermocouples were fixed on unmovable nut by epoxy resin. One thermocouple was placed in cooling reservoir. The last one was used to measure the room temperature. The temperature of the ball screw was measured by contact thermo sensors RAYTEK. The ball screw temperature was measured always between operating cycles. The field of temperature was measured by thermo camera FLIR. The test bed was thermally steady state before each experiment to ensure its thermal stability. A friction moment of the screw shaft was also measured using special test bed. The experimental variables were: rotational speed n (rpm), braking force F_b (N), flow rate in ball screw cooling sub-circuit Q_{ball} (l/min) and flow rate in nut cooling sub-circuit Q_{nut} (l/min). It was found out that he ball screw cooling has significant effect on thermal stabilization as show results of experiment and numerical model. Surprisingly low flow rate of cooling liquid is necessary for thermal stabilization of ball screw system.
Both heat sources were analyzed by finite element method using software ANSYS. It was necessary to perform a closed loop finite element calculation because of coupling between generated friction heat and the axial force in the screw shaft changed by thermal deformation. The programmed loop consists of thermal analysis followed by structural analysis. This enables updating of heat sources according to instantaneous structural condition. This loop is performed till the steady state. The numerical simulation was performed for different preload levels of ball screw.

The numerical model show significant influence of bearings preload upon thermal stabilization of ball screw system. Thus the FEM model can serves us as guideline already during structural proposal of ball screw system – selection of proper bearings and also choice of correct value of bearings preload (determined by FEM model for certain machine tool). It was found out that producers of machine tools often use very rigid supporting bearings. The reason is understandable, the proper stiffness of ball screw system is necessary for precise translation. However the thermal behavior of ball screw system is not considered at all. On the other hand very rigid bearings produce big amount of friction, which causes higher production of heat. Consequently bearings could be overloaded or even seizure of the bearing can be reached. Using of more flexible bearings is more suitable from thermal stabilization point of view and the impact on overall stiffness is negligible.

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kLa Measurement by DSM and Limitation of the DSM in Agitated Vessel

A. Siřínek

sirinek@student.fsid.cvut.cz

Czech Technical University in Prague, Faculty of Mechanical Engineering,
Department of Process Engineering
CZ-166 07 Prague 6-Dejvice, Czech Republic

The important characteristic of gas-liquid contactors is the intensity of mass transfer which is characterized by the volumetric mass transfer coefficient - k_La. For the k_La measurement various methods exist (i.e. steady state methods, dynamic pressure method, gassing-out method, dynamic start-up method). One of these methods is dynamic sulfite method. The method is based on simultaneous monitoring of dissolved oxygen and sulfite ions concentrations after an injection of sulfite solution (or other oxygen consuming species) to the batch initially saturated with aerating gas. The concentration of the sulfite oxidized in an analyzed sample of liquid determines the initial oxygen concentration corrected to non-ideal mixing. The volumetric mass transfer coefficient k_La is given by the ratio of the oxygen and sulfite concentration at any known time.

The main goal of this contribution is to verify the DSM (*Dynamic Sulfite Method*), as presented by Havelka et al. (1997), in an mechanically agitated vessel for further implementation of this method in an apparatus with an ejector-type gas distributor.

The second aim of this contribution is to verify the DSM (*Dynamic Sulfite Method*), as presented by Havelka et al. (1997), in a mechanically agitated vessel. It was found that the DSM is sensitive to fulfillment of several conditions: instantaneous sulfite oxidation and constant concentration of oxygen in bubbles.

The measurements were carried in a fully baffled vessel of the diameter 0.19 m (volume 5.9 l) agitated with the Rushton turbine. Distilled water (coalescent batch) was used as a model liquid. Only pure oxygen was used as a gas phase and it was fed under the agitator. A pulse of Na_2SO_3 and 10^{-3} M $CoSO_4$ mixture was introduced at the start of experiment. $CoSO_4$ serves as a catalyst of the sulfite oxidation reaction. The responses of oxygen and conductivity probes were recorded and k_La evaluated consequently.

The effect of sulfite and catalyst amount, location of pulse injection and the same of the sampling point were tested. At catalyst concentration lower than 10-6 M the rate of sulfite oxidation reaction is not sufficient to fulfill the condition (1) of instantaneous sulfite oxidation.

$$c_{Lo} = c^*_{L,in} - \frac{1}{2} c_S \qquad (1)$$

The effects of sampling and pulse injection positions were not proved.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Material Behaviour during Laser Machining

Z. Hovorková

Z.Hovorkova@rcmt.cvut.cz

Research Center of Manufacturing Technology, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 128 00 Prague 2, Czech Republic

Material behaviour during laser machining was observed in terms of the depth of stock removal in dependence on number of laser-beam passes and in terms of the temperature behaviour during laser-beam incidence on material. Experiments proceeded on alloys, which are often used by laser applications (steel 14 220 and 19 436, cast iron 42 2420, duralumin, brass and bronze).

Material properties of heat-treated work pieces by high temperatures are important at most processes of heat treatment. Physical and optical properties of material in the whole temperature range are critical components in calculation of temperature behaviour.

Physical properties of material determine:

- energy quantity needed to the melting and vaporization of the material,
- energy quantity transferred during conduction into material during laser-beam incidence.

Among physical material properties influencing the process of laser machining belong to:

- melting temperature [°C],
- boiling temperature [°C],
- thermal conductivity [$W.m^{-1}.K^{-1}$],
- density [$kg.m^{-3}$],
- thermal capacity [$J.kg^{-1}.K^{-1}$],
- thermal diffusivity [$m^2.s^{-1}$],
- coefficient of thermal expansion [K^{-1}],
- latent heat of fusion [$J.kg^{-1}$],
- latent heat of evaporation [$J.kg^{-1}$].

Optical material properties affect the quantity of used energy. Among optical properties belong to:

- absorption coefficient [cm^{-1}],
- reflection coefficient [-],
- absorptance [-],
- emissivity [-].

Experiments leading to the establishment of depth of stock removal in dependence on number of laser-beam passes proceeded on 5-axes MCVL 1000 LASER machining center. Squares of size 10x10mm were machined on the specimens. The speed of laser-beam movement was changed within the range of 20, 60, 80 and 100 $mm.s^{-1}$ and the number of laser-beam passes (from 1 to 50) in these experiments. Power and frequency were constant (50W, 4 500Hz). Operating mode was pulsed.

From the performed experiments it follows, that dependence is a linear between the depth and the number of laser-beam passes. The depth of cavity grows linearly with the growing number of laser-beam passes. The regression equations for dependency of the depth of stock removal on the number of laser-beam passes and coefficients of determination R^2 for different speed of laser-beam movement were obtained from graphic dependencies. Regression equations make possible to determine the working conditions for achievement of desired depth of cavity for laser micro-milling before the full machining.

Preliminary model of distribution of incoming heat was made at description of thermal behaviour during laser machining. It was used two material properties at present, namely temperature conductivity and heat conductivity. We assume zero reflectance and 100% absorption (black body). Preliminary consideration outgoing from measured values leads to the following conclusion: for small temperature conductivity, for stock removal there is critical its heat conductivity, when most of incoming heat is used for stock removal. Smaller amount of incoming heat is probably necessary for stock removal for bigger temperature conductivity. This consideration is necessary further to study.

For obtaining of experimental values of temperatures we performed measurements of temperature fields during laser machining. Thermo camera LAND FTI 6 from the Eurotherm Ltd. firm was used on this measurement. System makes possible accurate and high stable temperature measurement range from –20 to 2 000°C. The measurements were performed on the JK 701H LUMONICS laser machine. Measurements of temperature fields proceeded behind various working speeds of table (200, 500 a 800 $mm.min^{-1}$). The other parameters of laser were constant. The weld 10mm long was created on these materials. At laser-matter interaction it was necessary to blow away the cloud of plasma, rising above interaction region. If we did not blow away the cloud of plasma, we would measure plasma temperature but no real temperatures in the place of laser-beam incidence on material. From the measured values it follows: during 0.1s we can observe the rapid heating of the work piece. Further, temperature does not change with the growing time.

Optimal parameters and equations made possible to determine the working conditions for achievement of desired depth of cavity are the result of performed experiments of micro-milling. From the performed experiments the influence of thermal conductivity and thermal diffusivity on stock removal was determined. From the measured temperature fields the influence of these properties on achieved temperature during laser-beam incidence on material was showed. It is necessary to continue with study of these dependencies.

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Simulation Tools in Project Management

T. Růžička

Ruzicka@fs.cvut.cz

Departmen of Manufacturing Technology, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07, Prague 6, Czech Republic

This article introduces knowledge gained from an application part of doctoral thesis. It describes key advantages and benefits as well as its drawbacks. This article is based on several practise applications in the Czech Republic and it tries to recommend an optimal implementation level.

Simulation programs for manufacturing industry have significantly spread around the world. More and more companies use the advantages of simulation techniques for management of their businesses. In the cases when every part of the supply chain optimisation of its own cost and all supply chain use simulation program for optimisation through whole business then there are usually very good results. Only clear quotation with legitimated and identified costs is healthy basic for successful business and profit for every one of stakeholder.

Supplier who out-sources to bigger company hasn't so stable position that doesn't need to make better and better services. Clear costing is first key for success. There is on-line competitors' network. Multinational companies have so wide suppliers network all over the world that everybody can get better offer than is yours every time. It means that simulation has two main usages:

1. multinational companies should use simulation programme for choosing the best offer which includes all aspects as transport cost, import/export duty etc.
2. each supplier should use simulation programme for optimization of its own cost and for doing correct and clear calculation

Manager has to know what is the goal, tool and cost. Every operation, manipulation, storing, material item cost some money. Moreover, each company has its own fixed part of organization which generates fixed cost as for example heating, lighting, amortization, support staff, managers, research and development departments. The most important thing is to know itself. Prices of raw materials are still changing like energy, utilization of machines and others. It's very difficult to remain still flexible, to be able to offer enough capacity and in the same time to have good utilization of capacity, satisfied customers and to prepare correct strategy for the future.

My research brings very clear evidence that simulation program can describe internal production and managerial relations as such. Then this model shows and is able to answer lot of questions and helps in project management so much that company sees its own reserves, strengths and weaknesses.

The biggest part of my research was done in the market of plastic products in one multinational company. There are many issues which have to be resolved. The main goal of multinational company, whole the place a role of a customer in this supply chain, is mapping of opportunities and finding the best way in the business. In this case, simulation tool is used

to make the model of their supplier's network. Model is made from such elements that give limits, direction and space to simulate the behaviour of whole business all over the world. It includes production, transport, storing and selling costs. Because this multinational company has production capacities and stores in the all continents and each product is delivered from one supplier to all stores in the world at same selling price, it is important to decide where final product is sold with profit and where with financial loss and to identify the final financial result of the company through our whole the world. Simulation program finds the opportunity with the biggest profit. It means which supplier is available and suitable for the production of particular product. Actually, simulation program is used here to make decision in the tenders. Clear results and factually based policy in out-sourcing definitely generate the business success.

Last but not least important usage of simulation tools for project management is direct the implementation in each of suppliers who compete in the tender for some product or produces some product and is under competitive pressure. Supplier has usually made the model of its own production of particular product. This model is made in the details and considers all aspects of production which are important for the production. In this case there are production programmes for very long time with strategic significance for company.

Suppliers are producing in dynamic environment there are lots of factors which are dynamically changing. For example, last year the market of crude oil for plastic granulates was under extreme pressure caused by the hurricane in the North America that destroyed mining towers and therefore prices of raw materials (plastic granulates) increased sharply. Then suppliers had to quickly react and optimize their own providing policy. They started with the material's standardization, buy larger amounts and therefore they get amount discounts. That is why supplier has to know exact costing structure which is usually sensitive, but for them it is so important that it allows the supplier to make correct policy and decision in competitive environment which is good motivation for active approach. They can identify profit every time they can do analysis and find reserves. Although the prices of raw materials increased about 100%, final product cost is still the same, because suppliers achieved very good optimization in production processes. They often invested into automatization lines instead of labour cost. For these investments they needed to know its recoverability. That is the reason for this implementation of simulations tools. Of course that all information is very sensitive and supervisor of this model has to be reliable and has to provide correct information for management.

It is clear that application part of my doctoral thesis provides certain evidence that simulation tools have strong position in today's business, bring new advantages and open new space for rational improvements. Who can manage to know itself these can improve themselves and be more competitive than others.

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The Main Aspects of Mg Alloys Melting

Herman, A.

Ales.Herman@fs.cvut.cz

Department of Manufacturing Technology, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

During the processing of magnesium alloys, the oxidation of the liquid metal must be absolutely prevented as liquid magnesium often reacts intensively with the oxygen of the air. The non-precious character of the metal and the low standard electrode potential lead to the known high oxygen and nitrogen affinity of magnesium melts. As the Pilling-Bedworth ratio for magnesium is 0.81 [1], no dense oxide layer is formed. Therefore the attack on the metal continues. To minimize the risk of the magnesium melt to catch fire and the contamination of the melt by oxidation products, it is indispensable to shield the melt against the ambient atmosphere while it is handled. Magnesium and its alloys are increasingly used to substitute other metals, elastomer, and plastics. The decisive factors are excellent properties like low density, good casting properties, electromagnetic shielding, high specific strength and elasticity. Because of these features magnesium and its alloys became very popular in automobiles, computers, aerospace, sports goods, mobile phones, and many other applications. Today only 1-1.5 wt% of a typical
medium sized car were made out of Mg, Aluminium is the dominating light metal in the automotive sector and almost 10 wt.% of cars were produced from Al. Several car manufacturers are going to increase the share of magnesium to get a further reduction in weight. The further growth of magnesium applications in different industries will only be possible, when further improvements will take place. The non-precious character of the metal and the low standard electrode potential lead to the known high oxygen and nitrogen affinity of magnesium melts. As the Pilling-Bedworth ratio for magnesium is 0.81 [10], no dense oxide layer is formed. Therefore the attack on the metal continues. Generally the following shielding methods are available for magnesium melts. The different techniques can be combined or applied individually [2]:

- covering by melt-viscous salts or salt mixtures
- doping of the melt by cover forming, passivating elements
- handling of the melt under an inert gas atmosphere
- handling of the melt under a reactive gas atmosphere in connection with the formation of thin passivating films

The pros and cons of these techniques are widely known [3]. The today industrially used inert gas sulphur hexafluoride (SF_6) is characterized by a high GWP (Global Warming Potential) factor of 23,900 related to the CO_2-induced damage to the earth atmosphere. By signing the Kyoto Protocol the countries of the European Union have committed themselves to reduce the emission of greenhouse gases by 8 %. From 1 January 2007, the use of sulphur hexafluoride in magnesium casting will be prohibited, unless the used amount is below 500 kg annually[4]. The only industrially feasible alternative is toxic sulphur dioxide (SO_2). With regard to the explained problems, in the last five years a rise of the activities concerning oxidation protection systems for magnesium can be noted [3]. According to the new reports SO_2 and BF3 can contribute to the substitution of SF_6. Numerous further fluoric substances like HFC-134a [4] and fluoric ketone [4] were suggested as substitutes. Also constructive measures to reduce the oxidation potential of the melt were presented.

Injecting CO_2 into the furnace chamber at high pressure by a suitably designed nozzle causes the gas to expand and produce solid CO_2. In a downstream "snow tube" the fine, crystalline snow forms particle agglomerates. This CO_2 snow precipitates at the bath surface, lowering the surface temperature of the bath (at – 78°C CO_2 has a cooling effect of 573 kJ/kg). This reduces the magnesium's proneness to evaporation. Moreover, sublimated CO_2 snow causes the gas to expand and displace all oxygen from the bath surface area. After the successful completion of the preliminary experiments (CO_2-pellets) a nozzle was constructed which generates solid CO_2-snow out of liquid CO_2 (agglomerated particles of solid CO_2) to receive a practical orientated charging possibility of the molten bath surface with solid CO_2. The nozzle of the CO_2-snow installation was designed for an expansion of the CO_2 underneath the triple point at 5.18 at the die mouth. If this expansion takes place within the nozzle the snow generation of the CO_2 also begins within the nozzle which results in a reduction of the throughput till a total obstruction of the nozzle.

The outgoing speed out of the nozzle has nearly sound velocity due to the great gas amount. As the corresponding high impulse of such a gas/solid matter jet on a magnesium melting is not wanted, the two-phase jet which emerges out of the nozzle must be braked in a topped "snow tube". Here the fine, crystalline snow can be nodulized into particles. After a number of preparatory investigations a test furnace was converted for operation with CO_2 snow.

The melting was heated up to a temperature of approximately 700° C. During the snowing the melting is cooled down to 675° C 25 mm underneath the molten bath surface and the temperature of the furnace atmosphere cools down from 550° C to approximately 400° C at the same time depending on the duration of the snowing [2]. Under real conditions, oxides - so-called dross – form at the surface. The dross temperature (900 – 1000 °C) is clearly higher than the bath temperature. The existing dross is a "source of fire" leading to localized continuous exothermal reactions. Without protective measures, this could eventually turn into an uncontrollable fire. Covering the surface with CO_2 snow stops the oxidising reactions. Also the method's suitability in the event of a fire was proved. A fire on the surface of the bath was successfully extinguished by CO_2 snow.

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Section 9

ENERGETICS
&
POWER ENGINEERING

The Power Station's Machine Block Transient Simulation in Operation States

J. Špetlík*

spetlij@fel.cvut.cz

*Department of Power Electrical Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

With process of dispersed generation systems (DGS) penetration to distribution network, solution of special transient events in DGS (substation short circuit, pass into islanded operation state) becomes more important. Assuming the fact, that number of DGS type sources is increasing (Germany), it is necessary to analyze stability phenomena of these systems. Transient dynamics solution in such case studies is strongly dependent on chosen model. Commonly used *0dq* models are sufficient in transients near the steady state operation point. This project solves the case studies with more accurate model.

Presented model of generator computes with the stator variables in physical (*abc*) form. In the papers [1] – [3] is demonstrated its importance, namely in the cases with *dq* non-symetrical machines. Main technical problems connected with DGS operation are voltage and power stability. This group of problems is often solved with simulators based on *dq* – transformation (Simulink – SimPowerSystems). However, these simulators do not comprehend solution for harmonics, which can be present during transient and in specific cases could cause errors in protection functions. For dynamic behavior demonstration purposes data of dominant types of dispersed generation sources are inputted (machines with appropriate parameters, *abc* model). Finally is made the comparison of behavior each of them during occurred transient in *abc* and in *0dq* reference frame. First chosen type of transient is machine connecting to grid, second three-phase short circuit. On these examples can be seen *dq* model validity in each case.

Machine model was created in software Mathematica. Input parameters (generator *0dq* parameters) are re-computed from inductance [$\mathbf{L}_{0dq}$] matrices to *abc* matrices from the same machine. Note, that *abc* parameters are time dependent and for computation more demanding. For further analysis, important quantity is electromagnetic torque T_e, which can be written in general form as partial derivative of coenergy $\partial W_c / \partial \theta$.

The *abc* model is applicable in short term dynamics i.e. during transients and subtransients events. For symmetrical machines gives same results as 0dq based models (compared in Simulink / SimPowerSystems). In the model can be also recomputed machine with *dq*-asymmetry and in final solution gives expected results with harmonics (which cannot be accomplished in standard *0dq* model). Furthermore, model can be extended to compute with non-symmetrical *abc* parameters (self and mutual), which cannot be expressed in standard *0dq* model machine description. Current dependence of inductances L(i) can be implemented as

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Diagnostics of Compensation Capacitor Temperature Profile

Pavel Mindl

mindl@fel.cvut.cz

ČVUT-FEL, katedra elektrických pohonů a trakce, Technická 2, 166 27 Praha 6

To increase reliability of compensation capacitors banks, knowledge of capacitors internal temperature distribution is needed. Capacitor temperature profile prediction is possible, but practically complicated due to unknown parameters of mathematical model. Therefore basic experiments focused on temperature profile and power loses of compensation capacitor bank has been done.

For capacitor temperature profile experimental investigation a two special capacitors were made. Each capacitor was equipped by two "K" thermocouple temperature micro-sensors type 5TC-TT-K-36-36 situated across aluminium and polyethylene foil roller. Three PT 1000 micro-sensors were situated on both sides of capacitor cover and in the middle of capacitor. Each micro-sensor was electrically insulated from the aluminium foil and connected to the metering unit.

Measured capacitors were filled by different type of internal insulating media.

The first capacitor was filled by insulating gel, the second one by nitrogen (N_2) gas.

During measurement were capacitors connected to the AC power supply. Roller temperature profile was established in voltage range from 200V up to 500V under external temperature 21 – 22 °C.

On the basis of experimental results mathematical model for capacitor internal temperature distribution is being evaluated. Mathematical model for heat transfer is based on electrical equivalent circuit with "lather structure" with internal additional sources representing internal power losses. Heat transfer between two points in the capacitor roller is given by formula

$$\Phi = \frac{\upsilon_1 - \vartheta_2}{R_\vartheta}$$

Where: υ_1 ... temperature of point 1

υ_2 ... temperature of point 2

R_υ ... temperature resistance between points 1 and 2

Differential temperature resistance of capacitor elementary volume with length l and cross-section area S is:

$$dR_\vartheta = \frac{1}{\lambda}\frac{dl}{dS}$$

This formula is adapted for cylindrical shape of capacitor roller. For radial direction heat flow is expressed by formula:

$$R_\vartheta = \frac{\ln\frac{r_2}{r_1}}{2\pi\lambda h}$$

Due to different temperature properties of insulating media (gel, N_2) the shape of roller temperature profile is rather different for measured capacitors. But any temperature extreme has not been detected. Due to good temperature micro-sensors electrical insulation there was no problem with mains voltage interferences. Temperature calibration of micro-sensors was done by 0°C (melted ice temperature) and 60 °C (tempering bath).
More detailed results are presented in research report /1/.
Next investigation will be focused on capacitor temperature profile under different ambient temperatures and investigation of high order harmonics currents influences. Detailed analysis of power loses under high order harmonics currents load is prepared.
For presented experiments especially diagnostic assembly was built. Obtained results are applied in development of the new types of compensation capacitors.

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Experimental Results on Bearingless Disc-Slice Motor

J. Pavelka *, B. Syrovátka **, D. Vydra *

pavelka@fel.cvut.cz

*Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This contribution continues the information given in [1]. The main aim of the research is to develop an electric drive with the bearingless disc-slice motor for a speed higher than 100 000 rpm. General information about the basic drive principle and construction was given in [2]. This type of drive can be divided into the following parts: bearingless disc-slice motor, power electronic amplifier, main board with voltage sensors, current sensors and interconnection part, position sensors part and controller.

The bearingless disc-slice motor was designed, constructed and manufactured in the year 2002 and basic tests were done during the year 2003.

The power electronic amplifier was designed and manufactured in the year 2002. This amplifier used excitation circuits for PNP and NPN FET power transistors composed of discrete electronic components. This solution conformed to low switching frequencies but was not acceptable for switching frequencies higher than 5 kHz. The new power electronic amplifier was designed and manufactured according to following requirements: switching frequency 25 kHz, maximum switching current 10 A with independent supply of six independent coils in star connection and electronic power supply ± 30 V (+60 V; +30 V; 0). Excitation drivers IR2104 were used instead of discrete electronic components. Only NPN power transistors were used and a optical coupling between power and control part was applicated. High over voltages appeared during initial tests. Snubber RC circuits were completed.

The main board contains circuits for voltage and current measurements. Voltages are measured just on both ends of excitation windings and adjusted to controller input level in voltage dividers. Currents are measured as the voltage drops on the measuring resistances connected in series with the excitation windings. These voltage drops are amplified. Output voltages of these amplifiers are adjusted to controller input levels. Interconnection part serves for linking of all separated blocks of the drive.

The selection of a suitable sensor principle was the most difficult problem during the research. The analysis of possible principles was given in [1]. The eddy current principle was chosen on the base of this analysis and the first prototype for our concrete application was manufactured in the year 2005.

The elementary measuring circuit is configured as an equilibrium differential bridge for gaining the smallest electronic evaluating and controlling circuits offset, which causes the rotor center displacement from the stator center. The output signal of the evaluating circuit can be acquired from the change of the voltage amplitude, produced by L, C_p, R_o circuit damping, or from the change of the voltage signal phase difference. The voltage value from the bridge output is acquired as the difference of the voltage from the bridge transversal branch A and of the voltage from the bridge branch B. This output directly determines the rotor displacement x from the centre position to both sides (± x). The sensor output voltage dependence on rotor displacement is linear.

Complete position sensor is composed of 4 parts - DC supply ± 12 V, sensor coils part, excitation circuit and evaluation circuits. Sensor coils can be divided into two groups: excitation coil and six sensing coils. Sensing coils are located symmetrically in three axis. All coils are created as printed circuit board. Excitation coil is connected to supply frequency generator. Signals from 6 sensing coils are carried back to evaluation circuits. The evaluation circuit outputs are three DC signals, that represent the rotor displacement in three axis each of which is shifted by 120 °. Those 3 signals are directly connected with A/D converters of DSP (digital signal processor) controller. First tests were done in autumn of the year 2005 and they confirm applicability for bearingless disc-slice drive. Sensor delay is not measurable, sensors have linear analog voltage output $V_r = 0 – 3.3$ V for the rotor displacement 0 – 2 mm. For the centered position $V_r = 1.65$ V. Sensors are not influenced by the power PWM supply of motor windings.

Microprocessor MOTOROLA DSP56F807EVM is used as the controller. The controller performs two tasks – the stabilization of the rotor position in the air gap and the speed control. The software program controls currents in six windings independently. Each current is the sum of the stabilizing component and the torque component. The stabilizing component is the result of the position control loop with PID controller. First experiments with stabilization of the rotor without rotation were done and rotor levitated in the air gap. Oscillations of the perpendicular axis were found out. The rotor rotation as a result of an electromagnetic torque was also tested. The rotor was fixed on the mechanical bearing and stator windings were supplied from the electronic power part. Current control loops with PI controllers and PWM modulation were used. The system operated without problems.

The control system realized in a microprocessor software is based on the current mathematical model. The voltage mathematical model was studied during the year 2005. Its advantage is a simplification of determination of the rotor position. The disadvantage is the requirement of identical parameters of all motor windings.

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The Results of Measuring on AMB According to ISO

L. Synek , J. Pavelka

synekl@fel.cvut.cz

Department of Electric Drives and Traction, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Advantages of turbomachinery with AMBs (Active magnetic bearing) as well as their numbers and variety have increased extremely over the last few decades. The costumers of these machines expect that their machines are running safe and reliable and that they have a high efficiency and availability. In order to satisfy these requirements an integrated fault detection and diagnosis become increasingly important for these machines. Rotors in AMBs already offer a variety of advantages compared with conventional systems. Some of them are the tuning possibilities for stiffness and damping, the absence of wear, the reduction of friction, the high running speeds, and possible unbalance compensation.

The workplace of magnetic bearings of the Electrical Drives and Traction department is equipped with different types of ABMs. One of theses was used for the identification of a frequency response function according to the standard ISO 14839 Part 3 – "Evaluation of stability margin". Identification and diagnosis procedures are based on the injection of simple harmonic signal to ABM position control loop.

While passive bearings, e.g. ball bearings or oil-film bearings are essentially stable systems, magnetic bearings are inherently unstable due to the negative stiffness resulting from static magnetic forces. Therefore, a feedback control is required to provide positive stiffness and positive damping so that AMB operates in a stable equilibrium to maintain the rotor at a centred position. A combination of electromagnets and a feedback control system is required to constitute an operable AMB system.

The AMB rotor should first be evaluated for damping and stability properties for all relevant operating modes. Active magnetic bearings support a rotor without mechanical contact. AMBs are typically located near the two ends of the shaft and usually include adjacent displacement sensors and touch-down bearings. Each displacement sensor detects the shaft actual displacement in one radial direction in the vicinity of the bearing and its signal is the fed-back to the compensator. The displacement of the rotor position from the bearing centre is therefore reported to the AMB controller. The controller drives the power amplifiers to supply the coil current and to generate the magnetic force for levitation and vibration control. The AMB rotor system is generally described by a closed loop in this manner.

The diagnosis procedures are provided by the microprocessor controller D8204 during main control operation on our workplace. The AMB is used as an actuator for generation of defined motions respectively forces and as very precise sensor elements for the contactless measurement of the responding displacements and forces. In the linear case, which means small motions around an operating point, it is possible to derive compliance frequency response functions from the acquired data.

At a certain point of this closed-loop network, we can inject an excitation E(s) as harmonic or random signal and measure the response signals V_1 (sensor signal) and V_2 (control signal) directly after and before the injection point. The ratio of these two signals in the frequency domain provides an open-loop transfer function G_o with $s = j\omega$:

$$G_O(s) = -\frac{V_2(s)}{V_1(s)} \qquad (1)$$

The closed-loop transfer function G_c is measured by the following ratio:

$$G_C(s) = -\frac{V_2(s)}{E(s)} \qquad (2)$$

The sensitivity function offers two advantages over evaluation of the minimum distance on the Nyquist plot. First, it is generally easier to construct the maximum magnitude than to find the minimum distance. Indeed, the usual computational method for finding the minimum distance in the Nyquist plot is to find the maximum value of the sensitivity function and then to invert it. Second, measurement of the sensitivity function is relatively simple. At a certain point of this closed-loop network we can inject an excitation E(s) as harmonic or random signal at an injection point E and measure the response signal V_1 directly behind the injection point. The ratio of these two signals in the frequency domain provides the sensitivity function G_s:

$$G_S(s) = \frac{V_1(s)}{E(s)} \qquad (3)$$

The definition of each stability zone is given for evaluation of the stability margin. The peak sensitivity at zone limits is determined by the ISO 14839.

Zone A: The sensitivity functions of newly commissioned machines would normally fall within this zone.

Zone B: Machines with the sensitivity functions within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with the sensitivity functions within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: The sensitivity functions within this zone are normally considered to be sufficiently severe to cause damage to the machine.

The detail results of identification measurements are given in [3] and will be presented on poster.

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Matrix Converter Induction Motor Drive Control

J. Lettl, S. Flígl

lettl@fel.cvut.cz

Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Electric Drives and Traction
Technická 2, 166 27 Praha 6, Czech Republic

The designed concept of the matrix converter induction motor drive control system with emphasis on the PWM modulation strategy employed in the hybrid traction drive with electric power splitting is presented. The matrix converter inclusion in the drive is advantageous especially with regard to the reactive component reduction.

Matrix converters provide an all-silicon solution to the problem of converting AC power from one frequency to another, offering almost all the features required of an ideal static frequency changer. They possess many advantages compared to the conventional voltage or current source inverters. A matrix converter does not require energy storage components as a bulky capacitor or an inductance in the DC-link, and enables the bi-directional power flow between the power supply and load. The most of the contemporary modulation strategies are able to provide practically sinusoidal waveforms of the input and output currents with negligible low order harmonics, and to control the input displacement factor.

Great number of sophisticated strategies of pulse width modulation methods, and control algorithms for induction motor control in terms of various optimization criteria are known in case of indirect frequency converters, whereas both the inverter and the rectifier can be operated with pulse width modulation. The instantaneous state of both the output and the input converter waveforms depend at any time on the switch state of the converter power switches S. Suitable switch states sequence of the nine matrix converter switches can be indirectly derived from the given switch states sequence of the twelve switchers of the indirect frequency converter. The matrix converter instantaneous switch state matrix **S** can be afterwards determined by means of the instantaneous switch state vectors $\mathbf{s}_{ABC}$ and $\mathbf{s}_{RST}$ as follows

$$\boldsymbol{S} = \boldsymbol{s}_{ABC}\boldsymbol{s}_{RST}^{T} = \begin{pmatrix} S_A \\ S_B \\ S_C \end{pmatrix} \begin{pmatrix} S_R & S_S & S_T \end{pmatrix} = \begin{pmatrix} S_{AR} & S_{AS} & S_{AT} \\ S_{BR} & S_{BS} & S_{BT} \\ S_{CR} & S_{CS} & S_{CT} \end{pmatrix}$$

The matrix converter realised on the base of new progressive semiconductor elements (IGBT´s modules) is used to treat the electrically transmitted power part of the hybrid traction drive with electric power splitting. The electrical torque split device consists of a special electric generator with both rotor and stator rotating. The rotor is connected to internal combustion engine and its torque is via air gap electromagnetic forces transmitted to the stator. The torque and the output shaft angular speed constitute the mechanically transmitted power. The remaining part of the internal combustion engine power is transformed into the electric power and represents the input power of the electrical transmission.

The special “Host PC – Target PC” digital control system was developed for the realised experimental test bed. The matter consists in the processor throughput. While in case of the digital signal processors it can be as far as 100 MIPS at 16 bit DSP with fixed point, 200 MIPS at 32 bit DSP with fixed point, 20-200 MIPS/MFLOPS at DSP with floating point only, in case of processors for PC it can reach e.g. 9000 MIPS and 2600 MFLOPS.

The basis of the control system consists of two common personal computers. The first one (Host PC) should be equipped with any multitasking operating system and the MatLab programme must be installed on this PC. It serves for compiling of the target real-time applications and for monitoring purposes only, such as downloading and displaying of measured waveforms, commands entry, etc. One serial port of the RS232 standard and one parallel port enabling operation in the ECP mode are inevitable. The second one (Target PC) works in real time and the matrix converter control programme is processed on it only. The most important component of this PC is the Multi I/O PCI card Meilhaus ME-2600i containing A/D and D/A converters and digital inputs and outputs. All the signals are reprocessed and adjusted in interface cards situated in the control rack. Here is also placed the IGBT’s switch pulses generating card based on a FPGA device. To make the work easy, the firmware for the Target PC and the monitoring programme for the Host PC were prepared. The firmware consists of the libraries set programmed in the ASSEMBLER and C language enabling faster algorithm implementation and testing. It has the real-time kernel with 50 – 200 microseconds period and contains synchronisation, communication, and I/O card specific routines. The monitoring programme consists of the set of the mutually communicating programmes programmed in the MatLab, JAVA, and C languages. However, from the user sight it seems to be one application only. This software is very important for easy control application developing.

The developed matrix converter control hardware and software system makes it possible to achieve greater throughput of the digital control system and its variability. The results obtained on the built-up experimental test bed have proved proper function of the designed conception of the matrix converter control system and implemented PWM strategy.

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Vector Controlled AC Drive with Induction Motor Nonlinear Model

J. Lettl, R. Ratz

lettl@fel.cvut.cz

Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Electric Drives and Traction
Technická 2, 166 27 Praha 6, Czech Republic

The vector controlled induction motor drive behaviour in case of taking into account the nonlinearity of the induction motor magnetizing inductance is presented. The magnetizing current is optimized in order to obtain the minimal stator current at the given torque, which means that the magnetizing flux is not constant.

The vector control is also known as the "field oriented control", "flux oriented control", or "indirect torque control". Using field orientation, three-phase current vectors are converted by the Clarke-Park transformation to a two-dimensional rotating reference frame "d-q" from a three-dimensional stationary reference frame. The "d" component represents the flux producing component of the stator current and the "q" component represents torque producing component. These two decoupled components can be independently controlled by passing through separate PI controllers. The outputs of the PI controllers are transformed back to the three-dimensional stationary reference plane using the inverse Clarke-Park transformation. The corresponding switching pattern is pulse width modulated and implemented using the space vector modulation (SVM). This control simulates a separately exited DC motor model, which provides an excellent torque-speed curve. The transformation from the stationary reference frame to the rotating reference frame is done and controlled with reference to a specific flux linkage space vector (stator flux linkage, rotor flux linkage or magnetizing flux linkage). In general there are three basic types of the induction motor vector control: stator flux oriented control, rotor flux oriented control, and magnetizing flux oriented control. The most challenging and ultimately, the limiting feature of the field orientation, is the method whereby the flux angle is measured or estimated. Depending on the method of measurement, the vector control can be divided into two subcategories: direct and indirect vector control. In direct vector control, the flux measurement is done by using the flux sensing coils or the Hall devices. The more common method is indirect vector control. In this method, the flux angle is not measured directly, but is estimated from the equivalent circuit model and from measurements of the rotor speed, stator current and voltage. One common technique for estimating the rotor flux is based on the slip relation. This requires the measurement of the rotor position and stator current. With current and position sensors, this method performs reasonably well over the entire speed range. The most high-performance drives today employ indirect field orientation based on the slip relation. The rotor flux oriented control is described below.

Applying the rotor flux oriented vector control all the stator and rotor voltage equations are described in the rotor flux oriented reference frame. There are two main approaches to solve these equations. First the magnetizing inductance is expressed as a function of the rotor magnetizing current space phasor modulus and secondly the magnetizing inductance is expressed in terms of the magnetizing current space phasor. The first method is considered.

As a result of the main flux path saturation, the magnetizing inductance, and the stator and rotor self inductances are not constant but vary depending on the magnetizing current. Currents and voltages were measured trough different supply voltages and after that the obtained results were calculated by means of SigmaPlot. The magnetizing inductance values were expressed by a polynomial.

Comparative simulation of vector control system that is taking into account the non-linear character of the magnetizing inductance, but has a constant magnetizing current is compared with the system, that also take into account the non-linear character of the magnetizing inductance, but furthermore has an optimized magnetizing current in order to obtain minimum stator current for the required torque. The built-up MatLab model consists of two main blocks. The Control Unit block and the Induction Motor block represent the regulator and the induction motor, respectively. The compared results are obtained by using two models in one simulation process. The Control Unit block of the first one is taking into consideration the constant magnetizing inductance value and in the second case the magnetizing inductance value is variable and depends on the magnetizing current.

The real drive control board is realized using TMS320F241 Texas Instruments DSP and Eupec PIM power module BSM15GP120. A standard squirrel cage induction motor of nominal power 550 W and nominal voltage 3 x 230 V in Δ connection is employed. A standard incremental encoder 1024 pulses per revolution is used as a positioning sensor.

The drives that utilize flux vector control model with speed feedback meets the highest precision and dynamic requirements giving asynchronous drives servo type performance. Drives that count with the magnetic non-linearity character of the induction motor in their control conception have a much higher torque overloading capabilities, less torque ripple and better dynamics than the ones utilizing a linear control model.

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Combined Magnetic Bearing

Jan Vitner

vitnerj@fel.cvut.cz

CTU in Prague, Faculty of Electrical Engineering, Dept. of Electric Drives and Traction
Technická 2, 166 27 Praha 6

Magnetic bearings stabilize the shaft at a rigid position with a certain stiffness and damping. They allow a rotational motion of the shaft with no friction (vacuum). Advantages of active magnetic bearings are e.g. ability to work in vacuum, in weightlessness, in chemical aggressive environment. Other advantages are the possibility to change their stiffness and damping and thereby to change the proper frequency of the rotating system oscillation.

There are two different conceptions of radial magnetic bearing at our workplace. Both of them are controlled by a digital signal processor. One of them is the combined magnetic bearing and the second one is an active magnetic bearing. The active magnetic bearing uses a system of four electromagnets for stabilization process. The combined magnetic bearing utilizes 3-phase winding system with permanent magnets. Such kind of the conception is quit new and the use of permanent magnets is energy saving. Power losses are consisted from the joule losses in the stator winding, losses of leakage inductances, rotor losses and losses depending on the properties of the control parts.

Active magnetic bearings support the rotor without mechanical contact. AMBs are typically located near both ends of the shaft and usually include adjacent displacement sensors and touch-down bearings. The position control axes are designated X_1, Y_1 at side 1 and X_2, Y_2 at side 2 in the radial directions and Z in the thrust (axial) direction. This way a five-ax control is usually employed.

Last year the stabilization process of both magnetic bearings was done. The shaft is typically driven by an induction motor. The motor is driven by a 3-phase converter MICROMASTER. With this converter we can measure properties of the bearing in a wide range of velocity.

Stabilized position of the rotor with the accuracy 40 μm is been reached. The value is amplitude of the rotor oscillations around the stabilized position. The amplitude of the oscillations depends very strongly on the sampling rate of the used position sensors. The same amplitude was reached for the driven shaft at 1500 rpm. These oscillations are evoked by the axial asymmetry of the shaft.

The input voltage of the bearing is 150V. The weight of the rotor is 15Kg and successful stabilization process is reached with the power drain around 60W.

The AMB rotor should first be evaluated for damping and stability properties for all relevant operating modes. There are two parts to this assessment. First, the run-up behavior of the system should be evaluated based on modal sensitivities or amplification factors (Q-factors). This concerns all eigen frequencies that are within the rotational speed range of the rotor. These eigen frequencies are evaluated by the unbalance response curve around critical speeds measured during the rotation test.

When the unbalance vibration response is measured, the sharpness of each vibration peak corresponding to eigen frequencies of the two rigid modes and the first bending mode is evaluated: this is commonly referred to as Q-factor evaluation. These damping (stability) requirements for an AMB system during run-up are covered by ISO 10814 (based on Q-factors).

The second part, which is covered by ISO 14839, deals with the stability of the system while in operation at nominal speed from the viewpoint of the AMB control. This analysis is critical since it calls for a minimum level of robustness with respect to system variations (e.g. gain variations due to sensor drifts caused by temperature variations) and disturbance forces acting on the rotor (e.g. unbalance forces and higher harmonic forces). To evaluate the stability margin, several analysis tools are available: gain margin, phase margin, Nyquist plot criteria, sensitivity function, etc.

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Section 10

NUCLEAR ENGINEERING

Spectrometry of Linear Energy Transfer of High-Energy Particles Using Chemically-Etched Track Detectors

I. Jadrníčková, F. Spurný*

jadrnickova@ujf.cas.cz

Faculty of Nuclear Sciences and Physical Engineering, CTU, Břehová 7, 115 19 Prague
* Nuclear Physics Institue, Na Truhlářce 39/64, 180 86 Prague

Risks from ionizing radiation depend both on the radiation quantity (absorbed dose) and the radiation quality (space and time distributions of dose and energy deposition distributions on the microscopic level). The radiation quality is characterized by the methods and procedures of microdosimetry. Current concept of radiation protection results from the connection between quality of concrete radiation and physical quantity – linear energy transfer (LET). For the purposes of measurements of LET spectra, there are several techniques. The tissue-equivalent proportional counter is probably one of the most used and accurate methods. However, in some cases its use can be compromised, for example at high dose rates and/or in the presence of very intense low LET component in the radiation field to be characterized. On the other hand, track etch detectors have some advantages, especially in situations where dimensions and weight of detectors are important; high LET particles have to be characterized in low LET intense radiation beams and fields; and a long exposure time is expected.

The spectrometer of LET based on a polyallyldiglycolcarbonate (PADC) chemically etched track-etch detectors has been developed in the Department of Radiation Dosimetry, Nuclear Physics Institute, AS CR. In the studies, three types of PADC materials are used: one available from Page (England) with a thickness of 0.5 mm, and another one available from Tastrak (Bristol) with thicknesses of 0.5 and 1 mm. After irradiation, the detectors are etched in 5 N NaOH at 70^{o}C for 18 hours. To determine the LET value of a particle, the etching rate ratio V ($V=V_T/V_B$; where V_B is bulk etching rate and V_T is track etching rate) was primarily established through the determination of track parameters. They were measured by means of an automatic optical image analyzer LUCIA G. The V-spectra obtained were corrected for the critical angle of the detection and transformed into LET spectra based on the heavy charged particles calibration. This LET spectrometer enables determining LET of particles approximately from 10 to 700 keV per μm. From LET spectra, dose characteristics can be calculated [1].

Recently, the irradiations in heavy ion beams were performed with the goal to verify calibration curves for individual materials of the detectors. The experiments were realized at the Nuclotron of the Laboratory of High Energies at JINR (Dubna, Russia) and at the HIMAC installation (NIRS Chiba, Japan) in the frame of the ICCHIBAN programs; the detectors were exposed to various heavy charged particles with LET in water from 7 to about 600 keV/μm. Then the detectors were evaluated and the upgraded calibration curves were obtained by means of polynomial regression, including systematic uncertainty estimation. The curves slightly differ for each material – threshold LET value for Page is inferior to 10 keV/μm, for both PADC Tastrak is a little above this value [2].

The LET spectrometer was used to investigate dosimetry and microdosimetry characteristics in the carbon ion beam; the results are described in this contribution. Such studies are important because the particles as carbon have started to be used in hadron therapy; their physical and radiobiological characteristics differ from photons or electrons, and so it is necessary to investigate their behavior in a matter. The experiments were performed at the

Nuclotron, JINR in the ^{12}C beam with primary nominal energy 500 MeV/amu. Absorbed depth-dose distribution was established by means of a diamond detector and spectra of linear energy transfer were measured with the LET spectrometer. The measured LET spectra were also compared with theoretical calculations by program SRIM that simulates the passage of various ions through a matter.

It was be found that the LET spectra, determined by the LET spectrometer, are composed of the primary peak (that belongs to ^{12}C ions) and of the contribution from the fragments. At the entrance there are only tracks from ^{12}C, whereas behind the Bragg peak there are only tracks that correspond to the fragments. With the increasing depth, the mean value of LET increases, also the spectra become broader due to the straggling of ions [3]. The LET spectra were also calculated by program SRIM. SRIM takes into account only primary particles, whereas the track detectors measure all particles. This fact enables us to relatively assess the contribution to the dose from the fragments. Initially, the primary ions have enough energy to produce fragments and so the flux and energy deposition of fragments increase. Then, before and in Bragg peak region, the ionization losses and also energy deposition of primary ions rapidly increase, while the fragments production becomes relatively less important and their contribution to the dose decreases. Before the Bragg peak the contribution from fragments to the total dose ranges from about 16 to 36 percent.

From the LET spectra measured with the track detector, doses in given depths were calculated; the absorbed depth-dose distribution was also established by means of the diamond detector. The response of the diamond detector depends on the type and the LET of particles, so it is necessary to make correction of the response with the respect to charge recombination [4]. Relative absorbed depth-dose distributions measured with the track-etch detectors and the diamond detector (corrected to the recombination) are in a good agreement. The mean range of the ions was 37.3 g/cm^2, which corresponds to the mean energy of the beam about 480 MeV/amu. The difference between this determined energy and the nominal value is probably caused by the energy losses during the passage of the beam through the beam monitoring and diagnostics systems.

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Effect of Ionizing Radiation on the Estrogen Receptor - DNA Complex

V. Štísová*, S. Goffinont, M. Spotheim-Maurizot**, M. Davídková**

stisova@ujf.cas.cz

*Department of Dosimetry and Application of Ionizing Radiation, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic

Nuclear Physics Institute AS CR, Na Truhlářce 39/64, 180 86, Praha 8, Czech Republic

**Centre de Biophysique Moléculaire CNRS, rue Charles Sadron, 45100 Orléans Cedex 2, France

Binding of a protein to its specific DNA sequence is a fundamental step in the regulation of gene transcription. An exposition of DNA-protein complex to ionizing radiation may induce damage to both biomolecules and thus affect its regulatory function. Our research focuses to a complex formed by DNA and the estrogen receptor which is essential for transmition of the signal of female sex hormones, estrogens.

Prolonged exposure to estrogens has been shown to be an important risk factor for developing invasive breast cancer. This may be partially a result of the mitogenic effect of estrogens on breast epithelium, which may permit the accumulation of random genetic damage occurring in replicant cells (1). One of the possible treatment options for breast cancer is radiotherapy. Therefore the influence of ionizing radiation on the specific complex between ER and ERE should be investigated. The overall stability of the complex, sensitivity of both partners to irradiation, and types of damages induced to DNA and ER protein are of the main interest.

The studied model system is the recombinant human estrogen receptor alpha binding as a dimer to the ERE sequence. The sequence of nucleotides in ERE is palindromic, composed of two hexanucleotide half-sites separated by three nucleotides (5'-AGGTCAnnnTGACCT-3').

The two complementary 59-bp DNA fragments bearing the ERE sequence (Sigma Genosys) were labeled using the [γ-32P]-ATP (PerkinElmer). The recombinant human receptor alpha was purchased from Sigma-Aldrich. The DNA was incubated with ER for 1h on ice to form the complex. Irradiation was performed using the low-LET radiation ^{137}Cs γ-ray source (IBL 437, CISBio International) at a dose rate 9 Gy min^{-1}, or the ^{60}Co γ-ray source at a dose rate 38.2 Gy min^{-1}. Samples in low binding polypropylene tubes were immersed in ice-water bath.

The formation of complexes was studied by native retardation gel electrophoresis. Labeled free DNA and DNA bound to ER migrate as two distinct bands. The percentage of radioactivity in each band allows quantifying the binding of DNA to ER. Gels were vacuum-dried, and the radioactivity was assayed using the PhosphoImager Storm (Molecular Dynamics). The ImageQuant 5.1 software was used for all gel analysis.

The complex between ER and the labeled 59bp DNA fragment bearing ERE was irradiated with doses up to 2 kGy. Moreover, to estimate which of the two partners in the complex is more sensitive to irradiation, isolated DNA fragment and isolated protein were also irradiated with doses up to 2 kGy, and were incubated afterwards with the non-irradiated partner. The proportion of complexed DNA decreases linearly with the dose. For the complex

formed by the non-irradiated DNA and irradiated ER, the proportion of complexed DNA decreases faster with increasing dose compared to the case of irradiated complex, whereas for the complex formed by non-irradiated ER and irradiated DNA the proportion of complexed DNA decreases more slowly with increasing dose. Thus, the damage to the isolated protein hinders more efficiently the complexation than the damage to isolated DNA. Moreover, the protein irradiated in the complex seems to be protected and therefore is less damaged than the isolated one. The protein keeps its DNA binding ability at doses where the isolated protein already lost it. These observations are consistent with studies performed with other specific DNA–protein complexes: *lac* operator – *lac* repressor and DNA containing abasic site analog – Fpg protein. However in our studied system, the damage to the free protein is less significant for destabilization of the DNA-protein complex.

To identify the amino-acids most probably damaged by irradiation in the protein, the Monte Carlo-based theoretical model RADACK was used (2). Due to their high reactivity, the most probably damaged are the cystein residues. RADACK was used also to predict the relative probabilities of hydroxyl radical attack to reactive sites within DNA bases and deoxyriboses. From the comparison or results for the free and the complexed DNA one can identify regions within the base sequence, which are protected or sensitized. This effect can be due to the spatial protection of the binding sites by the bound partners and to possible conformational changes of biomolecules as the result of DNA-protein interaction.

The theoretical prediction of DNA damage is to be compared with experimental data achieved with the method of sequencing polyacrylamide electrophoresis. Current experiments are addressing this problem.

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Characterization of Temporal and Spectral Properties of Laser Diodes by TRLFS System Spectrograph

V. Kubeček, H. Filipská*, K. Černochová", J. John*, M. Čech, P. Hiršl

filipska@fjfi.cvut.cz

Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic

*Centre for Radiochemistry and Radiation Chemistry, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

"Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic

The aim of the presented paper was investigation of temporal and spectral properties of laser diodes in nanosecond and microsecond regime using detection system developed for investigation of uranium and other elements by time - resolved laser induced fluorescence spectroscopy (TRLFS) which is a unique method for direct actinide and lanthanide speciation at low concentrations in the framework of environmental studies.

The TRLFS method is being increasingly used for the study of various chemical aspects of actinides and lanthanides in solutions, suspensions or on the solid surfaces. In case of actinides, the studies mainly deal with problems related to questions of nuclear fuel reprocessing and waste disposals. In this frame, some lanthanides, especially europium, are also studied as some of them serve as good analogues of actinides [1].

The main part of the TRLFS detection system is monochromator/spectrograph ORIEL MS 527 with iStar 720 intensified CCD camera (ANDOR TECHNOLOGY) designed for low-light spectroscopy applications requiring fast gating. The monochromator/spectrograph ORIEL MS 527 contains four gratings (150 l/mm 190-800 nm, blaze 300 nm; 300 l/mm 250-1150 nm, blaze 500 nm; 600 l/mm 280-1200 nm, blaze 500 nm; 1200 l/mm 280-1600 nm, blaze 500 nm). The system parameters are: resolution 0.1 nm, accuracy ± 0.1 nm, repeatability ± 0.028 nm. The spectral range of the CCD sensor is 180-850 nm, it includes an optional digital delay generator, actually built into the head - the minimum optical gate was 1.6 ns.

The samples containing uranium excited by nanosecond laser pulses in UV spectral region produce fluorescence typically in visible spectral region lasting from nanosecond till microseconds depending on uranium speciation and surrounding medium [2,3]. Therefore it was desirable to have a similar source of light radiation for preliminary adjustment of the whole system.

For this reason we developed simple pulsed light source based on common red (640 nm) laser pointer. To achieve a pulsed operation, simulating laser induced fluorescence of uranium, we used as a power supply a commercial pulse generator producing rectangular pulses with duration from 5 ns with amplitude of 3 V into 50 ohm load. The light pulses generated by a laser diode were also measured with fast silicon photodiode and 500 MHz digital scope. The shortest pulses have duration less than 4 ns and repetition rate given by the

pulse generator. By changing the duration of the driving rectangular electrical pulse it was possible to vary the duration of the light pulses from this minimum value up to the continuous operation of the laser diode. In order to simulate exponential decay of fluorescence, we used instead of the coaxial cable between the pulse generator and laser diode a normal two wire cable which modified the electric signal driving the laser diode from the originally rectangular shape of the pulse from generator.

Using the above described spectroscopy detection system we were able to measure changes in spectral components of laser output for pulse durations between 35 and 740 ns. It was discovered that there were 3 longitudinal laser modes separated by 1 nm around the central wavelength of 645 nm. For the 40 ns long square pulse from the pulse generator the optical output from laser diode consisted of the burst of 5-6 shorter light pulses, which were not distinguishable by photodiode and oscilloscope, but were nicely resolved by TRLFS spectroscopic system. Increasing the duration of the driving pulse, the laser output became quasi-continuous.

For comparison we tested using the same technique actively cooled 90W quasi continuous linear bar laser diode array THOMSON type TH-Q1401-PO which is used for pumping of neodymium lasers. In this regime the diode typically operates in pulsed regime with pulse duration of about 200 μs. In this case, the pulse spectrum had only single maximum at 807 nm and was stable during the whole 200 μs long pump pulse.

In conclusion, we demonstrated that the simple 645 nm laser pointer driven by pulse generator can produce light pulses shorter than 5 ns and can be a useful tool for alignment of the detection part of the TRLF system. This apparatus was on the other side used for detailed characterization of spectral characteristics of this laser diode operating in nanosecond and microsecond regimes.

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Software for Independent Power Protection System of VR-1 Training Reactor

M. Kropík, M. Juříšková

kropik@troja.fjfi.cvut.cz

Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holešovičkách 2, CZ 180 00 Prague 8, Czech Republic

This contribution deals with software development for the VR-1 training reactor independent power protection system upgrade. The whole upgrade of the VR-1 reactor I&C started with the human-machine interface and the control room upgrade in 2001, continued with the control rod drivers and the safety circuits replacement in 2002. The third stage, the control system upgrade was carried out in 2003. The fourth stage, the independent power protection system was completely upgraded in summer 2005. All upgrades are being carried out in cooperation with Škoda Nuclear Machinery Company.

The independent power protection (IPP) system is component of the reactor safety (protection) system. There are strict requirements on quality and reliability of nuclear facility safety systems. The IPP system is a computer based system, so there is necessary to fulfil quality requirements on both hardware and software. There are stringent requirements for their quality, reliability and availability. To achieve these goals, the appropriate standards were applied [1], [2].

The IPP channel software life cycle was in accordance with the IEC-880 standard [2]. Firstly, the principal documents for the software development were established – the Quality Assurance, Verification & Validation, and Configuration Management Plans [4]. These documents define basic procedures and techniques during the development and testing of the software.

The software life cycle started with the setting of requirements, and continued with the software design, coding and integration of hardware/software. The whole life cycle was accompanied by verification & validation. During the whole life cycle, the relevant documents according to [4] were prepared.

The Software Requirements [4] were prepared as a standard text. The experience with setting of the Control System software requirements from previous stage of the reactor I&C upgrade was utilized. Detailed requirements for all microcomputer units, regimes of the channel operation and transitions among them, single data messages, and their format were set there. Focus was also put on requirements for the reactor power and velocity of power changes calculations (basic parameters for reactor safety evaluation). The principle requirements for safety functions of the IPP channel were prepared with care. The warning and safety limits for the reactor power and velocity of power changes were set. The unacceptable channel states were defined. The reactor's physics and operation experts were involved in the preparation of the Software Requirements.

The software was designed according to the Software Requirements [4]. The software structure for the single units and communication standards among them were established. The software was designed in the top-down manner. The basic algorithms and data structures were proposed, and the algorithms (e.g. for the reactor power and velocity of power changes) were thoroughly tested. The proper modularization of the software and the proposal of data structures was an important part of the software design life cycle phase.

The software coding life cycle phase continued after the software design. During the coding phase, the designed software was coded into the programming language. The principal programming language was the ANSI C language with restrictions according to standard [3]. Some parts of the software were coded in Assembly language (typically parts with direct service of the hardware), but the utilization of the Assembler was competently justified. The software was coded in the bottom-top manner. For the software coding and production, the reputable µVision 2 development system for 8051 compatible microcomputers of the Keil Software Company was utilized.

During the hardware/software integration phase, the developed software was programmed into the microcomputer units, and the integrated system was thoroughly tested. All channel safety, operational and test functions, regimes of operation, and setting and calibration were carefully checked. The tests revealed some minor problems, which were gradually removed.

The software for the independent power protection system was successfully developed and installed into the individual IPP channels. During the software development, the Department of Nuclear Reactors got much experience with the safety critical software production. The whole system together with the developed software was installed into the reactor I&C in summer 2005 and licensed. This independent power protection system upgrade substantially improves the reactor safety and the comfort of the reactor operation, and it also facilitates maintenance. The reactor I&C upgrade continues with the operational power measurement system upgrade in 2007. The complete reactor I&C upgrade brings the reactor I&C to top conditions and enables a prolongation of their functionality and maintainability for at least 10 next years

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Verification and Validation of VR-1 Training Reactor Independent Power Protection System

M. Juříčková, M. Kropík

jurickov@troja.fjfi.cvut.cz

CTU Faculty of Nuclear Sciences and Physical Engineering, Department of Nuclear Reactors, V Holešovičkách 2,CZ 180 00 Prague 8, Czech Republic

The VR-1 training reactor has been operated since 1990 by the Department of Nuclear Reactors, at the Faculty of Nuclear Sciences and Physical Engineering of Czech Technical University in Prague. The reactor was designed and built by the Škoda Company in co-operation with the Faculty. The reactor control and safety system (I&C) was developed in the mid- 80s. The original system is digital, it utilizes 8-bit microcomputers with software written in the assembly language. The technical design of the control and safety system is now quite obsolete. There are also problems with maintenance, and since its development, the quality demands (e.g. the IAEA, IEC, and IEEE recommendations and standards) were significantly evolved. Therefore, it was decided to upgrade the present control and safety system with the aim to apply the latest available techniques and technology.

The principal upgrade of the control and safety system started during the year 2001. The first stage was the human-machine interface and the control room upgrade. During the second stage of the upgrade in 2002, the control rod drives and the safety circuits were replaced. The third stage – the control system upgrade – was carried out in 2003. The next upgrade stage is the independent power protection (IPP) channels upgrade. The new IPP channel was developed in 2004; channel was tested and installed in 2005. During the last stage, the operational power measurement (OPM) channels are going to be upgraded probably in 2007.

The independent power protection system is component of the reactor safety (protection) system. There are strict requirements on quality and reliability of nuclear facility safety systems. The independent power protection system is a computer-based system, so there is necessary to fulfill quality requirements on both hardware and software.

The independent power protection system is redundant and consists of four individual channels. Each channel evaluates the reactor power and the velocity of power changes and compares them with safety limits. If the safety limits are exceeded, the channel disconnects its safety relay. The relays of all channels are connected to the reactor safety circuits. The safety circuits evaluate the states of individual channel relays in the logic ‘two out of three’. If the logic condition is met, the safety circuits break the control rods power supply. The rods fall down into the reactor active core and stop the fission reaction.

The general contractor of the new IPP project is Škoda Nuclear Machinery Company Plzeň, the hardware and software subcontractor is Tedia Limited. The Department of Nuclear Reactor prepared general, hardware and software requirements, software quality assurance, verification & validation and configuration management plans, developed the safety software for calculating units and carried out validation. The Department is going to take an active part in the later site acceptance tests of the system.

The IPP channel software development is divided into the life cycle phases in compliance with the IEC-880 standard. The software life cycle started with formulation of requirements, continued with the software design, coding and integration of hardware/software. The whole life cycle was accompanied by the verification & validation. The verification and validation are made in accordance of Verification & Validation Plan.

Verification is the process when the requirements of each phase of software life cycle are verified. The software design was compared with the software requirements to ensure that all requirements were correctly built into the design. The coding phase was verified by the checking of the coded software against the design. Also, software tests in the bottom-top manner were carried out.

After the hardware/software integration, thorough validation tests were accomplished. Validation is the process when the whole system of hardware and software is tested to fulfill the general requirements.

The first validation tests were accomplished with simulated input signals instead of neutron chambers. The arbitrary signal generator HPE1441A in a VXI rack provides a pulse signal. The PC controls the VXI devices via a FireWire line. A simple electronic circuit modified the pulse signal to get small pulses comparable with the neutron chamber signal.

The output data from the IPP channel was received in the other PC (notebook). The second PC was used to provide enough performance for the signal simulation PC. The signal of the IPP safety relay is scanned by the multimeter HP34401A. The notebook reads the safety relay status from the multimeter via the HPIB.

The software for both computers was designed with the HP VEE graphical development tool. The HP VEE software prepares the simulated reactor power and power change rate courses; next, it sends these data to pulse generator and evaluates received data from the validated channel.

The reactor operation conditions were simulated in such a way to provide exceeding of the reactor power and the power change rate safety limits and the safety function of IPP channel was expected. The safety limits were gradually changed from standard to the stricter conditions during these tests.

The behaviour of the IPP channel was investigated under the standard as well as non-standard operating conditions. Proper function of the IPP channel was confirmed.

After the successful simulated tests of the control system, the IPP channel was tested during normal reactor operation. The operation under normal conditions was investigated, and safety functions of the IPP channel were first tested with standard and then stricter safety limits.

The tests described in this article contributed to the successful upgrade and licensing of the VR-1 training reactor IPP system. The new IPP system substantially improves the reactor safety, operational comfort and facilitates the work of the reactor staff.

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Transmutation Studies of Plutonium at JINR Dubna

K. Katovský, J. Adam

katovsky@troja.fjfi.cvut.cz

Department of Nuclear Reactors, FNSPE, CTU in Prague
V Holešovičkách 2, Prague 8, 180 00, Czech Republic

*Nuclear Physics Institute, ASCR, Rez, 250 68, Czech Republic

Around the whole world, there is accumulated hundred tons of weapon grade plutonium. Large amount of plutonium is every year produced inside classical uranium reactors. This plutonium is very dangerous due to its toxicity and proliferation possibility, although it could be used to energy production. Department of Nuclear Reactors in co-operation with Nuclear Physics Institute in Rez and Joint Institute for Nuclear Research in Dubna, Russia, is participating in research focused on plutonium burn-up and its incineration using Accelerator Driven System.

There are three various kinds of research at Dubna. Firstly, using direct proton beam from Phasotron accelerator [1], secondly, investigation of burn-up using secondary neutrons produced in uranium-lead target blanket system [2] (facility called Energy and Transmutation), and thirdly, also using secondary neutrons produced in the lead target surrounded by various moderators [3] (facility Gamma-2). DNR is participating in two first experimental investigations.

There were held two experiments on direct proton beam with energy of protons 660 MeV and with ^{239}Pu samples, which weight app. 0.5 g each (446 mg and 462 mg). First irradiation experiment was short (5.25 min) due to observe short-lived residual nuclei; the second one was longer (96.45 min) to observe long-lived res. nuclei. Average proton currents were 25 nA ($4.93 \cdot 10^{13}$ protons) and 17 nA ($5.61 \cdot 10^{14}$). Residual nuclei yields were measured using offline methods of γ-spectroscopy. Total number of ~350 spectra were measured. The data processing and computation verification are in progress now.

Experiments at Energy and Transmutation facility are carried out within wide international collaboration of German, Russian, Armenian, Australian, Belarusian, Ukrainian, Slovenian, Grecian, and Czech universities and research institutions. There is many other studies provided by these institutions, like study of spatial and energetic distribution of neutrons and protons, energy spectra of neutrons measurement, ^{237}Np, ^{241}Am, ^{129}I, ^{238}Pu and ^{239}Pu incineration studies, computation verifications [4], etc. Authors of this article are focused on Pu and neutron energy spectra studies. Four experiments took place with protons (energies 0.7 GeV, 1 GeV, 1.5 GeV, 2 GeV), one with deuterons (1.25 GeV/A). Experiments were held on Nuclotron superconducting accelerator which has, unfortunately, much lower average proton current than Phasotron. Currents were approx. 60 pA, so to have integral intensity of protons around 10^{13}–10^{14}, irradiation longs usually 7 hours. Many results have already been presented, large amount of data are still in process.

As results – "B" and "R" factors' values were calculated (Eq. 1-3). There were observed 5 fission products of ^{238}Pu and 19 fission products of ^{239}Pu. Average value of ^{238}Pu / ^{239}Pu ratio (ratio of appropriate isotope production yields) is smaller than 1. So, if we consider the JENDL-3.3 library fission cross-sections, it can be assumed, that fission is mostly caused by neutrons with mean energy value smaller than 0.5 MeV (^{238}Pu has lower fission cross-section than ^{239}Pu in the energy area below 0.5 MeV). All results give a good opportunity to make

quality ADS benchmark. Coupled spallation target and fissionable blanket experiments are a real challenge for codes like MCNPX and these experimental results look good for validation. “Energy & Transmutation” is a unique facility and its potential should be used to make as much experimental work as possible. Using the obtained data hypothetical “transmutation times” of the radioactive samples were calculated. In this consideration 10mA current accelerator of 2 GeV protons was taken into account and irradiation times of 30 and 720 days. All amount of ^{239}Pu will be hyphoteticaly transmute during 2 years, unfortunately only 27.4 % of ^{238}Pu. During one month will be incinerate 1.14 % of ^{238}Pu and 4.28 % ^{239}Pu.

$$B\left({}^{A}_{Z}\mathrm{Res}\right) = \frac{\text{Number of produced nuclei } {}^{A}_{Z}\mathrm{Res}}{(1\,\text{g of target isotope}) \bullet (1\,\text{incident proton})} \quad (1)$$

$$R\left({}^{A}_{Z}\mathrm{Res}\right) = \frac{\text{Number of produced nuclei } {}^{A}_{Z}\mathrm{Res}}{(1\,\text{target isotope atom}) \bullet (1\,\text{incident proton})} \quad (2)$$

$$R\left({}^{A}_{Z}\mathrm{Res}\right) = B\left({}^{A}_{Z}\mathrm{Res}\right) \bullet \frac{A_{\text{target}}}{N_A} \quad (3)$$

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Criticality Calculations and Safety Analyses for the VR-1 Reactor with IRT-4M LEU Fuel Assemblies

J. Rataj, K. Matějka

rataj@troja.fjfi.cvut.cz

Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holešovičkách 2, 180 00 Prague 8, Czech Republic

The Paper presents basic information about calculations required for operating the training reactor VR-1 with the LEU fuel IRT-4M. The training reactor VR-1 is operated within the Faculty of Nuclear Sciences and Physical Engineering at the Czech Technical University in Prague. In the autumn 2005 the HEU fuel IRT-3M with enrichment 36% ^{235}U was replaced by the LEU fuel IRT-4M with enrichment 19.7% ^{235}U [1]. Calculations were made for two planned core configurations C1 and C2. The core configuration C1 is defined as "the essential preliminary core mainly for education and training purposes". The core contains nine 6-tube assemblies and eight 8-tube assemblies. The core configuration C2 is defined "mainly for R&D purposes". The core contains ten 6-tube assemblies and ten 8-tube assemblies. In the center of the core a large graphite unit is locate.

The Department of Nuclear Reactors performed detailed criticality calculations for both core configurations using MCNP code. The sensitivity studies and reactivity feedback coefficients were also calculated. Nuclear Research Institute in Rez in close cooperation with the Department of Nuclear Reactors performed transient analyses. These transient analyses were done only for the core configurations C1 by the RELAP code. All independent verification calculations have been performed for both core configurations at the Argonne National Laboratory.

All calculations and analyses were the necessary condition to gain the authorization to operating the training reactor VR-1 with the LEU fuel IRT-4M. Calculation results were incorporated in reports [3] and [4]. Reports were provided to the State Office of Nuclear Safety as a part of the license procedure of the LEU fuel IRT-4M.

Before detailed calculation analyses the first step was a design and choice of the core configurations with the fuel IRT-4M. The main objective was to design two core configurations C1 and C2. The core configuration C1 was defined as "the essential preliminary core mainly for education and training purposes". The core configuration C2 was defined "mainly for R&D purposes". Design of the core configuration C1 was made on the basis of following basic requirements:

- the core should be compact,
- the core should contain only 8-tube and six tube fuel assemblies,
- the core should contain a sufficient number of vertical channels.

Design of the core configuration C2 was made on the basis of following basic requirements:

- the core should contain a large graphite unit,
- the graphite unit should be located in the center of the core,
- the core should contain a sufficient number of vertical channels.

Several designs of core configurations C1 and C2 (approximately ten different core configurations) were prepared on the basis of above mentioned requirements. For all core configurations basic criticality calculations were done:

- for a case with all control rods at the top positions,

- for a case with all control rods at the bottom positions,
- for finding critical state of the reactor.

Calculations were done using MCNP code. The final core configurations C1 and C2 were chosen on basis results of calculation.

Criticality conditions for the new LEU fuel were calculated at the Department of Nuclear Reactors using MCNP code version 4C where the LEU cores were modeled. As the C1 core is basic operational configuration using the LEU IRT-4M fuel in the reactor, its neutronics calculations were done in 4 steps, A-D. For the C2 experimental core configuration the calculation was conducted in 3 steps only, A-C:

A) Calculations required for the typical core licensing:
i.e. criticality calculations for cases with all control rods at the top positions, all control rods at the bottom positions, determination of the suitable critical state (i.e. control rods' positions), worth of control rods and experimental channels, maximal and operational reactivity excess, ability to compensate, calibration curves for control rods.

B) Calculations linked with uncertainties during fuel production:
i.e. influence of different ^{235}U enrichment, ^{235}U mass, width of Al cladding, length of the assembly.

C) Calculations of neutron flux density:
i.e. neutron flux density both in radial and axial cross-sections, for each cell of the core, mesh calculations.

D) Calculations of reactivity coefficients, see:
i.e. Doppler effect, influence of moderator temperature, void coefficient.

The results of the calculations confirms assumption that the new IRT-4M fuel is fully suitable for operation in the reactor and no consequences affected nuclear safety of the VR-1 Reactor were found. State Office of Nuclear Safety gave the authorization to operating the training reactor VR-1 with the LEU fuel IRT-4M in September 2005. In October 2005 the first critical experiment with a LEU Russian fuel IRT-4M was performed at the training reactor VR-1 [2].

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IEAP Detector Laboratories of the CTU in Prague

V. Král, P. Beneš, T. Horažďovský*, J. Jakůbek, Z. Kohout*, V. Linhart, S. Pospíšil, T. Slavíček, M. Solar*, B. Sopko*,V. Sopko*, J. Uher, D. Vavřík, Z. Vykydal

Vlastimil.Kral@utef.cvut.cz

Institute of Experimental and Applied Physics, Czech Technical University, Horská 3a/22
128 00 Prague 2, Czech Republic

* Faculty of Mechanical Engineering, Czech Technical University
Technická 4, 166 27 Prague 6, Czech Republic

The Institute of Experimental and Applied Physics (IEAP) is a scientific-educational institution of the Czech Technical University in Prague (CTU) oriented on physics research and technological applications. The IEAP was founded as an experimental laboratory center for research in the field of particle and nuclear physics which is carried out in frame of international experimental collaborations. On the side of instrumentation and applications, the IEAP focuses on the development of measuring methods and techniques for new technologies such as the development of novel semiconductor detectors of ionizing radiation.

The IEAP detector laboratories have been built as an experimental base for research and development of detector technology. With high spatial and energy resolution, current research is oriented on two- and three-dimensional methods of dynamic object imaging. The laboratories are equipped with primary standard as well as sophisticated instrumentation. In the field of modern detector applications, the IEAP has the following equipments at its disposal:

- Imaging position sensitive detectors (such as pixel detectors) of ionizing radiation which at present provide the best spatial resolution for on-line rentgenography and neutronography together with tomography analysis of collected data.
- Tracking position sensitive detectors (such as strip detectors) which serve for charged particle tracking.
- 3D and semi-3D structures of semiconductor detectors developed as neutron sensors with high detection efficiency.
- Measuring system for α, β, and γ spectroscopy.
- Precision instruments for electronic tests of semiconductors (I-V, C-V, DLTS, …).
- Equipment for measurements and tests of semiconductor detectors made of advanced materials (GaAs, CdTe, InP, BN, …) with a possible use namely for position sensitive imaging and charge transport property studies.
- Coincidence gamma-gamma system with high energy resolution for instrumental neutron activation analysis.
- Equipment for radon oriented studies.

In detector technology, the IEAP has built the following basic facilities:

- Clean rooms (cleanness level 10 000) with laminar flow box.
- Clear dry air distributed in all laboratories.
- Technology equipment for material engineering (furnaces, chemical boxes, …).

The IEAP has acquired know-how and developed techniques for the investigation of new types of sensors of ionization radiation using state-of-the-art technology. The systems are devoted to spectroscopy or to current signal analysis of studied detectors. The signals are induced by α, β or γ radiation or also by short laser pulses. In spectroscopy, signals are read by standard readout devices consisting of charge sensitive preamplifier, linear amplifier with semi-gaussian shaping and analog-to-digital converter. For charge sharing studies, two standard spectroscopy systems are connected in coincidence. For current signal analysis, signals are read by a fast current preamplifier (1 GHz wide-band) connected to a fast digital oscilloscope (1 GHz band-width, 10 GS/s).

The IEAP is certified for qualification electronic tests of the ATLAS SCT silicon micro-strip detection modules [1]. Up to this date, more than 200 modules have been successfully tested. Furthermore, detection tests (called also laser tests) of these modules were also carried out. Such tests were performed by means of pulsed lasers (with wavelength 660 nm for simulation of alpha radiation and 1060 nm for simulation of minimum ionizing particles) driven by VME modules developed for data acquisition from the ATLAS SCT silicon micro-strip detection modules [2]. For position sensitivity assessment, a PC-driven 3-D micro-manipulator system was constructed.

The IEAP has high potential in applications of position sensitive detectors for material and medical imaging. Examples currently under investigation include two and three dimensional (tomography) imaging of samples from life and lifeless organisms, medical imaging such as mammography, archeological studies (revealing old ceramic letters), and dynamic defectoscopy which are performed with a micro-focus roentgen source Hamamatsu (5 μm spot) and the state-of-the-art MEDIPIX detector [3] together with a newly developed novel readout device [4] and PC-driven micro-holders, all placed inside a X-ray and electromagnetic-shielded case.

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The Influence of the Neutron Source on the Volume Heat Source Distribution in ADS

Dušan Kobylka

kobylka@troja.fjfi.cvut.cz

Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University in Prague
V Holešovičkách 2, 180 00 Praha 8

Safety spent fuel disposal has been solving at research institutes all over the world for many years. The transmutation of long-life radioactive isotopes is appeared as a one way how to resolve this serious problem. Therefore new reactor systems are designed and computed in the many countries. Two main types of nuclear reactors have a capability to transmutation: some critical system from the group of Generation IV reactors (especially Molten Salt Reactor) and Accelerator Driven Systems (ADS). Research institutes, universities and companies in the Czech republic (associated in the "Transmutation Consortium of the Czech Republic"), follow the reactor design with molten salts as fuel-coolant (mixture of molten salts (the coolant) include small amount of dissolved nuclear fuel and transmutated isotopes). The described project is focused on analyses of this type ADS.

The determination of the neutron flux distribution is the essential problem of the reactor designs (neutronics, transmutation, thermal-hydraulics, etc.). The neutron flux, as a function of coordinates and time, is described by the Boltzmann kinetics equation. Because ADS are designed as the subcritical reactors with external neutron sources, it is necessary to solve special type of this equation. On the assumption of reality simplification, the analytical solution for cylindrical core is described in [2] or [3]. The resulting equation, for the neutron flux as a function of radius and elevation, is of the form of two infinite series with an amount of terms. Individual terms describe: material properties of system, geometry and neutron source (shape, dimensions, neutronics, etc.). The equation was solved for a lot of combination of terms values, in order to determine their impact on the neutron flux distribution. The maximal value of neutron flux, in a form of the dimensionless non-uniformity volume coefficient K_{Vmax}, was observed and minimized. A minimal value of this coefficient was developed as appropriate and the maximal desirable value of 10 was calculated in [1]. The analyses results are described in the following articles.

The greatest influence on coefficient growth has the subcriticality of the system (alternatively power of neutron source), which is given by the multiplication factor k_{ef}. In the basic case of point neutron source, the subcriticality only k_{ef}= 0.96 leads to improper K_{Vmax} greater then 10. Growth of K_V in the dependence on k_{ef} has a nearly linear description: from K_{Vmax} = 3.638 at k_{ef}= 0.96 to K_{Vmax} = 113 at k_{ef}= 0.5.

The dimensions of the neutron source have also great influence on K_{Vmax} growth. It was demonstrated, that enlargement of diameter and height of the cylindrical neutron source reduces significative K_{Vmax}. The qualification of this rule is described in [1]. The grater influence has the diameter enlargement. For example: at the k_{ef}= 0.97 and point neutron source K_{Vmax} is about 9, change of source volume to diameter 1m and length 1m gives K_{Vmax} less than 2.5. The optimization analysis between changes of diameter or length is also described in [1].

The material composition of the system has also influence on value of K_{Vmax}. The diffusion length (L) shows the greatest impact from this group. Increase of diffusion length

lead to reduction of the K_{Vmax}. The observed functionality indicate a strong exponential decrease.

The last observed influence on K_{Vmax} was a position of the neutron source in the reactor core. As optimal was evaluated allocation in the centre of core. The position in outer limits the core height leads to growth of K_{Vmax}.

The analyses show important influences between several parameters of system. The optimizing analysis was made, which reduces K_{Vmax} under the values of critical reactor systems, i.e. 3.638. More about this calculation is described in [1].

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Innovation of Equipment for Training at VR-1 Sparrow Reactor

A. Kolros

kolros@troja.fjfi.cvut.cz

CTU in Prague, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Nuclear Reactors

V Holešovičkách 2, 180 00 Prague 8, Czech Republic

The training VR-1 Sparrow reactor is the experimental nuclear facility especially appointed for education and teaching of university students from different technical universities in the Czech Republic and other countries. Since 1990 the VR-1 reactor has been using for experimental education focused on reactor physics, in-core dosimetry, radiation protection, nuclear safety, nuclear control systems and monitoring of environment. Every year more than 150 university students participate on experimental exercises, more than 25 special exercises are prepared for them. The department has been preparing experts in the Czech nuclear programme, co-operates in international nuclear engineering activities (ENEN, NEPTUNO, WNU) and also participates to spread the nuclear erudition.

Objectives

- innovation of experimental equipment for measurement at the VR-1 reactor by new identical devices EMK-310 for detection of neutrons and gamma
- introducing new experimental exercises which will exploit abilities of new devices EMK-310
- expanding number of site for measurement from 3 to 5
- increasing number of university students in group from 8 to 15

After 15 years the partial innovation of equipment for neutrons and gamma measurement was needed. Both the experience and the knowledge of reactor group from existing measurements and experiments at VR-1 reactor were put to the project of innovation. The solution of the problem has been finding at EMK-310. The EMK-310 is new dosimetry device especially designed to measure in nuclear applications. It was developed and made in close co-operation with firm TEMA Ltd.

The EMK-310 is three channel amplitude analyzer designed for counting applications. The device can conveniently fits on a desk or table. Its contains high voltage power supply (300-2000 V), preamplifiers for gas filled detector and scintillation probe, linear amplifier, three fast parallel discriminators, three counters, 8MB memory and processor. Max. input rate of discriminator is 700 kHz, max. input rate of counter is 10 MHz. A large eight-digit Light Emitted Display (LED 15 mm) showing the contents of either counters is a special option for teaching group of students. The small Liquid Crystal Display (LCD, 4 rows x 20 signs) is set to auxiliary manual setup. The EMK-310 can work independently in simple counting mode “start-stop-reset” or link-up with PC computer via USB2.0. More devices (max. 8) can be connected to local measurement net via RS 485. The time synchronization between different devices can be lower than 1 μs.

The possibilities of EMK-310 are very wide. It allows, in pulse mode, processing signals from different kind of gas filled neutron detector used at VR-1 reactor - SNM corona detectors, ^{10}B, ^{3}He proportional detectors and CFUL, KNT fission chamber (optional). The connecting of scintillation probe is also possible. A software controlled SCA and MCS windows provide for easy experiment setup of all parameters, measurement counting and differential characteristic of detectors, counting external analog or TTL signals. All front end electronics are programmable. The EMK-310 directly supports external sample changer that operates with TTL signal.

For application involving the study of signals that may vary with the time, example study of delay neutrons or nuclear reactor dynamics, the EMK-310 provides a Multichannel Scaling (MCS) acquisition mode. MCS dwell times can be set from 1 ms to 100 s.

The user can select a “Power Save” mode or a “Full Power” mode for battery operation or switch to “AC Power” operation. The “Power Save” mode minimizes battery discharge by LED display switch off. One front panel LEDs provide a complete picture of the batteries´ operation and status. A AC adapter is included with the device.

The change of old counting equipment by new EMK-310 three channel analyzer will increase quality of teaching of university students and improve of experimental measurements at VR-1 reactor.

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Innovation of Teaching at the VR-1 Training Reactor Induced by Renovation of the Facility

R. Skoda *, K. Matejka*

skoda@troja.fjfi.cvut.cz

*Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, V Holesovickach 2, Prague, Czech Republic

The Czech Technical University's Faculty of Nuclear Sciences and Physical Engineering (CTU) has been successfully operating its research nuclear reactor VR-1, so-called "SPARROW", since 1990. Within the scope of the Reduced Enrichment for Research and Test Reactors (RERTR) programme, that was initiated by the United States Department of Energy (DOE), CTU has recently successfully converted SPARROW from the Russian made IRT-3M fuel containing highly-enriched uranium (HEU, enrichment: 36 % 235U) to the Russian IRT-4M fuel containing low enriched uranium (LEU, enrichment: 19.7 % 235U). This mission has been consistent with the global non-proliferation policy goal of minimizing the use of highly-enriched uranium in civil programmes worldwide. Several challenges related to such a fuel swap are discussed. Technical, computational, safety, contract, legal, and economic issues are described as well as the international effort which lead to the fuel change being fully completed during the autumn 2005. Even in a complex environment where DOE as an investor, the State Office of Nuclear Safety (SONS) as a regulatory body, CTU as a user, two Russian suppliers, several Czech subcontractors, and International Atomic Energy Agency must agree on the same terms how the Russian-origin HEU is to be repatriated from the Czech Republic to Russia and at the same time to be replaced by the Russian-made LEU, the process has been finalised in a smooth manner that did not disrupt the CTU education programme for its reactor.

We present the basic information linked to the completed nuclear fuel swap in the university reactor. Until the fuel swap, the reactor was operating with the fuel IRT-3M, enrichment 36 % ^{235}U. After the fuel swap with the new fuel IRT-4M, enrichment 19.7 % ^{235}U, the limit for LEU of 20 % is fulfilled. Changes of the reactor's operation as well as improvement of nuclear safety, radiation protection, physical protection, and emergency plans are discussed here.

The fuel swap involved a direct cooperation of DOE and National Nuclear Security Administration (NNSA) from the RERTR programme, a Russian fuel supplier NZCHK-TVEL, SONS, Euratom, International Atomic Energy Agency (IAEA), and a Russian company SOSNY, which was repatriating the HEU fuel IRT-3M. Since CTU expertise is in education and not in transport or logistics, several other subcontractors were also involved.

Global thread and proliferation reduction initiatives became even more pronounced after 11th September 2001, hence gearing projects like RERTR to speeding up. The main aim of the RERTR programme is to decrease fuel enrichment of research and test reactors from HEU to the internationally agreed level for LEU of 20 % or lower, making this fuel less attractive for proliferation. Overcoming several obstacles (e.g. core size, neutron spectra,

Plutonium production, etc.), it is nowadays only a question of time when all the non-military research reactors will be converted to operate with LEU fuel.

CTU took part in the RERTR programme in mid 1990s together with the Nuclear Research Institute Rez (NRI). At that time no suitable LEU fuel existed to replace HEU IRT-2M, so it was agreed CTU would be providing NRI with practically fresh IRT-2M, in exchange for IRT-3M from NRI (at that time, IRT-3M did not posses the ideal parameters for the NRI reactors); therefore preparing SPARROW for the expected ITR-4M fuel since the geometry of IRT-3M/IRT-4M differs from IRT-2M. The clear strategy behind was that once IRT-4M would become available and licensed, both institutions' reactors could be easily convertible for LEU. Since 2004 CTU has been closely cooperating with NNSA about financial and technical assistances to help to conduct the fuel swap. At that time the timing was right because the LEU fuel was licensed in November 2004 and could well be synchronized with the upgrade of the reactor's I&C [1].

The fuel swap [2] has been prepared in close cooperation with IAEA, SONS, and Euratom providing regulatory framework, under the leadership of DOE, looking after technical and financial aspects, importing LEU from NZCHK Novosibirsk Russia and exporting HEU to SOSNY Dimitrovgrad Russia. Since the legal frameworks in each country emphasise different details, it was necessary to sign two three-party contracts accompanied by two similar two-party contracts to complete the fuel exchange.

The first contract among CTU, IAEA, and SOSNY covers the repatriation of HEU to Russia. As the contract is done on "Ex-Works" reactor site conditions, other Czech and Russian subcontractors needed to take their parts in delivering the fuel or liaising with customs and tax authorities.

The second contract among CTU, DOE, and TVEL (which represented NZCHK) deals with the import of the LEU fuel to the Czech Republic on "Delivery-Duty-Paid" conditions. Similarly, several subcontractors were involved.

The Czech Technical University replaced the Russian made fuel containing highly-enriched uranium by the new Russian fuel, IRT-4M, containing low enriched uranium. The fuel swap was supported by the Reduced Enrichment for Research and Test Reactors programme, which was initiated by the United States Department of Energy. It was shown that the technical, computational, safety, contract, legal, and economic issues can be successfully tackled by the international effort which lead to the fuel swap being completed during the autumn 2005, i.e. 6 months after the decision to swap the fuel was made. Although the reactor has been now operating with the new LEU fuel just over one month, the results from using the new fuel are favourable and swapping the fuel before the start of a new semester did not harm or disrupt the education programme on the reactor.

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Section 11

CHEMISTRY

Disposal of Nutrients from Small Sources of Pollution

Jana Pangrácová

jana.pangracova@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Nutrients are minerals essential for the microorganisms' growth. The main representatives are nitrogen (N) and phosphor (P). These macro-biogenic elements occur almost in all types of water, mostly in surface water, groundwater and especially waste water. An increased level of nutrients causes several problems, e.g. eutrophization of surface water, a toxic effect of non-dissociated ammonia (NH_3) on fishes, a negative impact on drinking water creation from eutrophizated surface water or presence of nitrates in drinking water.

Waste water almost always contains abundance of nitrogen and phosphor and therefore the disposal of these nutrients is important. Hence, the aim of this project was to study possibilities of the disposal of nutrients from small sources of pollution. The whole research was carried out in a closed cooperation with the research center VÚV T. G. Masaryka in Prague.

The disposal of nitrogen and phosphor from small sources of pollution was monitored on six small sewage disposal plants (**SDP 1** – **SDP 6**). Five of them were activation plants and one plant was equipped with rotational biocontactor (**SDP 6**). These sewage disposal plants are designed for the loading from three to twelve equivalent inhabitants. Nitrogen was eliminated biologically by using specific ability of microorganisms to decompose organic nutrients. For a phosphor disposal, both the biological and the chemical coagulations were used. More specifically, ferric sulphate $Fe_2(SO_4)_3$ was utilized as a coagulant. All sewage disposal plants were periodically verified by a visual inspection. Volume rates of flow, a concentration of oxygen in activation and in a biozone, a temperature of water in activation and in a biozone, a temperature of air and a volume of activated sludge after thirty minutes of sedimentation were recorded every day. Below presented values from measurements are averaged.

The small sewage disposal plants produced the following values in an outflow:

SDP 1: 2.8 mg of $N\text{-}NH_4^+$/l, 28.2 mg of N_{total}/l and 5.1 mg of P_{total}/l.
SDP 2: 5.6 mg of $N\text{-}NH_4^+$/l, 26.9 mg of N_{total}/l and 5.3 mg of P_{total}/l.
SDP 3: 6.4 mg of $N\text{-}NH_4^+$/l, 42.6 mg of N_{total}/l and 7.1 mg of P_{total}/l.
SDP 4: 3.6 mg of $N\text{-}NH_4^+$/l, 31.1 mg of N_{total}/l and 7.5 mg of P_{total}/l.
SDP 5: 7.3 mg of $N\text{-}NH_4^+$/l, 41.5 mg of N_{total}/l and 7.5 mg of P_{total}/l.
SDP 6: 4.7 mg of $N\text{-}NH_4^+$/l, 23.2 mg of N_{total}/l and 5.8 mg of P_{total}/l.

The **SDP 1** disposal efficiency of $N\text{-}NH_4^+$ is 91%, N_{total} is 54% and P_{total} is 36%.
The **SDP 2** disposal efficiency of $N\text{-}NH_4^+$ is 89%, N_{total} is 57% and P_{total} is 31%.
The **SDP 3** disposal efficiency of $N\text{-}NH_4^+$ is 87%, N_{total} is 43% and P_{total} is 24%.
The **SDP 4** disposal efficiency of $N\text{-}NH_4^+$ is 91%, N_{total} is 52% and P_{total} is 34%.
The **SDP 5** disposal efficiency of $N\text{-}NH_4^+$ is 83%, N_{total} is 43% and P_{total} is 31%.
The **SDP 6** disposal efficiency of $N\text{-}NH_4^+$ is 91%, N_{total} is 65% and P_{total} is 41%.

Coagulation of phosphor was applied to the **SDP 3** and **SDP 6**. Duration of coagulation on the **SDP 3** was 106 days and the daily amount of a coagulant added to the activation was 705 ml of $Fe_2(SO_4)_3$ per day. Duration of coagulation on the **SDP 6** was 65 days and the daily amount of a coagulant added to the biozone was 353 ml of $Fe_2(SO_4)_3$ per day. The **SDP 3** produced these outflow values: 2.3 mg of P_{total}, 0.8 mg of $P\text{-}PO_4^{3-}$/l and the disposal efficiency of P_{total} and $P\text{-}PO_4^{3-}$ is 74% and 83%, respectively. For the **SDP 6**, 2.7 mg of P_{total} and the disposal efficiency of P_{total} equal to 72% were measured in the outflow. Therefore, the overall disposal efficiency of phosphor increases up to 50% and 31% for the **SDP 3** and **SDP 6** cases, respectively.

There are no allowable limits given by current standards on the quality of the outflow of small sewage disposal plants. Hence, obtained values are compared to the emission limits given by the NV 61/2003 standard for sewage disposal plants designed for the loading from 500 to 100000 equivalent inhabitants. It is important to highlight the fact that, in the case of the low capacity of a loading, a small sewage disposal plant is very sensitive to the variation of a loading and therefore, the technology of the disposal can be disrupted. Contrary, large-scale sewage disposal plants are almost fault-tolerant in the term of the loading variation.

The quality of the outflow of large-scale sewage disposal plants has to be lower than 30 mg of $N\text{-}NH_4^+$/l, 20 mg of N_{total}/l and 6 mg of P_{total}/l. The average quality of the outflow for the **SDP 1** to **SDP 6** is 5.1 mg of $N\text{-}NH_4^+$/l, 32.2 mg of N_{total}/l, 6.4 mg of P_{total}/l and, for the case of phosphor coagulation, 2.5 mg of P_{total}/l. The quality of clear water is high and fulfills given emission limits, except violated limits in the case of ammoniated nitrogen ($N\text{-}NH_4^+$).

The prescribed disposal efficiency for large-scale sewage disposal plants is 70% for $N\text{-}NH_4^+$, 75% for N_{total} and 80% for P_{total}. The average disposal efficiency for the **SDP 1** to **SDP 6** is 89% for $N\text{-}NH_4^+$, 52% for N_{total} and 33% for P_{total}. In the case of chemical phosphor coagulation, the average disposal efficiency of phosphor (P_{total}) is 72%. The given emission limits for the disposal efficiency are fulfilled only in terms of ammoniated nitrogen ($N\text{-}NH_4^+$). Also chemical phosphor coagulation did not lead to the demanded improvement, but the disposal efficiency is high enough.

Although not all limits are fulfilled, the outflow quality sounds good and the disposal of nutrients from the presented small sewage disposal plants can be classified satisfactorily.

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Use of Solid Phase Extractants in Radiochemical Neutron Activation Analysis

M. Lučaníková, J. Kučera*, F. Šebesta, J. John****

lucanikova@fjfi.cvut.cz

Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

*Department of Nuclear Spectroscopy, Nuclear Physics Institute, Academy of Sciences of the Czech Republic, 250 68 Řež near Prague, Czech Republic

**Centre for Radiochemistry and Radiation Chemistry, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

In the past fifteen years, separation based on use of solid extractant (SEX material) or solid phase extractant (SPE material) has become increasingly popular for separation of various elements mainly in water samples and their subsequent sensitive determination using various analytical techniques. On the contrary, applications of SEX or SPE materials in radiochemical neutron activation analysis (RNAA) have been rather limited until now, although this approach offers a number of advantages. The main advantages of use of SEX or SPE materials involve the ease of performance, a possibility of mechanization and/or remote handling of separation, which are important elements of the reduction of radiation burden for workers.

In this work, three new RNAA procedures were developed for determination of selected elements using new specifically tailored composite materials, which were prepared by incorporation of active components in an inert matrix made of modified polyacrylonitrile (PAN). The first two separation procedures were used for simultaneous determination of Cu, Cd, Mo, As, and Sb in biological samples by RNAA. In these procedures, SPE material $Zn(DDC)_2$-PAN containing solid zinc diethyldithiocarbamate in PAN binding matrix and SEX material C301-PAN containing liquid bis-(2,4,4-trimethylpentyl)dithiophosphinic acid (CYANEX 301) in PAN binding matrix were used [1-3]. The third separation procedure was developed for determination of Re in biological and environmental materials by RNAA using SEX material Ali336-PAN containing liquid trioctylmethylammonium chloride (ALIQUAT 336) in PAN binding matrix [1,4].

Conditions for quantitative retention of the elements of Cu, Cd, Mo, As, Sb, and Re on the SEX or SPE materials were studied in column experiments. The elimination of a non-negligible retention of the radionuclides ^{24}Na, ^{42}K and ^{82}Br in the PAN binding matrix itself, which would cause a high background in γ-ray spectrometry of the separated fraction of biological samples, was achieved by addition of Na^+, K^+, and Br^- ions to the feed and washing solutions. The decontamination factor DF of 5.10^5 for ^{24}Na, $> 10^6$ for ^{42}K was found in the fractions separated from the biological materials analyzed, while the activity of ^{82}Br was not detected, because most of ^{82}Br was removed on sample decomposition.

The weight distribution ratios (D_g) for $Zn(DDC)_2$-PAN and C301-PAN were determined in the range of 0.01-4M H_2SO_4. Higher D_g values were found for the elements studied (except for Mo) for C301-PAN compared to those for $Zn(DDC)_2$-PAN. The use of C301-PAN for RNAA appears more advantageous, because it allows carrying out separations from more acid solution, which is needed when the decomposition of samples is carried out in mineral acids. The D_g values for most of the elements were sufficiently high in the range of 0.01-1M H_2SO_4, except for Cd, for which a decrease of D_g with the increase of H_2SO_4

concentration was noticeable. Therefore, pH ~ 1 was applied in the RNAA procedures developed for separation and determination of Cu, Cd, Mo, As, and Sb in biological materials.

The D_g values for Re using Ali336-PAN were determined in the range of 0.01-4M HCl. The decrease of D_g values was observed with increasing concentration of HCl. The solution of 0.1M HCl was therefore applied for determination of Re using RNAA.

The break-through capacities Q_B (for a break-through of 1%) for all materials were determined at pH 1. For instance, values of Q_B for Cu of $2.65 \cdot 10^{-2}$ mmol·g^{-1} and $1.92 \cdot 10^{-3}$ mmol·g^{-1} were obtained for $Zn(DDC)_2$-PAN and C301-PAN, respectively. A Q_B value for Re of 0.11 mmol·g^{-1} was determined for Ali336-PAN. The experimentally determined capacities appeared to be sufficient for the RNAA procedures tested.

The accuracy of the RNAA methods developed for determination of Cu, Cd, Mo, As, and Sb was proved by analysis of several CRMs, including both plant and animal materials with both relatively high (NIST SRM-1515 Apple Leaves, NIST SRM-1577b Bovine Liver) and very low levels of trace elements (NIST SRM-1549 Non Fat Milk Powder). The results obtained compared in most cases with the NIST certified values within the uncertainty margins, thus proving accuracy of the procedures developed. The accuracy of procedure for determination of Re was proved by analysis of several RMs. The results obtained from RNAA procedure based on use of Ali336-PAN compared very well with results of determination of Re obtained from RNAA based on liquid extraction of Re with tetraphenylarsonium chloride in chloroform from 1M HCl.

Newly developed RNAA procedures based on use of SEX or SPE materials are simple, sufficiently selective, and sensitive to allow determination of elements at trace and ultratrace levels in biological and environmental samples.

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Sorption Properties of New Solid Extractants Based on Malonamide Compounds

J. Šuľaková*,°, Jan John*,°, F. Šebesta*,°

sulakova@fjfi.cvut.cz

*Centre for Radiochemistry and Radiation Chemistry, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

°Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

DIAMEX process, with malonamide compounds as extractants, is one of the processes proposed for chemical separation of minor actinides and lanthanides from high level liquid nuclear wastes issuing the reprocessing of spent nuclear fuels. For similar type of applications, granular solid materials with malonamide extractants impregnated onto a suitable support, were recently proposed [1]. At the Czech Technical University in Prague, novel composite solid extractants (SEX) / extraction chromatographic systems, with N,N'-dimethyl-N,N'-dibutyltetradecylmalonamide (DMDBTDMA–PAN) or N,N'-di-methyl-N,N'-dioctyl-hexyloxyethylmalonamide (DMDOHEMA–PAN) as extractants incorporated into a modified polyacrylonitrile (PAN) binding matrix, have been developed. The main advantage of the new SEX-based procedures is a combination of the selectivity of common extractants used in liquid-liquid extraction with the simplicity of column arrangement. In this study, sorption properties of these materials were characterised in detail.

In the first phase, dependences of Eu, Am, Pu, and U weight distribution coefficients, D_g, were determined for all the new solid extractants. The data obtained revealed that the behaviour of the solid extractants prepared from solution of PAN in DMSO or from its solution in cc HNO_3 is almost identical for all the nuclides studied.

A comparison with published data [2-4] has shown that in the nitric acid concentration range 2–8 mol/l the behaviour of the solid extractants closely follows the behaviour of DMDBTDMA or DMDOHEMA in liquid-liquid extraction – for all the nuclides a sharp peak was observed on the dependence of D_g on nitric acid concentration at the HNO_3 concentration 6 mol/l. However, the measured D_g values are significantly higher than the values that can be calculated from the published values of distribution ratios, D, for liquid-liquid extraction which is another argument in favour of the application of the new solid extractants. As expected, for Eu and Am, the D_g values are generally higher for the DMDOHEMA–PAN material. For U and Pu, the performance of the DMDBTDMA–PAN and DMDOHEMA–PAN materials is almost identical.

When correlating the behaviour of the solid extractants with that of DMDBTDMA or DMDOHEMA proper in liquid-liquid extraction at low nitric acid concentrations (below 1 mol/l), the D_g values of all the nuclides were unexpectedly found to increase sharply with decreasing nitric acid concentrations, while the respective D values steadily decrease. The reason for this difference is currently under investigation.

The kinetics of uptake of europium from 0.1M $NaNO_3$ + 0.001 M HNO_3 solution was found to be relatively fast. It is somewhat faster for the materials prepared from PAN solution in DMSO – the equilibrium has been reached approximately in 1 hour for both the DMDBTDMA–PAN(DMSO) and DMDOHEMA–PAN(DMSO) materials. For the materials prepared from PAN solution in cc HNO_3, the kinetics is by ~ 50 % slower.

Practical dynamic extraction capacities for europium were determined for solid extractants prepared from the solution of PAN in cc HNO_3. All the break-through curves measured were almost symmetric, practical capacities *Q(V)* and *Q(m)* could therefore be calculated from the mass of europium contained in the volume of feed solution that passed through the column till 50% break-through. In Table 1 these data are compared with the theoretical capacities calculated from the known contents of malonamides in SEXs and assuming 1 : 2 ratio of Eu and malonamides [4] in the extracted complex.

Table 1 *Comparison of experimental practical capacities and theoretical capacities of the SEX materials prepared from HNO_3 solutions of PAN (0.001M Eu + 0.1 M $NaNO_3$ + 0.001M or 3M HNO_3, ~ 4 BV/hr)*

SEX	*Theoretical capacity (mmol/g)*	*HNO_3 (mol/l)*	*Practical capacity*	
			Q(m) (mmol/g)	*Q(V) (mmol/ml)*
DMDBTDMA-PAN(HNO_3)	0.379	0.01	0.070	0.008
		3	0.029	0.004
DMDOHEMA-PAN(HNO_3)	0.344	0.01	0.034	0.003
		3	0.017	0.002

From the results obtained, it can be concluded that the new solid extractants comprising two extractants from malonamides family incorporated into a binding matrix of polyacrylonitrile are promising for their potential application in the partitioning of lanthanides and minor actinides from high active waste. More research will be needed to explain the behaviour of the new materials at low nitric acid concentration.

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Influence of Radiation on Inner Environment of Container with Spent Nuclear Fuel

V. Čuba*, S. Neufuss, V. Múčka**, R. Silber**, M. Pospíšil****

vaclav.cuba@fjfi.cvut.cz

*ČVUT, Centrum pro radiochemii a radiační chemii, Břehová 7, Rraha 1
**ČVUT, fakulta jaderná a fyzikálně inženýrská, Břehová 7, Praha 1

According to the CR state concept, spent nuclear fuel produced by two nuclear power plants in Czech Republic should be stored in deep geological repository. It should be operational around 2065. Until then, the spent fuel will be stored in transport-storage containers, deposited in intermediate spent fuel storages located in NPP premises. Safety of these interim storage facilities and final disposal sites can be proved only by experimental validating and/or modelling of all the processes that may potentially lead to release of radio nuclides to the environment.

Radom human mistake or defect of container material may result in early groundwater ingress to the inner environment of the container, while gamma and beta emitters would still have high activity. The ionising radiation may affect mechanisms of container and fuel coating corrosion. The conditions inside the container may significantly change and inner container materials degradation and oxidation of fuel matrix may be possibly accelerated. Due to water radiolysis, hydrogen, hydrogen peroxide, hydroxyl radicals and aqueous electrons are produced. Oxygen may be generated in consequent reactions or possibly in recombination processes, followed by formation of hydroperoxyl radical [1]. These species and their reactions may significantly change conditions and processes proceeding inside the container. They may especially contribute to increase of electrochemical potential (Eh) and to decrease of pH in the environment [2]. Pan et al. [3] found pH values as low as 2 resulting from the hydrolysis of internal metal parts of the container.

Presented paper deals with preliminary results of simplified experimental simulation of radiolytic corrosion of steel container after groundwater leakage under anaerobic conditions. Experiments were performed with tablets of standardized carbon steel. For removal of undesirable adsorbents (e.g. adsorbed oxygen, rust), steel tablets were treated in 1% solution of hydrochloric acid. After chemical pre-treatment, the tablets were inserted to thin-walled glass ampoules filled with distilled water. Possible nitrogen saturation of water with continual measurement of residual oxygen concentration was performed prior to filling. Due to expected conditions in deep repository and in order to meet the optimum temperature of corrosion, irradiation experiments were mainly oriented on ^{60}Co gamma irradiation (dose rate 0,2 kGy/h) at higher temperature. For comparison purposes, accelerated electrons irradiation (energy 4,5 MeV, dose rate 0,5 kGy/s) at laboratory temperature was also applied. Progress of corrosion was evaluated via analysis of amount and type of corrosion products. Solid corrosion products adsorbed on steel tablets were analysed using RTG micro-structural analysis. Total Fe^{2+}/Fe^{3+} ions concentration in water was measured using atomic absorption spectrometry (AAS). Fe^{2+}/Fe^{3+} distinguishing was performed using UV/VIS spectrophotometry. All sets of irradiated samples were compared with non-irradiated standards. Doses of radiation ranged from 0 to 120 kGy. Several different sets of samples were prepared and each set was treated differently:

a) Distilled water, carbon steel, irradiated by gamma rays at normal temperature.
b) Distilled water, carbon steel, irradiated by gamma rays at temperature 50 °C.

c) Distilled water saturated with nitrogen, carbon steel, irradiated by gamma rays at normal temperature.
d) Distilled water saturated with nitrogen, carbon steel, irradiated by gamma rays at temperature 50 °C.
e) Distilled water, carbon steel, irradiated by accelerated electrons at normal temperature.
f) Distilled water saturated with nitrogen, carbon steel, irradiated by accelerated electrons at normal temperature.

Obtained results clearly indicate that irradiation under specific conditions may strongly affect kinetics of corrosion and amount of corrosion products. Comparison was made with non-irradiated samples containing both nitrogen saturated and non-treated distilled water. In accordance to presumptions, steel tablets in non-irradiated samples containing deoxygenated water underwent only insignificant corrosion changes, obviously due to lack of oxygen and/or other species that could possibly start corrosion processes. Radiation corrosion of steel tablets caused by accelerated electrons irradiation was also negligible, probably due to short contact time of water with carbon steel and due to high dose rate of radiation.

In the presence of oxygen, amount of corrosion products in samples increased with contact time of solid (carbon steel) and liquid (distilled water) phase. Furthermore, the rate of corrosion increased at higher temperature. After irradiation by gamma rays, extensive changes to rate of corrosion and to both type and amount of corrosion products were observed. These changes occurred in all gamma - irradiated samples and were strongly dependent on conditions of irradiation and pre-treatment of samples.

The results indicate that corrosion processes under anaerobic conditions may be strongly affected by irradiation, especially at higher temperatures. It was verified, that radiolytic corrosion is strongly affected by presence of oxygen. Future experiments should be focused on study of kinetics of corrosion at wider array of temperatures. Saturation by nitrogen should be replaced by argon or helium saturation. Influence of dose rate should be also thoroughly examined. Performed experiments verified that radiation corrosion of containers with spent nuclear fuel under anaerobic conditions can be serious issue, especially at higher temperatures.

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Study of Sorption Properties of New Composite Materials for Radioanalytical Determination of 59-Ni and 63-Ni

O. Fišera*, F. Šebesta**

ota.fisera@fjfi.cvut.cz

*Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

**Centre for Radiochemistry and Radiation Chemistry, Czech Technical University in Prague, Břehová 7, 115 19 Prague 1, Czech Republic

Radioisotopes of nickel ^{59}Ni and ^{63}Ni are activation products of nickel in constructive materials of nuclear power plant. Generated radionuclides are long lived and therefore monitoring of their concentration in radioactive waste is necessary. ^{59}Ni and ^{63}Ni are weak electron capture and beta emitters. Selective separation from other radionuclides is necessary before radionickel determination. Liquid scintillation counting is usually used for measuring of radionickel activity.

Chelating agents based on oximes, mostly dimethylglyoxime (DMG), are used as active component in sorption materials for separation of nickel [1–4]. Sorbent containing DMG is commercially produced as Ni Resin (Eichrom Technologies, USA) but it is relatively expensive for use.

Study of new and cheaper composite materials for selective separation of radionickel in radioactive waste was the aim of this work. Chelating agent dimethylglyoxime and diphenylglyoxime (DFG) as active components were immobilized in porous matrix of binding polymer polyacrylonitrile (PAN). Sorption properties of those materials were compared with commercial Ni Resin. Weight distribution ratios, sorption kinetics and operating capacities were investigated during experiments performed.

Sorbent DMG-PAN (grain size < 0.5 mm) was prepared by impregnation of beads of PAN with solution of DMG in methanol. DMG-PAN contained 18.9 % (w/w) of DMG. DFG-PAN was prepared by direct coagulation of the beads from the solution of PAN and DFG in dimethylsulfoxide using distilled water. DFG-PAN (grain size 0.5 – 0.8 mm) contained 20 % (w/w) of DFG. Preparation of DMG-PAN by direct coagulation of the beads was also tested, but no DMG was immobilized in beads of PAN due to solubility of DMG in water. Ni Resin (grain size 0.1 – 0.15 mm) contains 11 % (w/w) of DMG.

Batch experiments were performed using buffer solution (NH_4OH, NH_4Cl, ammonium citrate) adjusted to desired pH value and labelled with ^{63}Ni. Total nickel concentration was $5 \cdot 10^{-6}$ mol/l.

Kinetics of nickel sorption was tested at volume/mass ratio 200 for different time intervals. Buffer with pH = 8.8 was used in case of DMG-PAN and Ni Resin and buffer with pH = 10.3 was used in case of DFG-PAN. Both sorbents with DMG had very fast kinetics of sorption. Ni Resin achieved the equilibrium after 2 hour of contact. Equilibrium of sorption on DMG-PAN was achieved after 4 – 6 hour. Very slow kinetics was observed in case of DFG-PAN. True equilibrium was not reached even after 29 hour of contact

Weight distribution ratios D_g of nickel were determined in pH range 5.6 – 11.1 at volume/mass ratio 200. Time of contact was 4 hours (DMG-PAN and Ni Resin) or 24 hours (DFG-PAN). Highest values of D_g for DMG-PAN and Ni Resin were observed between pH = 7.2 – 10.3, with the maximum D_g = 5300 ml/g (Ni Resin) or D_g = 1260 ml/g (DMG-PAN) at

pH = 8.7. Optimal pH for sorption of nickel on DFG-PAN was shifted to pH = 10.3 and higher values. Higher D_g values of nickel were determined for DFG-PAN (D_g = 14410 ml/g) than for other two sorbents.

Dynamical experiments were carried out for determination of operating capacities and testing of nickel elution. Columns with bed volume BV = 1.2 ml filled with sorbents were used. The same buffer solutions as for kinetics study were used as the feed. Concentration of stable nickel(II) was $5 \cdot 10^{-3}$ mol/l. Flow rate of feed during nickel sorption was 1.5 BV/h, for rinsing and elution was flow rate 3 BV/h. Sorption and elution of nickel was two times repeated. Precipitation of nickel with DMG outside the column was observed in case of DMG-PAN and Ni Resin. For column with DFG-PAN no such precipitation was observed. The highest operating capacity Q = 34 mg Ni/g of dry absorber was determined for DMG-PAN. This is about two times higher than for Ni Resin with the capacity Q = 15 mg Ni/g and about one half higher than for DFG-PAN with the capacity Q = 22 mg Ni/g. Lower capacities (~ 40 %) were determined for DMG-PAN and Ni Resin in case of repeated sorption. It is probably caused by dissolution of DMG in aqueous solutions.

Elution of nickel is possible with 3 – 1M nitric acid solution. For sorbents with DMG is elution quick and quantitative. In case of DFG-PAN elution with 3M nitric acid solution was very slow.

From the experiments performed it follows that it is possible to prepare cheaper material DMG-PAN with comparable properties as Ni Resin. DMG-PAN has lower values of D_g and rather slower sorption kinetics, but those properties can be improved using smaller grain size of the absorber. In addition, DMG-PAN has higher operating capacity, which enables treatment of larger samples. Practical use of DFG-PAN is limited due to very slow sorption of nickel.

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Radiation Removal of Lead Complexed with Ethylenediamine Tetraacetic Acid and Citric Acid in Aqueous Solutions

M.Pospíšil, B.Drtinová,V. Čuba*, V. Múčka, J. Dolanský

milan.pospisil@fjfi.cvut.cz

Department of Nuclear Chemistry, Faculty of Physical Engineering and Nuclear Sciences, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic
*Centre for Radiochemistry and Radiation Chemistry, Czech Technical University, Břehová 7, 115 19 Prague 1, Czech Republic

Some strong chelating or complexing agents like ethylenediamine tetraacetic acid, citric acid and others are intensively used either in the nuclear industry as decontamination and washing solutions or may be applied as effective solutions for washing of soil contaminated with various toxic metals. In addition to chemo-degradation processes of removal of these complexing agents from their aqueous solutions the most promising modern methods seem to be the photo- or radiation – induced degradation, often utilizing synergistic effects of different promoters [1]. Another question dealing with removal of heavy metals by radiation reduction of their ions from solutions is whether and under what conditions they can be removed also from solutions containing these complexing agents. Several papers state that both agents, EDTA and citric acid are radiolytically destroyed by oxidative mechanism e.g. the OH radicals attack on these acids proceeeds with high rate constants achieving values about 10^9 dm^3 mol^{-1} s^{-1} [1,2]. On the other hand it was found [3] that the rate constants for reactions of solvated electrons e^-_{aq} with some EDTA complexed metal ions (reducing mechanism) may reach the same values depending on the pH and ionic strenght of solution. Therefore this contribution presents the results of preliminary experiments aimed at study of water solutions of Pb^{2+} ions complexed with EDTA and citric acid.

The starting solutions of Pb^{2+} ions (in form of nitrate, chlorate and their mixture) with initial concentration 100 mg/L containing $6x10^{-4}$ mol/L EDTA or citric acid ($5x10^{-4}$ – $5x10^{-3}$ mol/L) and different radical scavengers or solid promoters were irradiated under intensive agitation in sealed thin – glass ampoules by accelerated electrons (4,5 MeV) from linear accelerator. Doses ranging from 0,5 to 100 kGy (dose rate of 0,5 kGy/s) determined by alanine dosimeter were applied. Subsequent centrifugation (5000 revs per minute) was used for the separation of product- finely dispersed metallic particles eventually the mixture of this product and particles of solid promoter. The changes in metal concentration were determined with error ± 3% by means of atomic absorption spectroscopy with flame atomization.

The experiments show that in slightly acid solutions the EDTA complexed lead may be reduced at a dose of 40 kGy up to 97 % without addition of typical OH radical scavengers such as Na(K)formate. The reduction degree decreases in the order: nitrate, mixture of chloride with nitrate and chloride. This finding and the fact that the nitrate appears to be effective e^-_{aq} scavenger give evidence for the determining oxidative mechanism in the first step of reaction e.g. for the reaction of OH radical with $(PbEDTA)^{2-}$ complex. Hydrogen can be probably abstracted by OH radical from different position in this complex and resulting radicals may lead to reduction of Pb^{2+}. On the contrary, in the alkaline solutions containing $2x10^{-3}$ mol/L CO_3^{2-} (pH about 10) the OH radicals are predominantly scavenged. Therefore the direct reaction between e^-_{aq} and $(PbEDTA)^{2-}$ complex may be assumed which leads to the same final reduction effect as in the former case. For the systems containing solid promoters

based on various metal oxides the best results were obtained with cuprous oxide. Regardless of its amount in the range of 0.125 – 0. 5 mg/mL the lead may be reduced up to 95 % at a dose of 40kGy. An extra addition of 10^{-3} mol/L potassium formate leads to the total reduction already at a dose of 20 kGy. The surface ions Cu^{+} probably cause in this case as additional reducing centres to the reducing species from radiolysis of water (e^{-}_{aq} and H atoms). Similar effect was observed for the same system with free (non-complexed) Pb^{2+} ions. However without formate the maximum achieved reduction degree was only 50 % even at highest doses. In this system the surface Cu^{+} ions appear to be also the only reducing agents.

Radiation reduction of lead complexed with citric acid takes place also at pH 5 without formate scavenger and achieves degree of 90% at a dose of 50 kGy. Analogous results were obtained at pH 5.4 and 7 adjusted with HCO_3^{-} or CO_3^{2-} solutions. The highest reduction degrees at lower doses (20 – 30 kGy) show the systems containing formate scavenger with its appropriate concentration dependent on concentration of citrate complex.

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Section 12

BIOMEDICAL ENGINEERING

Long-term Atypical EEG Data Analysis – Preprocessing, Classification and Visualization

J.Rieger*, L. Lhotska*, V. Krajca**

riegerj@fel.cvut.cz

* Department of Cybernetics, FEE, CTU, Technicka 2, 166 27 Prague 6, Czech Republic
** University Hospital Bulovka, Budinova 2, 180 81 Prague 8, Czech Republic

In this paper we present results of the software development for long-term EEG records analysis. The developed system consists of several basic modules. Each of the modules enables data or information visualization it is working with. Main modules of the described system are: main window (simple EEG browser), segmentation setup, feature space metrics setup, classifiers (kNN, backpropagation neural network, k-means cluster analysis), module for training set creation and editing, spectral analysis – spectrogram and spectrogram of multiple electrodes, 2D and 3D brainmapping, features values visualization, digital filtering, online support. Almost all modules are designed as browsers and scrollbars can be interconnected to each other. All presented tools for signal preprocessing, classification and visualization provide quite detailed setup, have brief help and allow saving of configuration for later use (presets). System is implemented in Borland C++ Builder version 6.0, support scripts (feature extraction, data conversion etc.) in Matlab.

The main window serves for browsing the EEG signal and allows access to all other functions of the program. It is possible to set up way of visualization and processing of individual electrodes as needed - for example, it is possible to exclude (from visualization and/or computation) electrodes that are disconnected, have no signal, or are inadequate (ECG, EOG, respiratory signals) etc. Scale of individual electrodes as well as common scale for all electrodes and several other properties for displaying (grid, timestamps, numbering of segments, isoline, colors etc.) can be set up.

Segmentation form provides relatively detailed setup of adaptive and nonadaptive segmentation. EEG signal is generally a nonstationary signal, consisting of combination of relatively stationary signal (delta, theta, alpha and beta waves) and special waveforms (graphoelements) – epileptic activity, sleep spindles, K-complexes etc. Adaptive segmentation allows to find and separate graphoelements from background. Also nonadaptive segmentation can be used (usual segment length is from 1 second up to several minutes).

The functional cores of the system are the training set and classifiers. The user has several options for creating training set - reading the traning set from a binary file (for example created in Matlab), generation of the training set by cluster analysis (simple k-means) or generation of the training set manually by moving segments from the main window to the corresponding classes of the training set. The user can define required number of classes, add and delete classes, set up their coloring, etc. For individual segments of the training set, it is possible to change their scale, sampling frequency, to move them between the classes, delete, or deactivate (such segments are not used for classification). Whole training set can be saved for later use. Classification procedure follows standard scheme – feature extraction, feature space metrics setup (user can select, which features will be extracted and used for euclidean distance computation, if feature values will be normalized etc.), classification. For classification, only simple classifiers as nearest neighbour and neural network are used. Segmented input EEG signal can be colored according to classification result (each of the training set classes has assigned a different color). Result of classification can be displayed in very compressed form allowing to estimate main trends of several hours long EEG signal on one single screen. Note: although EEG signal classification is often the

main issue, the system does not provide more tools for classification. Extracted features can be simply saved to an ASCII file in ARFF format, which can be imported into Weka – extensive freeware tool for data-mining. Results of Weka analysis can be imported back to EEG analysis system for visualization.

During development of our system, it was found, that rather than more classifiers and feature extraction algorithms, tools for comfort visualization and simple inspection of EEG signal are of importance and use. Many of them were implemented and some are briefly described in the following text.

Analysis in frequency domain is provided by spectral analysis – spectrogram. Again, system proposes very detailed setup (window length for FFT computation, window step, displayed page length, usage of welch algorithm and many more). There is a 3D alternative of spectrogram, which can be roughly compared to extended CSA (compressed spectral arrays). Also, spectrograms of multiple electrodes can be displayed on single screen, giving very complex insight into spatial and frequency structure of long-term EEG record.

Spatial distribution of some of EEG signal characteristics (both in temporal and/or frequency domains) can be explored using 2D and 3D brainmapping. In 3D brainmapping, chosen features are mapped onto real 3D head model, values between individual electrodes are computed using interpolation. Disadvantage of this visualization is analysis in single time moment, temporal dimension can be added by 2D brainmapping alternative.

Very comprehensive form of visualization is provided by “feature bars”. Chosen feature is displayed in color modulation corresponding to given range setup (X axis = time, Y axis = electrode, value is coded by color). Many of features can be displayed in this form on single screen for several hours of EEG signal. Feature values for this type of visualization can be also simply imported from binary file, created for example in Matlab – advanced methods of feature extraction (nonlinear analysis etc.).

Developed application has several more modules for EEG signal processing and visualization (digital filtering, extracted feature visualization suitable for biofeedback etc.). Most of the implemented tools have also support for online analysis.

The system was successfully tested on real world problems – sleep, coma and epileptic EEG records analysis. For example, coma EEG classification accuracy of approximately 80% was achieved. Also, sleep stage structure can be simply revealed using spectral analysis.

In the future, the system will be probably extended by more tools for visualization, according to demands of its users (coherence analysis and mapping, biofeedback games, AVS stimulation). Also, usability of advanced nonlinear signal processing techniques will be investigated using Matlab (wavelet, fractal, chaos analysis, PCA & ICA etc.) and successfully tested methods will be incorporated into the system.

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Systematic Feature Construction from Ultrasound Images in Medicine

M. Švec, R. Šára, D. Smutek*

xsvecm@cmp.felk.cvut.cz

Faculty of Electrical Engineering, Department of Cybernetics,
Czech Technical University, Charles Square 13, Prague 2, 121 35

*1st Medical Faculty, 3rd Department of Medicine,
General Faculty Hospital in Prague, Prague 2, 128 08

Hashimoto's lymphocytic thyroiditis (LT), one of the most frequent thyroid disorders, is a chronic inflammation of the thyroid gland. This disease changes the structure of the tissue. Changes are diffuse (they affect the entire gland) and can be detected by sonographic imaging. Information extracted from images by computers may provide additional support for diagnostic hypothesis. Automatic recognition of LT has been attempted based on textural image features [1, 2]. Classification was done with features selected by a search procedure out of 129 features. The optimal features achieved sensitivity and specificity of 100% in a crossvalidation experiment on an independent set of 18 subjects [2]. Although high success rate was achieved, the results were limited to one particular setting of one specific sonograph. This has been recognized as the most important obstacle to bringing the method to online clinical practice. The reproducibility issue is a long-standing problem in similar quantitative methods. In relevant works, parameter settings were adjusted for optimal visualization, fixed to have standardized conditions, or kept at values normally used in clinical practice. Some authors tried to tackle this problem by changing the gain setting during the experiment and capturing for each gain at least five images of the object. Some also removed the mean of each image in order to eliminate effects of unequal ultrasound gain settings.

The goal for current research was to quantify reproducibility of features used previously [2] and to verify possibility to systematically generate simple features with the same or better discrimination ability as previously mentioned textural features.

Reproducibility is the possibility to achieve the same classification results under different sonograph setting, different gland delineations in the manual segmentation step (depending on physician's knowledge and experience), and different scan orientation (longitudinal or transversal). The proposed analysis [3] is general enough to be applied to other data interpretation problems involving complex and non-linear dependencies on variables that cannot be controlled. Features used in the sensitivity analysis are the selected features F2, F6 and F7 [2]. Feature probability distributions (FPD) for each class were estimated by histogramming. The idea of the sensitivity analysis is to quantify the changes of these histograms under various modifications of the data acquisition. A suitable statistic for this purpose is a divergence measure between two feature probability distributions, Jensen-Shannon divergence (JS). Using JS the sensitivity is measured by comparing the inter-class difference (difference between N and LT class) and the within-class difference (difference between FPD and changed FPD, for given class N or LT). Changes in FPD are given by different 1) sonograph gain setting; 2) thyroid gland segmentation; and 3) scan orientation.

Longitudinal scans provide greater amount of image data from a larger contiguous area of the gland tissue, therefore they should be more useful for automatic texture analysis. However, distance between N and LT tissue is not always bigger for longitudinal scans than

for transversal scans. This can be due to longitudinal artifacts in surrounding and examined tissue, e.g. muscle fibers or vessels. On the other hand inter-class distance is large in transversal scans when F7, 21 × 21 (rectangle in pixels to compute feature) features are used and in longitudinal scans when F6, 31 × 31 features are used. Hence, the results could be improved by taking into account longitudinal and transversal images individually, e.g. by combining two classifiers, one using F7 on transversal scans and another using F6 on longitudinal scans. There is high sensitivity to thyroid gland segmentation according to JS distance in larger samples. This can be related to sample placement method that leaves small areas along the boundaries uncovered by samples. To guarantee reproducibility of results under different gain settings, transformation to recalculate features from arbitrary gain to standard gain should be found. From the results, it follows that direct transformation of complex features is unfeasible but re-mapping of the raw image values prior to feature computation seems feasible.

The sensitivity analysis shows that the results for 31 × 31 texture samples and 41 × 41 texture samples are sensitive to small changes in sonograph setting. Both are also sensitive to different gland segmentations. They are stable under transversal and longitudinal scans. The 21 × 21 pixel samples are insensitive to different gain settings and their sensitivity to different gland segmentations is small. They can also distinguish scan orientation, since there is a significant difference between inter-class distances of longitudinal and transversal scans. Distance between N and LT tissue is bigger for transversal than for longitudinal scans.

Texture features based on Gabor filters were generated [4] and tested using JS distance. Features were systematically generated by changing parameters of Gabor functions to comprehend textural changes in direction and intensity. However, the results of sensitivity analysis using these simple features are not comparable to those of previously described texture features.

For greater difference in sonograph parameter setting it will be necessary to remap raw image values by a corrective transformation. The corrective transformation is a topic for ongoing work.

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Bone Formation by Metamorphosis from Fibrosis Tissue to Lamellar Bone on Distraction Osteotomy

M. Petrtýl*, J. Danešová*, J. Lísal*, I. Mařík, A. Wohlmuthová*, D. Jandeková***

jaroslav.lisal@fsv.cvut.cz

* Laboratory of Biomechanics and Biomaterial Engineering, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

**Ambulant Centre for Defects of Locomotor Apparatus, Olsanska 7, 130 00 Prague 3, Czech Republic

This thesis is focused on exact formulation of speeds (like time changes) biomechanochemical processes at metamorphosis from fibrosis tissue to lamellar bone. Attention is focused on space between two bone fragments of diaphysis of human femur after distraction osteotomy. Fundamental stoichiometric equations and other relations are presented in complex form and as the first approach to very complicated metabolic processes.

Processes of bone formation contributing to genesis lamellar bone can be separated into three phases.

1st phase is characteristic by the creation of haematoma and pre-osteoblasts in separation point of diaphysis between bone fragments. In the haematoma are arising accidental directed collagen fibers (1st generation), arising from fibroblasts. In this phase are in motion very intensive cell proliferations and genic expresions.

2nd phase of bone formation is characteristic (by tension loading on distraction osteotomy) by the evolution of extra-celluolus matrix which is formed by directed collagen fibers (2nd generation) and by the creation of osteoblasts. 2nd phase is also typical by very intensive genic expression and continuing cell proliferation, which is not as intensive as in 1st phase. On the contrary, the cell differentiations are very intensive and osteoblasts are created. By tension loading we can see the differentiation of fibrous tissue

3rd phase is characterized by the creation of the lamellar bone and by the presence of osteocytes in this bone. In the space between the walls of the ends of two bone fragments of diaphysis is the tissue mineralized, on the contrary in the marrow (central) part is the tissue thinning.

These three phases represent the fundamental metabolic processes that can be expressed by the three basic stoichiometric equations. From the solution we can get reciprocal relations of the time changes in concentrations of constituent substances. Thus we can come to following conclusions:

1. Matured osteoprogenitoral cells, multipotential phylum cells and fibroblasts decrease and simultaneously substances which initiate genesis of collagen fibers 2nd generation and osteoblasts increase with the accrual of the collagen fibers (1st generation) and the pre-osteoblasts.
2. With the accrual of the collagen fibers (1st generation) and the pre-osteoblasts decrease matured osteoprogenitoral cells, multipotential phylum cells and fibroblasts and simultaneously are in motion future influence processes 3rd phase of bone formation, it means decrease quanta of enzymes (f. ex. Phex) and proteins (osteopontin, bone sialoprotein and others).
3. Substances which initiate genesis of collagen fibers 1st generation decrease and simultaneously increase (in 2nd phase of formation) substances which initiate

differentiation of osteoblasts in formation processes of metamorphosis from fibrosis tissue to lamellar bone with the accrual of the collagen fibers (1st generation) and the pre-osteoblasts.

4. Substances which initiate genesis of collagen fibers 1st generation decrease and simultaneously increase waste products in 2nd phase of formation (for example bone sialoprotein, osteokalcin, osteopontin or enzymes) with the accrual of the collagen fibers (1st generation) and the pre-osteoblasts. Waste products are also remainder of collagen 1st generation (fibrosis collagen).
5. Waste products in 1st phase formation (for example fibrosis collagen 1st generation, proteins, enzymes etc.) and substances which initiate differentiation of osteoblasts increase with the accrual of the collagen fibers (1st generation) and the pre-osteoblasts.
6. Waste products in 1st phase formation (for example fibrosis collagen 1st generation, proteins, enzymes etc.) increase and waste products of 2nd phase of formation decrease with the accrual of the collagen fibers (1st generation) and the pre-osteoblasts .
7. Initiation of genesis new osteoblasts decrease and substances which initiate mineralization of collagen 2nd generation increase with the accrual of the collagen 2nd generation and osteoblasts.
8. With the accrual of the collagen 2nd generation and osteoblasts decrease initiation of genesis new osteoblasts and simultaneously decrease mineralization of collagen 2nd generation and creation of osteocytes. Process of finishing lamellar bone is retarded.
9. Initiation of genesis new osteoblasts and waste products in 3rd phase of formation decrease with the accrual of the collagen 2nd generation and osteoblasts. It means that metabolic processes and cell proliferation slow down.
10. With the accrual of the collagen 2nd generation and osteoblasts decrease waste enzymes and proteins in 2nd phase of formation and increase substances which initiate mineralization of collagen 2ng generation.
11. With the accrual of the collagen 2nd generation and osteoblasts increase „reserve“ fibroblasts (which should perhaps produce fibrosis collagen, like „reserve“ for potential local reparations, resp. maintenance broken parts of tissue).
12. Substances which initiate mineralization of collagen 2nd generation increase with the accrual of the collagen 2nd generation and osteoblasts .
13. With the accrual of the mineralized lamellar tissue and osteocytes bound in this tissue decrease molecular mixture which initiate mineralization of collagen 2nd generation and decrease differentiation of osteoblasts.

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The Method and the Equipment for Detection of Fatigue and Alcohol Intoxication in Operators and Drivers using the Analysis of Signals of Cardiovascular System

P. Smrčka, J. Kašpar, K. Hána

smrcka@fbmi.cvut.cz

Faculty of Biomedical Engineering, Czech Technical University, Technická 2,
166 27 Prague 6, Czech Republic

We have designed, constructed and now we are intensively testing portable experimental equipment, which will be able to distinguish sleep-deprived individuals with alcohol intoxication from vigilant individuals with no sleep deficit. Special algorithms, based on multifractal analysis of heart rate variability signal were developed and implemented in this equipment. The system contains sensors for steering wheel movements, radial and axial acceleration of the vehicle and three types of sensors for heart rate detection. The system is relatively simple to use and in the control unit of this system are implemented adaptive algorithms for early detection of mentioned dangerous states of the driver (alcohol intoxication or sleep deprivation); these algorithms are still under the development; the algorithm of a classificator is currently derived from a classifier based on some parameters mentioned in [1], [2]. The classifier is adaptive, with an adaptation time of not less than 40-60 minutes: the first approximately 15-20 minutes are necessary for the driver to adapt to driving under the given conditions, and the driver must undertake at least two 10-20 min. medium-term cycles, which can be seen in all measured parameters.

It is clear that "degree" of sleep fatigue is measurable only indirectly, on the basis of measurement of a lot of signals carrying any information about fatigue. All symptoms extracted from these signals will be called the fatigue indicators. Especially in the last 10 years, statistical and spectral properties of inter-beat interval sequences (measured as the distance between two successive R-waves on an ECG record, RR) have attracted the attention of researchers, and it has been shown that heart rate fluctuations carry much more information about neuro-autonomic control that had previously been supposed. In the experimental part, we have obtained 23 pairs of approximately 80 minutes long ECG records (sampling rate 500 Hz, resolution of the AD converter 16 bits). In each pair were one record from vigilant state and one record in alcohol intoxication or sleep deprivation. For the experimental and technical details see [3]. Original measuring equipment is described in [4], nowadays we are testing new miniaturized experimental version with real-time adaptive estimation of selected indicators. The experimental data were preprocessed (filtration, segmentation) and heart rate variability signal was extracted. The basic idea of the fractal analysis of time-series is in quantification of self-similarity of rescaled segments of the signal. The integration (or accumulation) is the step that can be interpreted as the mapping of the original (bounded) series to the integrated signal with fractal behavior. In fractal signals the distribution is scale dependent and this dependency can be quantified using so called self-similarity indexes; in monofractal signals the dependency is exponential and it is possible to calculate one and only self-similarity exponent; on the contrary for the multifractal signals it's not possible and we must characterize signal using more local exponents of self-similarity.

We have conducted classical statistical HRV analysis and then fractal and multifractal analysis. For this purpose we have used several different methods: (1) classical statistical

pNN50 and SDNN HRV indexes, (2) the DFA-estimator - Detrended Fluctuation analysis, (3) the WAV-estimator based on dispersion of the wavelet transform coefficients, (4) the WTMM-estimator - Wavelet Transform Modulus Maxima, which represents so-called multifractal formalism. Classical statistical methods for HRV analysis were insufficient, mono and multi-fractal analysis allowed rather distinctive differentiation of both states. The best results were given by the multifractal descriptor derived from the 3rd order distribution function. Well-known Gaussian formalism with the 2nd order statistical moments gives only the suboptimal results in case of heart rate fluctuations. We have not found significant mutual difference between the states of sleep deprivation and alcohol intoxication. The main advantage of introduced methodology may be in an automatic, absolutely noninvasive procedure and relatively easy accessible source signal (heart rate).

Distinguishing between the vigilant and sleep deprived (or vigilant and intoxicated with the alcohol) persons using the fractal and multifractal analysis of heartbeat time series will be probably possible. On the other hand we have found no significant mutual difference between the states of sleep deprivation and alcohol intoxication. The length of fluctuations on which the discrimination occurs, coincides with the scales from hundreds to thousands heart beats. One important limitation emerges from this fact: at least 40-60 minutes of the ECG record are necessary for the sufficient discrimination. Nevertheless we believe this methodology will be useful in practical situations in the traffic or industry. Proposed interpretation comes from the analysis of 23 independent datasets, so some (but no so far going) generalisations are convenient. In the near future it will be necessary to carry out more experiments in order to verify this methodology and, especially, its accuracy. For the first experimental group the results are quite promising.

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Influence of Rigidity at Hip Replacements upon Stress State in the Walls of Femoral Diaphysis with Regard of the Bonding Stiffness between Replacement and Bone Tissue

A. Jíra*, M. Petrtýl*

ales.jira@fsv.cvut.cz

*Department of Structural Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The most reliable clinically tested hip implants can remain in a human body for a period of about 20 years. One of the main reasons for re-operations of the patients is the high rigidity of stem implants, the total material difference from biological structures and properties of tissues. The perfect implant cannot be designed without a perfect knowledge of the biological environment.

The spectrum of dynamic deformations of the human femur is very wide. The dominant loads are created by bending moments, torsion moments, normal and shearing forces. These loads fields have a fundamental influence on the modeling and remodeling of the bone tissue. In the sound femoral bone (without an implant) are fluctuate stresses and strains in physiologically natural values which initiating the remodeling of the bone tissue (to the extent of each physiologically regular limit cycle), and thus ensure equilibrium (stability) of the whole bone system. If an implant is inserted in a femur cavity, physiologically stable transition of forces and moments is impaired. The stress-state fields in the walls of the diaphysis are not distributed. High flexural rigidities of rigid implants can initiate the resorption of the bone tissue resulting in the releasing of the implant. Our effort is aimed at minimizing a “shield effect” that arises in this way, and at the maximum possible approximation to the natural transition of the stress that is typical for a sound bone.

The new artificial replacements generations are such implants that have very similar material properties to the properties of a live tissue. These materials must be biologically tolerated by a surrounding live tissue. While the modulus of elasticity of rigid (metallic) stems are approximately ten times higher that the stems with the gradient of elastic properties (GEP) have the same modulus of elasticity in the surface layer of stem. After special treatment of stem surfaces, these materials create (or support) the initiation of strong physical bonds with molecules of a connective tissue. Between the implant and the live tissue, the physical bond interfaces are created.

The objective of this work is numerical determination of (by means of the FEM) the stress fields in the walls of femur diaphysis for a rigid implants and for composite replacements with the GEP in comparison with stress distributions in the walls of femurs (when the replacements is not applied). The cases of the different variants of separate ties at the replacement stem were compared. The models of stem/diaphysis were created by CT data sequences from men’s femoral bone and than were converted into the FEM. Individual variants with implants were judges with respect to the bond stiffness between implant stem and the bone tissue in three variants.

The following principal results can be presented:

- If the bending rigidity of an implant is reduced (on the value of modulus of elasticity at compact bone), the effect of "stress shield" is lowered - approximately 50%, and the extreme stresses are transferred from the interface between the implant and the bone tissue to the first/second internal (central) medial lamella of a composite.
- On the interface between a rigid implant and a bone, the normal stresses are concentrated in the lower third of the stem of the implant, and these extreme values are transferred to a compact bone.
- If a composite implant with the gradient of elastic properties (GEP) whose modulus of elasticity in the surface lamellas has the identical elastical modulus as a compact bone, the *continuous transition* of normal stresses σ_y (from the stem to the bone tissue) is then achieved. On the interface between a live tissue and an inanimate implant, the identical values of stresses and strains are achieved both in the implant and in the cortical bone.
- If a composite stem is applied, the normal stresses in the wall of a cortical bone are almost identical to the normal stresses of a sound bone (without an implant).
- If a composite stem is applied, the load from the implant to the bone tissue is transferred almost along its entire length. If a rigid implant is applied, the load is mostly transferred in the lower half of a stem and at the end of an implant.
- A rigid or elastic implant inserted in a femur cavity increases its flexural rigidity generally and thus substantially changes the distribution of stress fields in the femur diaphysis in comparison with the distribution of stress fields in the sound femur diaphysis.

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Visualization of Large Biological Tissue Specimens Using Confocal Laser Scanning Microscopy

M. Čapek* **, L. Kubínová, K. Hána*, P. Smrčka***

capek@fbmi.cvut.cz

* Faculty of Biomedical Engineering, Czech Technical University,
nám. Sítná 3105, 272 01 Kladno 2, Czech Republic

** Institute of Physiology, Academy of Sciences of the Czech Republic,
Vídeňská 1083, 142 20 Prague 4 - Krč, Czech Republic

Introduction

In biology there is often necessary to visualize a biological specimen which size is greater when compared with the field of view of a used optical acquisition instrument. The visualization of such the specimen can be achieved by volume reconstruction.

We study biological specimens by using a confocal laser scanning microscope which is able to capture a digital volume representation of the specimen. We investigate great specimens containing, for example, a human tooth pulp, an epithelial layer and a vascular bed of chick embryonic gut or chick embryonic kidneys.

Methods

Prior to volume reconstruction, large biological specimens must be sliced to thin physical slices. This step is difficult due to high preciseness required. One has to cut the slices very carefully to eliminate large distortions of objects in the cutting planes.

The thickness of the physical slices must be smaller than maximal depth of focus of the confocal microscope. When the specimen is larger than a field of view of the microscope in the horizontal orientation, several overlapping volume "tiles" from the physical slice must be captured.

The first step of volume reconstruction of a large biological specimen is acquisition of sets of digital volume tiles from all investigated physical slices.

The second step is composition of neighbouring volume tiles of the same physical slice to compensate for a restricted field of view in the horizontal orientation. For this purpose we applied a registration algorithm based on a least squares function and rigid-body geometrical transformation which uses pixel information in overlapping areas of volume tiles [1].

The next and most demanding reconstruction step is registration and composition of volumes of neighbouring physical slices of the specimen. This step compensates for a restricted field of view in the vertical orientation. Here we applied an elastic registration algorithm which models elastic deformations by using B-splines [2]. Since deformations between objects of adjacent physical slices are extensive, the registration is driven by user-inserted-markers, not by pixel values like in the second step.

The last step is filtering the whole reconstructed volume by a 3D Gaussian filter to eliminate objects discontinuities, especially in the areas of cutting planes.

The resulting large digital volumes are rendered and visualized by using a VolumePro 1000 hardware rendering board made by TeraRecon Company (USA) that provides real-time 3D volume rendering. The visualization enables us to see internal structures of large biological specimens and count, measure and evaluate studied objects, etc.

Results

The described approach has been applied to volume reconstruction of a human tooth pulp. This very large biological specimen consists of 244 physical slices and digital representations of physical slices have been composed from up to six overlapping digital volume tiles.

Conclusions

We developed an approach for volume reconstruction and visualization of large biological specimens based on rigid-body registration of overlapping volume tiles of physical slices and elastic registration of images of neighbouring physical slices. This approach can be used in practice to visualize, evaluate, measure and count objects of interest.

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Power Grip of Hand

J. Čulík

culik@ubmi.cvut.cz

Czech Technical University of Prague, Faculty of Biomedical Engineering

The aim of paper is a calculation of the stress state at hand bones and hand tendon forces as an effect of the power grip the object for example the tongs.
We suppose:
- the hand clamps the object between wrist and nth (2nd, 3rd, 4th) link finger,
- diameter of clamped object is a free parameter,
- thumb doesn't work,
- the finger link lengths make Fibonacci's sequence [1],
- tendons are at tendon vaginas and follows finger bones form
- tendon curvature has near the joints radius *r,*
- f_{ij} is perpendicular distance the tendon from joint center,
- at tendon vaginas aren't friction,
- fingers are numbered from forefinger and the finger link from wrist,
- the bending moments aren't at finger joins,
- each finger links has its flexor and extensor,
- bones are ideal stiff and tendons are ideal flexible,
- metacarpal part is solved as one joint,
- the 1st finger links are connected (corpus ossis metacarpalis) and there bounding enable a small difference of their slopes.

The object grip of hand has follow schema: $A_i(x_i,y_i)$ are turning center of finger links, $B_i(X_i,Y_i)$ are connection points between object and finger surface, $S_i(x_{is},y_{is})$ are bone links axis centers. The coordinates of points A_i can be calculated from

$$x_{i+1} = x_i + L_i \cos\alpha_i, y_{i+1} = y_i + L_i \sin\alpha_i$$

α_I is slope of ith finger link and L_i is its length (distance between turning centers).
The position of poits B_i are

$$X_1 = -r_1 v \frac{y_2}{L_1}, Y_1 = r_1 v \frac{x_2}{L_1},$$

$$X_{i+1} = \frac{x_i + x_{i+1}}{2} - r_i v \frac{y_{i+1} - y_i}{L_i}, Y_{i+1} = \frac{y_i + y_{i+1}}{2} + r_i v \frac{x_{i+1} - x_i}{L_i}$$

r_i is bone radius and v is parameter which defines distance between finger surface and bone axis.
Rotation angles α_i of bone link axis are

$$\beta = \alpha_2 - \alpha_1,\ \alpha_2 = \alpha_1 + \beta,\ \alpha_3 = \alpha_1 + (1+k)\beta,\ \alpha_4 = \alpha_1 + (1+1{,}5k)\beta$$

The 1st approximation is $\alpha_1 = 0$. Angle β will be determined to be distance between B_1 a B_{n+1} equal size of grip object *d,* the value of *k* is calculated to be for *d*=0 the points B_1 a B_{n+1} at the same position, it means that for its distance is valid

$$\begin{aligned} \Delta x &\equiv L_1 + L_2 \cos\alpha_2 + \ldots + \frac{L_n}{2}\cos\alpha_n - r_n v \sin\alpha_n = 0 \\ \Delta y &\equiv L_2 \sin\alpha_2 + \ldots + \frac{L_n}{2}\sin\alpha_n + r_n v \cos\alpha_n - r_{c,1} v = 0 \end{aligned} \quad (1)$$

If we set to (1) formulas for angles α_i we have the system of equation with unknowns β and k which can be solved with help Newton´s iteration method. Now we rotate the hand to be the grip force F vertical

$$tg\alpha_1 = \frac{X_{n+1}}{Y_{n+1} - vr_1}$$

The geometry of hand finger position for power grip of round post can be determined likewise.

The tendon forces F and joint forces H, V which have influence on finger links can be calculated from the equilibrium conditions (moment and force conditions)

$$\sum_{j=i}^{n} R_j f_{i,j} - \sum_{j=i+1}^{n} R_j f_{i+1,j} - H_{red,i+1} c_{y,i} - V_{red,i+1} c_{x,i} + F_{y,i} r_{x,i} - F_{x,i} r_{y,i} = 0$$

$$H_{red,i} = H_{red,i+1} + F_{x,i},\ V_{red,i} = V_{red,i+1} - F_{y,i}$$

where H_{red}, V_{red} are reduce forces without tendon forces influence. The final joint forces are

$$V_i = V_{red,i} - \sum_{j=i}^{n} R_j b_{y,i}, H_i = H_{red,i} + \sum_{j=i}^{n} R_j b_{x,i}$$

Now can be calculated tendon forces and stress state at fingers. The hand load can be divided to fingers to be equal tendon forces or stress maximum at all fingers.

The poster will show the algorithm for power grip of post with circular diameter too. The finger position geometry is deferent but the stress state calculation is same.

The maximal values of stress are calculated from

$$\sigma_{x1} = \frac{N}{A_{r1}} + \frac{Mz}{I_{r1}}, \qquad \sigma_{x2} = \frac{N}{A_{r2}} + \frac{Mz}{I_{r2}}$$

where σ_{x1} , σ_{x2} are maximal normal stress at compact and spongios part of bone and

$$A_{r1} = \pi(r_1^2 - \lambda_1 r_2^2),\ A_{r2} = \pi(\lambda_2 r_1^2 - \lambda_3 r_2^2),\ I_{r1} = \frac{\pi}{4}(r_1^4 = \lambda_1 r_2^4),\ I_{r2} = \frac{\pi}{4}(\lambda_2 r_1^4 - \lambda_3 r_2^4)$$

$$\lambda = \frac{E_2}{E_1},\ \lambda_1 = 1 - \lambda,\ \lambda_2 = \frac{1}{\lambda},\ \lambda_3 = \lambda_2 - 1$$

The maximal value of shear stress is

$$\tau_1 = \frac{0{,}90412966.Q}{2(r_1 - \lambda_1 r_2)} \left(\frac{r_1^3 - r_2^3}{I_{r1}} + \frac{r_2^3}{I_{r2}} \right)$$

The described algorithm was implemented on computer. The program has as output the graph of hand position and the values of stress and tendon forces.

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Photophysics of New Fluorescent Probes with Amino-benzanthrone Chromophore

D. Pánek*, J. Sýkora, M. Hof**, J. Urbanec***, M. Dvořák*, M. Michl*, T. Staněk*,V. Fidler***

panek@troja.fjfi.cvut.cz

* CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Physical Electronics, V Holešovičkách 2, 180 00 Praha 8, Czech Republic
** Jaroslav Heyrovský Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, Dolejškova 3, 182 23 Praha 8, Czech Republic
*** University of Pardubice, Faculty of Chemical Technology, Dept. of Organic Technology, Studentská 95, 532 10 Pardubice, Czech Republic

Monitoring of solvent relaxation by time-resolved fluorescence measurements has recently become an extremely useful method in membrane research. It has been shown that suitable fluorescent dyes allow direct observation of viscosity and polarity changes in the proximity of the probe molecule that can be intentionally located in the hydrophobic backbone or in the hydrophilic headgroup region of the phospholipid bilayer.

Solvent relaxation refers to the dynamic process of solvent reorganization in response to a sudden change in the charge distribution of a dye as a consequence of its electronic excitation. The solvent temporal response can be monitored through observation of the fluorescence maximum dynamic Stokes shift of the dye probe.

Developments of pulsed picosecond laser diodes with a high (MHz) repetition rate lead to a broad application of the solvent relaxation in membrane studies. Several years ago, relatively cheap laser diodes emitting at 405 nm have become available. Absence of labels that absorb in this range lead to an idea to synthesize new dye, N-palmitoyl-3-aminobenzanthrone (ABA-C_{15}), which proved to be an advantageous headgroup-region label for membrane studies [1]. The label consists of an aliphatic chain linked to the chromophore (aminobenzanthrone). In order to study more thoroughly the interaction of the dye with the molecules in a bilayer, a set of similar dyes was synthesized. These dyes were used for experiments presented in this work. We focused mainly on the influence of the temperature and the length of the aliphatic chain on the specific position where the label self-locates within a membrane.

Three labels, ABA-C_7, ABA-C_{15} and ABA-C_{19}, were incorporated into large unilamellar vesicles (LUV) formed by lipid molecules, 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC). LUVs were prepared by extrusion of the turbid suspension. Vesicles are quasi-spherical shells composed of lipid bilayers that encapsulate an aqueous space. They are used in research laboratories as model membranes and in pharmaceutical and cosmetic industry as nanoscale containers for drugs and other substances. Extrusion is one of the methods used for preparation of vesicles [2]. It involves pushing a lipid suspension through pores with diameters of the order of 100 nm. Extrusion method has the advantage that it produces a relatively mono-disperse, predictable vesicle size without any additional contaminants. We prepared vesicles by the extrusion of mixture of DPPC and the label dye

with 1 mM total lipid concentration and 100:1 lipid-to-dye ratio. 10 mM HEPES-100 mM NaCl buffer was used for maintaining constant pH 7.4.

Label fluorescence decays as well as steady state spectra were recorded with Edinburgh Instruments FSFL900 system. Decay kinetics was recorded using time-correlated single photon counting method. Blue-emitting diode laser IBH NanoLED-07 (405 nm peak wavelength, FWHM <150 ps, 1 MHz maximal repetition rate) was used as an excitation source for time-resolved measurements. Fluorescence in time-resolved measurements was detected by cooled Hamamatsu R3809U-50 microchannel plate photomultiplier attached to the Jobin-Yvon HR10 monochromator with 8 nm bandwidth. Temperature of the sample was kept constant by a thermostat.

Excitation and emission spectra and a set of kinetics were measured for each dye at three temperatures, 29°C, 40°C and 47°C. At each temperature, a decay was recorded every 10 nm over the whole range of emission from 490 to 620 nm. From the measured steady state spectra and the set of decay kinetics, time-resolved emission spectra were obtained by spectral reconstruction (i.e. relative normalization of the fitted decays to the steady state emission intensity) [1]. Log-normal fitting of such spectra allows, consequently, to reconstruct e.g. time evolution of the emission maximum position, or time-evolution of the emission peak FWHM. Such data give us an insight into the membrane micro-polarity and micro-viscosity at the label's position.

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Preprocessing and Visualization of Body Surface Potential Mapping Data

Václav Chudáček, Lenka Lhotská

chudacv@fel.cvut.cz

Czech Technical University/Gerstner Laboratory, Technická 2, Praha 6, 160 37, Prague, Czech Republic

Introduction

Analysis of electric field of the heart using standard 12-lead ECG system is recently most widely used method for diagnosis of heart diseases. Body Surface Potential Mapping (BSPM), that measures electric potentials from several tens up to hundreds electrodes placed on the human thorax shows in some cases higher diagnostic value – due to measuring of electric potentials more thoroughly – obtaining thus the information for standard 12-lead ECG inaccessible [1]. This is one of the reasons why research of body surface potential mapping in last decades draws big attention.

Practical usage of BSPM is in many ways limited. On one side there are morphological imaging techniques (angiography, echocardiography, PET) proving as stumble block. Those techniques have higher costs but they provide us with precise anatomical data. On the other hand even though BSPM provides us with better diagnostic values, there are difficulties with practical problems of measurement (method is time consuming and uncomfortable for the patient) and interpretation (not so common as standard 12-lead ECG). The only exception nowadays is research in the field of arrhythmia, where BSPM holds is commonly used [3].

Reason for further optimism of BSPM usage in clinical praxis lies in research of inverse problem in electrocardiology. Result should not only be map of potentials on human thorax but map of potential on human heart acquired non-invasively.

Method and results

Aim of our research was development of program that would be able to visualize and basically preprocess measured data, thus that it would be useful for further use in medical research and school purposes. We have used the Cardiag 112.2 system (Czech MECG device) with 80 electrodes in 16 x 5 equidistant matrixes [2]. The system allows recording of standard ECG, vectorcardiograph and body surface potential mapping. We have developed modular software tool that enables us:

- Load the data from the database
- Semi-automatically recognize missing or corrupted leads
- Automatically repair of missing or corrupted leads
- Doing basic signal pre-processing task – such as simple filtering
- Signal analysis – QRS complex detection etc.
- Visualization of the standard leads using zoom and different time axis
- Visualization of Body Surface Potential Maps

- Visualization of important feature that can be found on the map – such as maximum and minimum of the map as well as some not so commonly used features such as QT dispersion
- Create and visualize integral and isochronic maps
- Important feature selection and visualization
- Exporting extracted feature in format suitable for further processing in data-mining tools such as WEKA

Discussion and conclusion

Aim of this paper was to show the results of our work with data from Body Surface Potential Mapping, which is used in special cases for acquiring wider information on electrical heart function. For preprocessing we have used methods that enable us to extract some interesting parameters from BSPM maps that will be used in future research. Visualization of maps directly follows analysis of the signal – we have found out that the best way to visualize is one period of the lead signal – in this way we are able to acquire the borders of the signal.

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Camera Calibration and Reconstruction of Points Using Linear Transformation

viktor.hudak@fbmi.cvut.cz

Department of Biomedical Informatics, Faculty of Biomedical Engineering, Czech Technical University in Prague, Nám. Sítná 3105, 272 01 Kladno, Czech Republic

This work is about a camera calibration and reconstruction of points by using linear transformation. This operation is used to reach object coordinates in the three-dimensional world space from its pictures (two-dimensional space). The result of this transformation is matrix (4×3, four rows and three columns), which is the key to obtain real coordinates from the knowledge of objects coordinates on the picture. With this coordinates we can determine the position of the object in the real space and we can reconstruct the scene.

Special (passive) markers can be mounted to the followed object in order to we could easy find most important parts of object, which we need to make his virtual reconstruction.

When we can obtain coordinates of the object, we can make virtual-reality simulation of the object and we can monitor the movement of the object in the real space. The results of this work could be used in determination and cure of disorder in movement coordination. Patient is expect to move some specific object from one location to the another, when he can see the position of end location of object on the screen and there is computer using two or more recorders to monitor patient manipulations with the object.

To do camera or recorder calibration by this operation, there are needed at least two recorders, which will take sample pictures of the scene. When we have at least two sample pictures we can compute transformation matrix for each recorder, which we used to obtain sample pictures. For this purpose we need to know exact coordinates of some points in the real (tree-dimensional) space and then we also need to reach coordinates of this points in pictures (two-dimensional space). When we know both of coordinates, we simple obtain transformation matrix for each recorder. With known of this matrix we can use them to determine location of any point in the real space, without influence of optical errors and distortion created by transformation from the three-dimensional space to the two-dimensional image space.

To be able to reconstruct coordinates of an object in space, we need to know its coordinates in at least two of its images (vectors $\mathbf{b}'$ and $\mathbf{b}''$) and the corresponding transformation matrices (vectors $\mathbf{M}'$ and $\mathbf{M}''$) of viewing operations T′ and T″, respectively.

The reason why we need at least two images is that one view gives us only a line on which the point, we are looking for, must lie. The second view gives us another line and in an ideal situation these two intersect. However, in the real situation they usually do not intersect because our measurements aren't done that precisely.

Since we cannot find the exact solution, i.e. the intersection, we at least try to be as close to it as possible. To do so we need to use the least squares method.

The first thing we have to do when doing a reconstruction is to find corresponding points in different images. We measure their coordinates as precisely as possible. Then general equation of their transformation is

$$[\mathbf{a}^{1*4}\mathbf{M}^{4*3}] = [\mathbf{b}^{1*3}],$$

where **a** is a object point in space and **b** is its image in a projective plane under a viewing operation represented by matrix **M**. (Obviously, in object reconstruction **a** is computed given **b** and **M**). From the two viewing operations T′ and T″ we get two separate linear equations representing particular viewing operations.

$$< a_1, a_2, a_3, 1 > \mathbf{M'} = < b_1', b_2', 1 > \text{ and}$$

$$< a_1, a_2, a_3, 1 > \mathbf{M''} = < b_1'', b_2'', 1 >.$$

By amalgamating these two equations, we obtain an over determined and inhomogeneous system of linear equations, which in matrix form can be written as

$$< a_1, a_2, a_3 > \mathbf{N} = \mathbf{c}.$$

As we have said before, this kind of system does not have a solution as such so we are trying to find the best possible solution. The least squares method helps us retrieve the coordinates of point A using the right inverse of the coefficient matrix **N**.

$$\mathbf{aN} = \mathbf{c}$$

$$\mathbf{aNN}^T = \mathbf{cN}^T$$

$$\mathbf{a} = \mathbf{cN}^T(\mathbf{NN}^T)^{-1}$$

$$\mathbf{a} = \mathbf{cN}^+.$$

The solution (the point A) is homogenous coordinates of the point we are looking for.

To compute transformation matrix and points coordinates we use Matlab (computer program). After computing transformation matrix we can use them to reach real coordinates for any point from two different pictures of one scene, which we obtained from recorders. So we need two two-dimensional coordinates of a point and two matrixes (each one for each recorder) to compute tree-dimensional coordinates in the real space.

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Object Visualization with Virtual Reality Modeling Language

Vizualizace objektů pomocí jazyka VRML

Veronika Jiráková, Zoltán Szabó

veronika.jirakova@fbmi.cvut.cz

Katedra biomedicínské informatiky, Fakulta biomedicínského inženýrství, České vysoké učení technické v Praze, Nám. Sítná 3105, 272 01 Kladno, Česká republika

VRML (Virtual Reality Modeling Language), jak je vidět již z názvu, slouží tento jazyk pro popsání světa virtuální reality.

VRML se snaží popsat svět tak, jak ho vnímají naše smysly. Ve virtuálním světě se lze volně pohybovat, všechny objekty lze volně prohlížet, dají se různě měnit jejich tvary a dá se poslouchat i 3D zvuk.

Pomocí internetu a prohlížeče s přídavným modulem, který prohlížeči umožní se vyznat v jazyce VRML, se můžeme do virtuálního světa podívat. Tyto přídavné moduly jsou volně dostupné na internetu.

Výhodou jazyka VRML je jeho možnost použití na WWW stránkách. Tam nám potom VRML umožní prohlížet si trojrozměrný svět zcela přirozeným způsobem a pracuje dobře i při pomalém spojení. Dalšími jeho výhodami jsou rozšiřitelnost, dynamika jeho objektů a jeho nezávislost na platformě, na které je provozován. Je to vcelku málo výhod, bohužel má VRML tak jako jiné programovací jazyky i své nevýhody.

Naopak je jeho nevýhodou, že k vizualizaci virtuální scény, je zapotřebí značného výkonu procesoru. Ale to není jediným problémem VRML. Ve VRML není možnost interakce s dalšími virtuálními osobami. U rozsáhlejších scén a u scén s mnoha texturami je pomalý rendering. A uvnitř světa VRML se též nedá zobrazit HTML stránka.

Při tvorbě virtuálního světa vytváříme soubory s příznačnou příponou wrl, tedy world-svět. Jde v podstatě o textový soubor, který musí mít na prvním řádku standartní text, tedy hlavičku, podle které prohlížeč rozpozná, že se jedná o soubor s příkazy v jazyce VRML.

Takové soubory se dají vytvořit několika způsoby.

Jeden ze způsobů můžeme uskutečnit pomocí textového editoru, což může být dosti náročné, pro člověka, který přesně nezná popis a syntaxi jednotlivých klíčových slov. Uzly, které zapisujeme do VRML souboru, můžeme zapsat s chybami, ve špatném pořadí, se špatnými atributy nebo s nesprávnými hodnotami atributů. Výhodou tohoto způsobu je, že nepotřebujeme žádný software k vytvoření scény.

Dalším způsobem je použití speciálního editoru s různými předdefinovanými objekty. Takový editor téměř ihned vytvářenou scénu zobrazuje. Mezi tyto editory můžeme zařadit třeba modelovací program CosmoWorlds od firmy Silicon Graphics a nebo program Community Place Conductor od firmy Sony. A nemusíme při tom podrobně znát syntaktickou podobu všech prvků VRML. Bohužel v těchto speciálních editorech můžeme vytvářet pouze jednoduchá tělesa.

Ale využití editoru pro CAD technologii, který nám umožní zapisování scén a objektů, které tvoříme do formátu wrl, je zřejmě nejpropracovanějším způsobem. Na uživatele jsou však kladeny nároky na jeho znalosti ohledně CAD technologie.

Při práci s objekty v jazyce VRML, potřebujeme jako uživatelé, aby se tyto objekty díky našim podnětům dynamicky měnily. Bohužel se jedná jen o jednoduché propojení mezi námi, jako uživately a vytvořenou scénou. Ve VRML nejsou k dispozici prostředky, které by podle našeho přání měnily a zpracovávaly události. Pokud si například přejeme změnit hodnotu TRUE na hodnotu FALS, musíme využít uzlu Script. Při zpracování událostí v uzlu Script lze použít dva jazyky. Prvním z nich je jazyk Java. Je to oběktově orientovaný programovací jazyk, který je nezávislý na platformě. Byl vytvořen firmou Sun Microsystems, Inc. Druhým je jazyk JavaScript. JavaScript, dnes ECMAScript, byl vytvořen firmou Netscape. Je to také na platformě nezávislý programovací jazyk a je velmi podobný jazyku C++.

Ve VRML můžeme vytvářet různá geometrická tělesa jako kvádr, kužel, válec či kouli a to jsou jen ta nejzákladnější. Další tělesa např. můžeme vytvořit pomocí základních bodů a jejich spojnic. U těles pak můžeme měnit jejich velikost, polohu, barvu, či jim měnit texturu texturu. Můžeme vytvářet i trojrozměrné texty a jiné další objekty. To pochopitelně není vše co bychom mohli s tělesy, jejich pozadím a okolím dělat, ale na výčet všech úkon bychom potřebovali víc prostoru, než jen dvě stránky. Jednoduše řečeno, můžeme pomocí editorů či svých znalostí převést náš normální skutečný svět do virtuální trojrozměrné podoby.

Prezentovaný materiál je částí týmového projektu na Fakultě biomedicínského inženýrství ČVUT, který se zabývá kamerovým systémem pro rehabilitaci motorických poruch. Jedná se o převedení vyznačených bodů na těle měřené osoby, pomocí kamer a pomocí převodu dat do virtuálního světa.

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Image Processing Algorithms in MontiVision Programming Environment

Realizace algoritmů zpracování obrazu v programovém prostředí MontiVision

J. Potůček, Z. Szabó

Jaroslav.Potucek@fbmi.cvut.cz

Katedra biomedicínské informatiky, Fakulta biomedicínského inženýrství, České vysoké učení technické v Praze, Nám. Sítná 3105, 272 01 Kladno, Česká republika

Programové prostředí MontiVision, umožňuje namodelovat určitou situaci, a takto namodelovanou situaci, jako jednu z mnoha funkcí, umožní převést na jednoduchý zdrojový kód několika programovacích jazyků, jako jsou například C++, Visual Basic 6.0 nebo Delphi.

V našem případě jde o modelové situace různých funkcí při zpracování obrazu, např. Detekce bodu, hranic objektů a oblastí, Segmentace obrazu atd. Do prostředí MontiVision si načteme obrázek, nebo video, pomocí nabídky např. *Stream,* na levé straně programového prostředí, nabídka též obsahuje položky *Video*, *Audio, I/O a General*, zvolíme např. *Avi/Waw file source*. Tento "blok" načte video soubor s koncovkou -.avi nebo -.wav. Pomocí vazeb spojíme tento "blok" s dalšími "bloky" což jsou různé filtry, které jsou pod položkou *Transform Filters* u každé nabidky (Video, Audio, atd.), a které umožňují komprimovat (např. Video Encoder, Video codec, MJpeg compresosor) a dekomprimovat (např. AVI Decompressor, DivX Decoder, Mpeg Video Decoder, MJpeg Decompressor, atd.) obraz. Taktéž můžeme používat různé "bloky" simulující obrazové procesy (Absolute Difference, Blob Finder, Camera Synchronisation, Color Filter, Linear Filter, atd.) u jednotlivých "bloků" lze nastavovat jejich parametry (stupně šedi, rozlišení obrazu, zpoždění, přibližování – funkce lupy, atd). Takto si lze namodelovat každou takovou situaci, kterou potřebujeme.

Pokud chceme z takto namodelovaných situací vytvořit samostatný program v některém z programovacích jazyků (prostředí umožňuje vytvářet zdrojové kódy pro programovací jazyky C++, C#, Visual Basic 6.0, Visual Basic.Net a Delphi), zvolíme na Hlavní liště programového prostředí MontiVision nabidku *File,* zde si vybereme funkci *Export / source…*, poté se zobrazí nabídka programovacích jazyků, která nám umožní si vybrat pro nás nejvhodnější programovací jazyk, v mém případě jde o programovací jazyk C++. Po výběru programovacího jazyka se program zeptá, kam má vytvořený zdrojový kód uložit, a po zadání cesty nám uloží hotový zdrojový kód ve vybraném programovacím jazyku. Poté si můžeme uložený zdrojový kód načíst do kompilátoru programovacího jazyka (v našem případě jde o programové prostředí Dev C++), ve kterém tak můžeme vytvořit samostatný program s koncovkou exe.

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Diagnostic Measuring of Galvanic Cells in the Oral Cavity

K. Hána, J. Procházková, P. Smrčka, Š. Podzimek, J. Kašpar, M. Tomka, J. Bártová

hana@fbmi.cvut.cz

Joint Department of Biomedical Engineering of Czech Technical University and Charles University in Prague, Faculty of Biomedical Engineering, CTU in Prague, Studnickova 7, 12000 Prague 2 - Albertov, Czech Republic

*Institute of Dental Research 1st Medical Faculty and General Faculty Hospital, Charles University, Vinohradska 48, 120 21 Prague, Czech Republic

This work describes the construction of an appliance for measurement of galvanic cells electric parameters in the oral cavity, own developed method of measurement and first results. The aim of the study is to create a theoretical model of galvanic cells' dislocation in the oral cavity. The alloys of common or rare metals have been used in dentistry for a long time for their excellent physical conditions as pourment, malleability, tensillness or resistance. Last period they have been used in implantology for dental restorations as well. Metals from dental alloys are not the physiological part of the human organism in commonly used volumes. That is the reason for appearence of unwanted side effects in sensitive individuals after aplication of dental alloys. These side effects can be of physical or biological origin. During the interaction of the metallic denture with the agressive environment of the oral cavity each alloy more or less corrodes. This corrosion is characterized not only by simple chemical one, but electrochemical one, on the base of galvanic features when the dental alloys function as electrodes and the oral liquids - saliva, crevicular and tissue fluids - as bath. The ions are released from one electrode and intercepted by the other one. Such a way the movement of metal elements is performed. These mechanisms together with abbrasion caused by the mastication lead not only to the destruction of dental alloys but also to the ballast of the organism with the metal elements from the used materials. Both, the galvanic features and the exposition to released metal elements are able to evoke subjectively very unpleasant feelings in predisposed individuals while the objective findings using a large scale of serious diagnostic methods are rare. They can show both local or general symptoms. Galvanic voltage and currents function as tickler like any other physical irritant and the answer of the organism is characterized by standardly known features of inflammation: rubor, color, dolor, tumor and function laesa, depending on the health stage of organism and the intensity or irritation. Electric current often products some sides on the way between the electrodes depending on the resistive load of surrounding tissues. The manifestation of clinical symptoms has been influenced by the course of the current, its intensity, time of duration, irritability of organism, pain threshold and on other not always known factors.

This fact is very important for the differential diagnosis, because similar oral dyscomfort can be find often in older people suffering from pathological features as defects of CNS blood supplementation, lowered carotides blood flow, high or low blood pressure, atherosclerosis, pathology of the cervical backbone, psychical stigmatisation, gastrointestinal diseases and immune systen disorders. The current flow has been often followed by the biological reaction with the changes on the cell niveau. Clinical manifestation of these changes shows macroscopic changes of the tissue morphology, where the ephlorescences arised on the etiological base of relatively simple treated irritation imitate a serious affection e.g. Plummer-Vinson Syndrome, hypovitaminoses or leukoplakia. Side effects of released metal ions can cause local problems as deposition of metal elements into the nearest surrounding of the

electroactive metal denture. Consequence of the local toxic irritation of catapulted ions infiltrating by iontophoresis in neighbouring tissues is inflammation, oxidative stress, activation of immunecompetent cells, production of inflammatory factors and worse wash out of metabilic products. Without causal treatment the specific immune reaction has been activated and the inflammation has got to be chronical. In the course of such an inflammation the important role in the specific cell reaction is played by T-lymphocytes.

All negative influences are strictly individual and can be objectified only on the basis of measurement. In Czech Republic, there is the measurement of absolute maximal values of voltage and currents (going through the resistor 2200 ohm) performed and on the base of these values the mood of therapy is decided. The aim of our study is to create a theoretical model of galvanic cells´ layout in the oral cavity. For this purpose the methodical tip for establishment of this model was proposed. Due to this requests and to own experiences from the clinic practice we find out building of our own mobile device for the diagnostic measuring of current and voltage in the oral cavity accompanied with user's software. The mobile device enables the measuring voltage, current, their polarity, maximal value, internal resistance, capacity of galvanic cells, and the possibility to follow the effect of the loading of the one cell to the other cell. The single-chip microcomputer (Cygnal C8051F330) and A/D converter (Analog Devices AD7738) built the substance of the equipment. The resistor 2200 ohm is automatically wired in mode of the measurement current by the relay. The values of measuring quality are transferred to PDA (Personal Digital Assistant) or PC in the real-time by the serial interface RS232. The data are processed on PDA or PC and by the rectangle method the capacity of galvanic cell are calculated.

The final result should be the creation of a theoretic model by using the Finite Element Method (FEM) that enables to follow not studied potentially important dependences, and to make the diagnostic judgement of the physician in the clinical praxis easier using the graphical scan of measured parameters. Nowadays, when at least tens till hundreds of measured values in one patient are manually evaluated only on the base of the experience, this model will open a new age in the evaluation of data and will enable the thousands of measurements combine with further medical research (immunology…). This all would lead to the solving of the key problem: to the prevention of galvanic cells arise in the oral cavity for the concrete person or the prediction of voltage and currents decomposition in case of a new metal dental product added to older ones.

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The Use of ECG Heart Frequency and the Stress Index in Biological Feedback

K. Vospálková, R. Fiala, T. Funda, K. Hána, J. Kašpar, J. Kukla, A. Mach, J. Mikšovský, M. Mráz, L. Nešvera, P. Prašanec, P. Smrčka, J. Žáček

kamila.vospalkova@fbmi.cvut.cz

The Laboratory NMR SISCO, Fakulty of Biomedicinal Engineering, Czech Technical University, nám Sítná 3105, 27021 Kladno Czech Republic

The aim is to select the appropriate signs from the ECG signal and appropriate form for their final display to the operator. The forstering of the relationship between the autonomous nervous system and cardiovascular death rate accelerates the development of quantitative indicators of the autonomous activity. One such example is the HRV (Heart Rate Variability). Due to the easy use and large number of commercial devices HRV is a very simple tool for experiments and clinical studies.

HRV selectively reflects the work of the autonomous nervous system, it's sympathetic and parasympathetic components, their reactions to different emotional states, which are closely tied to the baroreflexes (responsible for the regulation of blood pressure) and breathing. The rythms of the cardiac and lung systems have a massive effect on all other body systems and their function. They are beginning to be considered as a link between psychic and somatic processes, where both way transfers are in this time beginning to be more palpable with the use of new technologies of applied psychophysiology.

The Heart pulse and the variability of the Heart rate (HRV). With the average of 70 pulses a minute, the heart will undertake 4000 pulses an hour, or about 100 thousand pulses a day. It is therefore a very powerful pump that is controlled by the central nervous system. The heart action is not regular, it is a very variable function dependent on breathing, psychic state, physical load, generally stress and by pathologies. The Heart can in some situations change rate very quickly and many are very perceptive to any change. Most of these changes or irregularities of our pulse do not indicate a pathological occurrence. Usually it is reffered to as the Sinus Respiration Arrythmia, which means that the rhytm of the pulse changes according to the breathing phase. During expiration the heart rate decreases and vice versa the heart rate increases with inspiration.

At the current time the Heart Rate Variability is begginig to be used as an important health index, the well being of the patient. We are not using the HRV biofeedback in the Czech Republic at this time. In other countries it is a quite used technique especially in preventive antistress programs and for the treatment of dysfunctions of attentionspan, dyslexia, reducing stress and even for helping asthmatics.

Measuring the HRV

a) The method in the time domain– the simplest method, where one heart frequency is given by the time or interval. On the ECG recording we can observe the QRS complex, the so called normal – to normal (NN) pauses (which are the intervals between the adjacent QRS complexes which arise out of sinus nodal depolarizations) or immediate Heart Frequency.

b) The Static Method – due to this simple method we can calculate a series of immediate heart frequencies in a longer time scale (most often for a duration of 24 hours). This method will allow the comparation of HRV during a longer time base (24 hours) a series of immediate heart frequencies or pauses in the cycles.

c) Geometric Methods – this method can be divided into three subgroups 1) The basal measuring of the geometric example (ex. The width of the distribution of the histogram of a

given plane) is changed to the measurement of the HRV, 2) The geometric image is a mathematically defined shape (ex. approximation of the distribution histogram by a triangle or the approximation of a differential histogram by an exponential curve), 3) The Geometric Shape is sorted to several models given to separate categories, which represent several classes of HRV (ex.eliptic, linear and triangular shapes of Lorenzes "plots")

d) The Metoda of frequency domains – from the 60. there are 23 different spectral methods for the analysis of the tachograph. The analysis pf Spectral Density (PSD) which give the basic information, as the strength is distributed as a function of frequency. The methods for the calculation of PSD can be classified as parametric and nonparametric. Both of these give comparable results. The merits of the nonparametric method is 1) simple use of the algorithm (FFT) and 2) high speed of data processing. In the parametric method they are 1) smoother spectral components, 2) easier postprocessing of the spectrum, and 3) accurate outlook at the PSD. The disadvantages of this method is the need to validate the model and it's complexity (the order of the model).

At the current tim the HRV measurements are done with many commonly available portable or static tools, which are in many cases financially acceptable even to individuals.

This study is not very widely known in the Czech Republic, even thought it is no new discovery. In it's final form the use of ECG of the beat frequency and the index of stress in biofeedback should give the operator easily understandable information of his psychic state and help with therapeutic methods for curing various pathological states and diseases.

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ZigBee Sensor Network in Bio-Medical Applications

L. Nestával*, J. Kašpar, R. Fiala**, P. Smrčka**, K. Hána**, J. Brada****

nestavall1@km1.fjfi.cvut.cz

* Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holešovičkách 2, Prague 8, 180 00, Czech Republic
** Joint bimomedical laboratory of CTU and CU, Faculty of Biomedical Engineering, Czech Technical University, Studničkova 7, Prague 2, 120 00, Czech Republic

Our project, with a work title "Advanced PDA", is focused on two basic functions. These are scanning of biological and technical signals and recording and representation of these signals. Example of the scanning signal is ECG or heart-rate.

From the beginning we tried to use wireless technologies for data collection and distribution. Essentially there are different requirements for wireless technology according to the way the data is collected. In the case of collecting data from a single node is required only to establish a wireless link between the node and collecting device (notebook, PDA). For collecting data from a number of devices in limited area (e.g. single building) it seems to be the most appropriate to build network infrastructure or use the network infrastructure which is already installed in the particular location.

We started with widespread technology Bluetooth, which appeared to be suitable as a cable replacement, but nothing more. Its main advantage is the fact, that the Bluetooth interface is implemented in many PDAs and the communication with the sensor node could be established without additional network infrastructure. Even if the Bluetooth technology supports advanced communication models (called piconet and scatternet) the application of this technology in a sensor network of a greater number of nodes appeared to be out of place.

WiFi have been another widespread technology which we have implemented. It provides much greater data throughput (11Mbps vs. 1Mbps in the case of Bluetooth) and expandable networking options, but on the other hand a much more maintenance – we use entirely infrastructure mode, because the ad-hoc mode degrades the main advantages of the WiFi technology - the scalability and the data throughput.

ZigBee is (unlike previously mentioned technologies) a wireless networking standard that is aimed entirely at remote control and sensor applications. It builds on IEEE standard 802.15.4 which defines the physical and MAC layers. The key features of ZigBee include very low power consumption, low data rate (250kbps), self-maintaining mesh networking and operation in license free bands: 2.4GHz and 915/868Mhz.

Even if the ZigBee node devices provide basic sensing possibilities (the wireless interface module is often combined with A/D converters etc.) our implementation uses the ZigBee only as a wireless interface, because the medical applications require more sophisticated preprocessing and therefore processing unit with better performance. The example of such demanding application is ECG scanning and processing. For this application we use our own ECG scanning unit for amplification and adaptation of the raw signal. The preprocessed signal is then sampled and further processed in a Cygnal microcontroller C8051C061. For the sampling of the preprocessed ECG signal are used two 16-bit channels of microcontroller's A/D converter. Sampling rate varies but mostly is used 250 Hz. Other channels of the A/D converter are used for scanning values which does not require high resolution (for example temperature). Because of the low data throughput of ZigBee interface it is not possible to transfer entire ECG sampled signal in real time. Therefore it is further processed in the microcontroller by means of Q-R-S detector programmed into the microcontroller. Then only

resulting R-R intervals are transferred via the ZigBee interface and that distinctively reduce the requirements for the data rate.

ZigBee offers three different network topologies: star, mesh and cluster tree also called hybrid. The network is established by three different types of devices. The most capable is a ”ZigBee coordinator.” It might bridge to other networks, and forms the root of the network tree. It is able to store information about the network. There is exactly one ZigBee coordinator in each network. A ”full function device” can act as an intermediate router, passing data from other devices. A ”reduced function device” is just smart enough to talk to the network; it cannot relay data from other devices. Our application considers two concepts of network topologies. In the first concept the sensor nodes should include the functions of full function device to allow routing in networks of average size. According to the other concept the sensor nodes should be reduced function devices and the routing should be provided by specialized devices which do not include sensor features. In both concepts the ZigBee coordinator features the role of a data collector – the data from particular sensor nodes are transferred via routers to it. The data should be then presented and stored in a “monitoring device” (PDA, PC) which should be connected to the coordinator.

The data in ZigBee network is transferred in packets, which have a maximum size of 128 bytes, allowing a maximum payload of 104 bytes. The device starts transmitting the data in the event of expired timeout or full buffer. In our system the size of the buffer is purposely lowered to the size of a frame generated by the microcontroller, which includes identification of the sensor node and history of last 10 or more R-R intervals. This solution allows the reconstruction of the data in the case that some packets have been lost.

The ZigBee modules are connected with sensor unit by UART interface and the device featuring the function of data collector is connected with the “monitoring device” via RS232 serial interface. Therefore the ZigBee interface seems to be transparent and the communication with the sensor node is done like ordinary serial communication.

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Optical Mapping of Brain Activity

M. Fejtová *, J. Otáhal **, H. Kubová **, R. Konopková **

fejtovam@k333.felk.cvut.cz

*Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Institute of Physiology, The Academy of Sciences of the Czech Republic, Vídeňská 1083, 142 20 Prague 4, Czech Republic

Electrophysiology is more than 200 years old, and in the last half-century electrical recording techniques have advanced to a level where observing the flickering activity of a single ion channel has become a routine, everyday occurrence. When it comes to the central nervous system, however, focal electrical recording leaves us with the proverbial dilemma of seeing the forest or the trees. We must choose between a detailed electrical accounting of the responses of one or at most a few individual elements out of a population of billions or a blurred recording of the average behavior of the system as a whole that ignores the variable response of individual units.

A number of new imaging techniques are available to scientists to visualize the functioning brain directly, revealing unprecedented details. These imaging techniques have provided a new level of understanding of the principles underlying cortical development, organization and function. The first technique is based on intrinsic signals. The second technique is based on voltage-sensitive dyes. Currently, these two optical imaging techniques offer the best spatial and temporal resolution, but also have inherent limitations.

Optical imaging of Intrinsic Signals (OSI) is a neuroimaging modality by which functional cortical activity is mapped by detecting activity-related changes in cortical light reflectance. The purpose of the project is to improve the resolution and accuracy of intraoperative mapping, decrease total time of intraoperative mapping and improve neurological outcomes. As opposed to other methods such as EEG corticography, OIS is non-contact and has better spatial resolution and should be used directly during surgical intervention. OSI invasive technique does not bring any load on patient and OIS implementation does not require significant operating room modification except for mounting the CCD camera onto the operating microscope to scan tissue. It can be used e.g. for description of spreading epileptic foci.

This project is divided into two parts:

- HW solution where the measurement chain will be constructed and SW solution for image processing,
- Pilot study for the system evaluation.

The system VisioBrain is designed as an open modular system, which enables its simple further extension. This system is created in the graphical development environment LabVIEW (developed by National Instruments). The basic block structure comprises of:

- Input module
- Module for acquisition data from appropriate electrodes
- Module for acquisition data from camera
- Data process module
- Storage module
- Module for data analyze
- Module for visualisation of data
- Module for test design

Continued improvement and implementation of this technique promises to shed new right on the functional organization of human cortex.

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Tool For Data Visualization in 3D

L. Nováková, P. Novák

{novakova, novakpe} @labe.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Visualization of the data is an important part of data analysis, because a graph or a picture is easier to analyze/understand for a human than a long list of numbers or strings. Visualization can become an important tool for communication between the data analysis expert on one side and the data domain expert (for example physician). It can help in understanding, preparing or analyzing the considered data.

The described tool has numerous applications, e.g. for visualization of

- the general time series data (or data where one variable can be consider as a reference similar to time for the other attributes),
- various 3D medical signals (spatial EEG, spatial ECG etc.),
- tracks of movements in medical domain (limbs or eyes) or in marketing domain,
- data from Matrix Transducer for Pressure Distribution Measurement (plantograph) [4],
- operator states (stress, blood pressure etc).

Types of data visualization

Input data can be displayed using several 3D projections or graphs. The basic graph type is classic 3D graph, information about each data point is enhanced so that additional information about further attributes can be depicted e.g. as a diameter of the corresponding sphere or its colour, moreover each graph points can be represented as a polygon. In this case additional attributes are mapped to the edges of this polygon. Size of the edges and intensity of colour of these edges correspond to actual value of attributes. This approach makes it possible to view this graph as multidimensional one [2].

This visualization tool makes it possible to depict time sequence of the considered pictures - this is useful to visualize e.g. series of isosurface graph (spatial EEG, plantograph).

User is provided by an option to transform and rotate whole graphical scene to see created graph from different directions to analyse input data easily.

Module Structure of the Tool

Entire tool is divided into several internal modules, namely input module, data storage module, control module, 3D projection module, math module and output module. Other modules can be added if necessary.

In the current version, the input module supports universal XML file format, this module is also ready to accept real time input using for example (D)COM interface. The input module transforms input data into the data storage module using an internal format, which is optimised for data visualization (painting). The data from the storage module are depicted on the screen using the 3D projection module. Using the control module, number of parameters of the 3D projection can be modified by the user, e.g. colour, profile, used multi-line, and thus visualize multidimensional data in 3D. The module supports various 3D views (translation, rotation and zoom of the graph). Moreover, there are provided some advanced features, e.g. animation of the graph, combination of pictures with the time series in the same graph.

The library of the math module makes it possible to calculate number of derived attributes using the data in the storage data module and use them in further 3D projections. This library supports e.g. calculation of basic values from statistics (mean, standard deviation, minimum,

maximum) as well as of some physical/geometric notions (e.g. centre of gravity). Even here, the user can easy add new formulas if necessary.
The current version of the tool offers two output possibilities: the first option creates the graph in the form of a static picture(s) while the second option provides an animation sequence of the graph in the standard video format. User can complement output video by other pictures or short video sequences as requested for presentation of his/her results.

Input format of data
Input format of this tool is designed in the universal XML format and it is divided into three main parts. The first part is environment setting, where the user can set the initial configuration of the attribute mapping on the graph, initial setting of the graph view etc. This part is not obligatory and the default setting is available. Using the second part the input attribute format is described, namely its name, its type (e.g. scalar, point2D, point3D, vector, matrix), numeric type (e.g. integer, long, float, double), used units (e.g. kg, m, ms) and specification of the source of data (it can be internal or the name of the external file). Internal data (if used) create the last part of input file – they consist of pairs providing name and value.

Implementation
The tool is implemented in the Microsoft .NET Framework (www.microsoft.com/net) programming environment enhanced by graphic libraries Tao Framework (mono-project.com/Tao). The graphics is programmed by the commands of OpenGL (www.opengl.org, www.nehe.org). The tool has been tested on Microsoft Windows XP Professional SP2, but it can run on all operating systems supporting the MS.NET Framework.

Future work
As the first next step real time input interface will be implemented to give possibility to visualize true real time data. (D)COM (Distributed Component Object Model) is the best candidate for this purpose. Moreover, to ensure the database connectivity seems to be one of the first steps towards this goal. Math module will be extended to contain more useful formulas. Extensive work is planned in the 3D visualization module to implement further types of the graphs to support visualization of special multidimensional data. It is envisaged that advantages of the tool will be tested not only in the medical domain, but also in the different application contexts for example data mining for data understanding and preparation.

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Measurimg and Processing of Thermobronchoscopy Signals

J. Žáček , R. Fiala, T. Funda, K. Hána, J. Kašpar, J. Kukla, A. Mach, J. Miškovský, M. Mráz, L. Nešvera, P. Pršanec, P. Smrčka, K. Vospálková

jaroslav.zacek@fbmi.cvut.cz

Joint Department of Biomedical Engineering of Czech Technical University and Charles University in Prague, Faculty of Biomedical Engineering, CTU in Prague, Studnickova 7, 12000 Prague 2 - Albertov, Czech Republic

In 2003 MUDr. Votruba from the hospital Na Homolce asked us if it had been possible to cooperate on development of a new method in screening of lungs cancer, which he and Ing. Bruha verified the pilot experiment [1].

The aim of this cooperation is the development of the method and experimental technical resources for material easy uninvasive diagnostic of endobronchially growing lungs carcinoma. A method which is able to catch a lung cancer in a very beginning stage. (The chance for patient to survive is relatively high). The principle of the method is a clinically verified fact that the tumor tissue is comparing with the healthy one warmer. A part of the solution will be detailed elaboration of the method of differentiation of tumour and normal tissue thanks to measurement of temperature changes in the breathing ways and following automatic process and evaluation of the data collection. Than, the suggestion and construction of the needed technical equipment and realization of the verifying experiments. The method will be a lot cheaper than the present ways (autofluorescence and fluorescence bronchoscopy and endobronchial ultrasonograph) with keeping of high sensitiveness.

Nowadays the screening of the lung cancer is also a much discussed process. Its getting perfect will play together with a better primary prevention (antismoking methods) the main role in decreasing of mortality and morbidity of BCA. It would be good to have an examination method which is cheap and also comparable with autofluorescence or fluorescence bronchoscopy [4]. It is practically sure that the tumor tissue is warmer than the healthy one. The term vision examination is successfully used in mammology and dermatology [2,3].

So far the temperature differences have not been diagnostically used either in our country or abroad.

The temperature difference between a bronchial tissue inflicted with the tumour and a normal tissue was watched by a study which was published in Journal of bronchology in 2005 [1]. The results of this study show that the temperature of the tumour tissue is much higher than the temperature of a normal tissue. It has not been said for sure what is the gradient of the temperature descent in the field of pathology, how important is the role of the higher temperature in the normal healthy tissue, how importantly is the temperature up above over the lymphatic ganglion affected with the tumor and finally how far is the distribution of temperature depended on size, placement and other parameters of the cancer process.

Nowadays the measurements are being done by a module made by ourselves - Advanced PDA “Breath 1.0” with internal Bluetooth interface for transfer of data into Pocket PC – PDA. The temperature of tissue in lungs is measured by a special thermistor made by Irish company Betatherm, it is designed for medicine application. The thermistor is pushed in the work channel of fiberscope, which further contains a micro camera. This camera is able to give a visual information from the examined locality in the real time.

The first step is to switch on each component of the device and connect it with DPA with help of wireless interface Bluetooth. Than the program "CEbreath2" switches on. Before the record starts the information about patient are filled into the memory. The thermoscope tube is lead into fiberscope and it is brought into the saving visual data mode in PDA. The doctor moves by the fiberscope along the set 17 key points of bronchial tree in the lungs. The measured point is given into PDA and at the time when the tube presses on the bronchi mucous membrane the screening begins for a specific time. Progressively all points are measured and the data are saved. The PDA immediately shows the results of measurements like the bronchial tree, where each point is assigned an appropriate temperature. We may choose from three options (the maximum – the most objective describes the moment when the patient exhaled, the minimum, the average).

The measurement is taken during standard bronchscopy examination in holonarcosis or local anaesthesia which is practiced by MUDr. Votruba in surgeries of the hospital Na Homolce and the Teaching Hospital Bulovka . There are just about 60 patients examined by this method on the present. Examinate patients consist of healthy persons to get reference values, patients with inflammation and finally patients with lung carcinoma.

Nowadays, on the basis of obtained experience, they work at the new generation of measuring device with all data display and the possibility of control on standard touch screen authorised for medical use to make simple ergonomic operating just by an examining doctor possible. Further information is connected with this problem such as the simplification of data interpretation and processing of integration of interactive lung map into the programme "CEbreath". Interactive temperature lung map has already had its first, so far working, version in which all carried measuring are processed. The map has been created in universal environment MatLab for farther research needs. Determination of temperature drop in lung of healthy man is our preferred target now. The results will be implemented to the temperature map and subsequently to the firmware of measuring device and to the software of processing and visioning screen.

Thermobronchoscopy in its final form should be able to diagnose "hot", thus metabolically active node with the aid of simple contact determination of temperature difference. Complex of this information could consequently supply output similar to E.G. PET/CT but in conditions of "real time" and with possibility of targeted biopsy. In future it is supposed to apply it to screening of lung cancer in practice. Special thank is due to Prof. Jiří Holčík who participates in the research of algorithms associated with change of temperature drop in lung tissue that would make possible to estimate volume and localization of lung carcinoma.

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Real-time EEG Map Visualization

J. Mužík*, K. Hána**

muzikj@fel.cvut.cz

*Department of Radioelectronics, Faculty of Eletrical Engineering, Czech Technical University in Prague, Technicka 2, Prague 6, 166 27, Czech Republic

**Faculty of Biomedical Engineering, Czech Technical University in Prague, Náměstí Sítná 3105, 272 01 Kladno, Czech Republic

This paper discuses several aspects of development of a fully modular system for real-time biological signal visualization, using two-dimensional maps. Although real-time biomedical signal processing is already a part of common clinical diagnostics, and multi-channel data mapping is also ordinarily used, current systems do not use both principles simultaneously yet. But computing power of present personal computers allows simultaneous usage of both the techniques.

The system described should allow a physician instantly observe consequences of specific impacts affecting human body. Conventional methods are usually focused on parallel recording of stimulus and subsequent reactions of organism and later offline reviewing and processing. However, this system can help physician reveal effect of causes which one would not otherwise noticed. The system was developed primarily in order to visualize multi-channel EEG, but modules for 64 channels ECG processing are currently also developed. Modularity here stands for an easy software blocks interchange.

Main application framework is the base block which connects individual modules and serves as a basic graphical interface. VectorBroker modules are used for data acquiring from external devices. Acquired vectors are then passed to main framework which passes them to preprocessing modules. After preprocessing, data vectors are passed to chain of DSP modules. DSM modules are independent components performing own signal transformations. DSP modules also have access to montage configuration, because knowledge of signal source position is for example necessary for calculation of coherence maps. Every DSP module can implement own graphical interface and thus can be independently controlled. Other important block is Visualizer, which is responsible for DSP output signal interpretation into signal maps. In this point, speed of transformation is the main feature, because a man requires at least 20 frames per second for a perception of smooth displaying. This module uses special method, which takes advantage of current graphic card acceleration for map interpolation a drawing.

Current EEG imaging systems usually uses fitting nonuniformely scattered electrodes into orthogonal mesh and subsequent interpolation, linear or using for example splines. Afterwards value of every pixel in the map is calculated from the interpolation function. This method however can not be used for drawing of the maps in real-time and almost full-screen, because number of pixel and thus also the number of interpolations, reaches 1 million.

Instead of this standard approach a new method was proposed. This method takes advantage of the fact, that almost all current computers includes graphics adapter which accelerate rendering of triangles. Modern dense-array EEG recording systems make use of 129 electrodes, with 128 amplifier channels recording 128 voltages relative to a single

common reference electrode. Electrodes are scattered nonuniformely on a head's surface and sometimes it is necessary to know exact position of each electrode related to underlying anatomical brain structures, so the position of electrodes should not be moved to fit orthogonal grid. Anatomical structure is usually taken from tomographic examinations like MRI

The first step of the algorithm is scattered electrode mesh decomposition into triangle mesh using Delaunay triangulation. Delaunay triangulation defines for a set P of points in the plane the triangulation DT(P) of P such that no point in P is inside the circumcircle of any triangle in DT(P). Delaunay triangulations maximize the minimum angle of all the angles of the triangles in the triangulation. There are number of methods how to implement Delaunay triangulation. For a small number of electrodes (10-20 system has n=19 active electrodes) it is possible to check all combinations of 3 electrodes and test if their circumcircle does not have any other electrode inside. For a larger number of electrodes, it is necessary to use some more efficient method, for example Guibas-Stolfi algorithm which has only O(n.log n) complexity.

The next step is to refine the mesh to be smooth for displaying. This is done by recurrent dividing each triangle into four smaller. Triangles could be also divided into other number of smaller, but simplest is to divide each edge in its half and then construct triangles from old vertexes and these new vertexes in halves of the edges. During this process a tree structure of triangles is being built, as for the later interpolation it is necessary to know the parent triangles for all smaller triangles.

The resulting mesh of triangles with known hierarchy is now ready for signal interpolation. The simplest method is linear interpolation, when the value at each vertex is defined as the mean value of both parent vertexes. This method however results in an angular image, with noticeable edges between electrodes, due to only C0 continuity. Much better results are achieved by using Bezier triangles. It is possible to imagine signal value at each vertex as z-coordinate in 3D space. Than we can use some approaches used in computer graphics. As the neighboring triangles are known, we can easily determinate normal vectors at each vertex and subsequently calculate control points to construct Bezier triangles.

Communication between all blocks is build upon Component Object Model (COM). This provides a facility to implement modules in different programming languages, as long as language supports COM. This is especially suitable for input modules because different hardware manufactures provides description of communication interfaces in different languages. It also opens the door to integration of MatLab-generated modules into system, since recent MatLab compilers support COM.

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Therapy of Paresis n. Abducens by Means of Biological Feedback

M. Fejtová *, R. Černý **

fejtovam@k333.felk.cvut.cz

*Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Department of Neurology, 2nd Faculty of Medicine, Charles University in Prague, Ovocný trh 5, 116 36 Prague 1, Czech Republic

We present a system now being developed in our laboratory for treatment of nystagmus and strabismus by biofeedback. Biofeedback was used in many systems for therapy of disorders of binocular vision, vergence and accommodation, strabismus and congenital nystagmus. Many methods for delivering feedback information about eye position were used in the past. These included electromyography of frontal muscles, auditory feedback, afterimage with flash light and eye position recording by electronystagmography or infrared photonystagmography.

Most system deployed were of experimental nature and hardly useable in routine practice. With advent of new technology of video-oculography, we present a first prototype of an easy to use system for extraocular muscles biofeedback therapy. Training of the extra-ocular muscles motility with high-gain sensory feedback has the aim of accelerated reeducation of normal horizontal and vertical eye movements in paretic strabismus and in suppression of unwanted movements in patients with nystagmus.

The feedback information employed is twice: visual with fixation target and actual gaze position simultaneously displayed on screen and auditory: tone high pitched, when difference between actual gaze position and target increases.

Team from Gerstner laboratory, Czech Technical University, developed the eye movements recording system I4Control®. The sensor input of the I4Control® system is ensured by a tiny camera, which is fastened to the head of the user using a spectacle frame. This ensures that the same type of image is obtained independently of the movements of the user (user's head does not have to be fixed). The main parameters for the choice of the camera have been its price and size. It was verified during the preliminary experiments that a simple black&white PAL camera with a CCD sensor (discrimination 208 x 156 points) fully meets our requirements.

The second part of the I4Control® system includes the control module which processes the PAL signal from the camera. Here, the PAL signal is digitalized, the pupil is detected (using classic filtering), and its position is calculated and expressed in the appropriate coordinate system. The output of the control module provides information about the requested modification of a cursor position, namely the difference [Δx, Δy]. This value is transmitted using standard USB interface into a PC.

At the beginning, the system I4Control® has to be correctly calibrated for a specific user. The user is asked to fix his/her gaze on the centre of the screen to specify the stable position - it is set and recorded by pressing the red switch of the control module. The system does not transfer a position of the computer cursor directly on the spot, which is being

observed by the user. It just ensures that the cursor flows in the same direction as eyes of the user with respect to a stable position set during the calibration phase. This means that the actual eye position does not effect the cursor position directly, but it changes the direction of cursor movement (in the same way as a joystick). The system evaluates the present position of the user's eye, compares it to the stable position and consequently makes the choice of corresponding actions. It works in an incremental mode: as long as an eye is out of the stable position the system keeps sending signals instructing the cursor to move on in the corresponding direction (given by the actual position of an eye in the coordinate system of the camera), this is stopped once an eye is back in the stable position.

The system is designed as a standalone device connected to the PC using standard communication interface (USB). Principles of device functioning and results from first phase of clinical study will be presented.

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Innovation of Bionics Subject

M. Fejtová, V. Fabián

fejtovam@k333.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

People do not copy just the randomness from the nature. It is the research area of the scientific field called Bionics. It aims to find solutions of the most variable problems in the nature, it observes living creatures/organisms and mimics their behaviour. Why it is the Mother Nature that improves its „developments" during thousands of years. Bionics is young and progressive science field that allows us to construct devices to support weakened organs supports or to build artificial organs. Since bionics is fast developing field it is important to choose the right tool for student education – e-learning. The aim of our work is to create the hypertextbook with the multimedia components that clearly explain some topics from bionics. The information about a several courses is stored in an XML format which allows full availability of all informations from course.

Bionics is relatively young science of constructing artificial systems that have some of the characteristics of living systems. Bionics is not a specialized science but an interscience discipline; it may be compared with cybernetics. Bionicists are convinced of the performance of nature's way of optimization. This sophisticated method is running already 3 billion years, in the biggest laboratory we can imagine: The surface of the earth. Now, the laboratory is large enough and the time is long enough to find good solutions (perhaps optimal solutions) under the biological constraints.

Million years ago nature has invented the technique to fly. Engineers of the last centuries thought that the bird feather includes the mystery of flight. It is difficult to mimic the feather. It is difficult to mimic the feather. The bat could be imitated more simply. Therefore Leonardo da Vinci designed his flight machine like a bat.

The course of bionics is offered to students in full-time form of Master study. It belongs to the category of obligatory courses having three hours of lectures and two hours of seminars or laboratory work per week. Each year it is attended by approximately 50 students. The aim of the course is to introduce to students following topics:

- analogy among nature and technique
- informative bionics
- biosensor and nanotechnology
- machine realisation of man's sense
- artificial heart, aorta valve replacement and pacemakers
- artificial kidney
- artificial lung ventilation
- neoarthrosis and bioelectric prosthesis

- man-machine systems
- virtual reality in medicine
- biotechnology

All these topics are scheduled to 14 lectures and 14 connected seminars/labs, where students have the possibility to train practically on examples the presented topics. The aim of our work is created a hypertext book of bionics. Hypertext lecture notes represent fundamental of each our e-learning course and enable students effective access to each information saved in text. It is simple, comprehensive and suitably structured text that provides students with several advantages in comparison with study of classical books or lecture notes. For example, student need not turn over the leaves of a book and search for related topics, connected links or explanation of a certain term. In hypertext lecture notes, it is „just enough" to click on a hypertext link and the system searches all in place of a student. For example, if student does not understand a certain term that is explained in other part of the lecture notes he/she clicks on unknown expression and the system finds corresponding explanation. Information in lecture notes are didactically ordered and use suitably accompanying multimedia elements of presentation (image and sound animations) and continuously verify correct understanding of content in all relations and in certain system that is hierarchically ordered according to importance and difficulty. Texts constructed in this way represent undoubtedly significant progress from the point of didactic processing and each student goes through the whole text not only with his/her own speed but also this text respects input knowledge, skills and experience of the student that in certain parts need not go through known information and possibly solve tasks that are redundant from the point of view of knowledge. Hypertext lecture notes are available to students in the format suitable for printing or in standard e-Book format.

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Technical Support for Optimisation of Artificial Lung Ventilation

K. Roubík, M. Rožánek

roubik@fbmi.cvut.cz

Faculty of Biomedical Engineering, Czech Technical University in Prague
nám. Sítná 3105, 272 01 Kladno, Czech Republic

The principal changes of the approach to artificial lung ventilation can be demonstrated on a novel ventilatory technique called high-frequency ventilation. High-frequency ventilation (HFV) can be characterized by its ventilatory rate. Ventilatory frequency during HFV is about 100 times higher than the physiological breathing frequency. The ventilatory frequency can be as high as 30 mechanically generated breaths per a single second (i.e. 30 Hz) during HFV, whereas the frequency of physiological breathing is only 20 breath cycles per minute (i.e. 0.3 Hz). The increase in frequency allows a significant minimization of tidal volumes and pressure amplitudes in the airways and in the lungs that makes HFV protective to the patient. A very significant reduction in the mortality rate of patients suffering from acute respiratory failure can be assured by the application of this method, nevertheless, there is still a large number of cases when HFV fails or when it is even much worse than conventional ventilation. This is because HFV is not a physiological case of ventilation; as a consequence, the high ventilatory frequency and a very high gas velocity in the airways in comparison with conventional ventilation, and ways of gas mixing, gas transport and gas exchange in the respiratory system, all work on very different principles than those acting during conventional ventilation. All the physiological regulative mechanisms acting during conventional mechanical ventilation are not applicable during HFV. Therefore, any HFV ventilator should be accompanied with a sophisticated control system conducting the real-time evaluation of the patient's effort, pressure conditions in the airways, software simulations of the alveolar conditions inside the lungs and real-time modifications of the ventilatory parameters reflecting the monitored and evaluated values.

Tracheal gas insufflation represents an adjunct ventilatory technique that can be combined with any ventilatory regimen. Its functioning consists in elimination of the anatomical dead space of the patient's airways by a special catheter with a continuous gas flow introduced into the close vicinity of the carina.

Considerable interest is focused on the area of ventilator weaning. The physicians are interested in finding any measurable parameters or score with a possibility to predict the efficiency of the ventilator outcome. Different parameters were observed by Martinez et al. [1]. Minute ventilation was measured and analysed in three time points. Baseline value was measured during 24 h before spontaneous breathing trial (SBT). The other value was measured immediately after SBT and finally the value of recovery (return to the baseline value) was measured. It is shown that measuring of minute ventilation could be a useful adjunct in the decision about extubating a patient or not.

Also non-standard methods are used in order to predict sufficiency of weaning. For example, ECG is measured and recorded in [2]. The ECG is analysed using an ECG holter. QRS complexes are automatically detected and R-R intervals are studied. The power densities are calculated from the signal and processed in a computer. The results show that spectral

components (low/high frequency and total power) of heart rate variability are considerably decreased in a group of patients that failed to wean from the mechanical ventilation.

The other way how to improve the patient's benefits while undergoing mechanical ventilation (MV) is to describe protocols, which will be used to provide the mechanical ventilation with a minimum risk of barotraumas, volumotraumas, etc. Single ventilator management protocol (VMP) used during MV decreases duration of MV. It suggests that MV is gentler if it is driven in consistence with VMP. Two groups of patients were studied. The results of the study show that the duration of MV was significantly shortened in the group of patients where the VMP was used [3, 4].

Slight modifications of the current ventilatory techniques can be efficient in reducing stress caused by artificial ventilator. One example is intelligent elimination of the endotracheal tube nonlinearity. Aim of the elimination of the airflow resistance nonlinearity of the endotracheal tube is to help patient make his or her spontaneous breathing easier, even though he or she is intubated. Continuous distension pressure is maintained in the lungs and oscillations of a ventilator are added to this pressure. A patient can breath spontaneously. The problem is that resistance of the endotracheal tube is not constant but it depends strongly upon airflow velocity. The resistance causes a pressure difference between both ends of the endotracheal tube. As a result, a patient has to exhibit a big effort to overcome this pressure difference and consequently it represents an increased work of breathing. The team of Fabry [5] documented efficiency of the automatic resistance compensation both on a physical model and on a group of patients.

To allow the patient spontaneous breathing while he or she is continuously connected to the artificial ventilator of any king is the aim of the demand-flow system that exactly compensates effects of the patient's spontaneous breathing activity in order to protect the standard ventilators from affecting their control system by additional gas flow generated by the patient.

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Modelling of the Inhomogeneous Changes in the Lung Mechanics Using an Electro-acoustic Model of the Respiratory System

M. Rozanek, K. Roubik

rozanek@fbmi.cvut.cz

Faculty of Biomedical Engineering, Czech Technical University,
Sitna 3105, 272 01 Kladno, Czech Republic

In spite of great research that is focused on artificial lung ventilation there still remains high mortality in the patients that are supported by the ventilatory technique. Therefore, new methods of artificial lung ventilation are introduced to improve the patients care and increase the patients benefit. High frequency ventilation is one of the new methods that is used in the clinical practice while treating acute respiratory distress syndrome. This type of artificial lung ventilation, which uses small tidal volumes and relatively high frequencies (5-20 Hz) is routinely used in neonates. It has been demonstrated in numerous multiclinical studies that the benefit of high frequency ventilation remains unclear, when it is used in adults. Adult respiratory distress syndrome can be caused by two different ways. A direct insult on a lung cells induces primary (pulmonary) acute respiratory distress syndrome. Secondary (extrapulmonary) form of acute respiratory distress syndrome is caused indirectly. Some studies show [1] that the respiratory mechanics, histology, morphological aspects and response to ventilatory strategies are different.

Our group developed and designed the model of the respiratory system according to the anatomy that can be used for both ventilatory techniques: conventional ventilation (classic method) and high frequency ventilation. The respiratory system is considered as an acoustic system in this approach. Weibel introduced a morphometry model of the lungs, where the geometrical dimensions of the airways and the volume of alveolar space in each generation are published [2, 3]. Electro-acoustic analogy [4] is method that allows describing acoustic systems by the mean of electric laws. Electric elements, which were computed from the geometrical dimensions of the airways, create electric circuit, which represents the model of the respiratory system. The complete electric model of the respiratory system has a similar structure as the respiratory system and therefore it is possible to set the elementary electric elements that correspond to the elementary airways. The model is divided into the halves and each part is computed independently. It results in a possibility to model the inhomogeneous changes in the lung mechanics and to observe an effect of these changes upon the suitability of different ventilatory techniques.

The results of the simulations that were conducted on the model show that mechanical properties of the respiratory tissue have significant effect upon total lung impedance. It is evident that higher pressure should be used to maintain the similar airflow, when the total lung impedance is increased. The total lung impedance is increased in the range of the frequencies that are used for conventional ventilation when the alveolar compliance is reduced. Total lung impedance is not significantly changed considering frequencies that correspond to the usage of HFV. These results show that the efficiency of the each technique of artificial lung ventilation depends on the mechanical properties of the respiratory system.

The simulations that were conducted on the presented model suggest why high frequency ventilation has controversial effect when used during acute respiratory syndrome in adults in multiclinical large studies. These studies include patients with acute respiratory distress syndrome regardless its origin. It means that patients with substantially different mechanical properties of the respiratory system are included in one group – patients affected by acute respiratory distress syndrome. It was shown using described model that mechanical properties have considerable effect upon the suitability and efficiency of artificial lung ventilation strategy.

It seems to be necessary to divide the patients into the groups regarding the properties of theirs respiratory system and provide a ventilatory strategy that will correspond with it and that will give the maximum benefit to the patient.

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Algorithms for Detection of Technical Artifact in Biological Signal Measured in High Noise Environment

J. Kašpar, K. Hána, P. Smrčka, J. Brada, L. Vojtíšek, L. Nestaval, R. Fiala

kaspar@fbmi.cvut.cz

Faculty of BioMedical Engineering, Czech Technical University, Studničkova 7,
120 00 Prague 2, Czech Republic

Monitoring of various biological signals on the patient is essential for prompt diagnosis determination in the modern medical care. Such a biosignal acquisition is very sensible process and many artifacts during long-term or one-shot monitoring may occur. Since in some cases it is not a real and dangerous problem that could be easily ignored, in many occurrences it is an essential task to obtain artifact-free signal.

The objective of this contribution is to briefly describe usual technical artifacts in the biosignal acquisition and summarize the algorithms for detection and filtering of such a kind of artifacts. Above all, we will deal with artifacts and algorithms for detection in the high noise environment.

For purposes of this contribution, by the high noise environment we mean an environment where strong static and variable electromagnetic fields are present. Usage of electromagnetic fields is fundamental in many modern diagnostics and therapeutic methods and can not be avoided. We can specify e.g. acquisition of an ECG signal in MRI scanner or more complicated question, an EEG signal acquisition during fMRI scan.

Development and construction of such device for ECG and EEG acquisition adapted for an operation in the high noise environment is planned in Institute for Biomedical Engineering at Czech Technical University in Prague.

Electrical potentials of the heart or the brain on the body surface are very weak, typically in range of mV or μV. Electronical device and its amplifying system with analog-to-digital converter (ADC) constructed for acquisition of these signals must be adequate then. This amplifying power brings us problems with signal quality and disruptive potential acquisition, so called artifact. There are two sources of artifacts: technical and biological. Factor influencing the signal quality and generating the artefact of interference from power line 50 Hz is high skin resistance under the electrode or bad grounding of the device or patient. Another interference occurs while using poor quality electrodes - noise from electrode impedance. Poor acquisition device architecture could bring amplifier noise, quantisation noise, saturation effects in amplifier or ADC, recording artifacts from electrode movement or artifacts due to other electrical activity, previously mentioned static and variable electromagnetic fields.

During device construction, it is necessary to implement algorithms for analog signal processing before the signal is digitalized. We use special analog signal processing methods and filtering. Whenever it is a special kind of filtering, in principle it has a common usage. Selective band-pass filter has a huge slope amplitude characteristic, that's why it sharply defines frequency band. By this means we can reach well defined frequency segmentation of the signal and to suppress parasitic and ghost pulses. Signal registration and evaluation is processed separately for various frequency bands and allows us to subtract useful information from the signal. Integrator is the filter for suppressing separate component proportionally to its frequency. Output of this filter is integral part of input voltage. Quadrate filter is nonlinear

filter. Output signal is proportional to square of the input voltage, alias immediate power. Next filtering allows us to compute average performance in selected time interval. Long-term monitoring techniques use this method for monitoring global parameters of the measured object.

Further and advanced algorithms for signal processing are implemented after the signal is digitalized. Following domains are typically studied: time domain while treating one-dimensional signals, spatial domain while treating multidimensional signals, frequency domain, autocorrelation domain, and wavelet domains. Domain is usually selected by trying different possibilities or by making an educated guess. Raw data from the measuring device are time or spatial domain. Discrete Fourier transform gives us frequency domain information. Autocorrelation is defined as the cross correlation of the signal with itself over varying intervals of time or space.

Special acquisition and recording software including many filters needs to be applied. Beside the hardware acquisition unit, this software is being developed in our institute. The median filter is normally used to reduce the noise in time domain. The median filter considers each sample in the signal and looks at its nearby samples to decide whether it is or it is not representative of its neighborhood. High frequency noise needs to be filtered usually by any kind of the low pass filter.

High noise environment produces artifact not to be easily removed generally. Fortunately during the MRI scan, which is in our sight of interest, we can use precisely defined pulse sequence; variable magnetic field is well described. This allows us to set-up the adaptive filtration of signals very effectively and eliminates thus this influence. Adaptive state model and Kalman's and Wieners filtration is typically used in the time domain.

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Concept of NMR Compatible Devices for Sensing Biological Signals

L.Vojtíšek, J. Kašpar, K. Hána, P. Smrčka, J. Brada

vojtisek@fbmi.cvut.cz

*Joint Biomedical Laboratories of CTU and UC
Faculty of Biomedical Engineering, Czech Technical University,
Studničkova 7, 120 00 Prague 2, Czech Republic
**Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University,
V Holešovičkách 2, Prague 8, 180 00, Czech Republic

The device SISCO 85 for nuclear magnetic resonance tomography is one of the most important instruments used in our Joint Biomedical Laboratories of CTU and UC. The device is engaged with most of projects solved by Albertov MRI team. Size of measure chamber, level of magnetic field and last but not least open system of control unit designates potentialities of suitable research aplications. MRI is used with much for verifications of course of treatments on small mammals like rats or rabbits. Second strong potentialities we can see in development of new biomedial technologies usable in NMR instruments. Of course there is uselessly developing of finished instruments.

Our ideas were also consulted with physicians and there were selected the useful possible ways of our next work. The first of ideas arose out of the needfulness of the control of patient's health conditions during the MR imaging. That is also supported by wishes of completment of functional tomography. In the second section of our ideas goes together requests on comfort the animals and also for staff service during the imaging of the small mammals. Devices, we want to prepare for the next testing and research by doctors could be NMR compatible ECG, EEG, thermometer or pulse oximeter, tonometer, manometer, easy and cheap anesthesia aparatus applying a suitable liquid and gas narcotica for small mammals, and complemental ventilation of the lungs – also for small animals.

Each mentioned devices are quite simple and daily used. But still not in such hard conditions like in NMR instrument. Problems are brought by extremly strong magnetic filed (2T), high electromagnetic field on μm lengths moreover we have to have a care about influence of the new device to the quality of NMR signal, and artifacts in MR Image.

Exactly selection of materials which can be used inside of cryomagnet is very problematic. For right function of MRI tomographs is necessary to observe the rules. There is refused to put any magnetic and feromagnetic materials into the cryomagnet. Their presents inside it, makes changes in the measuring magnetic field, rising magnetic inhomogenity and makes artifacts in images. Second problem with it is that if you put the magnetic or ferromagnetic object to the cavity of cryomagnet, you probably newer put it out. Also there are problems with most of metallic materials, especially materials with higher specific magnetic conductivity. Material also causes deformation of magnetic field and with all implications at the quality of image.

During the pulse sequence is used the relatively high power radiofrequency waves. Make a shielding against the RF disturbance isn't so difficult, even if effective signal is quite small. The question is how to make the shield NMR compatible. We see that if we use

conductive gel or special solid material instead of regular metal, and also when we put it as far as possible from the middle of cryomagnet (measuring place), is it possible to compensate the differences in inhomogenity by regular shimming.

More problems we still see in Foucault currents, which inducting in measured object. Defects caused by eddy currents are quite high and there is, in practice, impossible to clean of the useful signal by added hardware. We found the way how to get some useful information from damaged signal used special additional software with the special algorithms.

To construct shield against to so strong magnetic field is almost impossible too. Construction of device worked in strong magnetic field is possible by using nonmagnetic materials, and special electronic materials and parts. Second condition we have to realize is keep all absolutely without movements. Every movement causes induction of relatively high current in every conductive part.

To avoid problems with movements and also with shielding a lineout against the parasitic RF signal we can with success use the optics. We made first measuring with opto-electrical converter. Our converter works on wave length 850nm with duplex multi-mode optical line 50/125.

Still we made some experiments with more simple devices used in NMR, we tested functionality and we looked for artifacts. Next step we want to do is to modify our ECG device for using on rats. Than we are going to get some more data, and try onto use of prepared algorithms.

Also it is hard worked on the developing anesthesia apparatus for rats. (It is necessary to keep it under anesthesia during MRI experiment. We still used subcutan anesthetics but there is quite unsuitable even for us, even for the animals.

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Real-time Method for Segmentation of the Seismocardiographic Signal

P. Smrčka, K. Hána, J. Kašpar, J.Brada, L. Vojtíšek, R.Fiala, Z. Trefný

smrcka@fbmi.cvut.cz

Faculty of Biomedical Engineering, Czech Technical University, Technická 2,
166 27 Prague 6, Czech Republic

The QSCG device detects cardiac vibrations as they affect the entire body; the measuring sensors (solid-state accelerometers) are usually placed in the plate of the chair – additional instruments applied on the proband's body are not required. The results of the QSCG analysis are usable in various clinical fields, see [2], [3]. The first and most important step in the process of detection of significant characteristics of measured QSCG curves is to detect pseudo-periods in the signal regardless of the initial pseudo-period position. Other characteristics can be acquired by a relatively simple process over the appointed pseudo-period. This contribution deals with the preprocessing and automatic computer-based detection of beat pseudo-periods in middle-time QSCG records. Two independent approaches have been used to appoint the pseudo-periods – the first method is more precise and is intended for off-line QSCG analysis, the second method is easy, robust and is appropriate for real-time QSCG processing, see [1]. Quantitative seismocardiography probably offers a more complex view of both inotropic and chronotropic heart function. It will be suitable for: examining operators exposed to stress; for assessing the effect of work, fatigue, mental stress; for monitoring persons as part of disease prevention; for determining a person's ability to carry out their duties both on the ground and in the air.

For the development and evaluation of the proposed methods, we used 46 digital records of the QSCG, each 5 min length. The probands were placed in the sitting position and during the monitoring only very light physical activity (such as PC keyboard typing) was allowed. The experimental data were acquired using a solid state accelerometer built into the chair plate. The actual sampling frequency was 500Hz, and the resolution of the A/D converter was 16 bits. While the off-line method A is more sophisticated, method B is relatively simple and was developed for the detection of QSCG pseudo-periods in real time.

The first method (A) is based on detection of significant swings. The signal is passed from left to right and the lengths of monotonic rises of the signal are computed. In this way we obtain plenty of lengths. We proceed from the fact that the largest monotonic rises signal just the most important swings within the pseudo-periods and thus can be used to delimitate them. The significant lengths should thus correspond to important and visually recognizable swings of the signal in each pseudo-period. There is the question of how to appoint the threshold over which the lengths should correspond to the pseudo-period swing. We proceed from the assumption that the pseudo-periods should have approximately a similar length (due to the sophisticated transformation described above). Therefore, we move the threshold from the minimum to maximum value of the monotonic rises and measure the deviation of the pseudo-period lengths normalized by their mean. For some thresholds there should be minimal deviation and therefore the corresponding time point should limit the pseudo-periods.

The second method (B) is derived from a well-known and robust algorithm for QRS complex detection in traditional electrocardiograms (ECG), originally developed by Hamilton

et al. The algorithm is based on the first derivative of the input signal and many thresholds and parameters are automatically adapted to individual changes in the input signal using sophisticated empirical rules. The results (position of the dominant – so-called R - wave) are obtained with some detection delay (above 200 ms). For our purposes it is important that the initial values of many parameters are adjustable and by modification of these values the original method was slightly adapted to QSCG's different curve morphology. Namely the following parameters were changed: (1) length of the first derivative from the original 10 ms to 80 ms, (2) length of the high-pass pre-filter from 125 ms to 350 ms, (3) length of moving window integration from 80 ms to 200 ms. Optimal values were selected experimentally in order to achieve the best detection results. The function of the whole algorithm is as follows: output of the traditional ECG QRS detector gives the rough position of the systolic complex inside the QSCG - candidate X. Then the specific morphology of the QSCG curve is utilized to backward search the position of the J-wave – we expect the first big negative peak in MTI samples (about 100 ms). If the detection is successful, we assign the position of the peak as the I-wave;

Both suggested methods were applied to the preprocessed signal. The first one is based on the observation that the longest monotonic raising should signalize the pseudo-period origin. Automatic removing of misclassified (overlooked and over-abundant) pseudo-periods is incorporated into the method. The second method is based on modified well-known Hamilton-Tompkins algorithm for QRS detection in traditional ECG, adapted to BCG's different curve morphology; this method is prepared for operation in real-time. For good-looking and typical signals, the methods behave very well, achieving nearly complete success The success decreases with deterioration of the signal. On the other way, in such signals it is often difficult even for the human expert to recognize correct pseudo-period time points..

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System Design for Scanning Biological Signals in Strong Magnetic Field, an Application to Small Mammals

J. Brada, J. Kašpar, R. Fiala, K. Hána, P. Smrčka, L. Vojtíšek, L. Nestával

brada@fbmi.cvut.cz

Faculty of Biomedical Engeniering, Czech Technical University,
Studničkova 7, Praha 2, 128 00, Czech Republic

Small mammals, namely mice and rats, play an important role in biomedical research. These models are desirable due to low cost of maintenance and housing, short reproductive cycle, availability, and relative ease of transport. Over the last decade, a dramatic increase in mouse utilization has occurred due to the ability to modify the genotype of this animal rapidly. The major advantage of noninvasive studies is the ability to conduct studies on living animals without significant consequence to the animal or its physiology. However, live animal studies are difficult to perform because they generally require an anesthetized animal and animal technical support to monitor the animal throughout the measure procedure.

In vital noninvasive studies of small animals, the use of anesthesia is a major challenge. The small size of the mouse or other small mammal is particularly challenging for maintaining a stable anesthetic plane due to problems with mechanical ventilation and online measures and adjustments of biological signals.

The system design for scanning biological signals in strong magnetic field is proposed with the aid of device named 'Špulákova komora', source of strong magnetic field MRI SISCO 85/310 device and with use of the modular measure system 'Advanced PDA'

The 'Špulákova komora' is the plastic, transparent, non magnetic construction with cylindrical shape of diameter cca. 130 mm and length 300 mm. Measured anesthesia mammals are inserted inside. The dimensions of this device are sufficient for scanning common laboratory mammals like mice and rats and the device is suitable for bigger mammals like rabbits too. In addition to this, the device feature allows to measure biological signals in requested defined system environment as are temperature, pressure and breath mixture. It means monitor measured mammal state in strong magnetic field on surround conditions. Functional prototype of the 'Špulákova komora' device will be put to DNEP CTU database down and offered for measuring other partners.

The source of strong magnetic field is nuclear magnetic resonance imaging system MRI SICSO 85/310 device. Its superconducting (4,2 K) magnet coil generates homogenous magnetic field of strength 2 Tesla. This system was donated to FBMI CTU in 2001 by Deutche Krebsforsechungszentrum Heidelberg (DKFZ), which cooperates with FBMI since 1998 year. At this moment the measuring and the research is being proceeded. This SICSO 85/310 system is generally used for small mammals MR imaging. Mainly we cooperate with 1st Faculty of Medicine (Charles University Prague). The scanning biological data in strong magnetic field in cavity of superconducting magnet coil we could execute unconditionally on the rest of MRI SISCO 85/310 device.

The main part of whole system design for scanning biological signals in strong magnetic field is modular measure system called 'Advanced PDA'. The basic function of this

system is the scanning of biological and technical signals. This system was originally designed for technical support of our own research projects (telemetry, monitoring and storage of biomedical signals). The system is able to acquire signals via input sensors. Measured signals from experiment measure mammal, placed in 'Špulákova komora' device inside cavity of superconducting magnet coil, are passed on metallic or optical connection to the central control unit. Measured signals are digitalized and processed by the central control unit, then passed on by selectable communication interface (metallic connection (RS232, USB), wireless interface (BlueTooth, WiFi, GSM, GPRS-ethernet)) for displaying, archiving and further evaluation in given imaging unit. (Classical PC, notebook, PDA platform). The most advantageous feature of the system is its modularity. The whole chain is composed from preassembled modules via internal interfaces which represents very fast, effective and inexpensive solution. By simple software or hardware adjustments we can measure other quantities than those included by default modules. Modular measuring chain 'Advansed PDA' is ready to be strong and affordable tool for all potential partners in research and industrial area. Its author's collective was granted with the Innovation 2004 Prize by the Innovative Enterprise Association of Czech Republic, personally delivered by the Czech vice-prime minister Ing. Martin Jahn, MBA.

With using described system design for scanning biological signals in strong magnetic field we could measure mammal biological signals like electrocardiogram (ECG), electroencephalogram (EEG), mammal temperature, pressure etc. in defined magnetic field and space.

Due to scanning biological signals inside MRI SISCO device, we could append to our output measured biological signals images acquired by this device during experiment too. Then we can use them together and support our measured data and results with interesting diagnostic resource with powerful diagnostic imaging method.

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Measurments of Atmosferic Ions

L.Vojtíšek*(**), K. Hána*, P. Smrčka*, J. Brada*, J. Kašpar*(**)

vojtisek@fbmi.cvut.cz

*Joint Biomedical Laboratories of CTU and Faculty of Biomedical Engineering,
Czech Technical University, Studničkova 7, 120 00 Prague 2, Czech Republic
**Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, V Holešovičkách 2, Prague 8, 180 00, Czech Republic

In modern age is environmental care often used word. Especially air monitoring and consequently control of airborne release. In these days is quite normal periodically or continues measuring of concentration of waste products like CO, CO_2, NOx, and others in the atmosphere. But one of the parameters is still neglected. The parameter is spectrum of concentrations of air ions. The analysis of the electric state of the air shows the presence of various ion sorts. It could show us much about quality of air. We can say that, there are three parameters which are probed: weight (size), polarity and quantity ions in the surrounding air. It is known therapeutic effect of negative high mobility ions with proper concentration. This positive effect was observed in caves, are used for speleotherapy. We can easily explain that. From the beginning of human being there were the air ions in approximately same content all a round us rather concentration of light negative ions in the atmosphere has a favourable influence on human health. So we can feel the changes, somebody more some body less. By the human activity on the earth we could see the changes, mostly at places where we are spending most of our lives. Problem probably is in the modern constructions of buildings and using new synthetics materials without any knowledge about air electricity. It happens that in the new, beautiful, comfortable, and very expensive house people can feel the results like frequent headache, feelings heavy air, sleepelessness (or low-class slumber), on the other side decline of brain activity and felling asleep. Just people feel ropy in these houses. There is talked about “dead houses”.

We see there the problem which could be useful to solve. But we are not alone in it also on Institute of Scientific Instruments are interested in the research of ion field in office and living spaces. The object is to increase the concentration of light air ions in these spaces. Main purpose of our work is to deal with the problems of measuring of the atmospheric ions concentration. Some of the perspective methods are utilized for air ion fields measurement today: dispersion method, ionspectrometer method, Faraday cage method and gerdien tube method. Currently used methods are mentioned together with the method of Gerdien Tube. The measuring device was designed and made according to its principle. There is advisable to measure directly ion spectrum but in fact it may be a little expensive or technical exacting not. In fact ion-spectrometers works on the same principles like the gerdien tube. So we was decided tried first simpler method. The most useful in the sequel, for us, is method of Gerdien Tube. Some of the measuring devices electrical circuits and measuring sensing head are designed. Also several suggestions and calculations about air flow inside of the Gerdien Tube were made. The possible negative influences of the air flow inhomogeneity on accuracy of measuring were considered as well. The measurements of the air flow, Gardien Tube electrical properties and the measuring electronics were taken.

The gerdien tube consists of two electrodes. An electric field is between the inner electrode – collector and outer electrode. The field is imposed by voltage source. Air ion flow

from fan flows through the gerdien tube. In electric field one polarity move to collector (ions of second polarity goes by outer electrode and chassis to the ground) . Than we can measure ions by electrometer or produced current is measured by pA-meter. Measured current is proportional to air ion concentration. When we change the polarity of voltage source between electrodes it will measure concentrations of ions other polarity.

If collector is a few centimeters imbedded inside the outside tube we suppose that we can neglect boundary conditions. This idea was verified by measuring air influences at Constructions of Aircrafts Department at UT Brno. By that measuring was also confirmed notion about flowing inside our tube. It supposed to be bound to sinuous flow. This type of flowing is very difficult to exactly describe moreover we have to think about inhomogenity occasioned by blower. But if we put to way from the blower to tube fine sifter or strainer we evoke homogenous, small sinuous flowing. This effect is caused by small rising of pressure ahead the sifter compared to behind it.

By required levels of measured concentrations 100 – 10 000 ions in cm^3 is also gift the current level pA-meter. It has to approximately star at 100fA, ends at 10pA. Measuring amplifier is designed using ina116 Ultra Low Input Bias Current Instrumentation Amplifier. It has perfect properties, but it is very touchy, handle with it must be very careful. Is measured voltage on the high impedance resistor (0.1TΩ). That's bears problems with shielding not only for that amplifier, but also for source of the polarization voltage.

Precision of that device mostly depends on used method. Exact calibration is from the principle impossible. But the first experimental measurement on our device was compared with two different devices. First compared instrument is in Institute of Scientific Instuments, Academy of Sciences of Czech Republic, second at Departement of Electrotechnology, Faculty of Electrical Engineering and Communications, University of Technology in Brno.

Now we want to automate measuring using microprocessors ATMEGA 128 also this part is now nearly complete. Next step could be more cooperation with the doctors because exact principles of incidence air ions we still don't now. It is only known that there is health full.

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Section 13

CIVIL ENGINEERING

Price Trends Dynamic Model of Housing Premises Rent

L. Koláček

libor.kolacek@fsv.cvut.cz

Department of Applied Informatics, Faculty of Civil Engineering, Czech Technical University
Thákurova 7, 166 29 Prague 6

Housing premises rent has been big socioeconomic and political issue in the Czech Republic for a long time. The calculation model of maximum rent for square metre of a housing unit has been changed several times since the year 1994. These calculations were not based on dynamic models and they were derived from only a few factors. The first one was an „inflation", the second one was a „government decision-making coefficient" and the last one was a „city size coefficient". The rent was calculated for four housing categories. Number I. housing category represented the highest standard flats, whereas number IV. category represented the worst standard ones. The determination of rent value was not difficult as there was a direct relation among categories. In 1999 a ministerial housing rent regulation was amended and since then price increase has been influenced by only one factor expressing average change of construction works prices – the so called „construction works price index". The rent has been regulated in such a way until this year.

A new law concerning one-sided rent increase should bring a clearer concept. The law will be authorized by parliament next year, exactly on 1st March 2006 and will come into force by 1st October 2006. This new model is based on maximal rent increment per month. The increment is formulated as: $MP=(\sqrt[6-k+1]{CN/AN}-1)*100$, where MP is a maximal increment of monthly rent, CN is a final monthly rent value per 1 m^2, AN is an actual value of monthly rent for 1 m^2 and k is a year within the law validity. (k=1 applies to a year from 1.10.2006 to 30.9.2007, k=2 applies to a year from 1.10.2007 to 30.9.2008, k=3 applies to a year from 1.10.2008 to 30.9.2009, k=4 applies to a year from 1.10.2009 to 30.9.2010, k=5 applies to a year from 1.10.2010 to 30.9.2011 and finally k=6 applies to a year from 1.10.2011 to 31.9.2012. More information concerning this analysis model and its specifications can be found in the draft law [4].

The purpose of this project was to create price trends model of housing premises rent in Czech Republic from 1.10.2006 to 30.9.2012. This simulation model was based on Systems Dynamics methods. PowerSim Studio 2005 was used as modelling software. Systems Dynamics is a science that has been described in professional literature [1-3]. System Dynamics is a methodology for studying and managing complex feedback systems, such as the ones that can be found in business and other social systems and uses computer simulations for understanding change and complexity. This methodology was developed by J.W.Forrester who is a Professor emeritus at Massachusetts Institute of Technology.

Firstly, the main variables and constants have been identified as reference modes of system and units have been defined. Secondly, a causal-loop diagram (CLD) has been designed. CLD is a tool that helps to show causal relationship among a set of variables (or factors) operating in a system. In our case the CLD has been built from the following variables: "Actual value of monthly rent", "Ratio between final and actual value of monthly rent", "Rent increment" and "New value of monthly rent". A simulation model created in Powersim Studio 2005 is one of the main outcomes of the project. This software uses Stock-flow diagrams as a basic tool for modelling. All identified constants and variables have been used. A graphical software interface has been designed to make the operation of simulation as

simple and comfortable as possible. Before the simulation runs for the first time it is necessary to set important input values according to instructions in presentation mode. At first, the flat type depending on its standard and location will be set. The model describes six flat types and each of them sets different input value "p" that is important for calculation of final value of monthly rent. Next, another three input factors such as "Total flat surface" in m^2, "Basic house price" and "Actual monthly rent value" will be set.

Having set all the input values we can finally run the simulation in presentation mode. A chart presenting most important simulation results is placed at the bottom of the graphical interface. (e.g. such as "Maximal monthly rent value" and "Maximal monthly increment" in particular years always on 30th September).

The simulation shows that maximum monthly rent value depends mainly on input values and does not increase as a rule.

In presentation mode, the model can also be viewed in Stock-Flow diagram form. For this purpose a hyperlink "Go to Model" has been placed at the upper right corner of the graphical interface. In order to return a hyperlink "Back" has been placed under the diagram at the lower right corner.

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Computer Support of the Geodetical Subject Group

P. Hánek*, I. Janžurová*, P. Hánek (jr.)**

hanek@fsv.cvut.cz

*Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic
**Department of Mathematics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

For several years, there already exist on the server „gama“ web pages related to a group of geodetic subjects that are covered in lectures by the first author of this grant award. These subjects include the required course of the geodesy of the Underground Spaces (GP10) as well as voluntary courses such as the History of Surveying (DEJZ) and the Constructional and Industrial Geodesy (SPGD) offered in the advanced semesters of the geodetic studies. The second investigator is responsible for the relevant practical accompanying exercises. The third author created the web sites using the language PHP.

The web pages of the different subjects are utilised for the organisation of teaching efforts as well as for the mutual contacts of the teachers and students. However, the most important aspect of the web pages are publications of current scientific literature which are not readily accessible, and graphically difficult scientific materials and texts. These complete and extend the lectures and compensate for the lack of Czech scientific geodetic literature. Participating students must also exemplify the numerical accuracy of three of their complex exercises on the web pages GP10. The pages DEJZ include an important documentary collection of photographs of the geodetic and cartographic instruments of Czech origin from the 16 - 20 century as well as the explanatory legend in Czech and English languages. The Address of the English version was announced by the International Federation of Surveyors (FIG) to their numbers.

During this grant period a number of goals were accomplished. A series of computerized presentations which can be we used directly during lectures were created. Some of these can be part of web pages for home studies. Fur ther more the existing web texts were extended and updated to include new data based on recent scientific articles and textbooks. There new data also include publications by our research group and other co-workers. In addition, we have prepared new materials concerning the offered course of Engineering Geodesy for Water Management (IGVH). These new materials may serve as a basis for baccalaureate Thesis and were printed as hand-outs for the students. They can also be used in the subject of Constructional Geodesy (SGE) within the framework of newly introduced baccalaureate studies of civil engineering. In particular, these new programs include data dealing with Lasers in civil engineering, Geocentric coordinate system WGS 84, Projection of UTM (NATO), European altitude system, System GPS, Methods for measurement of size, which can be used in the subjects of IGVH and SGE. The series Influence of sunlight on the construction of bridges, Testing of digital levelling instruments, Systems of industrial measurement IMS, New possibilities of measurement for architecture, are designated for the SPGD. Materials dealing with the development of Teaching of mine surveying in Bohemia and the Prague school, History of mining as reflected in Bohemian, Saxon and Slovakian cities blazons were collected for the use of GP10 and DEJZ. The programs about the Projection, setting-out and accuracy of the construction of the eldest European tunnel by Eupalinos from the 6-th century B.C., and presentation of the trigonometric altitude

measurements in the book „Geometria" by Gerbert from Aurilac (pope Silvestr II) from the 10-th century A.C., and the History of European integration of surveying are of general use.

Other grant supported activities include a visit of collaborators from the Technical University in Dresden who held a lecture for invited guests about systems of industrial measurement. The lecture was accompanied by a demonstration of technical equipment which is not yet in use at the Czech Universities. Translation of the lecture is located on the web pages. Translation of another geodetic article was published in Academic Journal „Stavebni obzor" (2005/7). Finally, four lectures with grant themes were delivered at National Meetings (see Reference).

Unfortunately, after repeated breaks through, the administrator of the server "gama" has decided not to install the PHP server extension. As a result, the above described electronic results cannot be at present installed. Changes to the language Python and / or Perl is time-consuming. We reckon that the server of the Department will be installed in 2006.

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Measuring of Pore Water Pressure in a Mine Dump Using Multilevel Piezometers

M. Bubeníček, J. Záleský

michal.bubenicek@fsv.cvut.cz

Department of Geotechnics, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

Mining activity generally leaves behind earth structures formed primarily by heterogeneous clay of so called double porosity i.e. internal – natural and external – void content. Structure of the mine dump fill and the way of stock piling generate material which degrades in time. Voids amongst the soil lumps enable infiltration of surface and underground water into the mine dump. Growing pressure during growth of the mine dump, changes in the air temperature and its flow in the voids contribute to degradation of the material. The mine dump fill of originaly stiff consistency becomes locally mushy by gradual softening of the soil lumps. This is accompanied by decrease in the mine dump fill strength and increase in pore water pressure. Stability of a mine dump varies depending on shear strength characteristics and pore water pressure in the soil as well. Knowledge of pore water pressure distribution is for the mine dump stability calculations desirable and cost saving. On the other hand measuring of pore water pressure is complicated due to different degree of degradation of the fill. Course of pore water pressure in the slope is not ussually available owing to relatively high costs of measurements. Measuring of pore water pressure in cohesive soils using closed piezometers [1] is considered as the most appropriate due to their minimum volume changes. Multilevel piezometers are more effective in materials, where there is a demand for knowledge of pore water pressure distribution along the depth.

We carried out periodical measurements of pore water pressure and 3D deformations in a mine dump found on Rabenov slope close to Ústí nad Labem exploiting instruments installed during former research project GACR 103/02/1166 in 2004, and two more piezometers installed newly in 2005. Pore water pressure has been monitored in the lower part of the slope in the mine dump fill using a group of three BAT piezometrs installed with cone penetration at three levels of 5m, 12m and 20m below the ground. BAT system from Sweden consists of separate filter tips and one sensor [2]. When carrying out the measurement the sensor is lowered down the casing 1" thick and via a hypordemic needle connected to the filter tip. At the same time measurements of pore water pressure in a nearby open standpipe piezometer [1] in a borehole 27.0m deep were being obtained. Deformations were measured in a bore hole instrumented with combined casing for inclinometer and sliding micrometer measurement in 3D [1]. Further measurements were made in a group of two BAT piezometers installed with dynamic penetration at levels of 7m and 12m below the ground. This group is located 40m up the slope from the group of the three pizometers.

Results of the BAT and open stand pipe piezometers measurements show that first one does not response to the water regime with respect to the time as water table remains more or less constant. This is likely due to its retention capacity thus it can not catch changes in pore water pressure in a low permeable layer of the mine dump. On the other hand the latter picks up different values of pore water pressure in time [3]. The greatest range of pore water pressure changes was observed at depth of 20m below the ground where the slip plane was also indicated. The pore water pressure at depth of 20m exhibits continuous growth this year, which corresponds with increasing horizontal deformation development at the slip plane as

indicated by inclinometers measurements. The borehole initially exhibited plastic deformations usual in mine dumps. However shear deformations occured in May 2005, probably triggered by increase of pore water pressure in the winter/spring.

Pore water pressure measured in a group of two piezometers for three months in the autumn indicated stable artesian water upto 186,7kPa at depth of 12m where as almost zero values (slightly negative) were picked up at level of 7m. This an important finding as the pore water pressure distribution present at this location is completely different from pressumption of hydrostatic pressure in the lower part of the mine dump and from the other measuring group 40m down the slope.

Measurements of pore water pressure using multilevel piezometers (2 to 3 levels) helped to identify important features of mechanism of the sliding of the studied slope such as existence of separate hydraulic horizons and occurence of artesian water at certain depths. Artesian water has negative effect on slope stability and may occur due to shear deformation of the saturated soil with contraction behaviour or existence of isolated aguifer of limited drainage capacity.

In mine dumps where we do not know distribution of the pore water pressure or their important values e.g. artesian water it is desirable to use multilevel piezometers. Inteligent multilevel piezometers systems installed in common boreholes available in the market are expensive therefore limit number of measuring points in mine dumps. Furthermore there is a risk of undesirable vertical connection of layers of different permeability unless sufficient sealing is provided above and below each filter. On the other hand piezometer systems consisting of separate filter tips and one sensor allow installation with cone and/or dynamic penetration with minimal danger of system damage. This can significantly reduce cost of equipment and installation works. There is no risk of the vertical connection of layers as the filter tips can be installed separately in groups. The installation depth of a filter tip with cone penetration was limited by length of the sensor cable (20m) in the previous project. We achieved an installation depth of 12m with dynamic penetration (DPM) and were limited by a number of penetration rods in property of Department of Geotechnics.

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The article exploits outputs from a completed research project „Research and verification of methods of slope movements monitoring“ GA 103/02/1166 and from project FRVS G1 1080 „Field monitoring of relation between pore water pressure and slope movements“ and was directly supported by research project IGS CTU0502411 “Measuring of pore water pressure in a mine dump using multilevel piezometers“.

Thermal Comfort and Temperature Distribution in a Room with Radiant Cooled Ceiling

V.Zmrhal

Vladimir.Zmrhal@fs.cvut.cz

Department of Environmental Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Radiant cooled ceiling is relatively efficient cooling system, which can be used to achieve the optimal thermal comfort. Theoretically, the radiant heat transfer between a body and its surroundings is rather preferable than the convection heat transfer in the view of thermal comfort achieving and energy consumption. The influence of surface temperature on thermal comfort is positive. Therefore, it is possible to keep a higher indoor air temperature in a given space to achieve the same thermal comfort compared with convective systems. The airflow supply can be limited according to the fresh air requirements. Most frequently, the cooled ceiling system is combined with displacement ventilation.

The paper presents experimental measurement of thermal comfort and temperature distribution in such a space. The experiments were carried out in a test chamber with radiant cooled ceiling, displacement ventilation and internal heat load models. The test chamber, which represents office room, is located in a laboratory at the Department of Environmental Engineering in Prague.

The operative temperature t_o is the evaluative criterion for thermal comfort in air-conditioned spaces - ISO Standard 7730. The operative temperature depends on air temperature t_a, mean radiant temperature - *MRT* and air velocity w_a. From these quantities the thermal comfort in conditioned spaces can be predicted by the use of the *PMV* index (predicted mean vote). The comfort range of thermal comfort is normally considered as $-0.5 < PMV < 0.5$. When the air velocity is lower than 0.2 m/s, the operative temperature approximately equals to globe temperature t_g.

The presented experiments were carried out in an existing test chamber with a floor space of 4.2 by 3.6 m and a room height of 2.7 m. The radiant cooled ceiling of 7.2 m^2 area is located symmetrically in the chamber. The test chamber was ventilated by displacement ventilation. The exhaust and supply air openings are installed symmetrically in the front wall. The test chamber is placed in a larger, air-conditioned enclosure providing the chamber with required ambient conditions. The surrounding air was conditioned to provide minimal heat flux between both spaces, i.e. the temperature of the surrounding air was adjusted identically to the air temperature in the test chamber. Moreover, all chamber surfaces are very well heat-insulated to minimize heat loss. The models of internal heat gains were used (2 models of occupants, 2 models of PC and the window model representing shaded window without direct solar heat gains).

Measurement of temperature distribution was carried out along four vertical axes in the test chamber. The special multiple temperature probes were made. There were used 4x10 Pt100 sensors with minimal proportions (1,6 x 3,2 x 1,0 mm). The "*Indoor Flow System*" (Dantec) and globe thermometer was installed in the middle of the room. The measurement of thermal comfort parameters measurement (air temperature t_a, globe temperature t_g, air velocity w_a and turbulence intensity *Tu*) was performed in four room elevations - 0.1, 0.6, 1.1m and 1.7 m above the floor.

Vertical temperature profiles represent air temperature distribution in a space with radiant cooled ceiling. Air temperatures were evaluated during steady state measurement. For

isothermal conditions, the straight temperature profiles in occupied zone are visible. Next conditions represent measurement with maximal heat load (520 W) and minimal supply airflow (100 m^3/h). It reasons the fact that the capacity of cooled ceiling doesn't satisfy the requirement for total heat load removal out of the space. Part of heat load is removed by supplying non-isothermal airflow, which cause deformation of temperature profiles in the occupied zone. Next measurement brings information about variations of temperature profiles in a room with cooled ceiling caused by increased supply airflow (still the same dimensions of ventilation openings). The effect of increased airflow on temperature profiles is positive, but non-economic. The higher airflow and higher air temperature (higher heat transfer along the cooled ceiling) makes the temperature profiles line-up. Under the ceiling, the peaks caused by convection flow along heat gains are visible in all cases. The peaks are caused by internal heat gains (PC model and occupant model). The effect of convection airflow along the model of window is also visible. The effect of displacement ventilation is present in all cases near the supply air opening. The peak of temperature profiles caused by the lower temperature of supply air is visible in the height of 0.1 m above the floor. If the cooling capacity of the ceiling is sufficient and the airflow is isothermal, the peak of temperature profile is negligible.

Based upon thermal comfort requirements for sitting person in the summer, the air temperature difference between head (1.1 m above the floor) and ankle (0.1 m above the floor) must be less than 3 K. Temperature profiles document the executed requirement in all cases. For standing person, the difference between head (1.7 m above the floor) and ankle is maximally 2.9 K.

The predicted mean vote (*PMV*) index was evaluated on the basis of thermal comfort parameters measurement. The *PMV* index was calculated for activity level of 1 met, insulation value of 0.5 clo and relative humidity of air of 50 %. Results of *PMV* index for sitting person (0.6 m above the floor) and for standing person (1.1 m above the floor) show the wide range of thermal comfort for defined conditions. The results generate the line because of very low air velocity (0 – 0.1 m/s) in the occupied zone.

During experiments, the air temperature t_a, air velocity w_a and turbulence intensity *Tu* were measured in elevations 0.1, 0.6, 1.1 and 1.7 m above the floor. The draft risk (*DR*) can be calculated from these quantities, which predicts the percentage of people dissatisfied because of draft intensity. The measurement of thermal comfort parameters shows no risk of draft (*DR* < 5%) in a space with radiant cooled ceiling combined with displacement ventilation for elevations - 0.6, 1.1m and 1.7m above the floor. Local draft risk can be caused by increased airflow (area of supply air opening doesn't change) in ankle zone (0.1 m above the floor).

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Probabilistic Reliability Analysis of Structures Exposed to Time-Variant Actions

M. Sýkora*

sykora@klok.cvut.cz

*Department of Structural Reliability, Klokner Institute, Czech Technical University, Šolínova 7, 166 08 Prague 6, Czech Republic

Research study is aimed at improvement of probabilistic analysis of time-variant structural reliability under stationary and ergodic conditions within the referenced period $(0,T)$. Resistance variables **R** and permanent actions **G** are approximated by time-invariant random variables. Time-variant actions $\mathbf{S}(t)$ are described by intermittent rectangular wave renewal processes with exponential durations between renewals (rate κ) and exponential durations of load pulses (rate μ).

A currently used formula for the basic characteristic of a single renewal process $S(t)$, probability of "on"-state $p_{\text{on}}(t)$, is re-examined considering random initial conditions. A two-state Markov process is used for a renewal process with short load pulses and large intermittencies. The probability of "on"-state $p_{\text{on}}(t)$ is then shown to yield [1]

$$p_{\text{on}}(t) = Ce^{-(\kappa+\mu)t} + \frac{\kappa}{\kappa+\mu} \tag{1}$$

where C is a constant dependent on initial conditions. The last term of (1) is a "stationary" probability of "on"-state reached for a "sufficiently" long referenced period.

Two different load models with given initial conditions are distinguished: (*i*) time-variant actions likely to be "on" at the initial time point - $p_{\text{on}}(0) = 1$, (*ii*) time-variant actions assumed to be "off" at the initial time point - $p_{\text{on}}(0) = 0$. In addition, (*iii*) time-variant actions with random initial conditions are considered. In this case, the initial probability of "on"-state is derived as $p_{\text{on}}(0) = \kappa/(\kappa+\mu)$. The probabilities of "on"-states follow from (1) as

$$(i)\ p_{\text{on}}(t) = \frac{\kappa}{\kappa+\mu}\left[1 + \frac{\mu}{\kappa}e^{-(\kappa+\mu)t}\right],\ (ii)\ p_{\text{on}}(t) = \frac{\kappa}{\kappa+\mu}\left[1 - e^{-(\kappa+\mu)t}\right],\ (iii)\ p_{\text{on}}(t) = \frac{\kappa}{\kappa+\mu} \tag{2}$$

It appears that for (*iii*) the probability $p_{\text{on}}(t)$ is independent of time. However, numerical studies indicate that the non-stationary probabilities (2) for (*i*) and (*ii*) rapidly converge to the "stationary" value $\kappa/(\kappa+\mu)$ for "usual" actions on structures. Therefore, the probability $p_{\text{on}}(t)$ may be in common cases approximated by the time-invariant stationary value.

Considering an arbitrary number n of mutually independent renewal processes $S_i(t)$, time-variant reliability analysis is investigated. An upper bound on the failure probability $P_{\text{f}}(0,T)$ related to $(0,T)$ is derived as [2]

$$P_{\text{f}}(0,T) \le P_{\text{f}}(0) + T\sum_{i=1}^{n}\kappa_i \text{P}\left\{\begin{matrix} g[\mathbf{R},\mathbf{G},\mathbf{S}_m(\tau),S_i(\tau)] \ge 0 \cap \\ g[\mathbf{R},\mathbf{G},\mathbf{S}_m(\tau),S_i(\tau+\Delta t)] < 0 \,|\, S_i(\tau+\Delta t) \text{ is "on"} \end{matrix}\right\} \tag{3}$$

where $P_{\text{f}}(0)$ is the initial failure probability, $g(\cdot)$ is the limit state function and $\mathbf{S}_m(\tau)$ is the random vector of processes excluding the process $S_i(t)$. The probability $\text{P}\{\cdot\}$ in (3) is

evaluated considering that (*i*) a load pulse of the process $S_i(t)$ is initiated within Δt and $S_i(t)$ is thus "on" at $\tau + \Delta t$ while (*ii*) the vector $\mathbf{S}_m(\tau)$ is of a constant random value. Note that each component of $\mathbf{S}_m(\tau)$ is "on" with the probability $\kappa_m/(\kappa_m + \mu_m)$. Extensive numerical studies indicate that formula (3) provides estimates of $P_f(0,T)$ close to the exact solution for a wide range of load combinations and even when $P_f(0,T)$ is high, approximately $P_f(0,T) > 10^{-2}$.

The bound (3) may be simplified neglecting the first term of $\mathrm{P}\{\cdot\}$ in (3) as derived in [1,2] and adopted in [3]

$$P_f(0,T) \le P_f(0) + T\sum_{i=1}^{n} \kappa_i \mathrm{P}\left\{g\left[\mathbf{R},\mathbf{G},\mathbf{S}_m(\tau),S_i(\tau+\Delta t)\right] < 0 \,\middle|\, S_i(\tau+\Delta t) \text{ is "on"}\right\} \qquad (4)$$

The upper bound (4) can be effectively evaluated by any of the well-developed "standard" reliability methods for time-invariant cases such as FORM/SORM or advanced simulation techniques. However, the bound (4) may yield rather crude estimates when $P_f(0,T) > 10^{-2}$.

The bounds (3) and (4) are sums of probabilities, each evaluated by reliability analysis. Some of these probabilities can be often neglected being incomparably lower than the others. The optimization procedure is thus proposed to eliminate "less important" terms included in the bounds: (*i*) estimate probabilities by a fast approximate method such as the moment method ("rough" estimates) and determine "important" terms, (*ii*) evaluate the "important" probabilities by an advanced and perhaps more time-demanding method ("accurate" estimates), and (*iii*) evaluate the upper bound (3) or (4) using the "rough" estimates for the "less important" terms and the "accurate" estimates for the "important" terms.

The submitted research study indicates that the probability of "on"-state $p_{on}(t)$ may be for common actions approximated by the "stationary" time-invariant value. It appears that the proposed upper bound on $P_f(0,T)$ (3) provides estimates close to the exact solution even when $P_f(0,T) > 10^{-2}$. The simplified upper bound (4) mostly yields also estimates close to the exact solution and, moreover, can be effectively evaluated by any of the well-developed "standard" reliability methods for time-invariant cases. The proposed optimization procedure may help to reduce computational time required for evaluation of the bounds (3) or (4).

It is expected that formula for probability of "on"-state $p_{on}(t)$ will be derived for processes with arbitrary long load pulses within future research. A specialized software code should be developed for application of the proposed optimization procedure.

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Airborne Sound Insulation between Rooms in Dependence on Acoustical Performance of Elements

J. Nováček

jiri.novacek@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Calculation models for predicting the airborne sound insulation between rooms from acoustical performance of building elements are not used in the Czech Republic at the present time. It is caused by many factors: bad availability of acoustical data for elements, prediction models are not complete and valid for some building structures and situations (mainly the lightweight constructions), there are only few examples of the use of these models. In this way only direct sound transmission is usually predicted and the effect of flanking transmission is included as an empirical value.

Integration within the European Union leads us to associate procedures of designing buildings in the point of view of building acoustics as well as of other technical areas. Using of more accurate prediction models ensures reasonable design and makes material savings possible. It is in accordance with the idea of sustainable buildings. Some prediction models were included into the european standards (EN 12354) and a new workgroup within the European Acoustics Association were established. The purpose of this team is to gather indications about the prediction accuracy in various situations, gather relevant examples of input data for the models and to improve and extend the standards. These are also the goals of author´s PhD thesis in the scale of the Czech Republic.

The previous author´s work focused on a prediction of acoustical properties of elements and a direct part of sound transmission for various types of building structures. It was shown that the accuracy of predicted results is much more better for homogenous single structures (concrete walls, solid bricks etc.) than for slightly orthortopic partitions (for example hollow bricks) or double walls. With support of the grant mentioned below the theoretical background for next work was completed and the airborne sound insulation in some new buildings (where drawings available) was measured.

The measurements were made in two new dwelling houses in Prague – called "SLADOVNY" in Dejvice and "RUBEŠKA II" in Vysočany. Both of them are multi-storey buildings with heavy load-bearing walls and ceilings. Measured structures correspond to that ones studied in the previous work – concrete walls, solid brick walls, concrete slabs with heavy floating floors, lightweight double partitions. So it was easy to compare the airborne sound insulation of similar construction with and without flanking transmission (in laboratory conditions and in real building).

Good coincidence between predicted and measured values was observed especially for homogenous heavy structures when full theory is used. For elements with normal size (approximately 4 x 3 m) it is efficient to use model based on Josse-Lamure´s work with corrected input data – e. g. radiation efficiency, different speed of bending waves for thick walls and maximum level of sound insulation. Using this technique good results were obtained without knowing any special acoustic data for elements (which were not measured). Main benefit from usage of full-scale models was found for large plates and difficult situations (e. g. combination of heavy and lightweight structures).

In dwelling "RUBEŠKA II" heavy load-bearing walls and slabs are combined with double plasterboard partitions inside flats. Such structures can be regarded as partly excited large plates, because lightweight partitions have negligable influence on acoustic behaviour of basic element. Because of a large perimeter, elements have higher energy loses on edges and airborne sound insulation properties than common partitions. These assumptions are included in EN models and are in good accordance with measurements, as shown. Idea can be well used in designing sustainable buildings.

However, when heavy and lightweight structures are combined together one must take care on flanking transmission which can be of higher importance than direct transmission. It is due to absence of vibration attenuation in junctions. This effect is shown in one example and also here predicted results well agree with measurements. Using detailed models we can avoid mistakes caused by difficult work with empirical corrections.

For double structures we should expect less accuracy of predictions, although there is a straight effort to use models for such constructions as well as for homogenous ones. It is mainly due to usage of thinner elements with higher critical frequency. In a wide frequency range of interest forced sound transmission occurs for direct transmission path while for flanking paths only resonance transmission can set in. It is still hard to estimate or separate these two transmissions from measured data.

Measurements done for two concrete slabs with heavy floating floors are in good accordance with predictions. In that case benefits of floating floors well agree with results obtained from other simplified prediction procedures or graphical methods commonly used in practice.

The last measured structure (double plasterboard wall) is the most complicated one. Airborne sound insulation can be affected by plenty of factors here – construction details, quality of manufacture, real distance between steel studs, filling with mineral wool or indirect transmision due to internal doors. Here the predicted sound insulation is slightly overestimated.

Presented research shows advantages and problems of using detailed models for estimating airborne sound insulation between rooms in practice. It gives some explanations for application of these models for exemplary situations and building structures in the Czech Republic. It shows for which kind of structures the airborne airborne sound insulation can be estimated accurately and when one should expect less accurate results. The theory included in EN standards were completed and enlarged for some other type of structures and situations. This work is in close connection with author´s PhD thesis and will be included as a part of it with an effort on the use of these prediction models for designing sustainable buildings in common practice.

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Energy Effects of the Urban Microclimate

M. Kabrhel
K. Kabele

michal.kabrhel@fsv.cvut.cz

Department of Microenvironmental and Building Services Engineering, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

The measurement of external parameters in a city centre was the aim of the research project. The next thing was to define parameters, which describe properties of the external surfaces and define influence to external air temperature change in comparison with area without these influences. According to this characteristic significant parameters to buildings may be defined.

The inhabitants live in advanced countries in cities. Cities can be characterized like regions with high density development and with different landscape morphology then in free landscapes. The building forms crimp air flow and increase wind speed in the narrow spaces. Buildings and communications have higher absorption capacity in comparison with countryside where overgrown grass weed or shrub shade surfaces. The air is warming up by increased traffic concentration and the technical arrangements operation. These factors involve temperature difference between the town parts and countryside.
We are focus to building energy consumption and we differentiate the heating and the cooling energy. We notice the most important items and their effect. It is necessary analyse, in frames of climate, difference in the summer and in the winter season. Items with influence to external microclimate are air temperature, wind speed, transport and technical arrangement. The air temperature is dependent on solar radiation in urban areas. The radiation depends on the sun position in the sky (earth position and time), absorption capacity of surrounding surfaces and the wind speed. Solar radiation impacts especially on surfaces with low reflectance (communication, roof) and thermal energy is storage. The air is warm-up in this area. Transport and operation of technical equipments have further contribution to this process. The air temperature is reduced by green surfaces and fountains.
Vaporization heat is taken away from surroundings by moisture vaporization process and that is cause of the temperature decreasing. The wind speed has main influence to the temperature field of the city. The dead calm supports rise and evolution of UHI (Urban Heat Islands), region where is higher temperature than in the surrounding area. Higher speed of the air supports possible temperature decreasing. Transport partly increases air temperature by engine running, running air-conditioning as well as emissions which implicate the smog.
The technical arrangements are in this case arrangements necessary for technology and operating of the building. For example it is air-conditioning or refrigerating aggregate.
We assume from the forecast earth warming, that average outdoor temperature will rise in the Europe and that extremely temperature changes will be common.
It is necessary to make arithmetic and proposal of buildings and calculate their influence to surroundings before build-up process starts. The computer simulation can be used to purpose of this analysis.

CFD programs are using during the investigation local climate changes; the ENVI-met program is very suitable in this case. Programs allow simulate buildings and surroundings with different border conditions as a location a building parameters.
It is possible technically determine complicated terrain effect on the temperature field diffusion. Areas with higher or lower average temperature may be described. Calculation is based on solving three-dimension turbulent fluxion; base is Navier-Stokes quadratic equation. The calculation is realise with time step second and is very exacting to computer performance and time. Results are time-dependent values and it is not simple interpret them.

Suitable locations were chosen in Prague city centre and in a sub-urban area. Six long-time measurements were realized in different locations totally. Data-loggers with integrate memory were used, 3 pieces with temperature and humidity sensors and 3 with temperature sensors.
Measurement time interval was 15 minutes. The measurement was realised in period from 1st July to 1st December 2005. The next measurement is supposed during winter period 2006, because it is significant to describe winter period in a city centre. Simultaneously reference data set from suitable meteorological stations were acquired. Furthermore additional solar radiation measurement was realised.
Averages daily difference was determined from measured values in chosen locations. Data set will be used for development of the parametric model, which will describe influence of the build-up area, the city, according to the local external air temperature and to the building energy consumption.

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Interactive Methods and Tuition Aids for Teaching of Concrete Structures Design in Czech and English Language

J. Vašková, I. Broukalová, M. Frantová, L. Tožičková

vaskova@fsv.cvut.cz

Department of Concrete Structures and Bridges, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Teaching of concrete structures design has a long history and tradition at the Czech Technical University. Well-known experts could be mentioned from the history of education in this field – professors Klokner, Bechyně, Hruban, Jílek and many others. Nowadays, tuition at CTU in general is changing and tuition of subjects taught by Department of Concrete Structures and Bridges changes and progresses too. Changes are induced by two main reasons. The first is the adoption of a system of study based on two main cycles – bachelor study and master study. The second reason is application of modern methods for structural design including implementing of new European standards.

Organisation of study at the University in Prague poses claims to prepare new system of teaching concrete structures design at present. First course of concrete design, which is optional for all student of bachelor study program Civil Engineering, is very general brief introduction to problem. However, for part of the students it is at the same time the only course in a concrete field. For other students elaborative courses were prepared and some intensify their concrete skill in special courses and subjects.

It is necessary to transmit information to students effectively; hours of contact with students rapidly decrease. This causes requirements to provide students with supplementary information in form of instructions for elaborating tasks and examples of calculation, data and tables needed in concrete design structural analysis. With increasing number of students also methods of testing and examining of students must be improved and performed more effectively.

Project developed several topics:

- Preparing manuals and syllabi, which correspond to presently implemented European standards (Eurocodes). The helps are concentred on design of concrete structures according to Eurocode 0 - Basis of Structural Design, Eurocode 1 - Actions on structures and Eurocode 2 - Design of concrete structures. The main parts of standards for design of concrete structures have already passed formal vote and have been published. At present standards are being translated into national versions and national annexes are prepared for publishing. Czech Republic is a member of European Committee for Standardization and members of the Department of Concrete Structures have taken appreciable part in process of development and implementation of new European standards. Thus tuition of concrete structures design agrees with the latest drafts of codes. The lack of data from Eurocodes and literature that corresponds to the latest versions of European standards is compensated by materials offered to students in copies or on website of the department both in Czech and English language.

- Demonstrating of the latest development and discoveries in new material research, modern methods and procedures of analysis. Profile of research work of the staff of Department of Concrete structures and bridges and also of students of doctoral study was presented to students of bachelor and master study programs. Records of laboratory loading of an element where increase of deformation together with progressing of cracking and

resulting failure are coming into being and they will be presented at lectures to make explaining and understanding of structural acting easier.

- Visualisation of concrete element in laboratory testing and comparing with numerical simulation was taken around to show students behaviour of element at loading and development of failure at ultimate load. In the outputs of simulation of beam bending, growth of stresses in concrete and reinforcement and other influential effects may be depicted to explain behaviour during laboratory loading.

- Preparation and verifying of program EuroCADcrete that should help student to understand concrete design, exercise in calculations and examine students´ knowledge. Trial testing of students was performed and response of students and teachers was evaluated and analysed. EuroCADcrete is an interactive courseware tutorial, a learning tool for designing of concrete structures. It was created on the basis of software MxFrame for structural analysis. It serves to learn students and test their knowledge in concrete structures design according to new European standards. A wizard guides users through particular steps of structural analysis and does not allow to continue until the step is solved correctly. It signalises mistakes and offers help to correct them. All activity of the user is saved in a central database. Teacher may control the student procedure with help of MxTeachersTool program. This program enables to create new tasks, set properties of a task and check results.

- Schedule, working tasks and tutorial materials for seminar Fire design of structures were worked out. Within this project, content of the subject came up and developed. A license of program TCD 6.0 was loaned out for one year. Specific output from this program are temperature profiles of heated cross-sections (plates, beams, columns) necessary for fire analysis. Using this program, data for elaborating of students' schoolwork were derived – tables, charts, temperature profiles.

Elaborating of theme of project contributes to effectiveness and improving of tuition quality, which is very important at time of transformation of teaching process and formation of new subjects of bachelor study, namely branch Structural engineering and Architecture and structural engineering. With support of this project part of samples, helps and demonstrations for seminars were prepared, visualisations, demonstrations and exhibits for lectures both in Czech and in English version.

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Biocorrosion of Solid Soffit Constructions of Built in Roofspace Apartments and Effective Prevention of them

D. Bedlovičová, P. Bednářová

bedlovic@fsv.cvut.cz, bednarov@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engeneering, Czech Technical Uneversity, Thákurova 7, 166 29 Prague 6, Czech Republic

Efficient prevention of a mould attack on building structures or ceiling structures of loft conversions and thus prevention of related health risks is possible only on the basis of knowledge of the actions going on during a mould attack. Even though the study of moisture distribution in relation to the mould attack on building structures in particular has been the subject of interest for many years and prominent experts have participated in it, the level of knowledge obtained cannot be considered as sufficient. It is mainly due to the fact that increasingly new materials and new structural compositions are used in new conditions, i.e. in more demanding climatic conditions and internal environment conditions, or there are more demanding requirements for the structures' function.

The distribution of moisture in the structure or its mould attack is the result of not only physical and chemical properties of materials, but of natural factors, which change in a discontinuous and irregular way. Due to their adaptability to diverse life conditions and to various substrates, micromycets themselves are able to adapt to new and, in terms of their phylogenetic development, unknown compositions of building materials.

Based on the research carried out to-date, the two basic causes of biodegradation of ceiling structures of loft conversions may be identified as follows:

- reduction in surface temperatures of the ceiling structure (thermal bridge appearance, penetration of cold air inside the enclosed airlock at a point of the ceiling structure etc.)
- non-standard temperatures and relative air humidity in the interior (reduced infiltration, increased moisture content in newly built structures, a change in the heating method and system, etc.).

These factors in particular can be labelled as risk factors decisive for the occurrence and propagation of micromycets on the surfaces of the structures mentioned above. The objective of research is not only the problem of initiation of biological degradation processes in terms of boundary conditions of internal and external environments and materials use, but, at the same time, the problem of preventative protective measures eliminating their appearance.

The research was preceded by study and collection of materials most often used for ceiling structures of pitched roofs in loft conversions for housing purposes, study of the effect of external and internal boundary conditions (temperature, moisture content, structure-individual layer order composition, ventilation method etc.), and also classification of the mould attack in terms of building material types and micromycet species (genera).

The research itself is carried out at three levels:

1) The mathematical and physical analysis of boundary conditions – a computerized design and evaluation of individual compositions of structures of pitched roofs with a possibility of bio-deterioration prediction on internal surfaces of structures,

2) *Field investigation*

Alternative designs of pitched roofs which guarantee identical internal and external conditions in the given time interval. For all alternatives, a spectrum of alternatives of internal boundary conditions (external boundary conditions – winter season) was created as was technologically feasible. The measurement of surface temperatures, temperatures in the roof envelope composition, moisture content values in materials and sampling of exposed ceiling structures to determine a potential biological attack,

3) *Laboratory investigation*
   a) evaluation of field samples taken
   b) simulation of selected boundary conditions with a potential prediction of a biological attack and individual specification of occurrence of individual species of micromycets for selected materials and boundary conditions
   c) selection of materials suitable for preventative treatment of structures to eliminate the mould attack occurrence
   d) treatment of building materials by fungicide agents based on biodegradation prediction and investigation of the efficiency of these measures.

Investigation work was further subdivided into five experiments (by the number of roof structure compositions solved, which are monitored in terms of temperature, moisture content and mainly biodegradation occurrence, i.e. the occurrence of micromycets on the internal surface of the structure).

Due to the fact that the measurements and experiments, which are currently, i.e. during the winter season, still in progress to observe the external boundary conditions, the conclusions to be formulated may be only very preliminary. With regards to the time patterns of the moisture content, temperatures inside the structure and the surface temperatures, a relative accordance with the results of the mathematical and physical analysis may be stated, even at the level of biodegradation prediction. The behaviour of treated parts of surfacing of loft conversions of interest will be further monitored by continuous sampling; following a laboratory analysis the samples will be compared with the results of experiments while simulating boundary conditions in the laboratory.

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Experimental and Numerical Investigation of Plastic Behavior of concrete

M. Frantová, J. Vašková, P. Štemberk

michaela.frantova@fsv.cvut.cz

Department of Concrete Structures and Bridges, Faculty of Civil Engineering,
Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6,

The behavior of structure can be described with a numerical model to represent all stages of loading. Its advantage is the low material consumption during experiments. For a numerical examination of stress states in concrete structures it is necessary to model the structure properly. It means to model the material of structure as correctly as possible.

In the papers [1]-[3], methods of modeling a concrete with taking advantage of its plastic behavior are described. This model can be used for modeling concrete structures. They also describe an extension of this model for use with concrete in the very early ages.

There are some groups of models of concrete – plasticity models, damage models, cracking models. For the investigation of ultimate limit states of concrete structures it is preferred to use plasticity models, especially for concrete the Chen model of plasticity.

Chen model of plasticity is a three-parameter model for concrete displaying isotropic hardening. This model expresses the elastoplastic behavior of concrete. The typical behavior of concrete is the varying stress-strain characteristics under tension and compression. Two different, but similar, functions were proposed for each of the loading surfaces, in the compression-compression region and in the tension-tension or tension-compression regions. The loading surfaces of Chen model for concrete in the biaxial-stress plane are composed of two curves. A part of the loading function is valid in the compressive area and it is a parabola. The part of loading function describes the tension and tension-compression areas and it is a hyperbola. Since the parts of the loading function are different, it is important to determine the correct stress-state zone. The curves representing two extreme situations are the initial yield surface and the failure surface. The innermost curve represents initial yield surface which is defined with initial yield stresses. The outermost curve represents the failure surface defined with ultimate stresses. An expansion of the initial yield surface leads to subsequent loading surfaces.

We have programmed Chen model of plasticity and implemented to the existing open program SIFEL. This program was created at our faculty in the department of mechanics. We have checked its functionality on several simple examples.

Concrete, one of the most common building materials, is design to serve as a hard solid. Unlike in the case of steel structures where steel members are being assembled already as a material of designed properties, concrete in majority cases is placed as a liquid substance and then gradually it becomes the solid material of the designed properties. Recently, the emphasis is put on the speed of construction. Therefore it is necessary to find how much construction process can be expedited. This often results in overloading of solidifying and hardening concrete. At this stage the structure of concrete is not fully developed. The effect of overloading, of course, depends on the specific application, as overloading can also result in proper consolidation of concrete, which is actually a positive result. On the other hand, the formwork is not infinitely stiff and so engineers try to reduce the hydrostatic pressure by the assumption that at some age the concrete can, at least partially, support itself. Then, if we know what is going on inside concrete, inside the formwork, one can increase the height of continuously poured lifts of concrete that means to expedite the construction process.

The solidifying and hardening state is dominated by the rapid progress of hydration, which must be taken into account without exception when dealing with solidifying or hardening concrete. The evolutionary function, as its name implies, is introduced in order to describe the evolutionary changes in the microstructure of solidifying and hardening concrete and therefore to control the mechanical behavior of concrete in the modeling. The function of microstructure evolution, which expresses the effect of aging, was identified from experiments on the evolution of penetration resistance, pullout resistance and compressive strength of concrete at the ages up to the final setting time. The comparison between the compressive strength evolution and expressed by the evolutionary function and experimental data shows very good agreement, see papers [2]-[3].

The mechanical behavior of solidifying and further hardening concrete is influenced by the rapidly progressing hydration. Chen model of plasticity was originally derived for solid materials with different strengths in compression and tension, such as concrete or some types of soil. In the papers [1]-[3], a combination of Chen model of plasticity and an evolutionary function of the microstructure is proposed. At very early ages, the microstructure of concrete is developing very rapidly which means that once compared with already hardened concrete, the material parameters of the Chen model should be a function of the microstructure evolution. Therefore, the material parameters used in the Chen model are formulated as a function of microstructure evolution. The proposed modification of the Chen model considers this effect in terms of the degree of hydration. So all material parameters are depending on the function of the evolution of microstructure. Therefore, it is obvious that the loading surfaces are changing with increasing time. With increasing strength of concrete the loading surfaces are expanding.

In the papers [2]-[3], an example of uniaxial compressive strength is shown. In this example the experimental data with results obtained from modified Chen model are compared.

In these papers, modification of Chen model was described, so that it is possible to use for solidifying and hardening concrete. Therefore, the parameters of Chen model are defined as a function of microstructure evolution. The data for an example was obtained experimentally beforehand. Results obtained from this modified Chen model of plasticity was compared with results of the experiments. Very good agreement of both results verify the possibility of using Chen model of plasticity not only for hardened concrete but also for hardening concrete with yet evolving structure.

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Risk and Reliability Assessment of Structures Exposed to the Impact

Karel Jung

jung@klok.cvut.cz

Klokner Institute, Department of Structural Reliability, Šolínova 7, 166 08 Prague 6, Czech Republic

Incidents where a train derails on the approach to a structure and collides with the structure are rare. However, the consequences may be very high and the risk cannot be ignored. The impact forces given for design of structures in EN 1991-1-7 seems to be very low and do not provide sufficient information for design of structures that span across the operational railway such as road bridges.

The objective of the research is to minimize risk to people, structures and environment. The suggested approach is to make optimization of design, which could be applied for any type of structure. The main risk associated with the impact of a train is harm to persons travelling in the train. It follows that the main priority should be to minimize this risk. The significant factors considered in the study include railway switches on the approach to a structure, a number of tracks, a speed of derailed train, a type of train, a number of trains per day and direction, a number of passengers per train.

The probabilistic networks represent a suitable tool for risk assessment of accidental design situation. For decision analysis, they can be directly extended to influence diagrams (decision graphs). Bayesian networks or influence diagrams provide an important generalization of decision trees. These methods are applied in the study taking into account the economic and social consequences of derailment. The fundamental rules are given by Bayes' rule and law of the total probability. Three different types of nodes are taken into account. The discrete chance node represents a discrete random variable with a finite number of states. The chance nodes represent random variables having two or more states. A more detailed description of the nodes is provided in [1], which also indicates difficulties in input data specification.

A Bayesian network is made by a set of nodes representing random variables and a set of links connecting these nodes in an acyclic manner. Each node has assigned a function which describes how the state of the children node depends on the parent node. The nodes are interconnected by directional arrays indicating their mutual causal links. All the causal links must be by appropriate input data (conditional probabilities or utility units) linked to the assumed states of described nodes. The utility nodes describe the cost of structures, additional cost of safety mechanism and cost of injury.

Risk assessment of bridge pier located near the railway facilitates to make decision about bridge support location. As it is shown the optimal distance is 3 m for the speed of 120 km/h and 5 m for the speed of 160 km/h. Presented results should be considered as examples valid for the assumed input data. These data are assessed here without due regard to specific conditions of trains and railway tracks, which may be necessary to be considered.

For the structural design, the actions due to impact may be in many cases represented by an equivalent static force giving the equivalent action effects in the structure. This simplified model may be used for the verification of static equilibrium, for strength verifications and for the determination of deformations of the impacted structure.

Eurocode EN 1991-1-7 gives recommendations for impact forces due to derailed trains. The analysis of models for impact forces made in the project shows that the resulting forces are in a wide range from 3,1 MN for speed of 60 km/h to 15,7 MN for speed of 160 km/h. The design forces after train deceleration remain in range from 2,9 MN to 14,9 MN. The models of impact forces given in EN 1991-1-7 are considered up to distance 5 m from the centreline of the nearest track to the structural member only. It may be expected that the forces beyond distance of 5 m will in reality exist and should be taken into account during the structural design. These rules should be amended taking into account obtained results including outcomes of risk assessment.

The studies indicate that for the design of structures located nearby the railways the upper bound of the accidental impact forces should be recommended in the National annex of EN 1991-1-7.

It is shown that The International standard UIC Code 777-2 and EN 1991-1-7 do not provide recommendation for the optimal decision about the location of structures near railways. It is shown that Bayesian approach represents suitable tool for risk assessment of accidental design situations due to the train derailment. Further research and more data are needed to specify a more detailed Bayesian network facilitating to make decision about location of the structures in the vicinity of railways.

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Determination of Discharge Travel Time in the River Channels System by Neural Networks Models

Ondřej Fatka

fatka@fsv.cvut.cz

Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Czech Technical University,Thákurova 7, 166 29 Prague 6, Czech Republic

The literature (1-4) used in the project describes contemporary hydrologic forecast models and the theory of the method of neural network. In the Czech Republic, the forecast survey has been managed by the Centre of Weather Forecast of the Czech Hydrometeorological Institute. The model AQUALOG has been used to predict hydrological situation at partial watersheds of the Elbe River. This model based on the knowledge of physical processes of the runoff genesis in a catchment is characterized by procedures describing simulation of main catchment processes (precipitation dynamics, runoff routing and the management of reservoirs). At the middle and downstream parts of channel network, where the runoff is already fully concentrated and where it is possible to differentiate runoff contributing and non-contributing units, the method of equivalent discharges has been also applied.

In the recent period, namely the method of artificial intelligence has been developing. The method of neural network is one of the methods used in this category of wide hydrological development. The method is based on the analysis of input-output parameters of a hydrological system. Therefore, this method is one of the back box simulation procedures. The research results in relatively different hydrological fields show a useful outcome of this method in classification of correlation between input and output parameters but also some problems namely by extrapolation outside of the observed data system and the accuracy.

In this paper, the research results on ,, Determination of discharge travel time in the river channels system by neural networks models" are presented. In the focus of this study was the hydrology of the Radbuza catchment, a tributary of the Berounka watershed: the river section between profiles of Stankov (upper inputs) and Lhota (lower outputs). The selection of this section is based on the ground field investigation. This river segment is not affected by any significant man's interventions. The number 14 flood events (between years of 1994 and 2005) were analysed in this study. The analysed number of events corresponds to the data available. The data were provided by the Czech hydrometeorological institute. The water stage records were digitizing in hourly intervals in the period of 2000 – 2005. These flood events were divided into calibrating, validating and testing data (ration 2:1:1) in the chronological order. The calibration of the model was applied for 3 sorts of the neural network (Multilayer Perceptron Neural Network - MLP, Radial Basis Function - RBF, Linear function). Their effectiveness was identified by the extent of calibration , validation and testing error. The minimum error is related to the calibration and testing the radial network. The error is related to the selection of input patterns, the number of hidden neuron, the type of transmission function, the character of input data, and to the design of the computational diagram.

It was solved two computational diagrams variants. In the case of the discharge simulation, discharges (water levels) course in lower profile on definite time step forward the information was inclused in frames of information about the discharges (water levels)

course in upper section in relevant time step. At the same time the input data was completed by the information about foregoing discharges (water levels) course in lower profile and about precipitation total in precipitation gage Stankov. The analysis was going in the one-hour time step. However, if the discharges (water levels) course (e.g. on time t+1) in lower section was thought as output for Neural networks training, there was the data about the foregoing discharges (water levels) course in the same section. The rest of inputs worked downgrade of the neural networks properties teaching in this case and it was indicated as insignificant. The number of needed input variables increased with the increasing predictions duration. The simulated discharge (water level) of the time t+1correspond significantly to observed values, however, it is decreasing with increased duration of the prediction.
The second case of computational diagram differs significantly from the first one. In this case, only one input discharge value of the time t has been evaluated. The number of outputs corresponds to the supposed extend of the discharge travel time. The discharge series were advanced back on time level t with the one hours time step. This way, 30 time shifts were created corresponding to shifts from times t+1 …… t+30. The input discharge data was complemented by information on the interface of altitudes between input and output sections for consistent time shifts. The travel time it is possible to characterize by the minimum deviations between simulated and measured time shifts. After adding the information on the relation between altitudes of the water levels between the input and output sections, the correlation coefficient increased to a value near 1, and, thus, the significant effect of this information on the quality of results confirmed.

It is evident that the information resulted from the method of neural networks are affected by the choice of the data distribution into the calibration, testing and validation.

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Interpretation of Three-dimensional Statistical Factors in Landscape Affecting Condition of Reclamation

J. Petruchová

jana.petruchova@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Mapping and Cartography, Thákurova 7, 166 29 Praha 6

Areas with open-casts cover hundreds of hectares in the study area near Teplice in the Northern Bohemia. Large areas have already been excavated and have been reclaimed and large areas are now technologically or biologically reclaimed. According to the Czech Mining Law, mining organizations are responsible for the post-mining reclamation. Reclamation investments reach high values. Their effectiveness has not yet been controlled in the Czech Republic.

The reclamation process can be characterized by several phases. The first one is called technical phase and it lasts about two years. Terrain morphology is prepared including a final surface cover created by fertile soil layer. The morphology is determined by resulted landforms and their slope stabilities and by pit shapes themselves. Their final morphology and cover type are designed by experienced specialists in individual mining organizations. Selected areas with low slope were transformed to pastures or agriculture fields. Deep excavated areas are often transformed into water basins. The Barbora Lake as the largest one is an example of them serving now as an already famous recreational center. Certain areas were prepared for the permanent vegetation – forest or non-forest. The forests are mixed forest – with mixed deciduous trees, or deciduous and coniferous trees, and with shrubs sometimes. The technological phase has to create completely new landscape different from the one before mining activities. The final morphology is influenced by shapes of the final state of mining; however the final morphology is designed according to getechnics stability laws. At the moment, the ground surface is formed by deep soil layers whose character is not suitable for planting. New final soil layer with appropriate quality is distributed on these areas of previous mining. This step is the last one of the technological phase. The second phase is a biological one when grass and two or three year-old trees are planted out. The biological reclamation comprises not only reforestation, but also new vegetation areas for pasturing and preparation of agricultural fields for crop growing. The main purpose of the biological phase is to create new landscape surface resisting erosion.

Reclaimed areas are formed by individual parts with different shapes and sizes varying from tenths of hectares to hundreds of hectares. Each part is characterized by its number, reclamation type, year when reclamation started and year of ending. The total area of reclamation has more then 3000 hectares in the study area. The first reclamation processes were finished already in 1959 – in the earliest case, and there are many reclamation areas whose reclamation process has not been finished yet.

The goal is to determine which areas developed according to reclamation projects, and which developed diversely, what was the reason of it. Vegetation indices (VI) were used for evaluating of reclamation development from 3 multitemporal TM satellite data from years 1988, 1992, and 1998 with resolution 30m of the given territory were processed. Radiometric and geometric corrections were performed and the data are in the Czech Republic

geographical coordinates. The Ikonos (2003) data were the last satellite date set in the time series. The image seriously influenced by haze and clouds were preprocessed.

Twelve vegetation indices were calculated from individual images (individual years). Relations between the red visible band with lowest values of the visible band and the near infrared band (NIR) are used by newly calculated channels to differ vegetation from other materials.

Vegetation indices were calculated from reflectance that is why digital values were transformed into it. Dark object subtraction method was used for the atmospheric correction individually for individual bands according to their histograms.

Nine vegetation indices were used for the evaluation: NDVI, DVI, RVI, PVI, SAVI, MSAVI, TSAVI, EVI, and WDVI.

Their values were compared among individual years where average values of each reclaimed area were the comparable values. Relative values of VI were used for the final evaluation of reclaimed area developments. These values took into account climate differences among years. The final evaluation discovered reliability of ground truth data taken from reclamation projects and showed where the reclamation lasted longer and therefore ended later if compared to the projects, e.g. The evaluation presents more or less correlated VI values for certain age and forest types of reclaimed areas.

Vegetation indices describe behavior of the land surface regarding the vegetation health state. To study the vegetation development from multitemporal data is a very sensitive problem. There were three image data with nearly exactly several year differences (August 9, 10, 14). Differences between individual VI´s are not mutually linear for selected period. The younger the forest reclamation the higher differences between NDVI and other vegetation indexes. Similar trends can be found at MSAVI and SAVI, then at PVI, at DVI and at WDVI. The decrease which is shown by all indices except for NDVI is at six-year old area not only with forest, but also with a grass part. By comparing only time development of NDVI we found out, that it is not at all linear for individual areas. What can be clearly discovered are dryer (1992) and wetter years (1998,) if compared to 1988. Even those clouds on Ikonos image from 2003 have been removed; the results probably don't show real VI´s values. Reasons can be extremely dry summer at year (2003), Ikonos image was not taken in August, but in September and the cleaning process may have affected the data.

Testing of nine vegetation indexes showed that their assessment of improvement among years is not the same. DVI and PVI proved 60 per cent of improvement in areas (both reclaimed and tested) what was the optimistic result in the whole study period, while NDVI and RVI showed only 30 per cent (45 from 140) of improvement for reclaimed and 20 per cent for tested areas (4 from 20). It will be followed be applying three-dimensional analyses.

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Interaction Between Columns and Cassette Walls

G. Szabó, T. Vraný

gabor.szabo@fsv.cvut.cz

Department of Steel Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6 - Dejvice

Introduction

The modern covering wall systems are designed by using thin walled steel segments e.g. thin walled cassettes. These walls primarily take advantage of the transfer of the load acting perpendicularly to the plane of the wall, i.e. wind load. These members also can carry load acting into own plane. This effect is called skin action. The elastic behaviour of the skin action by static load is known by foreign and home researches (Brian, Davies, Strnad) e.g. [1], [2]. The stressed skin action of cassette wall was also studied by Rybín [3], the results of his work will be fully used. Whereas Rybín focused in his work on the behaviour of the cassette wall itself, now the aim of the project is to investigate the interaction between cassette wall and steel frame, and first of all, the influence of cassette wall on the load bearing capacity of column, subjected to bending and compression, in case of buckling in the wall plane. Cassette wall completely or partly prevents the column against out-of-plane flexural buckling and lateral-torsional buckling. This fact leads to increasing the column buckling resistance.

The main aim of the project is the design of the method or model, wherewith it will be able to determine the load capacity of pressured and/or bended column stabilized by thin walled steel cassettes.

While lateral restraint of column provided by cassette wall was determined in [3], its torsional restraint is not known. To determine this effect of stabilization by cassettes, the experiments and numerical analyses of connection between steel columns and cassette walls were carried out in CTU in Prague.

Experiments

A set of experiments was carried out in the laboratory of CTU in Prague to determine the stiffness of elastic rotational support that is provided by cassette wall to the column. This stiffness C_ϑ is called rotational stiffness. The probed parameters, which influence C_ϑ were the following: width of column flange, sheet thickness of cassette, and the number and position of screws used to connect the cassette to the column flange.

In experiments the column was replaced with steel plate, which represented the flange, in order to enable comfortable manipulation with specimen. The length of specimens in cassette span direction was only 750mm because the experiment was focused on the local effects of the column - cassette contact area. The cassettes were supported in such a way so as the deformation was only local, near the contact. Each cassette was connected to the flange by two or three self-tapping screws with rubber chock (JZ2-6.3x19-E16). The position of screws was varied with respect to the axis of the flange. After the specimen had been completed it was hanged up. The loading was carried out by cantilever, which was welded in place of web of column section. The specimens were loaded by torsional moment that developed rotation of the column flange. The relation between torsion moment and flange rotation was recorded in each load step. The loading was static. The number of realised tests was 16.

Numerical Study

The software package ANSYS 8.0 was used for the numerical analyses. Various finite element models were made for the cassettes. Both cassette and the column flange were modelled using shell elements. In order to save solving time, only the column flange was modelled. Connection of the cassettes to the flange was the same as in the experiments. Full Newton-Raphson geometrically and materially non-linear procedure with large deflection effect was used in the analysis. A number of alternative boundary conditions was tested until the model corresponded to the specimens.

The shell element SHELL181 was used for the modelling of the cassettes and for the flange, too. The difference of these 2 types of elements was in the thickness and in the yield strength. The connection between the cassettes and the flange was simplified: equal deformation in each direction was applied to the nodes in the position of screws. The model was gradually tuned while the simplification effect was eliminated. A contact pair was created between the cassette and the flange, to prevent the penetration of material: the CONTA174 element was used for the modelling contact elements and TARGE170 for the target elements. Boundary conditions were defined according to the real test specimen arrangement. Load was applied as uniformly distributed torsion moment along the centre line of flange.

Comparison of Experimental Results and Numerical Study

Results from numerical model and from experiments were compared. The secant stiffness values were evaluated and compared. The model gives acceptable results from the flange width up to 250mm. That means that the model can be used to the parametric study.

Results of Study

The effect of restraint against rotation provided by cassettes was checked by formula for continuous torsional restraints proposed by Lindner [4]. From this comparison it is clear that the cassette wall stiffness supports the column against torsion in some cases fully and in other cases partially, the restraint is nevertheless efficient even when it is partial.

Obtained stiffness will be used in the global behaviour model of the beam-column that is partly or fully supported by cassette walls.

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Stability of Cold-formed Purlins

J. Egrtová, T. Vraný

jana.egrtova@fsv.cvut.cz

Department of Steel Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6 - Dejvice

Introduction

Purlins are used in metal building roof construction to support light-weight roofing which is usually made of corrugated sheet metal or sandwich panels. Roofing provides lateral support to the purlin. In turn, the purlins support the roof sheeting, provide lateral supporting to the main building frames and are required to carry axial force from the building end walls to the longitudinal wind bracing system. Cold-formed purlins are efficient, economical structural members of low weight, produced from high strength steel sheet. They are available in a large range of the Z sections [1].

Typical roof purlin systems are single span, double span system (purlin is physically continuous over one support) or, in most cases, continuous over a number of supports. Then the continuity is physically obtained by sleeved purlin system or overlapped purlin system. Generally behaviour of examined static system is affected by following factors: static scheme of the beam, type of locking the continuity, cross-section, sign of loading, type of sheeting, position and distance between sheeting fasteners [4].

Content of this paper is analysis of constituted factors that affect buckling resistance of continuous purlin with continuity provided by overlapping. In order to make lapping of the sections possible, one flange of the section should be wider than the other. The inverted section fits inside the original. Another possibility is to use Z section with end lips under at least 20° angle. There is double cross-section in this overlapping area, but the resistance and stiffness are reduced by slip in connection. Determination of the ultimate bending capacity of cold-formed steel beams is complicated by potential failure mechanisms of material yielding, local buckling, distortional buckling, lateral-torsional buckling, and combinations thereof. Because Z-purlins are point symmetric and the applied loading is generally not parallel to a principal axis, the response of gravity loading is complex. The problem of the behaviour of cold-formed thin-walled Z shape purlin is further complicated when purlin is only partially restrained by connected sheeting: upper flange is laterally and rotationally restrained by connected sheeting, bottom flange is free. In hogging moment areas the bottom flange is under compression and it is subjected to possible buckling out of plane of the purlin web. The resistance of purlin acting as continuous beam under gravity loading is affected by mentioned free flange buckling and by interaction of moment and reaction. Methods of analysis of such system are known for only physically continuous beam [3], for sleeved or overlapped system general calculation methods of analysis do not exist.

Experiments

The series of one-point bending test is right now in progress in laboratory of CTU in Prague. Set of experiments is carried out to determine the local and distortional buckling resistance in hogging moment area (area of internal support of continuous beam under gravity loading). The experimental scheme is reversed in comparison to the original continuous beam. Static scheme of the tests is continuous three-span beam. Outside supports are pinned, internal spring supports are flexible in vertical direction with stiffness derived from required moment

ratio. The loading is controlled by displacement in order to enable to study the behaviour of the purlin after it has yielded. Loading force simulates reaction in support on continuous beam. This static scheme was selected to give a truth end conditions of purlin on point of transition from hogging moment to sagging moment area.
There is test 20 specimens in test structure. Each specimen consists of two parallel purlins, which are laterally restrained by trapezoidal steel sheeting. Variable values are: length of specimens (2 lengths: 4.3m, 5.6m, corresponding to original continuous beam of span 6, 9m), length of overlapping (2 lengths), 2 types of cross-section, density of sheeting fasteners (in each channel of sheeting, alternate scheme). Also specimens without overlapping were tested for the sake of comparison.

Numerical Study

The software package that is used for the analysis is ANSYS 8.0. The purlins are modelled by using shell elements SHELL 43 (4 node plastic large strain shell). For solution is used geometric and material non-linear analysis with imperfections (GMNIA), supported by eigen-buckling analysis.

Results of study

The problem of the behaviour of cold-formed thin-walled Z shape purlin is very wide. Subject of the work is determination of buckling resistance of continuous purlin with continuity provided by overlapping. For solving this problem the experiments are absolutely essential, they are just proceeding in laboratory of CTU. The collapse is observed at the end of overlapped area, with relevant influence of lateral buckling of the free flange. In the near future the experiments will be finished and a numerical model will be further developed and calibrated using the experimental results.

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Innovative Lectures on Geotechnics in BSc. and MSc. Programs of Study in Civil Engineering

L. Lamboj, J. Jettmar, J. Pruška, J. Salák

lamboj@fsv.cvut.cz

Department of Geotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Geotechnical Engineering is one of the main topics in Civil Engineering and it plays the important role in recent study programs as stand-alone branch of study at European Universities of Technology. At our faculty the Geotechnical Engineering is traditionally a specialization at branch of study Structural and Transportation Engineering. Constituent subjects of Geotechnics are essential components of courses of study in all specializations and fields of study at this faculty. About 1,500 students are instructed in Geotechnical subjects every year, both in the Czech and the English languages.

These subjects as a combination of natural science and engineering approach help students establish their relationship to the environment, find and discover connections between nature and technological growth and lead them to feel responsibility for consequences of civil engineering practice. Ecological aspects of geotechnical lectures cannot be substituted by any other specialized subject.

Two years ago, the courses of study were divided into Bachelor and Master study programmes and together with this transformation the decision about the reduction of the number of lessons was accepted. The most problematic consequence of this alteration was a lack of classtime for theoretical basis of Geotechnics – mineralogy, petrography, soil and rock mechanics. The limited amount of direct contact time can be compensated by supplementary on-line courses, which enable its users both to study individually and to check the level of mastering the new knowledge. Thus, the course can improve the examination results of students.

For these tasks it is necessary to keep the computer equipment of the department computer classroom on current standard through the periodical update, both hardware and software. One principal aim of the grant project, passed in internal grant competition of CTU, was to improve the material basis for this format of lectures. The department computer classroom, which had been used for teaching subjects concerned with numerical modelling in geomechanics since October 1998, was equipped with 5 new computers in 2003 and 5 old computers and server being fitted in 1999. This coexistence was not sustainable for the new tasks having been faced up to hardware, concerned with the regular work of hundreds of students.

As planned, new computers, fileserver with Raid data storage, scanner and print server were installed together with new versions of geotechnical software. However, the financial support of this project was limited and investments in software updates were fulfilled by other department research and development projects of Czech Grant Agency and FRVS (University Development Fund).

As the project was consequent to the long term ideas of modernization of the instruction at the department, and as the material basis was improved, the authors of the project together with the other department members would continue in transforming of lectures and in extending of on-line courses in teaching process.

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Testing of Properties of Fine-grained Concretes

Vladimíra Mlčochová

vladimira.mlcochova@fsv.cvut.cz

Department of Concrete Structures and Bridges , Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

Newly developing technologies of concrete production and ever more exacting demands quality, durability and strength require very good knowledge of concrete properties. Properties of components, their mutual interaction and effect in the mix, influence properties and behaviour of fresh concrete and finished concrete. This article deals with testing of properties of fine-grained cement grout, which is typical of a significant rate of mineral admixtures and additiones.

Cement mortar, that was examined in terms of alluded experimental measurement, contains an amount of supplementary cementitious materials. For cement CEM I – 42,5 Radotin and fine - grained sand grain size 0 – 1 mm, mineral admixtures such as silica fume, ground limestone, fly - ash were added. Total rate of these additions in this case is higher than in common mortar mixture for concrete‘s production. Using admixtures which are up to 0,25 mm may reduce internal friction of freshly mixtures, restrict bleeding and increase cohesion mixtures. Required workability and consistency mixture was reinsured addition of superplasticizer Stachement 2000 and 2050 at keeping low water cement ratio. In order to eliminate negative properties of segregation and bleeding from mixtures, viscosity modifying agent Stabilan KP- 1 was used. For obtaining view about influences of particular components, more components from single components and their various dosage were used in production experimental mixture. From set properties that characterize behaviour mortar mixture in fresh state, examination was specialized mainly on assesment rheological properties, i.e. flow and agility mixtures and its segregation resistance against the rising of free water to the surface of fresh concrete or mortar.

Flow/spread table test in the publications features like base at determined consistence of fresh mixture. Sample mixtures put the experimental cylinder on measuring board, which is lifted after filling. Examination rests in measurement maximum rate diffusion „ sizes cakes" constant volume in produced mixtures.

V-funnel test is an examination of flowagility for assesment of rapidity of flow mixtures. This property informs with acceptable approximate measure of viscosity mixtures. Principle of testing is based on measurement of time when certain content mixtures leave off funnel. Flow-times can be easily measured in the first stadium experiment, when differences of measured flow-times were quite distinct. However, during experiment, it is showed that measurement those characteristics, in conditions of short interval of mixtures‘ flowing out from funnels, isn't decisive enough and then variable time when mixture reaches the maximum spread was measured.

Segregation is the tendency for coarse aggregate to separate from the sand-cement mortar, whereby happens to mixture distribution on cement suspension and row settled solid particles, mixture so subsides to be homogenous. If segregation is displaced, concrete after hardening is highly compact, consistent and resulting physical characteristics are better. Bleeding is the

development of a layer of water at the top or surface of freshly placed concrete. It is caused by the settlement of solid particles (cementing materials and aggregate) and the simultaneous upward migration of water, which brings along with it small components to the surface. A water pocket or void can develop under a prematurely finished surface. After evaporation of all bleed water, the hardened surface will be slightly lower than the freshly placed surface. Rate of bleeding is possible to be reduced by decreasing water/cement ratio or remixing. A small amount of bleeding water which is absorbed during the beginning of hydratation process isn't on defect.

In this work, testing method based on following subsidence surface cement mortar in measuring cylinder was proposed. Bleeding rate was determined as quantity of separated water read on measuring cylinder scale, and segregation as high settled layer solid particle read on measuring cylinde scale. This layer was finded out change resistance by pricking mixtures with steel bar.

Executed examination in a row cases proved significant dependence between kind and dose used components. At establishment properties these mixtures it is necessary consideration also to influence combination separate kinds addition and admixture in light of their reciprocal tolerance. Knowledge of the properties of fine - grained cement mixture is specificly part of technology concrete, from which it is possible expect her next development.

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Ventilated BIPV Systems - Structural and Energy Design

K. Stanek*

kamil.stanek@fsv.cvut.cz

*Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thakurova 7, 166 29 Prague 6, Czech Republic

BIPV Systems

Building Integrated Photovoltaics (BIPV) is rapidly developing concept of integration of hi-tech renewable energy sources into building envelopes. Built environment represents wide field for utilization of photovoltaic (PV) systems. BIPV systems can be designed in the form of façade or roof cladding or semitransparent PV glazing with emphasis on its full functional, structural and aesthetical integration and cooperation with the building. The accent shall be put on full utilization of possible synergy effects. In this manner photovoltaics adds a new function to the traditional functions of the building envelopes – independent production of electrical energy.

One of many possible ways of integration of photovoltaic system into building is a ventilated PV façade. By the ventilation (forced, natural or combined) a high efficiency of sunlight conversion at solar cells is ensured. At the same time the waste heat from a ventilated air gap can be collected and utilized.

Limited number of research teams in Europe is specialized in the field of BIPV systems, particularly in the ventilated PV façades. The leader in the field is joint team of researchers from the Hoschule für Technik in Stuttgart (Dept. of Building Physics) and from the Loughborough University (CREST). Under supervision of this team the experimental ventilated PV façade at the Mataró Library in Spain was built up.

Ventilated PV façade at the FCE, CTU in Prague

During 3rd quarter of the year 2005, a large-scale experimental PV installation was raised at the Faculty of Civil Engineering, CTU in Prague, with the support of the State Environmental Fund of the Czech Republic. The system consists of two parts – a ventilated PV façade and an open-rack roof PV installation. Total number of 386 monocrystallic PV panels (Solartec SI 72-106) was used (176 at the façade, 210 on the roof). The façade installation is the first mechanically ventilated PV system in the Czech Republic. Research on the system is firstly aimed at understanding the behavior of PV applications in relation to buildings and secondly at a potential of mechanically ventilated PV systems utilizing the waste heat.

The façade installation is equipped with an extensive measurement of key physical quantities. Total number of 52 sensors is placed on the façade. PV panels' backside surface temperature, air temperature and airspeed in the ventilated gap and global radiation on panels' surface are measured. Measured data are collected and stored in data acquisition system connected to PC. The roof installation is equipped with 8 additional sensors including pyranometer measuring global radiation on horizontal surface and ambient temperature sensor.

Numerical model

At the same time a complex simulation model of the ventilated PV façade is being developed in MATLAB. The model consists of 4 partial models – a meteorological model, airflow model, electrical and thermal model. The meteorological model processes tabulated meteorological data loaded from the METEONORM database. The most important quantity is solar radiation incident on a sloped surface of the façade (90°, southwest) which is calculated from radiation on a horizontal surface [1]. Other necessary meteorological quantities are ambient temperature and wind speed.

The airflow model is based on a computation of a velocity profile between flat parallel plates. Flow regime is considered to be 1D turbulent for uncompressible newtonian fluid [2].

The thermal and electrical models are characterized by strong interdependency due to relation between efficiency of solar cells and their operating temperature (efficiency is decreasing with increasing operating temperature). However, the operating temperature can be effectively lowered by mechanical ventilation. The electrical model is based on empirical Photovoltaic Array Performance Model [3]. The thermal model comprises all the main heat transfer modes occurring in the system. Heat is conducted from the cells towards panel surfaces, where it is radiated and convected to the surroundings or to the ventilated air gap, respectively [4]. The heat from the air gap can be collected and further utilized in the building.

Conclusions

The numerical model will be verified after adequate number of measured data is received. Verified model will perform as a software tool for designing and optimization of ventilated PV systems integrated into buildings.

As a part of the project web pages http://fotovoltaika.fsv.cvut.cz were created to provide all the information about PV system at the FCE and BIPV systems in general.

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Management of Water Supply Operations – Loos Analysis

R. Veselá*

renata.vesela@fsv.cvut.cz

*Department of medical and ecological engineering, construction faculty, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

Water losses indicate the amount of water leaked out of the water distribution system, not efficiently used and the amount of water taken but not discovered and not registered by the operator. Loss monitoring is one of the basic obligations of operators. Their size points to technical states and network operations, and at the same time is decisive for returns on future investment. Loss reports have recently recorded several changes. Values that describe the amount of unique leakage are continuously more often being used with traditional percentage data on losses related to the overall volume of supplied water. These methods try to cover various types of plants.

In the loss reports, the specification of a uniform content of some terminology used relating to water losses is important. The volume of water produced for realisation (WPR) is made up of water supplied (WS) into the system plus water taken (W_{taken}) minus water given (W_{given}) into another water system. Water produced for realisation is divided into two components – water billed (WB) and water not billed (WNB). Water billed is made up of water billed to households (WBh) and other water billed (WBo), which represents water billed to wholesalers and industry.

The notion of choosing one indicator for assessing water losses and comparing results is not simple. The totally different specific conditions and totally differing character of various water systems substantially influence the objective comparison of results.

The percentage of water not billed used to be the most widely used criterion for evaluating losses. It is calculated as the proportion of water losses in the piping network out of the entire volume and water produced for realisation. This criterion became accepted for its simplicity and the availability of the necessary data for calculations. Another advantage is the comparison of not billed water volume. The main insufficiency in this indicator is that it only has a descriptive economic significance. It is dependent on the volume of WPR, but it does not take into consideration the technical state of the network. It cannot be used to compare areas with various consumer demographics, for various lengths of water network, various structures of terrain or for fluctuation of production and billing.

In the early 1980s a technical criterion called unique leakage (UL) began to be used to evaluate losses. It expresses the volume of water not billed for 1km of converted length of network and is given in thousands of cubic metres per km per year. It has several advantages compared to the previous criterion. It is more precise than the percentage of water not billed, systems with varying network structures can be compared due to it, and mainly it takes into consideration the size of sections of the water supply network by implementing converted length. Unique leakage also has its disadvantages, one of which is the need to know the structure of the network (in this regard the background information for calculations is less available than for the calculation of a WNB percentage). Another disadvantage is that it is not totally evident from the calculation whether there is leakage of water from the network or a mistake in billing.

Various water companies were compared. In this text I compare the following nine companies: Pražské vodovody a kanalizace, a.s (PVK), Severočeské vodovody a kanalizace, a.s (SČVK) (with a number of residents supplied of over 1 million), Brněnské vodárny a kanalizace,a.s (BVK), Vodovody a kanalizace Hodonín, a.s., Vodovody a kanalizace Hradec Králové, a.s., Vodovody a kanalizace Jižní Čechy, a.s. (with a number of residents supplied of between 100-400 thousand), Vodovody kanalizace Trutnov, a.s., Vodohospodářská společnost Sokolov, s.r.o., and Vodovody a kanalizace Beroun, a.s. (with a number of residents connected to the water supply of under 100 thousand). For each company the trend in number of residents was monitored, as well as the length of water supply network, volume of WPR and WB and the losses calculated from them.

The number of connected residents has seen a predominantly increasing trend in the past six years. Exceptions were for the company PVK, where the number of connected residents decreased by 48,000, for BVK with a decrease in number of supplied residents by 9,000, and for VAK Beroun, where the decrease was very slight by only 260 residents.

The lengths of water supply systems increased, except for VHS Sokolov and VAK Trutnov, for which the length of piping remained virtually unchanged. Conversely, the largest additions were recorded by VAK HK and VAK JČ, where the network grew by 500 – 600 km.

Monitoring the percentage of WNB showed a decrease in losses during recent years, but for some companies there was an increase in losses according to this criterion. The most significant decrease was recorded by VHS Sokolov, by approximately 20%. Another significant decrease was managed by PVK and by SČVK, which decreased their WNB percentages by over 10%. Other companies did not achieve an increase of over 2%, and VAK Hodonín, VAK Jižní Čechy and VAK Hradec Králové increased their loss percentages.

Conversely, the value of unique leakage calculated for 1 km of network (not converted, because detailed network data was not available) decreased considerably for all compared water supply companies. The largest value for this indicator belonged in 1998 to PVK, which currently has a UL of 16.42 thousand m^3/km/year, which is a decrease of over 74% on the previous amount. The highest percentage decrease in UL value was by VHS Sokolov, by 88% (from a value of 41.95 thousand m^3/km/year to 5.02 thousand m^3/km/year). For all the other companies the UL values decreased by over 60%.

The final criterion being monitored for loss evaluation was leakage per supplied resident. This criterion showed a decreasing trend for nearly all the companies for the period monitored. Only VAK Hodonín and VAK HK recorded a slight increase by around 2%. We can notice the most significant decrease for SČVK (by 56.37%, from 78.54 m^3/person/year to 34.25 m^3/person/year) and for VHS Sokolov (by 57.82%, from 68.95 m^3/person/year to 29.08 m^3/person/year). Other companies achieved a decrease in this value of 10 – 40%.

From the results shown, we can observe the development of water supply systems and the efforts of operators to decrease losses. The majority of water companies are achieving a proportionally considerable improvement in loss reports. The UL value in particular is on a good trend for all the selected companies. You can also notice the various values of loss sizes expressed using various criteria.

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Erosion and Hydrological Processes in the Small Alpine Catchment

VESELÝ P., PAUČKOVÁ M., KŘEČEK J.

pavel.vesely@fsv.cvut.cz

Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Czech Technical University,Thákurova 7, 166 27 Prague 6, Czech Republic

Whole research is held on the Rio Brusa catchement, The Dolomites, Italy, and covers erosion and hydrological processes there. The results of research were demonstrated on a several foreign conferencing and presented in few articles in scientific compilations. This short article describes research in small alpine catchment, focused on debris outflow and forest role there. It was though about idea, what would happen, if the forest would be completely skidded. The used statistical methods are typical for simple data processing and database is from three summers of last years (2002-2005). Results show on very important attendance of forest in mountains, because it slows the erosion processes. second idea was developed thank to study brunch of researcher – structure engineer. It was thought that the debris – dolomite and limestone – is possible to use for constructing as filling material for concrete to houses' foundations. Sometimes people decide to create natural parks and reservations, or protected areas, but not everywhere. And is the Nature able to revenge to human specie? Not only globally, it would touch all of us very fairy. Local disaster is a little bit painful, because they can cause death of us on holydays or of our relatives anywhere and nobody is guilty in fact.

The research should describe one possible situation, which can occur in the high mountains' areas. Namely, we will talk about Italy – north part of country. The Dolomites region lies there. And high mountains do have deep valleys, fast flowing water, debris fields and wild forests. But not always. Unfortunately, we, as people, live almost everywhere, also on mountains. They are used for becoming of timber and firewood, for excavation of fallen stones and for tourism. It is main source of money for people living there on this place in Europe. Service's employees very often live as close to the valleys as possible and also using the natural wood sources there. In case of no protected area, of cause. And thank to it, on some places, there are no trees more. The man is not only destroyer of environment. Also rain showers and high precipitations scratch flora from hills' slopes. And there is no many for replanting and recovering of nature. Why though? Following study shows possible disaster could be appeared in mountains' valley or under it after heavy rain with high gross precipitation amount. It was determinated the study area, where the main data set was taken. The methodology of research and data processing and the results were created. But it is still necessary to continuing in data taking. What could happen if there would be no forest in the valley? The outflow of stones-debris could be after not strong rain so big that could destruction of lower laying villages, with people of cause.

The typical "leaf"s" shape of the observed catchment touched also this case. Small watershed lies close to Austrian border. In fact, it drainages own waters to Rio Rienza, flowing trough first parallel valley to Austrian borders, south direction. Rio Brusa - Bruntsbach is the main drainage stream. Due to data collection it was possible to develope many statistical relations between water outflow, precipitation amount, and storage capacity of area.

The outcomes of processing were distinguished to two categories. How much of water is caught by forest averagely from the whole watershed and how much of water is absorb by forest from the debris and bare rock areas. In the watershed we can find est. 1,76 km^2 of bare rock and debris areas and est. 2,84 km^2 of forested and grassed areas. Global reduction due to forest of water moves around value 98 % of total precipitation amount by very many observed precipitation heights. On the other hand, reduction of water flowing through debris and bare rock increased quickly with climbing up of precipitation heights. It opens door for possible scenarios.

In the mountain regions we find many types of rock erosion – as releasing, moving and depositing of stone pieces and soil pieces from upper to lower parts of watershed. Many factors – climate, soil and rock type, vegetation, topography - influent the erosion. They lead from raindrop over sheet, interrill, rill and gully to sediment transport erosion in the channels. According to this phenomenon debris outflow research has been being held since 2002 in the watershed. Results of research are relations between maximum discharge and intensity, respective height of precipitation and equation giving average outflow of solid material from area according to maximum discharge during "high water" event, which songs:

$m = 195542 . Ln (Q) + 667198$ [m – kg/ (m^3/s) Q – l/s]

If we chuck all trees and soil is taken out due to erosion, we could premise, that the total precipitation amount fallen on the watershed would flow out also with stones and rest of soils. For this occasion the increased precipitation height were estimated. Estimation computes with idea, that the percentage of absorbed water from bare rocks not e.g. 85%, but 0 % and for computation the rainfall heights conformably increased.

The observed and computed results are not so dangerous and huge and one could shift them out, but. According some regional formulas, maximum outflow from the watershed could be, forest included, around 28 m^3 and other events shown in fig. 10 say that we have to be careful. Nobody is going to destroy nature now, but if it had happened, it wouldn't be good. Observed catchment own est. 50 years old forest and it looks lake planted by man. It shows on possibility that in non protected are is timber normal trade article and with relation to climate changes it seems to be a problem, because changes cause the extremes in hydrology. It means increasing of precipitation amounts, causing big erosion on the skin soil surface. Hopefully, the similar researches will warn us against rash landuse. On the other hand, it is possible to use the debris caught in the end of catchment like a building-stones and their yield is computed also from shown equation.

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Efficiency of Primary Sedimentation

V.Jáglová

veronikajaglova@centrum.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering,
Czech Technical University,
Thákurova 7, 166 27 Prague 6, Czech Republic

Primary sedimentation (settling), the principal form of primary treatment, is the oldest and the most widely used unit operation in wastewater treatment. Primary treatment is the first step in many wastewater treatment plants and reduced suspended solids and biochemical oxygen demand (BOD) loading on downstream treatment processes.

Efficient solids and BOD removal in primary clarifiers enhances the effectiveness of downstream biological treatment processes, lowers the oxygen demand, and decreases the rate of energy consumption for oxidation of particulate matter.

Primary treatment equalizes raw wastewater quality and flow to a limited degree, thereby protecting downstream unit processes from unexpected surges in flow.

The most common form of primary treatment is quiescent settling with skimming, collection and removal of settled primary sludge, floating debris and grease.

While primary treatment is used in almost larger wastewater treatment plants, it can be omitted for smaller wastewater treatment plants. The solids that would have been captured in primary treatment then become part of the secondary sludge.

In the last years, particularly, thanks to the improvement of fine screens and enhancement of their screening efficiency, primary clarifiers are eliminated from the technological process of the wastewater treatment. This is typical mainly for smaller wastewater treatment plants (less than 10 000 PE).

The problem of lack of nutrients for bacteria in the biological treatment process results at simultaneous high efficiency of fine screens and primary clarifiers and then it is necessary to supply this nutrients to activated-sludge system and it add to the operating costs.

The question is, if it is possible to eliminate primary clarifiers from large wastewater treatment plants (over 10 000 PE) and this space resulted from the elimination could be used for needed intensification of the wastewater treatment plant, actually for settlement tanks.

The target of this grant was to determine primary settling efficiency. The grant outcomes will be the part of doctoral thesis named “Sludge balance of wastewater treatment plants”.

Wastewater samples for this grant were taken from the Prague Central Wastewater Treatment Plant on Střelecký ostrov.

Wastewater was taken from wastewater divider before the inlet to the primary clarifiers.

Raw wastewater contains suspended particulates heavier than water, these particles settle by gravity under quiescent conditions.

Gravity settling is an effective removal method for raw wastewater suspensions, which range from a low concentration of nearly discrete particles to a high concentration of flocculent solids.

For the calculation of primary clarifiers, where gravity (simple) settling runs, is important to know the suspension settling characteristic.

The most widespread method that goes out from the suspension analysis (so-called settling tests) was used. This suspension settles on static condition in water column definite

height and diameter of experimental settling column. Well interspersed wastewater (ap. 20 l) filled the settling column and the samples were taken from the selected depth in different time intervals. The suspended solids concentration was determined from these samples.
In the beginning the wastewater suspension was apportioned for the whole column height. Sample was taken in arbitrary depth h for the time t_1 after filling suspension. In this sample with concentration c_1 were particles with maximum settling velocity $u_1 = \frac{h}{t_1}$.

All particles with settling velocity $u_{to} \geq u_t$ were separated. These particles comprise $(1-x_o)$ from the original total amount of particles in the settling suspension. Mass share of the separated particles, with the velocities $u_t \leq u_{to}$ is determined by integral $\int_0^{x_o} \frac{u_t}{u_{to}} dx$.

Total particles elimination from cleaned suspension equals $x_c = (1 - x_0) + \frac{1}{u_{t0}} \int_0^{x_0} u_t dx$.

Last equation member could be determined by graphic integration from the velocity curve obtained by settling test for yields 0 to x_o.

Samples were taken in determinate time sequence and established concentrations were plot on a graph depending on maximum particles velocity. The result is settling velocity curve that characterises given suspension. It is possible to determine primary clarifier efficiency owing to this curve.

The main outcome of this grant is that the shape of the settling velocity curve is different from the shape mentioned in the literature. The real shape complies with logarithmic curve shape.

Final conclusion of this grant is valuation of the primary clarifier efficiency for primary clarifier in Prague Central Wastewater Treatment Plant. Realised sedimentation tests showed that value u_{to} is 0,66 m/h for suspended solids concentration 115 mg/l. From these laboratory values imply that the efficiency of primary sedimentation in primary clarifiers in Prague Central Wastewater Treatment Plant is about 95%.

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The Influence of Temperature Changes on Dynamic Behaviour of Structures

Jan Herel, Michal Polák

Jan.Herel@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept.of Structural Mechanics

Thákurova 7, 166 29 Praha 6

This paper describes configuration and results of a long term experiment. The supporting structure of the bridge from the pre-stressed concrete is observed from view of changes of temperature and of influence changes of temperature on dynamic behaviour of the structure. There is description of measuring line for measuring changes of temperatures and configuration of measuring line for observation of dynamic behaviour of a structure. At the end of the paper, the results from the initial stage of the experiment are also given.

Experiment described in this paper is pursued mainly from these two arguments:

Temperature load is an important part of stress of bridge constructions. Because of the transition from the Czech standard "Bridges load" (ČSN 736203 „Zatížení mostů") to the Czech standard "Part 2 – 5 Construction load – temperature load (ČSN P ENV 1991-2-5 „Zásady navrhování a zatížení konstrukcí – část 2 – 5: Zatížení konstrukcí – zatížení teplotou") the question arises, if prescribed design temperature gradients fully correspond to the climatic conditions of the Czech Republic.

Some authors ([2], [3]) present in their publications recently, that dynamic properties of building constructions depend on their temperature. The question is to which extend such influence shows in big bridge constructions of pre-stressed concrete.

The results of the experiment may be used even to estimate the level of degradation supporting construction of the observed bridge based on the possibly observed permanent trend of the change of its dynamic characteristic (in particular its natural frequencies) like in [1].

The box-girder bridge at the 63rd km of the motorway D1 over the Želivka reservoir was chosen for the experiment. The motorway D1 crosses this valley in the form of two bridges of identical construction one for each traffic direction. Both bridges consist of a pair of cells. The experiment is performed only on the left bridge used for the traffic from Brno to Prague.

The supporting structure of this bridge was assembled of two rows of segments of cellular type of a constant height of 4,20m and width of the upper slab 6,0 m, which were mutually connected. The total width of the supporting structure is thus 13,0 m.

The supporting structure consists of a 3-span frame (54 m, 75 m a 54 m) from pre-stressed concrete.

The measurement of dynamic response is performed on cells A and B. Inside of cell A is 16 – channel - measuring device from BMC – GmBH, Puchheim. The dynamic response in cells A is measured by 3 inductive relative displacement transducer type W20 from Hottinger Baldwin company, which are placed as follows: one in the central field in the middle of the span and two in the first and the third field always 18m from the axes of the bearings on the abutments respectively. The three absolute displacement transducer of deflection B3 (Hottinger Baldwin) are situated in the same points as the relative sensors. The dynamic response is also measured by two strain gauges, which measure relative deformation in the direction of the longitudinal axis of the bridge on the inside surface of the upper and bottom

slab of the cell and by temperature sensor. Cell B is equipped similarly as cell A, but without the sensor of temperature and without two absolute sensors in side spans.

The measuring device MS2+ from the firm Comet System with 10 temperature sensors N1ATG7/0 (sensors 1-10) was installed on the bridge on 17th March, 6 sensors (sensors 1-10) were added on 27th March 2005. All the sensors are placed in a single cross-section of the cell A in the middle of the central field.

For the purpose of calculating gradients of temperature the sensors in slabs and side walls are placed in pairs. For the sensors nrs. 1, 3, 5, 7, 11 and 13 holes were drilled from the inside of the supporting structure so as to place the sensors approximately 2 – 3 cm from external surface of the supporting structure. The sensors nrs. 2, 4, 6, 8, 12 and 14 are attached at inner surface of the cell A.

For the sensors nrs. 15 and 16 holes of an approximate depth of 2 – 3 cm were drilled from the inside of the supporting structure, in which sensors were installed and insulated, they check the surface measurement by sensors 8 and 14.

To measure temperature gradient on the side wall before the extension of the measuring device and addition of sensors the external side wall of the cell was selected, which is not protected from meteorological influence by other cells (sensors 3- 6). Since the sensors were added on 27th July the inner side wall is also observed (sensors 11- 15).

Naturally, the temperature of the air is also measured inside and outside of the structure. The sensor nr. 9 is suspended freely inside of the cell and sensor nr. 10 monitors the outside temperature of the air in the space between the cell A and the cell B.

This observation of the changes of the dynamic characteristics of supporting structure of the investigated bridge and their dependence on the temperature continues the study [4], in which basic natural frequency of the observed bridge was established as: $f_{(1)} = 2.55$Hz.

The highest temperature gradient 7.0°C was established, according to presumption, in upper slab (4:45 p.m., 21st May 2005) , which is influenced by the asphalt, warmed by sun.

The changes of basic natural frequency according to [4] are very little so far and they are within the range of the presumed mistakes in the result establishment.

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The Influence of Corrosion on Load Capacity of the Bolted Joints

J. Henzl, J. Studnička

jan.henzl@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The ATMOFIX is the trademark for Czech made (Cor-ten type) low-alloy weathering steel with relatively small content of alloying elements such as Cu, P, Cr, Ni, Mo, V, Ni, and Ti. These elements react with atmosphere and together creat upper closed layer – patina, which protect steel surface against atmospheric corrosion. For good patina a periodical drying and moistening of surface is needed. Relative humidity should be at least 60 %. Patina is not created in permanently wet conditions or when too aggressive atmospheres. The structure of weathering steel ATMOFIX consists of fine-grained ferrite with cementite precipitated at the grain boundaries of ferrite. The weathering steels were used primarily on structures of power lines masts and towers in the Czech Republic for their own internal protective system. There has been erected more than 4000 power transmission towers in last 30 years and now these towers are in very good condition with rusted patina well developed, but bolted connections are corroded strongly and owner is disappointed of it [1]. Authors tested load capacities of rusty joints that were cut from crashed towers and compared them with identical joints from steel untouched by corrosion.

First experiments to determination of influence gap atmospheric corrosion on load capacity of rusty bolted joints were carried out by VUT Brno (J. Vengrin, J. Melcher, L. Rozlivka) and EGE enterprise (C. Laub).

The specimens were prepared from crashed power line tower and subsequently arranged to tensile tests. Specimens were made of material corresponded to chemical composition to weathering steel ATMOFIX 52A. There were made and tested following specimens:

- Specimens A1, A2, bolted joints of angle staffs consist of two joint plates of thickness 8 mm, two angles L90x90x6, twelve bolts M20 5.6, nuts and washers.
- Specimen A4, bolted joint of angle staff consists of two joint plates of thickness 8 mm, two angles L90x90x6, only ten bolts M20 5.6, nuts and washers. This modification was simulated unexpected loss or fracture bolts.
- Specimen A3, bolted joint of angle staff consists of two joint plates of thickness 8 mm, two angles L90x90x6, twelve bolts M20 5.6, nuts, washers and jointing strip of PVC thickness 3 mm. This modification was simulated gap corrosion of joint.

Further were made and tested following specimens:

- Specimens K1, K3, K6, K7, bolted joints of angle staffs consist of joint plate and cover plate of thickness 8 mm, two angles L90x90x6, twelve bolts M20 5.6, nuts and washers.
- Specimens K2, K5, bolted joints of angle staffs consist of joint plate and cover plate of thickness 8 mm, two angles L90x90x6, only ten bolts M20 5.6, nuts and washers. This modification was simulated unexpected loss or fracture bolts.
- Specimen K4, bolted joint of angle staff consists of joint plate and cover plate of thickness 8 mm, two angles L90x90x6, twelve bolts M20 5.6, nuts, washers and jointing strip of PVC thickness 3 mm. This modification was simulated gap corrosion of joint.

Authors of this paper completed previous tests by own tests of joints untouched by corrosion. Specimens were made of steel S355 corresponding with mechanical properties to ATMOFIX 52A. There were prepared and tested only specimens K, whose geometrically configuration is identical to rusty specimens K. It was considered tensile failure of angle staffs in the weakened section (by holes) of angle [2,3].

Comparison of tests results of rusty and non-rusty joints is shown in following Table 1.

Table 1. Comparison of tests results.

Rusty speci-men	F_{max} [kN]	u_{max} [mm]	Non-rusty speci men	F_{max} [kN]	u_{max} [mm]	Failure mode
K1	484	18,0	K1	500	20,7	Angle staff failure
K3	475	12,0	K2	497	*	
K6	489	18,6	K3	495	20,9	
K7	441	15,2	K4	493	21,2	
K2	436	14,2	K5	469	17,6	Bolts failure
K5	438	15,6	K6	469	17,6	

F_{max} – tensile failure load
u_{max} – total deformation

As well expected the non-rusty joints showed higher load capacity than rusty joints. But the load capacity of non-rusty joints is not much higher than load capacity of rusty joints. These small differences in load capacities could be caused by gap corrosion. In present, the first author of this paper simulates behaviour of these rusty and non-rusty joints by FEM models in program ABAQUS.

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The Influence of Repairs on Long Term Serviceability of Reinforced Concrete Structures in Energetc Plants

J. Preininger

jiri.preininger@seznam.cz

Klokner Instute, Experimental department, Solinova 7, 160 08 Prague 6

Reinforced concrete constructions are during their lifetime exposed to effects of different aggressive environment with negative effects to their conditions and long-term use. General reparations and reconstructions have started in the beginning of 1990. During these reconstructions have been these reinforced concrete constructions provided by different methods of secondary protection against these negative effects of environment. The quality of the new protection methods is usually rated in laboratories, by the short-term tests. However, there were missing data about the effect of these methods in the real conditions, where the final effect was influenced also by the environment. There is a great occasion of the construction condition survey, which were reconstructed and protected against 10 years. Within my project solution were got the data about the constructions conditions. There was a possibility to compare the last 10 years and the situation before the reconstruction. The aim of the project also was to create the prediction model of old reinforced concrete constructions condition after the first general reconstruction.

The project was realised in two levels.

In the "ground" part there were the data got experimentally and completed by actual real construction dislocations. From that information were created the databases of the extent of research constructions dislocation and also the corresponding negative effects which affect the constructions. There was made an analysis of construction degradation before and after reconstruction. There was possible to analyse the protection efficiency in concrete conditions and compare the results with laboratory measurements, respectively set a relation between laboratory measurements and a final protection quality of real constructions.

In the "laboratory" part were checked survey laboratory methods of protection quality of secondary protection materials. Then were studied interaction processes of that gas with building materials, were got the information about part effect on concrete degradation and finally was checked the possibility how to eliminate or slow down these processes.

One of these project contributions may be taken to get the information about the scale of the concrete construction degradation depending on the corresponding environment of constructions with a secondary protection as well as constructions without it.

Within building-technical practising of concrete and reinforced concrete building constructions and addition of all available results resulted that their lifetime is limited. The main reason is environment degradation. Very fast construction degradation is supposed, for example, in a chemical or food operations, where the constructions are straight expose to negative effects. As well as these dangerous environments might be dangerous for building constructions an ordinary environment.

One of the important process which has a negative effect to building construction materials (concrete) and buildings durability is undesirable interaction of construction surface parts with aggressive parts of the atmosphere. One of the most famous processes of these types is the CO_2 reaction with products of portland slínek hydrotation (karbonatace). The result of the reaction is gradual loos of cement matrices alkalis (fall of pH), the loos of steel inset a

passivity, the aesthetic debasing of the construction surface and finally the static capacity weakening. This process is well known for a very long time. Since 60. , 70. of last century in advanced states is taken as a standard part of reinforced concrete constructions building an arrangement, which would reduce karbonatace process effects, or commonly surface construction reaction with an aggressive gas parts of the atmosphere.
There are not known the processes affected the gas parts transport velocity in a needed detail. At the same time is obvious, that understanding of the movement mechanism, very often inaccurate called diffuse, and understanding of the effects which could affect gas parts transport, has not only theoretical meaning, but can be also useful for rationalisation of practical arrangement proposal.
One of the research part of this project was setting down of different protection material parameters in a laboratory and in a building as well.

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Engineering Geological Explorations for Constructions at Dumps and Landfills (Localization and Features of Deposited Materials)

O. Mrvík

ondrej.mrvik@post.cz

Department of Geotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In connection of current construction development and the need of agricultural fund and environmental protection, the question of use of areas negatively affected by human factor in the past is becoming increasingly actual. It refers especially to areas of former dumps, heaps, tips and landfills. Use of such areas for building industry is in almost all cases connected with the need of solving many specific problems that should be dealed with already during the engineering geological investigation.

Materials deposited to dumps and landfills indicate range of specific characteristics subject both to the nature of its origin and changes reflecting different features of a dump (i.e. age, shape etc.).

The presented project deals with domain of convenient methods of engineering geological explorations at such sites. To attain at particular conclusions, knowledge gained from realization of many structures, built previously at problematic areas, was used. The knowledge was sumed up in a comprehensive search which subsequently enabled to envolve concept of engineering geological investigation for special conditions dependent on origin and geotechnical properties of dumps and landfills.

According to origin of the material, following groups were established:

- Mine and Uranuim Dumps
- Coal Mine Dumps
  - Open-Cast Mining
  - Deep Mining
- Thermal Power Plant Waste Dumps
- Metal Industry Waste Dumps
- Other Dumps and Fills

Engineering geological (EG) and geotechnical (GT) explorations at dumps and landfills should be conducted according to similar rules as for ordinary EG and GT explorations under natural conditions. Thuss, explorations at dumps and landfills differ in few points:

- Geotechnical properties should be assessed preferably before verification of geological conditions of an area due to artificial, man-made countryside character. A connection between soil and rock mechanics and engineering geology is necessary.

- Nature of tested soils – usually mixtures of clayey and sandy material containing variable amount of lumps, signifies predominance of field testing to laboratory methods of geotechnical parameters estimation in all cases.

- Importance of archive search due to heterogenity of materials. Properties of dumps and landfills depend especially on kind of industry, technology, processed raw materials, way of deposition, age, etc.

Excepting geotechnical properties, it is always necessary to verify ecotoxicity, influence on grounwater and projected construction. There is a hight importance of monitoring in almost all cases of construction at dumps and landfills. It is necessary to start observation by monitoring already before construction.

EG and GT explorations should lead to a possibility to answer following questions:

- nature of deposited materials, spatial distribution of basic geotechnical types
- properties of materials
- stability of the dump or the landfill
- subsoil stability
- deformations and its time dependence

Conclusions:

Generally, the methodology of exploratoins at dumps and landfills is almost equal to the methodology of a standard engineering geological and geotechnical explorations. Differences are mostly subjected to specific properties of tested materials (especially to its grading, origin, age, way of deposition, etc.).

Cooperation between geotechnical and project engineers is important when projecting structures at dumps and landfills. Exploration works should be supported by a careful search of all previous documentation. In-situ testing should prevail over laboratory methods. It is necessary to establish a monitoring net in advance.

A study from late 80`s has revealed that most of failures of so far realized projects was caused by underestimation of real conditions: artificial countryside, often to some extent recultivated and revitalized, makes an impression of totally natural conditions.

Incorrect evaluation of engineering geological conditions may lead to destruction of buildings, even very simple (e.g. garages). On contrary, it is apparent from the worked out case-study, that correct exploration and geotechnical conditions estimation allows to realize even difficult constructions at dumps and landfills (e.g. the Ervěnice corridor, moved church of the Ascension of Our Lady in Most, constructions at settling pits, etc.).

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Methodology of Historical Landmarks Pasportisation and Conditions Evaluation in Relation to Energy Raw Materials Open-Cast Mining

O. Mrvík

ondrej.mrvik@post.cz

Department of Geotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Current or formerly terminated open-cast mining of energy raw materials takes a negative effect in relation to cultural landmarks in most cases. As cultural landmarks are understood historical buildings, complexes, castles, chateaux, manor houses, churches and similar objects.

There are different negative influences of mining on cultural landmarks. The negative effects of mining can even approve at very long distances from a locality of exploration – and with significant timing relationships from a former process of mining.

It is important to deal with plenty of specific and highly professional problems already during preliminary projection of mining. Administratives at different levels have to tackle a lot of complicated, highly professional and variable problems and then to issue decisions or statements within branches far from their own profession. Regarding such problematics, e.g. clarification of causes of damage on a landmark and its surroundings, assessment of responsibilities for a damage and lyable persons, are getting actual.

To enable such questions and other problems be successfully solved, methodical guidelines for historical landmarks pasportisation and its conditions estimation in relation to open-cast mining of energy raw materials have been worked out. Subsequently, evaluations, recommendations for a future coexistence, including determinations of damages, responsible persons and subjects that should cover expences of arised damages and repairs, complete the pasportisation.

SCHEME OF THE PASPORTISATION:

Historical Factors (e.g): Type of the Landmark; Historical Significance; Former Recontsructions; Foundation of Sructures; Resistance to Direct and Indirect Impacts of Exploitation; Possibilities of Technical Stabilization; the Landmark Conditions; Use of the Landmark; Owner or Provider.

Existential and Territorial Factors (e.g): The Landmark does not Exist (is Situated within / out of Resource Limits, was Transfered); The Landmark is Situated within Protected Area; is a Part of Urbanized Landscape; Water Courses; Communications and Engineering Networks; Influence on Population.

Geological Factors (e.g): Regional Climatic Characteristics; Regional Geology; Rock Mass; Geomorfology; Geological Exploration; Engineering Geology; Rock Mass Weathering; Geotechnical Characteristics; Natural State of Stress; Discontinuities; Seismicity; Landslides; Day Water; Groundwater.

Mining Factors (e.g): Resource Characteristics; Raw Materials; History of Exploitation; Current Exploitation; Overburden; Mining Pit; Safety Pillars; Complications of Mining; Inner Fills; Field-engineering after the End of Mining; Monitoring; Outer Dumps; Raw Materials Processing.

SCHEME OF THE OVERAL EXPERT EVALUATION:

Feasibility of Estimation: Means and extent of affection of the landmark and its surroundings by exploitation or raw materials processing were (were not) clarified sufficiently. It is (is not) possible to make an overall expert evaluation.

Degree of Exposure: The landmark and its surroundings are not seriously affected; are not endangered immediately; small-scale failures may occure; danger of more serious failures (landslides etc.); serious failures (resource being endangered as well); total collapse of rock mass (landmark destruction, mining accident).

Values Ratio: The value of raw materials is superior to the value of the landmark and vice versa. Irresolute cases: alternative ways of mining or its adjournment are proposed.

Recommendations: to disallow mining; move the landmark; protect the landmark; allow mining after securing the landmark; allow mining under minimal limitations (the landmark should be secured); preserve at least remains of the landmark.

Culpableness and Compensations: Damages caused by different factors and reimbursed by different bodies can be recognised: natural factors (beared by all-society sources); direct influences of mining (beared by mining company); indirect influences of mining (beared by mining company, subsidy from all-society sources); influences of raw materials processing (beared by processing company); other antropogenous influences (beared by relevant bodies); combination of various influences (beared by relevant bodies); mining in the long past (beared by successors of former companies or by all-society sources).

MODEL LOCALITIES:

Six significant historical landmarks affected by brown coal open-cast exploitation in the North Bohemia was chosen: Jezeří Chateau, Hněvín Castle, Decanal Church in Most, Duchcov Chateau, Ahníkov Manor, Loket Castle.

CONCLUSION:

Pasports of model localities, including guidelines and recommendations, may serve professionals from geological – explorational companies for description and conditions evaluation of other objects so that no important aspects would be ommited or different influences of mining on historical landmarks and causes of damages would be understood in a bad way – either for ignorance of conditions or mistaken on purpose.

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Iron Corrosion in Drinking Water Distribution System

A. Grünwald, B. Šťastný, K. Slavíčková, M.Slavíček, J. Jindra *

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering,
Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

*VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Internal corrosion of water distribution systems gives rise to many problems for water utilities. The first is the failure of the distribution system pipes. This failure results in water leakage and loss of hydraulic capacity caused by buildup of corrosion products. The second problem is an unwanted change in water qualityas the water is being transported through the distribution system due to corrosion products entering the water. In cast iron and steeel pipe, the major corrosion problems are associated with the buildup of corrosion products on the pipe walls and the release of corrosion products into the water. Corrosion of iron is also the primary factor controlling biofilm growth.

Corrosion processes consists of a series of electrochemical reaction occuring at the metal surface in contact with water and its constituents. Corrosivity of a particular water depends on its chemical properties (e.g. pH, alkalinity, dissolved oxygen content, dissolved solids etc) and physical characteristics (temperature, flow, velocity), as well as the nature of the pipe material. In addition to general corrosion, localized pitting corrosion may also occur if there are imperfections in the metal, oxide film or scale. Pitting is accelerated by high levels of chloride and sulfate. Microorganisms can also promote corrosion by creating areas with different concentrations in oxygen, minerals and metals. Some microorganisms also catalyze reactions associated with corrosion process. Corrosion products of iron pipe provide habitats for microbial growth and react with disinfectant residuals, preventing the disinfectant from penetrating the biofilm [1,2].

The formation of passive layers on iron pipes has been subject of many investigations and the saturation or Langelier index has been widely used since it was introduced in 1936. This index indicates whether the water is supersaturated or undersaturated with respect to calcium carbonate. However, later investigations showed that the saturation index is insufficient to predict iron corrosion. The buffer capacity is referred to as the most important factor for the formation of good protective layers because an increased buffer capacity leads to slower precipitation of the corrosion products and the formation of more protective scales. The buffer capacity is related to the alkalinity of the distributed water and this is why an increased alkalinity is regarded as favorable.

The aim of this investigation was to determine the influence of the carbonate system, pH and the calcium content on the rate of uniform corrosion in water samples, taken on the water treatment plant Plav. Three places were chosen as locations for corrosion monitoring and taken samples for the analysis of the main characteristics of the treated water from WTP Plav in South Bohemia.

Temperature, pH, alkalinity levels, iron, manganese, calcium and magnesium concentration, disinfectant residual were measured at the inlet of WTP, in water after coagulation and filtration and at the outlet of WTP.

Corrosion rates were measured using removable steel coupons. Glas coupons were used to evaluate biofilm density. From pre-tests carried out, it was decided to use two exposure periods: 35 and 70 days. After this period the coupons were analysed.

Corrosion rate measured in crude water from Římov reservoir after 35 resp. 70 days exposition was between 45,1 and 243 $\mu g.l^{-1}$ resp. 56,6 and 212 $\mu g.l^{-1}$ and in final drinking water after 35 resp. 70 days exposition was between 58,5 and 106 $\mu g.l^{-1}$ resp. 31,6 and 72,1 106 $\mu g.l^{-1}$.

Corrosion rate showed a typical seasonal pattern with the maximum value in sommer and a minimum in winter.

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Case Studies of the Impact of Water Treatment on Biological Stability in Full Scale Distribution System

A. Grünwald, B. Šťastný, K. Slavíčková, M.Slavíček, R. Veselý*, N. Strnadová**

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering,
* Departement of Hydrotechnics
Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

**Departement of Water Technology and Environmental Engineering, Institute of Chemical Technology in Prague, Technická 5, 166 28 Prague 6, Czech Republic

Biological stability of drinking water in a distribution system has been gaining considerable attention in the fields of water treatment and water quality maintenance. Bacterial regrowth at the pipe walls of a distribution system can contribute to degrade this water quality. Bacterial regrowth can produce in distribution system numerous problems like promoting occurrence of pathogenic bacteria, favouring growth of superior organisms (protozoa, invertebrates and others), giving colour and bad taste to the distributed water). Biological stable drinking water is defined as one which would not cause reproduction of coliforms and heterotrophic bacteria. The link between biodegradable organics and bacterial regrowth in potable water has been noted by several researchers [1,2,3].

The BDOC test measures the gross amount of organic matter that is biodegraded by an inoculum of suspended bacteria over a predetermined period of time. The result of the test represents the fraction of DOC that is both mineralised and assimilated by heterotrophic flora, determined as the difference between the initial DOC and the minimum DOC observed during the incubation period. In drinking water BDOC represents generally 10 – 30% of the DOC. Volk et al [4] determined a BDOC value of 0,15 $mg.l^{-1}$ at 20°C and 0,30 $mg.l^{-1}$at 15 °C for biostability. The coliform occurrence could be limited when BDOC value was less than 0,10 – 0,15 $mg.l^{-1}$ within the distribution system.

The determination of DOC and BDOC in water is a particular concern to the water industry because biodegradable organic matter is almost the only limiting factor for heterotrophic bacterial growth in drinking water distribution system which produce changes in water quality.

The objective of this study was to evaluate the necessity of measuring both dissolved organic carbon (DOC) in distributed water and biodegradable dissolved organic carbon (BDOC) as indicators of bacterial regrowth potential. Three places were chosen as locations for monitoring and taken samples for the analysis of the main characteristics of untreated, filtered treated and final water. The samples were taken from the water treatment plant Plav (South Bohemia) where convential treatment, consisting of flocculation, sedimentation and filtration

is undertaken. The parameters in the physical and chemical analysis included temperature, turbidity, pH values, alkalinity, hardness, concentration of dissolved oxygen, iron and manganese content, phosphate, ammonium, nitrite and nitrate content, COD, DOC, free chlorine and BDOC.

BDOC was measured according to the method from Servais et al., which use water sample as inoculum, after 30 days of incubation.

BDOC levels in raw water from water reservoir Římov were between 0,35 $mg.l^{-1}$ and 0,54 $mg.l^{-1}$ (∅ 0,43 $mg.l^{-1}$), at the outlet of the water treatment plant Plav between 0,07 $mg.l^{-1}$ and 0,49 $mg.l^{-1}$(∅ 0,28 $mg.l^{-1}$). BDOC values in water after filtration varied between 0,19 $mg.l^{-1}$ and 0,54 $mg.l^{-1}$ (∅ 0,41$mg.l^{-1}$). BDOC levels in treated water were between 0,007 $mg.l^{-1}$ and 0,49 $mg.l^{-1}$. Results show that the chlorination after filtration caused a significant decrease in BDOC.

This study showed that the treated water distributed in the South Bohemian Distribution System has a good bacterial quality in normal conditions. However, it may favour bacterial regrowth in the distribution system under unfavourable conditions: water temperature higher than 15°C, concentration of free residual chlorine lower than 0,07 $mg.l^{-1}$ and BDOC levels higher than 0,30 $mg.l^{-1}$ at the outlet of the surface water treatment plant.

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Standardization of Symbols and Terms of Quantities in Engineering Geodesy Section: Measurement Precision

Vladimír Vorel

vladimir.vorel@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Special Geodesy Thákurova 7, 166 29 Praha 6

Great attention of both practice and research in engineering geodesy has been paid to the symbols and terms of quantities, specifically in the field of expression of data and measurement precision recently [1]. This fact results from increasing requirements of the customers for correct presentation of measurement precision, e.g. in documentation and layout network, in handing over records and marking out or checking measurement, in documentation on measurement of construction offsets, on load bearing capacity tests of bridges, etc. There is also the need to express the characteristics of precision uniformly when verifying the qualification of geodesic apparatuses on the company internal level and when calibrating them in the accredited metrology centres. The need of uniformity of the symbols and terms of parameters and characteristics of precision for communication of surveyors with other experts who require geodesic measurements and utilize their results (especially in the building and mechanical engineering industries) is also obvious. However, the current situation in expressing the data on precision in engineering geodesy is affected by a number of unclear points and ambiguities, obsolescence and diversity of new concepts and poor coordination with other technical disciplines and that also with respect to technical standards. We deal with the above mentioned problems in our workplace within the framework of the tasks of the Czech Standardization Institute and with support of the research project MSM 6840770001. The paper presented includes the information on the solution of the problems which have accumulated in this field and on the document that was completed in 2005.

The traditional marking with symbols of the subject "Theory of Errors and Balance Calculus" uses, among others, the term mean error (and the symbol $\overline{m}$ for principal mean error and m for empiric mean error) [2]. This marking has proved well, however, it is in conflict with standardization in other fields (e.g. building industry).

Some authors have started to use the modern symbol σ instead of $\overline{m}$ already some time ago, however, while retaining the former terminology. So e.g. σ is total mean error according to [3]. This marking approximates to the approaches of mathematic statistics – see the current ČSN ISO 3534-1 standard.

The terminology and symbols for expressing the precision of marking out and checking measurement in the building industry are governed by ČSN 73 0420-1 and ČSN 73 0212-1. The symbol σ is used on principle with the term standard deviation (as a precision parameter) and the symbol s – selective standard deviation (as a precision parameter) here which is compatible with ISO 3534-1.

Great difficulties occur when expressing internal and external precision of measurement as these terms from the theory of errors [2] are called repeatability and reproducibility in other disciplines – see the statistic methods, metrology and measurement methods in the building industry (ČSN ISO 5725-2, ČSN 01 0115 and ČSN ISO 7078).

Expressing precision in engineering geodesy does not correspond to the customs in metrology (and also in mechanical engineering) where according to ČSN ISO 01 0115, the characteristic associated with the result of measurement which describes dispersion of values is called uncertainty of measurement. This uncertainty can be represented by e.g. selective

standard deviation. Unfortunately, the term "uncertainty of measurement" has not been introduced in geodesic practice till the present.

Disunity is obvious also in the company's literature when stating precision of total stations. The manufacturers reference to the procedures of technical standards, which are, however, different, e.g. SOKKIA according to ISO 12 857-2, TRIMBLE according to DIN 18723 (identical with TOPCON) and LEICA according to ISO 17 123-3.

The above mentioned problems were solved in a substantial part within the framework of the research project MSM 6840770001 in 2005. The normative technical document [4] represents an implementation output from this project. It contains the terms and symbols for the frequently applied field of engineering geodesy that is called geodesic monitoring of construction sites and includes also expressing precision.

Geodesic monitoring of construction sites includes inspections of geometrical precision, measurements of offsets and also loading tests of structures. Systematic monitoring of geometrical and physical properties of structures, description of the current situation and an estimate of the future development is the purpose of these activities.

The compilation of the normative technical document [4] was based on the applicable methodological standards ČSN 01 0115, ČSN ISO 3534-1 and also on the specific standards ČSN 73 0212, ČSN 73 0220, ČSN 73 0420 and ČSN 73 6209.

The normative technical document [4] contains the terms and symbols of the quantities (including expressing precision) from the following fields:

Basic quantities, measurement of length, measurement of height, theory of errors, analyses of precision, checking measurements, measurement of offsets, loading bearing capacity tests.

The completed normative technical document [4] forms simultaneously a base for a revision of ČSN 01 9322.

Uniform marking and terminology of quantities indispensably belongs to assuring quality in engineering geology. The presented normative technical document [4] provides a starting point for it even in the field of expressing precision of measurement. The proposed marking with symbols is intended for use in documentation of both results and technological intermediate products of measurement, in computer input and output data and in specialized literature.

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Experimental Verification of Statistic Acceptance in Building Constructions

J. Neumanová

jana.neumanova@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Statistical acceptances are founded by a few standards including ISO standards. If we work with random quantilies, we can use methods of mathematical statistics. We process real values of statistic analysis and we use them for statistic acceptance.

Methods of statistic acceptance are either hundred-per-cent inspection which is determined for critical geometrical parameters and we check all items of production or sampling inspection which is determined for other important geometrical parameters and can be done it only as statistic inspection (is not possible to do per-cent inspection). Sorts of statistic inspection are statistic regulation (measuring or comparisoning) for check of running process and statistic acceptance (measuring or comparisoning). Sampling procedure for inspection by attributes is determined to find out accuracy within construction verification and then to its sampling. We compare real value of geometrical parameters with given values in project documentation, standards or regulations. The task is to determinate by using acceptable probability (which is given in advance), suitable and defective geometrical parameters. Geometrical parameter is the quantily which determines space position, extend and form of the building. Acceptable probability is the probability of occurrence of geometrical parameter values past tolerance which is 10% according to standard ČSN 73 0205 [1, 2].

At experimental function verification of statistic acceptance in building constructions according to standard ČSN 73 0212-6, the level of quality was judged according to geometrical parameters that are given for the inspection process. According to this case height deviations of cement - concrete covers of roadways (highways) in transverses cuts. Three values populations of high deviations of roadway cover with normal distribution N (μ, σ^2) were modeled in program Matlab 6.5. The population extend N = 1000 and expectation μ = 0 were chosen. Standard deviation was determined from limiting deviation for cement - concrete covers which is $\pm$ 10 millimetres. Values populations for probability of exceeding limiting values of critical parameters α (10%, 8%, 7,5%, 7%, 6,5% and 5%) were modeled. We did hundred-per-cent and sampling inspection. At sampling procedure for inspection by attributes real deviations were devided to precisions and nonprecisions according to limiting deviation. For sampling plan PRQ = 4% (acceptable quality level) and CRQ = 15% (non - acceptable quality level), is prescribed quality level Pd = 10%. It correspondes with standard ČSN 73 0205. The efficiency of sampling plan is determined by operating characteristic that with given producer´s risk and consumer´s risk determines extend of random sample size *n* and the highest acceptable number of defectives in sample – acceptance number *Ac*. In our case - n = 65, Ac = 5 and number of samples was 10. Hundred-per-cent inspection proved to acceptance of two populations from tree populations and sampling inspection proved to nonacceptance these of populations. Only at option α = 7,5% and less, sampling procedure for inspection by attributes proved that the set was suitable for hundred-per-cent control, too. Then we checked the populations for other values PRQ (0,75%, 0,25% and 1,5%) and CRQ (10%, 6,5% and 15%). Hundred-per-cent inspection proved nonacceptance of all three populations. Sampling inspectation wasn´t done [3].

We believe that experimental verification of function of sampling statistic acceptance shows that prescribed quality levels P_d in standard ČSN 73 0205 do not coorresponde to statistic model of tolerance. There is connection with conditional probability of values appearance in model population with normal distribution and probability of item in random sampling. This proves that population accepted by hundred-per-cent inspection, is not considered as acceptable for sampling inspection. Prescribed level of quality is not suitable for our statistical sampling. Therefore we did control by using empirical tolerance limits. We used population of height deviations values of highway D1 (geodesy control of layer AB in kilometers 77,2 to 77,8) from diploma work of Mrs. B. Dubnová from 1979. This population does not have normal distribution. At the first we did check using parametrical tolerance limits. For sampling plan PRQ = 4%, CRQ = 15%, we chose confidence level γ = 0,99 or γ = 0,95 and share of collection P = 0,95 or P = 0,95. For this values the population was proved hundred-per-cent inspection and sampling inspection, too. These empirical tolerance limits are very suitable for acceptance our population of height deviations even it does not have normal distribution. For calculation we used nonparametrical empirical tolerance limits which presumption of normal distribution nonconsider. Hundred-per-cent inspection and sampling inspection demonstrated the population of values for confidence level γ = 0,90 and share of collection P = 0,90 for sampling plan PRQ = 4%, CRQ = 15% and PRQ = 0,75%, CRQ = 10% and for PRQ = 1,5%, CRQ = 15% [4].

At statistic acceptance the distribution of probability of real deviations are usually other then normal distribution. There is suitable to use the statistic nonparametrical empirical tolerance limits. From these experimental verifications yield that the methods of statistic acceptance are good for checking geometrical accuracy of construction. These methods are economical in geodetic works in ground and in control measuring. With using of these methods is possible to make objective decision about quality of population. It guarantees with advance determined probability that only sets which fulfill claim between producer and consumer will be accept. Using of statistical acceptances is general claim at management quality according to ISO standards row 9000.

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Monitoring of Dynamic Behavior of the Prestressed Concrete Slab

T. Plachý, M. Polák, A. Rezek

plachy@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept.of Structural Mechanics
Thákurova 7, 166 29 Praha 6

In practice, various kinds of damage on concrete structures can be found. Undetected damage can lead gradually to the failure of structural members or the structure at all. Therefore, damage detection and localization of a structure at the earliest possible stage is very important. The need for methods that can be applied to complex structures led to the development of methods that examine changes in modal characteristics of the structure. It is suitable to verify methods, which use results of an experimental modal analysis for estimation of a degradation degree of a structure, on simple structural elements where we know their damage state.

The experiment described in this paper is focused on monitoring of the influence of high intensity fatigue loading on the change of the modal characteristics of the fully prestressed concrete structures, which are designed to be no tensile stress there when maximum design load is applied.

For the purpose of this project, SMP CONSTRUCTION a.s. made a prestressed concrete slab. The dimensions of the slab were 130 x 1155 x 4500 mm with ends expanded to the height 400 mm for tie of the prestressing bars. Slab was made from concrete C45/55 with eleven prestressing bars of diameter 15.7 mm. The slab was put on two bearings to be a simply supported with the span 3500 mm with cantilevered ends 500 mm on both sides.

The tested slab was designed as a fully prestressed concrete slab to not comply the safety condition in the lower part of the slab when the high intensive cyclic loading is applied.

Tests of the slab were carried out in laboratories of Faculty of Civil Engineering, CTU in Prague. The prestressed concrete slab was loaded in four point bending to get a constant bending moment in the mid-section of the slab. The cyclic load was applied to the slab in several steps. This fatigue load of the slab was induced by harmonic force with frequency 5 Hz. The amplitude of the dynamic load was chosen to not comply the safety condition for the fatigue loading of the concrete.

After each load step, a complete experimental modal analysis was carried out with separate measurement system.

For the excitation of the slab during the experimental modal analysis the Modal Exciter Type 2732 (Bruel & Kjaer) was used. The exciter was placed under the slab linked to the slab with the flexible drive rod. The exciter produced a random driving force over the frequency range of 5 to 400 Hz. The force transducer Endevco 2311-10 placed between the flexible rod and the slab measured the excitation force. The response of the element onto forcing by the exciter was measured by three piezoelectric acceleration transducers Bruel & Kjaer 4507 B 005 in a chosen net of points on the upper face of the slab. The point of excitation was designed to be able to excite basic bending modes of natural vibration of the slab. Values of the Frequency Response Function were obtained as an average from ten

measurements**.** The window length of the time signal processing was 32 s, the frequency range of the window was set to 400 Hz.

The program MEscopeVES (Bruel & Kjaer) was used for modal characteristic evaluation from measured Frequency Response Functions. With regard to a frequency range of the dynamic analysis 5 to 400 Hz nine natural frequencies and mode shapes were evaluated. Modal characteristics of the slab, which were measured after each loading step, were mutually compared. For comparison of natural modes, changes of a mode surface curvature $CAMOSUC_{(j),x}$, changes of a modal flexibility matrix [δ] and the second derivative of changes of diagonal members of a modal flexibility matrix Δ[δ]″ were used.

In this experimental dynamic study, the influence of the dynamic cyclic fatigue loading to the change of the modal characteristics of the fully prestressed concrete element was monitored. The modal characteristics after several loading steps were evaluated. Mode shapes were mutually compared using three different methods: $CAMOSUC_{(j),x}$, Δ[δ] and Δ[δ]″. From the lower values of these methods it results that no significantly changes of dynamic behavior of the slab occurred after 125 000 loading cycles. Some isolated peaks only indicate few measurement inaccuracies in the vicinity of node lines of mode shapes. The project still continues, more measurements will be done on this slab and two more slabs will be investigated to make more general conclusions.

We would like to thank SMP CONSTRUCTION a.s. for making and preparation of the slab and for their financial participation.

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Strength of Glass in Contact to Inserts

M. Eliášová

elasova@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Glass with its new function is one of the most progressive materials nowadays. It is not only the filling but also the load-carrying element. Glass does not yield, it is a brittle material and its stress concentrations may not be ignored. Ductile material (steel, aluminium) yields if it is locally overstressed and therefore stress concentrations are limited. For glass is important to give an attention to the details and way of their design. Ultimate load depends on the edge finishing, methods of the drilling, bolt positioning and type of the bolts. The structural glass is usually combined with other materials, mostly with steel. There is a lack of knowledge, design rules and procedures, which strengthen use of this attractive material. Designers have limited coherent approach to these problems at present. The paper presents experimental observations of glass in contact with inserts of steel, aluminium, polyamide and epoxy resin.

Four sets of tests with the different contact materials were carried out in the laboratory of Czech Technical University. Influence of the edge finishing, size and thickness of the glass panel and the corner distance was taken into account. All tests were carried out for annealed float glass. Heat-strengthened and fully toughened glass samples will be investigated in the second step. Totally 81 tests were performed. Glass panels were placed between the inserts and loaded by a force to the failure. Two test machines with the load capacity 400 kN and 1000 kN were used for the experiments. The first one allowed recording force – deformation curve. A transparent box protected the observer against the dangerous glass shards was used. The shape and thickness of the glass panels and the contact area of inserts were measured before testing. The edge finishing of the glass panels was taken also into account. During the loading of the test specimen an attention was given to the first crack appearance as well as to the shape of the failure in glass panels. Deformations δ of the upper and bottom inserts were measured after the tests.

The failure modes of the glass panel in contact with inserts were observed during the loading stage. It is possible to describe different initial damages according to the shape of the first crack in the glass panel. “The corner crack” is a breaking of the glass panel from the corner of the insert. “The inside crack” is a vertical crack inside the glass panel. “The surface flake” is a scaling of the glass panel’s surface. “The edge crack” is the breaking of the glass panel’s edge from one insert to the other. Different failure modes were observed at the collapse as well. “The fast failure” is a fast fragmentation of the glass panel into very small pieces of glass. Usually this failure mode was without any initial damages. Next one is “fragmentation” of the panel into big pieces of glass after crack propagation. The “cut through the insert” occurred for inserts with Young’s modulus lower compared to the tested glass panel, e.g. epoxy resin and polyamide.

The comparison of the test results may be based on the predicted reduction of the resistance in contact, which is included in the form of joint coefficient β_j. The ultimate resistance can be calculated as $F_{red} = \beta_j f_{c,u} A_i$, where β_j is the joint coefficient, A_i is the contact area of the glass, $f_{c,u}$ is the characteristic strength of glass in compression and is considered as 500 MPa.

The inserts of steel, aluminium, polyamide and epoxy were tested. The force at the failure was compared for each material. The tests with polyamide and epoxy inserts exhibit similar results due to the similar modulus of elasticity. Suggested values of joint coefficients β_j, which were determined for glass panel with smoothed edges, are 0,50 for inserts from aluminium, 0,55 for steel; 0,25 for polyamide and 0,25 for epoxy.

The glass panels of thickness 10, 12 and 15 mm were tested in the same way as three sizes of glass panels: 120 x 120, 150 x 150 and 180 x 180 mm. Resistance was observed by tests in range from 400 MPa to 500 MPa without any influence of glass panel thickness. The maximal forces in compression were at the same level for different size of the glass, joint coefficient β_j varies from 0,65 till 0,75.

Three different lengths of insert from aluminium were tested (60, 90 and 180 mm). The glass panels had the same size and thickness. Maximal reached forces at failure of the glass panels were compared. Behaviour of the 60 mm long inserts was similar to the 90 mm long inserts behaviour. First crack appeared at the corner, then the edge failed and finally the glass panel failed completely. For the 180 mm long inserts, the failure of the glass panel was different. The scales of glass flaked off from the surface of the panel. The size of the insert may be demonstrated also from the point of view of distance between the specimen edge and insert edge L_c.

Two types of edge finishing were tested: smoothed and polished. Influence of the edge finishing was investigated for aluminium and polyamide inserts. From comparison of results was found that edge finishing hasn't influence to the resistance of glass panels for materials with higher Young's modulus as steel or aluminium.

Four sets of tests were performed to investigate the behaviour of the of float glass in contact with different material. The type of contact material has an impact to the joint resistance. The tests results indicate an influence of the corner distance L_c as well. The influence of the edge finishing was observed especially for insert's materials with higher Young's Modulus. The experimentally obtained joint coefficient β_j varies from 0,25 for insert from polyamide up to 0,55 for insert from steel. Further experiments for fully toughened glass panels and FE method allow to precise contact resistance of glass panel for design. Contact resistance will be used as the first step for the study of bolted connections.

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Interaction of Connectors in Glass Structures

M. Eliášová, R. Vencl

eliasova@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Modern trends as well as new technologies in production and materials are used in civil engineering. Glass, with its new function, is nowadays one of the most progressive materials. Considering the fast research and development, glass is more often used for bearing glass structures. Contrary to common materials (steel, aluminium), which can reach plasticity, glass behaves elastically until it breaks by a brittle fracture. Connections have to be designed with great care. The main question for this type of connection is to determine the state of stress and the level, to which the forces of individual bolts act together. In this case was used the photoelastic reflecting method, which is suitable especially for transparent materials, as glass. One of major questions in glass structures design is the connection between the glass components and the joints to the supporting structures. Designers have limited coherent approach to these problems at present. The knowledge in glass connection is limited even though it is one of the most important parts of the structure.

In the last few years there has been significant progress in development and application of large-area glass facades of civil structures, particularly in the case of roofs and facade systems. Nowadays there are used for the joint between glass elements and supporting glass structures or between glass components following types of connections:

- the bolted connections by means of steel splices (e.g. the connections of bearing glass fins with the use of shear or fiction bolts),
- the spider connections (individual glass components are fixed to the supporting steel structure at points using bolts),
- the glued connections (this type of connections is not used in ordinary practice due to lack of knowledge).

For bolted connection of glass bearing structure it is important to eliminate direct contact between glass and bolt. High local stress cannot be reduced by plasticity because of the brittleness of glass. For this reason are used various types of inserts between glass and bolt. These inserts are made from different materials, e.g. silicone, polyamide, neoprene, epoxy resin.

Continuing experiments are directed towards bolted connections of bearing glass structures by using steel splices. The main question for this type of connection is to determine the state of stress and the level, to which the forces of individual bolts act together (one or two bolts in row, two types of glass – float and toughened glass). The experiments of bolted connections were carried out on the simplified model with the steel splices. Considering the natural properties of glass (transparency and optical sensitivity) the photoelastic reflecting method was used. This method is appropriate especially for determination of the stress. The test specimen has to be made from transparent and elastic material, which is characterised by the temporary birefringence. A plane polariscope is composed of a white or monochromatic (one wavelength) light source and two linear polarizers with crossed axes named the polarizer and the analyser. The glass element to be analysed is placed between two polarizers. The light ray, emitted by the source, crosses the first polarizer. It is then considered to vibrate in a plane normal to the direction of propagation determined by the orientation of the polarizer. The

luminous ray then meets the glass panel. Glass is optically isotropic under normal conditions but becomes birefringent, when it is loaded. Using the source there are black (dark) and colour strips. The black strips are named the isoclinics; they correspond to the points, where the secondary principal directions are parallel to the directions of the polarizer axes. The colour strips are called the isochromatics and they are points of the difference between the secondary principle stresses.

The test specimens were made from float and toughened glass with nominal dimensions 680 x 300 mm and with thickness 12 mm. Drilling of the hole for bolts was carried out with chamfer (45°) and smooth edge finishing. Between glass and bolt was used insert from hard plastic with external diameter 40 mm and internal diameter 18 mm. Bolts M16 quality 8.8 were loaded by shear. Steel splices were made from steel S235 with dimension 165 x 100 mm and thickness10 mm. The test specimens were held in loading by the machine with special hinge, which was from one side of glass panels due to using of the photoelastic reflecting method. The free side of the panel was painted with reflecting coating. Test specimen were loaded by a tension force to the level of F = 10 kN, where values of isoclinics and isochromatics were measured. Measuring of toughened glass was more difficult because was necessary to determinate original state for the level of F = 0 kN. Real state of the stress around the hole of toughened glass is difference between the level of F = 10kN and F = 0 kN. In general 20 test specimens were tested. Results of the experiments correspond to the presumption about distribution of the stress around holes in the glass panels.

Performed experiments improve and uplift knowledge of bolts behaviour, which are loaded by shear in the joints of bearing glass structures. From results was also possible to obtain behavioural properties of in-line bolts including the determination of internal forces of individual bolts for two types of glass (float and toughened glass). These experiments show that stress is not distributed uniformly to the bolts in one row and that the photoelastic method is appropriate for determination of stress in glass elements. After this first set of experiments there will be a second set, which will consist of a total 40 specimens.

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Statistical Analysis of Input Parameters of the Rock Mass

J. Pruška, J. Salák

Pruska@fsv.cvut.cz

Department of Geotechnics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29, Prague 6, Czech Republic

The classical approach used being used in engineering structures design means to consider the relationship between the capacity C (strength or resisting force) of the element and the demand D (stress or disturbing force). The Factor of Safety of the structure is defined as $F = C/D$ and failure is assumed to occur when F is less than 1. The classical engineering design is based on a single calculated factor of safety. The approach which is frequently used to obtain a more rational assessment of the risks associated with a particular design is to carry out a sensitivity study. In the case of the geomechanical model the output results (and also behaviour of the model) mainly depend on the input parameters. The inherent variability of rock mass is difficult to be taken into account. To select the critical values of strength parameters have been used on the parametric analysis of rock mechanics. In the recent time engineers encounter problems of the input parameters in using uncertainty modelling approach (sensitivity analyses) such as Monte Carlo Simulation or Latin Hypercube sampling.

In *Monte Carlo simulation* the random problem is transformed into several deterministic problems which are much easier to be solved – sample inputs are used to generate sample outputs with statistical or probabilistic information about random output quantity. Monte Carlo simulation is simple to be used and therefore has found much favour in geomechanics, particularly in stability analysis of rock slopes [1]. However, this simple (and best-known) random sampling scheme required for good accuracy and repeatability many samples. In practice for generating a probability distribution of the safety factor of rock slopes the minimum number of selection is between 200 up to 2000.

Latin Hypercube sampling technique [2] is a relatively recent technique which gives comparable results to the Monte Carlo technique Latin hypercube sampling preserves marginal probability distributions for each simulated variables. To fulfill this aim, Latin hypercube sampling constructs a highly depend joint probability density function for the random variables in the problem, which allows good accuracy in the response parameter using only a small number of samples

One of the essential questions in the probability analyses is determination of the proper distribution which can be used to fit a given data set. Experts opinion on the choosing the distribution in accordance with the define properties or events is disunited and therefore some of the most useful distribution were mentioned: (1) *Normal* or *Gaussian* distribution is generally used for probabilistic studies in geotechnical engineering. The using the normal distribution as a basis for a Monte Carlo analysis in certain investigations can cause numerical instability (2) *Beta distributions* are very versatile distributions which do not suffer from the extreme value problems because the range is bounded by specified values (3) *Exponential distributions* are sometimes used to define events such as the length of discontinuities in a rock mass, rock bursts etc. (4) *Lognormal distributions* are useful when considering processes such as the crushing of aggregates in which the final particle size results from a number of collisions of particles of many sizes moving in different directions with different velocities. (6) *Weibul distributions* are used to the outcome of tests such as point load tests on rock core in which a few very high values may occur.

Latin Hypercube sampling was used on the statistical analysis of the input parameters on the Prague tunnel Mrázovka numerical modelling [3]. The Mrázovka tunnel is the part of the north-western sector of the City Circular Road in Prague and is located in the very difficult Prague Ordovician geological conditions. Due to increased deformations occurring at the excavation with a horizontally divided face saving grouting was performed and later on, a vertical pattern of the sequence was used in the further course of excavating the Mrázovka tunnel. The numerical analysis was carried out by means of the PLAXIS program system. 3D behaviour of the excavation face area was simulated by using the so-called β-method. The modelled area (profile at km 5,160 WTT covers an area of about 200 m wide and 110 m high) was divided into eight basic sub-areas according to the types of rock encountered. The rock mass behaviour was approximated by means of the Mohr-Coulomb model. The intervals of input parameters of the rock mass were determined on the basis of the engineering-geological investigation results. A comparison of theoretically determined deformations with the values obtained by monitoring [4] was used for verifying the applicability of the mathematical model. The results of statistical study show that final settlements of WTT will be with probability 95% between values 71 mm and 213 mm. The interval of settlement without deformations caused by excavation of pilot adit is from 65 mm to 198 mm. The recognised range is in coincidence with measured value 194 mm (value does not include effect of pilot adit).

The results of analysis show the effect of variation of input parameters of rock mass behaviour on results of FEM. It can be seen, how different can be this influence. Difference of outputs is given by disparity of geological layout. However it can be clearly seen, how important is at least basic study of input parameters variation for determination of final structure behaviour. Latin Hypercubes method is advantageous procedure for qualified statistical evaluation of FE calculation. Latin Hypercube sampling preserves marginal probability distributions for each simulated variables. To fulfilled this aim, Latin hypercube sampling constructs a highly depend joint probability density function for the random variables in the problem, which allows good accuracy in the response parameter using only a small number of samples. These method allows radical time saving with regard to common statistical methods (Monte Carlo, estimations of probability moments etc.).

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Capacity-increase of Prague-Ruzyně Airport

Ing. Petr Pánek

petr.panek@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7, 166 29 Praha 6 - Dejvice

Air transport in Europe is presently undergoing a stage of dynamic development. There is a stable growth in the interest of air carriers in using the air space above the Czech Republic, and the year-to-year growth in the volumes of transport at our largest airport (Praha-Ruzyně) is self-evident. The growth in transport volumes is so huge that it has exceeded all estimates and forecasts in terms of capacity and operating needs of Praha Ruzyně Airport. At the same time, this growth is incomparably higher in relation to the outside world. This fact had a prominent share in accelerating the modernization and capital investment at Ruzyně Airport.

EUROPE Project

The nearly used up capacity of the Terminal North 1 (6.8 million passengers/year) at Ruzyně Airport led to one of the most significant building works of the last time. It is the EUROPE Project, or so-called "Construction V". The construction of the Terminal North 2 amounting to nearly 10 billion CZK represents simultaneous implementation of 6 structures (connecting link, terminal, finger C, circulation routes, collector, luggage sorting unit) whose operation as a whole should start in January 2006. Their main purpose is mainly extend the airport capacity and serve flights from and to EU countries, in keeping with the protocol set by Schengen Agreements. Apart from a further growth in capacity to over 10 million passengers per year in the first stage (which thanks to the installation of technologies could lead to a figure of 15 million passengers per year in the next stage), the airport will offer a wider choice of services for the travellers and persons based in the airport complex. By building finger C near the Terminal North 2, the number of boarding bridges will go up by 10 (i.e. reaching a total of 27). The number of check-in desks in the new terminal will be 20 at first, but with a possibility of adding another 40. New conference rooms and facilities for VIP and business clients will be opened, and the number of shops and catering facilities will also go up.

The companies participating in the EUROPE Project are Metrostav (connecting link and related facilities, part of circulation routes, collector), Doprastav (circulation routes), Hochtief VSB and ŽS Brno (finger C), Skanska CZ and Strabag (Terminal North 2), VanDerLande (luggage sorting unit).

Parallel Runway 06R/24L

The total capacity of the airport corresponds to the capacity of its weakest point (i.e. one of the elements: air space, operating surfaces, terminal, interchange, traffic system airport – city). The vital element which mostly determines the airport capacity are operating surfaces and of them most frequently the runway system.

The performances of Praha – Ruzyně Airport in relation to the number of aircraft movement in the last years has approached the capacity limit of the runway system, and therefore its capacity must be increased so that it does not become a limiting factor in the airport development. That is why Letiště Praha s.p. is preparing an extension of the airport runway system by implementing of a new parallel runway RWY 06R/24L, running in parallel to runway 06/24.

The present-day take-off and landing runway (hereafter referred to as VPD) 06/24 is the most commonly used runway due to weather conditions and limitations of runway 13/31, which is designed in such a way that the take-off and landing corridor passes directly above large housing developments of Prague 4, 5 and 6.

The new runway will divert air traffic above an area whose settlement is by 95 % less dense allowing maximum reduction of traffic on the existing neighbouring runway 13/31. Noise impacts should be also significantly limited by the optimization of the runway system control. The new parallel runway should be primarily used for landing in both directions, while the existing runway should primarily serve for take-offs. By separating take-offs from landings in using different runways, the times of aircraft taxiing along the airport will, among other things, reduce.

Runway 06/24 is, therefore, presently overloaded (the minimum time lag of 2 minutes between landing and taking off planes frequently limits the number of arrivals, and so arriving planes must wait in the air). If Prague Airport fails to meet the demand of carriers continuously, it will cause flight delays, and each delay at Prague Airport is immediately transferred to other airports in Europe.

The new parallel VPD 06R/24L will be located 1525 metres south of the existing runway. This distance ensures independence of all movements on parallel runways. The new runway dimensions are 3550 × 60 m, and VPD will be equipped as an instrument runway for precise approach of category I in direction 06, and in direction 24 it will be even equipped as an instrument runway of category III. The third approach category will allow e.g. automatic landing at the airport at zero visibility to the very touch down.

The investments for the new parallel runway should amount to 5–7 billion CZK. The latest date of the start of the parallel runway construction presumed is 2007, and the planned date of putting into operation is 2010.

Airport Connection with City Centre

The present connection of Ruzyně Airport with the Prague centre is provided by personal cars or taxis. The arterial road to the airport, however, tends for be congested in rush hours. At the same time, the transit through the city is becoming complicated taking increasingly more time. For personal cars, this may be further aggravated by the problem of insufficient parking places near the airport building. Another possibility of getting to the airport is by public transport. In the case of Praha Ruzyně Airport, there are buses or minibuses. Here, of course, the problem of low road capacity remains.

Some airports world-wide have been connected to the national railway line or are accessible by metro. The main disadvantages of travelling by these means of transport, however, is a lack of local knowledge and poor orientation of tourists in the transport infrastructure of a foreign country, but also not always convenient travel intervals and adequate timetable simplicity. Other difficulties result from the fact that the people travelling to the airport usually have more pieces of luggage to which neither metro or train carriages, nor the station structure are adapted (being usually fitted with many staircases).

For these reasons, high-speed railways have been built – or are under construction – in many places world-wide, providing a direct connection of some central city railway station with the airport terminal. These railway lines are served by specially modified sets of wagons running in short regular intervals and allowing passengers easy transfer from the city centre straight to the airport.

The problem of airport accessibility must be always solved in the context of transport infrastructure of the entire city and its surroundings. Despite the many solutions available, two concepts generally exist. One possibility is a line between the city centre and the airport operated only for the transfer of airline clients, while the second option is to extend the ex-urban transport system by building a link to the airport.

For Ruzyně Airport, two alternatives of interconnection with the Prague centre are presently under consideration. One of them is a high-speed railway, i.e. modernization of a railway line from Masaryk Station to Kladno, which would involve electrification along the whole line and extension of the existing track to a two-rail track, while the second alternative is extension of metro line A from Vítězné Square to Ruzyň. Each of the options has its strong and weak points, but whichever will win, the result should be a significant increase in the quality and capacity of the Prague centre – Ruzyně Airport link.

Geodetic Monitoring of the Lightweight Cable-Bridge over Berounka-River in Radotín

T. Jiřikovský

tomas.jirikovsky@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

The article informs about detailed geodetic measurement of the Radotín-bridge, design and a realization of a new geodetic network for its long-time geodetic monitoring, and about some testing and research measurements performed up to this day.

Between autumn 2003 and spring 2004, a general reconstruction of the cable-footbridge over Berounka-river in Radotín was made. Compelling, lightweight 130 m long reinforced concrete unsymmetricaly suspended construction was put into operation in 1991. It allows direct connection to Zbraslav for pedestrians, cyclists and motorcyclists, and transfers many power and telecommunication lines.

For a structural designer's statics review and a project of the reconstruction, the detailed information about actual shape of the bridge and the pylon was needed. It means new geodetic surveying. Some deformations (which were not measured until now) grew up already in the course of the construction in 1991 and during hundred-year flood in 2002: especially pylon sag, tilt, and the movement of the bridge deck at the Radotín-side support. This whole new detailed geodetic surveying was made by the Department of special geodesy CTU in winter 2003/2004. With that, at the same dept. was prepared design and the project of the new geodetic network for a long-time periodical regular (emergency as well) monitoring of shape changes of whole object.

For a detailed surveying were used a 3D polar method, two station-points, two ČSNS-level marks and a special designed adaptor for precise placing the target-prism at measured points. In total 229 points were measured (every 2 meters, both sides), 22 points two or three-times for empirical evaluation of accuracy. In addition, 9 pairs of points at the pylon were measured with pulse-laser-distancemeter (without prism). As a result, there are local orthogonal coordinates of all points, which in detail describe space-shape of both main-girders (height and transverse deviations, roll, distortion). Preliminary expectations about the bridge-deck movement (approx. 45 mm) and pylon tilt (up to 280 mm in16 m height) were confirmed and exactly numerically and graphically expressed.

Based on these results and structural designer's statics review, the decision of necessity of establishing missed geodetic network for long-time monitoring was made. It is required for detection of transversal and especially height changes, which are important by cable suspensions condition assessment. The new network design was based on the modern 3D polar method of measurement with only one fixed station-point (thanks to the good visibility to all other points) and several orientation and verification-points. The polar method gives in the result 3D-ortoghonal coordinates of all measured points, so it is possible to evaluate both height and cross deviations or changes and even longitudinal changes (for instance temperature influence to the length of bridge-deck or other parts). Using modern precise measuring instruments (total stations) and eliminating disruptive factors (especially atmospheric influences and auxiliary geometric quantities) is relatively simple polar method able to offer valuable, high accurate results.

There were 28 observed-points built in nearby cantilever suspenders and at the other significant parts of the construction, three points at the pylon, five orientation and verification-points, four levelling marks and one fixed measuring-pillar as a station-point and as the origin of the local coordinate system. Observed and orientation points are stabilized by specially designed stainless steel plates 60×60 mm (with rain/snow-shroud and centering dot) and signalized by reflexive targets Leica. Every plate has a small dint for precise centering a new target in case of its damage or "blinding". The reinforced concrete measuring pillar is 140 cm high, in one piece with foundation block and with three inclined micro-piles anchored to the schist (shale) stratum (10 m deep). Pillar's head supports a brass centering plate equipped with universal fixing screw, at sideboards are two small levelling marks. The pillar even defines the origin of the local coordinate system, which +x axis is parallel with ideal bridge-line.

For monitoring measurements, the pillar and points at the bridge pier are count as fixed. All other points come to the calculation as points in demand. Whole network was designed for using high-precision total station Leica TC 2003, or instruments with equivalent parameters, and two measuring series. Usage of lower accurate instruments is possible, but needs more repeating of measurement. To ensure the results consistency and comparability is necessary to take measurements only at standard or near-to-standard conditions: it means balanced, stable bridge and atmosphere temperature 10 ºC, completely overcast and calm (no wind).

Regular monitoring measurements are planned to perform in 1-year period, if no downcasts or deflection detected, up to 5-year period. Up to this day, two regular measurements were taken and two special measurements on non-standard conditions (extreme summer hot and the opposite – winter hard frost). These measurements are useful for study of the bridge real behavior vs. computed models commensurate with temperature changes. The new geodetic network is ideal for these and similar experiments, thanks to its simplicity and accuracy.

It's expected that this network will not only serve for regular monitoring, but it can allow many opportunities to study light-weight bridge behavior on different conditions and affects of many influences, as well as more findings of applicability of the polar method to precise measurement. At present, at least one diploma thesis on this theme is prepared, and some measurements for research project CEZ MSM 6840770001 – "Reliability, optimization and durability of materials and constructions" are planned.

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Effect of the Location and Shape of the Exploration Gallery on the State of Stress and Deformation

J. Pruška, P. Růžička

pruska@fsv.cvut.cz

Department of Geotechnics, Fakulty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The main goal of the paper is characterizing the excavation effect on the state of stress and deformation rock massive during construction of underground structures (especially tunnels and collectors) by using present–day tunneling methods (New Austria Tunnel method and Norway tunnel method) respectively in consideration on excavation sequence and on the location of the exploration gallery with respect to future building on the 3D models.

3D models aren't using for their hardware and time seriousness in practice and 2D models are usually used. Nevertheless only 3D models make good realistic stress and deformations situated expect the plane of the excavation sequence. In the course of study of the excavation sequence influence and the location of the exploration gallery we are in realistic spatial problem and the influence of the areas situated in the vicinity of the face plane is impossible vanish. Description of this spatial behavior in the 2D models (so-called β-method) for well-established simplification gives not comfortable state. This project was above standard due to using 3D numerical models. Herewith is this project a benefit to the actual discussion about suitable location of the exploration gallery.

In the first phase solution of this project was necessary to select suitable characteristic cross section of the future tunnel, witch fulfilling the necessary conditions for comparative calculations. It was especially alternative of the vertical and horizontal excavation sequence in the course of selecting NATM and possibility location of the various shapes of the exploration galleries to in the structure profile. Another condition for objectively comparative of calculations was necessary to select characteristic rock types and the thickness of the overburden for the calculations. The last necessary condition was to select the shape of the exploration galleries and their location in the critical places of the calculation sections in consideration on the state of stress and deformation.

In the other phase solution was necessary select to suitable calculation software for analysis of query with respect to latitude of project solving and availability of hardware appointments. From amount of widely used in practice commercial FEM we have on the department of geotechnics the following software: Z-soil, Plaxis and Geo FEM. To short list we choose Geo FEM and Plaxis. After sometimes confrontation calculation we left from software Geo FEM, because it wasn't possible solved the true 3D problems and another analysis was executing in the Plaxis V8 and Plaxis3D tunnel.

The last, but the most-timed and technical difficult phase solution of this project was implementation already assuagement entrance requirements to the calculation consecutions. It was creating of 2D and 3D mathematics model in the software Plaxis or if you like Geo FEM, definition basic surrounding and thickness of hanging wall through the use of Mohr-Coulomb hypothesis, definition basic materials of lining with respect to timetable of construction and last but not least in the design of style excavation of rock massive while using NATM.

Altogether they were select four shapes of exploration gallery, which were situated to five types of rock massive for four various thickness of hanging wall. With respect to excavation profile the galleries were situated to three critical places by vertical and to three critical places by horizontal excavation sequence with respect to state of stress and

deformation. For total coverage of this definition entrance value would be necessary to make 480 analyses as plane problem. After sometimes testing calculations in the separated rocks and for various thickness of lining may be show, that this parameters haven't got influence on the shape and situating selecting of the exploration gallery to the future profile of underground structure. This result restricted the number of the necessary analysis approximately on the 40. For the compact imagining, which analysis including approximately other 10 – 15 phases, representative separately phases of construction future structure. 2D problem consists in using substitute method for 3D effect simulation and that is why was necessary type selection of analysis to check through using of 3D mathematic model. This model is most demanding on the hardware appointments and most time-consuming then 2D mathematic model.

Excavation and shrouding of tunnel with big section implementing classic technology is in the actual period and it is necessary separate to two and more sectional excavations with phase consecution their provision. This process can't be determinate only stability conditions, but also limiting potentiality the mechanization instruments.

Generally true and notorious hypothesis leading to the economy concept and construction of future underground structure consists in necessity excavation exploration gallery in advance before others works, for provision geology parameters in the route. The shape of exploration gallery is impact number of factories. In the last time it was knack from economist arguments designing small profile of galleries. Small profile galleries require different process of excavation and shrouding from final structure. In the present time is evident trend, when we aspire about exploration gallery the most similar to the partial section of the future tunnel. This trend naturally affecting shape of exploration gallery and modify of their provision.

The results can be summarized to the next arguments:

a) The parameters of the rock massive and the thickness of lining haven't got influence to the choice of shape of the exploration gallery
b) The most suitable shape for exploration gallery from the state of stress and deformation is circle or shoe
c) The most suitable place for the exploration gallery location of is to the future structure's arch
d) In the case, that the exploration gallery can not be situated to the partial section of the vertical excavation, the most suitable place is in the top of the excavation
e) The choice of horizontal or vertical excavation sequences is dependent on the rock massive geology parameters
f) 3D mathematic model offer realistic results than 2D mathematic model due to 2D discharging subsidiary methods (β - method used by the PlaxisV8)

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The Chances of CTU Graduates on the Labour Market

J. Šafránková, D. Dubnová

jana.safrankova@fsv.cvut.cz

Department of Social Sciences, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

There are a growing number of discussions about further development directions of the Czech Technical Faculty and its component faculties in the context of the transformations under way in the Czech society and with regard to the accession of the Czech Republic into the European Union. One of the sources of information is also the knowledge about the chances of the graduates from component faculties of the Czech Technical University on a labour market. In 2005, for that reason, survey gathering information about graduates from 1985 to 1993, 2001 to 2003 of all the six faculties of the Czech Technical University was realized. The subject of this survey is connected to five representative surveys realized within the Czech Technical Faculty, namely, the survey of students in the 2nd to 5th year of their program in 2001, 2004, students in the 1st year of their program (2001) and students who did not enrol after they had been accepted in 2002 and survey of the problematic of CTU graduates fro 1993 –2000 realised in 2003. In these surveys, the opinions of existing students as regards the instruction, motivation to study, and identification with a selected course of studying, etc., are being uncovered.

The survey information about the graduates describes their chances on a labour market, for example, what kind of work they prefer after graduation, how many of them work in leading posts, or work independently, in what kind of companies they are mainly employed, etc. What is very important is the feedback information about the instruction, assessment of the relevance of completed courses for the practice, and simultaneously finding out required knowledge and skills, which the students are missing in the instruction.

The target of the university is to pass on the theoretical foundations of their disciplines to the students and inform them about the future development directions of their chosen specialty. In spite of this, it has to response to modified conditions within society, of course, with the aim to secure as good as possible chances of its graduates on a labour market.

In the case of the position of graduates of the Czech Technical University on a labour market, 64 per cent of the graduates are employees, and almost 21 percent are entrepreneurs. At present, 2 per cent of the respondents are without any working position (on a maternal leave). Nobody is unemployed, however, 23 percent of the graduates state that they had been unemployed for a certain period. In terms of the company's size, one third of the respondents work in a small company up to 25 employees. Two fifths of the respondents work in the middle sized companies and almost one third of the respondents work in large companies.

In companies according to the type of ownership, one third of the graduates work in the Czech private company, another one third in a foreign company, 18 percent of the respondents have their own firm, and also one tenth of them work abroad. The graduates hold very different positions. Most of them perform organisational and managing work (one fifth of them) and projection work (one fifth of the respondents). 51 per cent of the respondents hold leading positions. More than two thirds of the graduates of the Czech Technical University work in the same or related field, which they studied.

In terms of the type of working position, two fifths of the graduates changed an employer after they had finished their studies. For a part of the graduates, the main reason for their finding a new employer were the organisation changes in their company, the need of a

higher salary, and a lack of good prospects in the company. 84 per cent of the respondents are satisfied with their current job. Three quarters of the respondents renewed their qualification after the end of their studies, more than one half of them in firm seminars.

The graduates show relatively high identification with a faculty and a field of study. 63 per cent of the graduates of the Czech Technical Faculty would study the same faculty and the same specialty, 11 per cent would study a different specialty; that means that 77 per cent of the respondents would study the Czech Technical Faculty. Next, the respondents evaluated, according to their experience with the practice. 81 per cent of the graduates value most the acquired ability of technical thinking. Three quarters of the respondents assess the theoretical preparedness as very good. 70 per cent of the respondents evaluate positively the orientation in a chosen field, and 56 per cent conception abilities. Practical knowledge from the field got a lower positive assessment only from one fifth of the respondents. In terms of the knowledge of foreign languages, the knowledge from the area of work organization and management, only one tenth of the respondents gave a positive assessment. In terms of the practice and preparation for a future profession, the graduates assess as best those forms of instruction in case of which they can actively participate; that means the projects – diploma and complex projects and exercise. Excursions and professional practice got the worst assessment. The majority of the respondents (30 per cent) had to complement their language skills after finishing their studies, 19 per cent had to improve the knowledge from the area of management and organization of work, 10 per cent the knowledge from the area of computer technology, and then the knowledge from economy, law and legislation. This is the reason why the graduates do not assess positively the knowledge acquired at the faculties from the area of management, work with people and the knowledge about a today's society, which are important for a good performance in practice.

The analysis of this sociological survey results brought a large set of valuable information about the position of the graduates of the Czech Technical Faculty on a labour market. In the first place, considering the needs of the Czech Technical University, relatively detailed evaluation of the instruction in terms of the knowledge utilisation in the practice is specifically important. The knowledge acquired in the survey reveals that the students go to study the Czech Technical University for the reason that they want to study in a university with a professional technical specialization. The graduates are satisfied with their original choice of the field of study. In terms of their future work, the graduates acquire a very good theoretical and a good professional training within their specialty. They miss practical experience and professional practice in firms however, this is insoluble for the time being. For above stated reasons, it would be good to concentrate more on the independent work of the students, on their skills to present and justify their work and on teamwork.

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Reliability of Local Pressure Measurements on Models in Boundary Layer Wind Tunnel

J. Král, M. Jirsák*

jkral@klok.cvut.cz

CTU Klokner Institute, Dept. of Mechanics, Šolínova 7, 166 08 Praha 6
*Aeronautical Research and Test Institute, Beranových 130, 19905 Praha - Letňany

A force effect of the ai-flow on the buildings is expressed by means of dimensionless coefficients of pressure (external, internal, differential ones) on the surface elements of the building or the forces on the parts of the building or on the whole building and the reference pressure. The aim of the project was the evaluation of the qualitative and the quantitative relations between the local coefficients of the external pressure on the appropriate building and on the model in the boundary layer wind tunnel.

The classical definition of these coefficients ("quasi-steady coefficients") results from the practise in other branches and it defines their values as a ratio of the average value of pressure in the given place and the average value of the reference pressure. The maximum values of the effects of loading on the building are determined by the multiplication of the maximum value of the reference pressure with a certain probability of the values of the respective coefficients of pressures or forces and by means of other coefficients (correlation coefficient of loading, dynamical coefficient etc.), other features of loading or other features of building can be considered. The different access to the pressure coefficient definition was published by Cook and Mayne (1980) and Cook (1990). The coefficients are defined from the measuring on the models in boundary layer wind tunnels as the ratio of the characteristic maximum value of pressure p_{max} in the given place with the required probability of the occurrence and the peak value of the reference pressure based on a reference ten-minutes velocity defined with the same probability. These coefficients are marked as "pseudo-steady coefficients". The extreme value of coefficients with the same sign as mean pressure coefficients is applied. The similar properties have the "peak pressure coefficients" according Stathopoulos. The priority of the probability definition of the coefficients of pressure should be the expression of the local pressures in the different places of the construction of the building with the same probability of the occurrence. Excluding of time is the consequence of the probability access. It means that the extreme values of the pressures in the different places of the building does not have to arise necessary in the same time moment.

The City Tower building in Prague was selected as an experimental building. Wind velocities were measured in the site by the standard anemometer. It was installed on the mast 13 m above the roof of the building near the north wall. A temperature sensor and pressure sensors were installed on the west, north and east walls on the 27^{th} and 18^{th} floor. Also, acceleration and velocity sensors were applied during the long-term measurements for the building response measurements. The long-term automatic measuring of local pressures on the building were running 16 month with a few relatively short interruptions. A large set of the pressure measurements is still under analysis. The results will be published later.

The model of the City Tower building for pressure measurements in the boundary layer wind tunnel was made at the length scale 1:400 [1]. First stage of the pressure measurements was performed with the standard boundary layer simulation [2] on a building model with and without surrounding buildings. The quasi-steady and pseudo-steady pressure coefficients

were determined as well as an influence of the surrounding buildings. Model analysis of the growing of the boundary layer above the modelled terrain on the windward side of the measured building was performed. Two models of the terrain for the western and north-western directions at the length scale 1:1250 were used for study of the wind flow velocity and turbulence profiles development in the wind tunnel. Results were utilised for development more accurate simulation of the oncoming boundary layer in given site [3]. The modified boundary layer was used during the second stage of the model pressure measurements without surrounding buildings. The new pressure quasi-steady and pseudo-steady coefficients were determined. They were compared with the coefficients from the first stage of the model measurement and with those ones from the pressure measurements in situ. The preliminary results of the comparison have shown relatively very good agreement of the quasi-steady pressure coefficients on the windward side of the building and its model. Results of the pressure coefficient comparison will be published later.

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Analysis of Crack Growth in Bridge Structural Elements Applying Discrete Numerical Methods

R. Novotný*, P. Brož*

petr.broz@fsv.cvut.cz

*Department of Concrete Structures and Bridges, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The research presented is concerned with the application of the dual boundary element method to the analysis of fatigue crack-growth problems, in the context of damage tolerance analysis with linear elastic fracture mechanics. The basic properties of elastic fields, namely static and kinematic admissibility, were applied in compliance with [1], to deduce the expression of the work theorem, the root on which boundary integral formulations of elasticity theory are based. It was shown that the displacement and traction boundary integral equations constitute a dual boundary integral formulation of the mixed fundamental boundary-value problem of elasticity theory. Thus, the dual boundary integral equations which include Cauchy and Hadamard principal-value integrals, define the basis of the dual boundary element method.

The most important and the essential features of the dual boundary element method in the incremental analysis of crack growth can be summarized as follows:

- The preparation of data is minimum whan compared with the requirements of the other numerical methods. Effectively, there is no need to discretize either the problem domain as in the finite element method or artificial boundaries as in the subregions boundary element method.
- The single region analysis of the dual boundary element method combined with the introduction of new boundary elements along the crack extensions eliminates the remeshing problems, which are characteristic of the other numerical methods. This is the most striking feature of the dual boundary element incremental analysis of crack growth.
- The execution time is greatly reduced, since the absence of remeshing allows the efficient use of an incremental decomposition method for the solution of the system of algebraic equations.
- The method performs reliable analysis since it is based on accurate stress intensity factor evaluations, as well as on accurate predictions of the direction of the crack-extension increment.

Effectively, the single-region analysis of the dual boundary element method represents a very important practical feature, essential for efficient three-dimensional analyses, since it eliminates the use of artificial boundaries which require remeshing in crack-extension analyses. The computational advantages of the method will be much greater in three-dimensions than in two-dimensions.

The displacement discontinuity technique can be combined with the DBEM formulation, as a means of reducing computing time and memory requirements. A modelling and discretization strategy based on the used of continuous, discontinuous and edge discontinuous elements was also proposed. This discretization strategy is robust and capable of dealing with general mixed-mode edge cracks. Detailed descriptions were provided for the implementation of special crack tip elements and the evaluation of singular integrals.

The DBEM single region analysis has proved to be particularly suitable for solving multiple crack problems, facilitating the construction of the model and its remeshing after each crack extension. Crack propagation is modelled using an incremental crack extension analysis based on the strain energy criterion and the Paris law. For each crack extension the DBEM is used to solve the model and the crack tip stress intensity factors K are computed from the crack opening and sliding displacements. Crack extensions are then automatically modelled with the introduction of new boundary elements along the crack fronts and a localized rediscretization in the area where cracks intersect the free surfaces. The devised localized remeshing strategy is robust and accommodates model changes in the original system matrices allowing for important savings in computing time.

The procedure was successfully employed to model the interaction and coalescence of coplanar and non-coplanar surface fatigue cracks.

Continuum damage simulations yield a framework for characterizing the degradation of the elastic qualities of concrete owing two microcracking and crushing. Concurrently, this theory offers a description of macrocracking that issues from localization of strain and damage. Though the theory is markedly phenomenological, a method is presented which provides rational bases for selecting the type of damage variable to be apply in the constitutive response. Two underlying models were used: the classical scalar damage simulation and a model that embraces damage induced anisotropy.

The gradient enhancement of the scalar damage model was discussed and it was shown the connection between the theory of elastic materials with voids and the scalar damage model. The resulting constitutive relation incorporates an internal length and presents localization limiting properties which are required in order to capture microcraking damage localization and macrocrack growth within a single continuum description. No doubt that the extension of the elastic theory to damage models with induced anisotropy could be performed on the same basis.

Elasto-plastic damage can be achieved with two different approaches. The simplest one is to consider that the material without voids and cracks is elasto-plastic. This idea leads to the use of the effective stress in the elasto-plastic model. It is also quite convenient to implement from a computational point of view. Damage deactivation due to crack closure was also incorporated in such elasto-plastic damage models. A complete coupling is physically more appealing if one wants to capture the decrease of damage due to material crushing. A made out simulation can be presented along these lines.

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The Effects of Drying Intensity in Masonry Structures

Zdeněk Půbal*, Pavel Sůva**

pubal@fseznam.cz

*CTU, Faculty of Civil Engineering

Thákurova 7, 166 29 Prague 6, Czech Republic

** Czech Institution of Civil and Structural Engineers
Sokolská 15, Prague 2, Czech Republic

In August 2002, a catastrophic flood on the Vltava River hit Prague. Among the areas most severely damaged, there was the low-lying district of Karlín with water levels reaching up to several metres and flooding large built-up areas. The consequences of flooding, i.e. the drying of houses have been remediated till the present day. The article presents experience in drying masonry structures in the affected area obtained to-date.

Experience of flooding of buildings

The flooding of buildings or foundations and underground spaces affect severely the structures, which are usually built of porous materials. Due to capillary elevation, water is sucked into the pores and rises above the water level. During floods, structures may be degraded by the aggressiveness of water containing chemical substances. In interaction with moisture, such substances may destroy building materials.

Apart from these aspects, after the pores are filled, the thermal insulation properties of materials are weakened due to increasing thermal conductivity. On the basis of undesirable technical and health hazardous effects acting on structures, there are demands for faster water removal from pores by drying up the structures.

The structures monitored during the drying process were masonry, stone, combined and concrete structures.

Experience of drying procedures

Natural drying without any technical equipment, by forced drying with the use of heat radiators and by using dehumidifiers carried out the drying of structures and spaces.

The experience showed that the drying of structures and spaces with the use of heat radiators proved to be the "fastest" method of drying, but at the same time, the one with the highest risks with regards to the building structures. Due to fast drying, failures in walls and horizontal building structures arose in the form of cracks. Maximum effects manifested by cracking were recorded in vault structures.

A method considered as safe is natural drying performed by discharging air at a high relative humidity – diagonal ventilation. The drying method using condensation dehumidifiers showed to be safer for structures, but slightly longer in time.

The experience gained from the drying process was that natural drying with the help of heat radiators must be performed by confronting the outside and inside relative air humidity. When using dehumidifiers where condensation occurs, it is necessary to close the dried up spaces to increase the efficiency and economy of the dehumidifier operation.

Effects of drying time on building structures

Based on the analysis of the drying procedures, the following conclusions may be formulated:

- In relation to the time of drying it was manifested that reduction of the time effect exerts force effects (stresses) in the structure. Based on this knowledge, laboratory research of drying time duration must be carried out to avoid reaching such stresses that damage the structure.
- Further knowledge gained from monitoring the drying process is the effects of chemical substances on structures. This aspect leads to the necessity of structural and static research of structures.

Conclusion

Practical experience gained from the drying process must serve as a basis for formulating and calibrating a theory of how to remove moisture from building structures.

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Time Variations of Ground Water Level under Residential Buildings

Zdeněk Půbal*, Pavel Sůva**

pubal@fseznam.cz

*CTU, Faculty of Civil Engineering
Thákurova 7, 166 29 Prague 6, Czech Republic
** Czech Institution of Civil and Structural Engineers
Sokolská 15, Prague 2, Czech Republic

The masonry is radically affected by long-term changes of humidity. Observation of these phenomena is absolutely inevitable when assessing masonry structures condition because an incorrect approach can represent threat to the static safety of the structure. The experience proved that the origin of absolutely major causes of defects of masonry structures which defects in less or bigger extent depreciate the masonry structures, decrease their life and usability, increase the requirements for repairs, maintenance and reconstructions, can be addressed to humidity effects and temperature changes. Vice versa it was proved that the structures are faultless if the exposure to these changes can be limited and if the effects of these phenomena are considered correctly already during structure design and its execution. But such correct prediction must respect many parameters, which mainly the humidity development is directly dependent on.

The masonry structures show defects of various types, which in their consequences represent shortening of the life of such structures, increase of costs for maintenance, necessity for repairs and reconstructions, possibly even the decrease of safety of such structures.

The detailed analysis of monitoring of actual influence of masonry structures in terms of theoretical and experimental way enables the definition of general conclusions about the prognosis of the life of masonry structures, and the proposal of methods to prolong their life.

This will represent an important contribution to conception decision-making about design, construction and maintenance of masonry structures, which shall by accompanied by high economical effect. The thorough verification of actual conditions of investigated structures enables the elaboration of recommendations for removal of defects and problems so that the structure gained required load-bearing capacity, durability, safety and the improvement of its performance.

It is therefore necessary to perform a thorough construction and technical investigation – such an investigation contains the following:

a) assessment of the technical status of the building in terms of mechanic resistance and stability where remediation of wet masonry is carried out

b) investigation of ground and surface masonry of the building in terms of humidity and type and content of salts forming patterns

c) chemical analysis of potential ground water occurring in contact with the building foundations

d) assessment of engineering and geological status of the building and its near surrounding and assessment of building foundations status in relation to the planned remediation action.

It is necessary to objectively analyse the causes of the problems of masonry buildings in areas affected by floods, gradually elaborate on an all-inclusive diagnostics of both damaged

and operated buildings with the target of securing their economic operation, upon securing optimum reliability for all users.

First, the occurrence of defects in masonry buildings was mapped in locations affected by floods, with a specification of typical defects and construction systems used. In order to create such a map of defects, the first stage of project was focused on a Prague location, namely the Karlín area. Simultaneously, initial status of masonry buildings in this area was documented. Authors already have hands-on experience with recent regeneration of masonry buildings, exactly in the Karlín area.

In order to specify various actual factors affecting on the structure and in order to determine their contribution to degradation, it was also necessary to collect and analyse results of previous monitoring of the structures, namely the development in defects, development in volume changes, and factors causing these, further the thermal regime and also foundations settlement development.

A detailed monitoring of time changes in climatic influence, namely humidity and heat in masonry constructions was performed. Such long-term measurement, covering period of three months, was carried out in a suitable building in the Karlín area. Primarily, the attention was directed to fluctuation of the level of ground water. The delay in variation of the water level in the investigated location in comparison with the water level in the river Vltava was identified. Experimentally gained data will further be used for calibration of mathematical models developed.

When modelling the transport processes, it is necessary to take into account that humidity occurs in building structures in the form of steam or water. In the theoretical area, it results in a study of transport phenomena of heat transfer and humidity with application to buildings. The humidity field by its nature compared to the thermal field has much more complex effects. Transfer of humidity compared to solving of heat fields faces a number of aspects, which influence humidity transmission, and which should be included in the qualitative description.

In the majority of construction materials, the most important factor influencing transmission of humidity is the gradient of humidity expressing the influence of capillary pressure and surface diffusion. The influence of humidity gradient is a primary factor and capillary pressure is the primary influence on humidity transmission. Next to the humidity gradient, transmission of humidity is significantly affected by gradients of the heat field . Heat and humidity fields are mutually affecting each other and solution of transmission equations for transmission of humidity and heat can be solved only for simultaneous carrying of heat and humidity in construction materials.

Theoretical analyses calibrated by measured values will allow to determine both the real behaviour of the given building and factors significant to its functioning (thermal regime, and also resulting hygienic and health factors etc.).

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Sensitivity of the Aqualog Hydrological Model with Respect to Redistribution of Input Time Series for the Lipno Catchment

M. Holeček

m.holecek1000@seznam.cz

Department of Hydrotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

A hydrological model simulates hydrological behavior of a watershed and its response with respect to input hydrological data.

In our work, the Aqualog hydrological model is used to simulate the Lipno reservoir inflows. The period of the data available for setting up the model is 3 years long (Nov. 2000 – Nov. 2003). The Lipno catchment (948 km^2) is divided into 4 sub-basins. The sub-basins were chosen just so that observed flows and inflow to the Lipno reservoir are outlet profiles from each sub-basin. The time series of inflows to the Lipno reservoir is not available; this means runoff from the Lipno sub-basin cannot be calibrated via observed flows, as the other three sub-basins can be, thus making the reliability of runoff from the Lipno sub-basin more uncertain. Furthermore, there are some missing data in the observed flows time series, which as well affects the reliability of the model.

Firstly, the comparison of observed and simulated flows at sub-basins outlets was done. Relative errors were computed as the percentual difference between simulated and observed flow ordinates for the overall time period. Basic statistical parameters of compared time series also were computed. For flood control, which is the most interesting for us, a good agreement between simulated and observed flows during flood events is needed. A comparison of observed floods (peaks and volumes) was done. Computed values are expressed in the same way as relative errors.

Table 1 Differences between statistical parameters of observed and simulated flows [%]. The confidence interval of relative error is taken as the 2.5 % both lower and upper quantile.

Station	mean value	Cv	Cs	relative error
Lenora:	10	-7	-16	(-58;143)
Č. Kříž	10	-16	18	(-62;230)
Chlum:	24	-13	-20	(-41;258)

Table 2 Differences between culmination ΔQ_{max} and volume ΔV of observed and simulated floods [%].

Station	Mar. 02		Aug.02,1st part		Aug.02,2nd part		Jan.03,1st part		Jan.03,2nd part	
	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV
Lenora	-9	-4	-53	-45	-1	-7	-12	-2	-13	-4
Č. Kříž	-26	-43	-14	-24	8	8	-4	-36	30	-15
Chlum	NA	NA	-24	-23	-11	-5	3	-3	-5	25

Culminations (all ordinates) are sometimes predated or lagged in comparison to the observed flows. This fact partially explains high values of relative errors.
Secondly, sensitivity of the model with respect to the redistribution of the input rainfall and temperature time series was evaluated. Uniform rainfalls and temperatures were created using Thiessen techniques and additionally precipitation were transformed into 3 hour uniform rainfall depth. Differences between newly computed inflows to the Lipno reservoir were evaluated. Relative errors were computed in the same way as before.

Table 3 Differences between statistical parameters of simulated and newly computed inflows to the Lipno reservoir [%].

mean value	Cv	Cs	relative error
8	-5	-21	(-17;48)

Table 4 Differences between culmination ΔQ_{max} and volume ΔV of simulated and newly computed inflows to the Lipno reservoir [%].

Mar.02		Aug.02,1st part		Aug.02,2nd part		Jan.03,1st part		Jan.03,2nd part	
ΔQ_{max}	V	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV
21	9	-23	-16	-10	-5	1	9	8	1

The purpose of the creation of this new time series is to estimate, to what extend it affects inflows to the Lipno reservoir, if uniform synthetic precipitation time series are generated and used instead of generation of mutually dependent precipitation time series for each station, which methodology is not yet developed.

Finally, the sensitivity analysis of the Lipno inflows with respect to the precipitation change was done. Precipitation causing observed floods were uniformly both increased and decreased to evaluate the change of culminations and volumes. This can give us estimate, how inaccurate meteorological forecast affects the inflow to the Lipno reservoir.

Table 5 Change in culmination ΔQ_{max} and volume ΔV with respect to uniform change of causal precipitation [%].

	Mar. 02 flood		Aug. 02,2nd flood		Jan. 03,2nd flood	
mm/day	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV	ΔQ_{max}	ΔV
-20	-35	-28	-41	-32	-33	-29
-10	-27	-13	-23	-17	-21	-19
10	34	22	34	20	39	25
20	80	46	80	41	87	53

As shown in Tab. 5, even not high differences in causal rainfall can affect resulting flood considerably. Improving of hydrometeorological forecast (QPF and temperatures during snowmelt time) still appears to be important.

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New Tendencies in Determination of Accuracy of Laser Levels

J. Kratochvíl

Jiri.Kratochvil@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Special Geodesy Thákurova 7, 166 29 Praha 6

This report outlines the content of the international standards ISO for determining accuracy of measuring instruments and is focused on determination of standard deviation of laser level in dependence on length of sight and on testing if obtained standard deviation is consistent with the specification that is indicated from the producer. The described test of accuracy of rotating laser level is appropriate completion of standard ČSN ISO 8322-6. This test is relatively fast and telling, it provides objective results and it could be applicable at the interdepartmental level at the control of metrology of geodesy.

At the beginning of this report it is necessary to remind the fact that the accuracy of laser levels (LL) with rotating laser, recently plentifully used in building profession, is necessary to be attested as consistent with ČSN ISO 8322-6 while the operation of geodetical working in building-up. The Law about surveying provides standards of series ČSN ISO 8322 as mandatory standards. The result of attestation according to ČSN ISO 8322-6 is a full characterization of the accuracy that is represented by sample standard deviation of determination of difference in elevation. So defined characterization of accuracy is not naturally considering about length of sight, but this is according to [1] very important. In addition ČSN ISO 8322-6 is missing, as well as others standards of series ČSN ISO 8322, very important statistical test for comparing experimentally obtained standard deviation with standard deviation that is indicated from the producer.

New tendencies in determination of accuracy of levels, theodolites, electronic distance meters and other measurments have led to publication of international standards ISO 17 123-1 to 7 (determining of accuracy of LL solves ISO 17 123-6), that are going to be implemented in our country in no distant time and that are going to substitute standards of series ČSN ISO 8322 which are valid now. In consideration of this progress was made a procedure for determining of accuracy of LL, it was made by the Department of Special Geodesy. This procedure is useful in the routine building activities, it enables to determine the standard deviation of high determination with consideration on influence length of sight and it contains suitable testing if obtained standard deviation consistent with specification that is indicated from the producer. This specified procedure does not have to replace ČSN ISO 17 123-6 that is being prepared in these days. It may be a supplement by task handling of interdepartmental metrology.

To realize this specified procedure it is necessary to **create a circle form** (r = 15 m) **test baseline** somewhere in plane terrain. Level position is in the middle of the circle, on the circle are evenly distributed points P_0 to P_n. The point P_0 is referential, others points (at least 15) are observed. The Points are stabilized by a nog and a screw with a rounded head.

Then **optical leveling** will be done. We will use a leveling rod and a level for technical leveling that stays in the middle of the circle. We determinate high of points P_1 to P_n twice (back and forth). We will count the average relative highs H_1 to H_n of the observed points that are outspread to the point P_0. Sample standard deviation of any high H_i will be represented by figure

$$s_H = \frac{1}{2}\sqrt{\frac{\sum_{i=1}^{n}\Delta_i^2}{n}}, \qquad (1)$$

where Δ_i are differences between determination of high back and forth.

In the next step we'll do **laser leveling**. With a laser set, i.e. LL and a leveling rod with an opticalelektronic detector, are twice (back and forth) determined the highs of the points P_0 to P_n. LL is again in the middle of the circle. The Relative highs H'_1 to H'_n will be counted in the same local height system as while optical leveling.

After measurement it is necessary to confirm a supposition, if the applied method of optical leveling is much more accurate then laser leveling. Counted sample standard deviation will be counted this way

$$s_r = \frac{1}{2}\sqrt{\frac{\sum_{i=1}^{n}\delta_i^2}{n}}, \qquad (2)$$

where $\delta_i = H'_i - H_i$ are quasireal deviation.

We can go on in the evaluation procedure, if it is valid that $s_r \geq 5s_H$. If it is not valid, it will be necessary to use another method with higher inward accuracy for reference measurement.

Providing linear increase of sample standard deviation in dependence on distance between LL and detector [1] will be re-counted sample standard deviation s_r (determined for 15m length) on sample standard deviation s (determined for 100m length) after figure $s = s_r.100/r$. This sample standard deviation characterizes a laser set and describes its outward accuracy.

In the end of the test we will make a **test of conformity** between standard deviation s_r and standard deviation σ that is declared by producer of LL. ISO standards from the field of metrology use χ^2 testing for this kind of the task**.** The same kind of testing is used in new ISO standards series 17 123. For building profession it is better to use a more illustrating solution that is limiting value of sample standard deviation [2]. Null hypothesis H_0: $s \leq \sigma$ is not rejected, if next figure is valid

$$s \leq \sigma(1 + \frac{1}{\sqrt{2n'}}), \qquad (3)$$

where s is sample standard deviation,
σ is standard deviation declared by the producer
and n' is the number of unnecessary measurement, $n' = n - 1$, for 15 points of baseline is $n' = 14$.

If higher figure is not valid than alternative hypothesis H_1: $s > \sigma$ is accepted.

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Instrumentation of the Experimental Microwatersheds in Jizera Mountains

L. Novák, M. Šanda

lukas.novak@fsv.cvut.cz

Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 6, 166 29 Prague 6, Czech Republic

Introduction

On the experimental watersheds Uhlířská and Kristiánov new installations began in 2005. Their specifications are listed below:

- Proposal for the additional measurements in the network of the experimental stations in Jizera Mountains
- Proposal for new gauging profiles for subwatersheds of Kristiánov and Uhlířská.
- Improvements of the river bed prior to gauging station installation

Area of interest

The experimental watersheds Uhlířská (Černá Nisa stream) and Kristiánov (Kamenice stream) are located in the northern part of the Czech Republic at higher elevation of Jizera Mountains. Both watersheds are located in the region with the highest annual precipitation in the Czech Republic which exceeds 1300 mm/year. The total area of watershed Uhlířská is 1.87 km^2, average altitude of watershed is 822 m above sea-level. The total area of watershed Kristiánov is 6.38 km^2, average altitude is 990 m above sea-level.

For the specification and comparison of the runoff generation from the headwater catchment area two new microwatersheds were proposed within the frame of the existing network. Locations were selected with the purpose of observing subsurface runoff in relation to the rainfall (Šanda, 1999). One of new microwatersheds covers northern part of existing watershed Uhlířská (Císlerová et al., 1997), related to the gauging profile of Černá Nisa - Horní Uhlířská, presently in the process of construction. The second watershed covers the highest part of the watershed Kristiánov on the stream Kamenice related to the constructed profile Horní Kristiánov on the crossing of the forest way Kristiánov-Ptačí kupy and the pipe culvert on the stream of Kamenice. The watersheds were selected in the way that their areas are identical, approximately 1.18 km^2. This attitude excludes factors of the watershed area for the future hydrological analyses of the transformation rainfall into the runoff. The watersheds are situated in the different altitude. The watershed Horní Uhlířská is situated in the area of 800-900 m above the sea-level, the watershed Horní Kristiánov is situated in range of 880-1100 m above the sea-level. The orientation of the hill slopes is also different. Slopes of the watershed Horní Uhlířská are oriented east-west, the watershed Horní Kristiánov is oriented mainly towards the west. Total forestation on the watershed Horní Kristiánov is lower than the watershed Horní Uhlířská. These watersheds will be specified in details according to the progress of the following research.

The modification of Kamenice stream – gauging profile Horní Kristiánov

In order to measure correctly water discharge as one of the most important hydrological parameters, modification of the stream beds of Kamenice and Černá Nisa at the short vicinity of the profiles had to be performed. Gauging profile for the watershed Horní Kristiánov is

constructed on the pipe culvert with its inner diameter of 1200 mm. Gauging device is suggested as Thomson V-notch spillway with the angle of 120°. Profile is made of the stainless metal plate with the thickness of 4 mm which is fixed to the concrete flange of the pipe culvert on its inflow end. The hydrostatic pressure of water is sampled by the pressure sensor BD Sensors LMP380i, which is connected to the data-logger Fiedler-Mágr M4016G with the data transmission via GPRS. The energy for system is supplied by the solar panel, which is located in the canopy of the nearby tree. Gauging of the water level in the place of gauging profile and the determination of discharge was launched in October 2005. Measurements are in the standard mode since the beginning of hydrological year of 2006 (since November 1st 2005).

The data-logger serves two sensors (LMP308) for the groundwater level at the area of the subsurface return flow near the gauging profile of the watershed Horní Kristiánov. Piezometers for this purpose were drilled by the pneumatic hammer Eijkelkamp. Wells are shallow with the depth of 70 and 120 cm. This work was performed by joint effort of the Water Research Institute, Prague and Faculty of Civil Engineering, Czech Technical University, Prague.

The modification of Černá Nisa stream – gauging profile Horní Uhlířská

For the gauging profile Horní Uhlířská relatively straight part of the stream with distinctive slope of the water flow was selected. This area is in the vicinity of the big boulder, which will be used as one part of the gauging profile for higher stages. This area is convenient for the diverting of water during the construction of the gauging profile as well. Profile was cleaned from debris, flood timber, grass and manually transportable stones during several campaigns. In October 2005 an attempt to break down one of bigger stones (approx. 3 tones) obstructing good hydraulic conditions was performed. The stone was drilled in the rectangular array of 30 mm wide holes. Such openings were filled by special expansion cement. This process of destruction proved to be successful and will be used during next efforts of the installation of a gauging profile in 2006.

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Cost-Benefit Analysis of Flood Protection Measures

F. Čihák, P. Fošumpaur, M. Horský, L. Satrapa,

fosump@fsv.cvut.cz

Department of Hydrotechnics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6

Recently, large floods which have been affected Middle Europe at the end of 90th and the most significant historically observed flood from 2002 caused large damage and carried away even human lives. This is reason why the need of a conceptual and systematic approach is very crucial at present time. Efficiency of the flood protection need to be objectively measured to answer a key question if realization of a proposed flood protection measure has any meaning or has not. Another task can be formulated by the optimizing problem of the flood protection in the given area where several scenarios of flood protection measure exist. Our task is then represented by finding the optimal scenario to reach the best value of criterion chosen. This criterion is obviously economically based.

This contribution is aimed to describe a new methodology to assess the economical efficiency of proposed flood control measures (FCM), respectively systems of FCMs. The methodology was developed at the Department of Hydrotechnics, Faculty of Civil Engineering, CTU and it is broadly applied for assessment of FCM projects included to the "Flood Control Prevention" program organized by the Ministry of Agriculture of the Czech Republic and the European Investment Bank.

The philosophy of the methodology proposed is based on the cost-benefit analysis. Costs are generally given by the realization and design costs of the proposed FCM and the benefit is evaluated with the use of the risk analysis method. Benefit of the FCM is represented by the flood damage value evaluated for the situation if the FCM is not realized. Flood damage is affected mainly by the peak flow of the flood, water level and velocity. To assess the flood damage hydraulic models are usually used to simulate flow conditions for floods with varies return periods of the peak flow. Consequently, a flood damage assessment procedure is started. This problem is in more detail described in our parallel contribution.

The risk analysis method is capable to objectively evaluate the flood damage caused by floods with a different exceedance probability. The flood risk is generally affected by the flood damage and by its occurrence probability according to formula:

Risk = Damage x Occurrence probability

The mean annual damage can be computed by:

$$R = E(D) = \int_{Qa}^{Qb} D(Q).f(Q)dQ \qquad (1)$$

where $R = \mathrm{E}(D)$ is the mean annual damage [\$],
$D(Q)$ is the damage for the peak flow Q [\$],
Q is the flow [$m^3.s^{-1}$],
$f(Q)$ is the probability density function of the yearly peak flows [-],
Q_a is the non-damaging flow [$m^3.s^{-1}$]

Q_b is the flow for which the occurrence probability is close to zero [$m^3.s^{-1}$].

The value of the mean annual risk can be computed either by the numerical integration according to formula (1) or by the stochastic approach (Monte Carlo Simulation). Second approach is based on the statistical analysis of the yearly peak flow series and it allows to assess reliability of the mean annual damage (its probability properties).

To asses the present value of the risk (capitalized value of the risk) a discount approach is used. The present value of the risk is affected by the discount rate. The discount rate ranges in the European countries from 1% to 10% (average value is approximately 5%). In conditions of the Czech Republic the value of 3% was chosen with respect to expected trend. The value of the capitalized risk R_s is then given by the formula:

$$R_s = \frac{R}{Dr} \qquad (2)$$

where Dr … is the discount rate. [-]

To assess the economical efficiency of the FCM the following system of criteria is used:
a) Payback period,
b) Relative efficiency,
c) Total efficiency.

These criteria allow to assess economical efficiency of proposed FCM and to answer the basic question if its realization brings benefit or not. Criteria are fully described in our latest works [1,2,3,4].

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Stochastic Weather Generator

P. Fošumpaur

fosump@fsv.cvut.cz

Department of Hydrotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6

To the most efficient preventive flood control measures belong methods of the real-time control of water resources. Recently, a number of various concepts of mathematical models of control systems have been proposed. The quality of those models is obviously strongly affected by the reliability of a hydrological forecast, which represents one of the most important input to the decision making model. This contribution describes calibration of a stochastic weather generator and it discusses a possibility of its application to improve the flood control of reservoirs.

The weather generator is used to produce a long term synthetic rainfall series which consequently enters to a rainfall-runoff model to obtain the catchment respond. These synthetic rainfall-runoff events allow to improve flood control system of the basin with the use of the optimization of reservoirs operation. In this study the upper part of the Moldava River to the Lipno reservoir is tested. It has been checked that space distribution of daily rainfall depths can be considered by their mean value for basin, so a single site weather generator was used. In the first step the daily rainfall depths were generated and their redistribution to hourly amounts was then performed.

The rainfall model consists of precipitation occurrence and precipitation amount module. To keep a character of daily rainfalls in particular seasons the order of Markov chain in the precipitation occurrence model was optimized separately for all months. This optimization was performed with the use of Akaike information criterion) AIC or (Bayesian information criterion) BIC. Let's denote the order of Markov chain for *m*'s months by *k(m)*. Consequently the transition probabilities $\mathbf{p}_m(i_1,i_2,\ldots,i_{k(m)}\rightarrow j)$ and the frequencies $\mathbf{N}_m(i_1,i_2,\ldots,i_{k(m)},j)$ for all possible previous states are determined for both: wet day or dry day will follow. The number of transition probabilities is $2*2^{k(m)}$. Then the base probability $P(x_1,x_2,\ldots,x_{k(1)})$ is computed for the first sequence in first month. The AIC for prec. occurrence model is then given by the formula:

$$AIC = -2\log P(x_1,x_2,\ldots,x_{k(1)}) - 2\sum_{m=1}^{12}\sum_{q=1}^{2*2^{k(m)}} N_{m,q}(i_1,i_2,\ldots,i_{k(m)},j).\log p_{m,q}(i1,i2,\ldots,ik(m)\rightarrow j) + 2K$$

where K is the number of parameters to be estimated in the model. The number of independent base probabilities is $2^{k(1)-1}$ and the number of independent transition probabilities depends on the Markov chain order for particular month:

$$K = 2^{k(1)} - 1 + \sum_{m=1}^{12} 2^{k(m)}$$

In the next step orders of Markov chain for particular month of daily precipitation occurrence model were determined. This task can be performed by an optimization:

$$AIC(k(1), k(2), ..., k(12)) \rightarrow \min$$

or

$$BIC(k(1), k(2), ..., k(12)) \rightarrow \min$$

This optimization was carried out with the used of a genetic algorithm where initial guess (first generation) was represented by the second order for all months [1,2].

The daily precipitation amount module (for wet days) is based on the two-parameter Gamma distribution. Its probability density function is:

$$f(x) = \frac{\left(\frac{x}{\beta}\right)^{\alpha-1} e^{-\frac{x}{\beta}}}{\beta \Gamma(\alpha)}$$

where α and β are parameters and the $\Gamma(\alpha)$ is the gamma function. Parameters α and β were evaluated separately for each month. The model allows include autocorrelation between successive nonzero precipitation amounts in daily series.

Daily temperatures are modeled as autoregressive process with respect whether the day has been simulated to be wet or dry. Daily rainfalls were consequently disaggregated to hourly rainfall depths with the use of the Random Cascade method and temperature variable was also generated. Created synthetic rainfall events were used to model the catchment respond with the use of deterministic hydrological model.

Rainfall generators can be very useful to simulate synthetic flood patterns. Stochastic rainfall-runoff events allow to analyze a catchment response and to optimize an operation strategy of water resources systems.

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3D Flow Analysis around Hydraulic Structures

P. Fošumpaur

fosump@fsv.cvut.cz

Department of Hydrotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6

This research continues on our work [2] where an optimization of the turbine intake structure with the use of 2-D mathematical modeling approach has been studied. The optimization of the design of intake structure objects can be solved by physically based models in labs or by mathematical modeling. A combination of the both approaches can be very advantageous as it allows to compare results reached and more reliable design can be supposed. Physically based models and mathematical models are obviously aimed on the optimal design of shapes and dimensions of hydraulic structures which are in direct contact with flowing water. Among these questions belong for example design of weir piers, separating pier between the weir and the hydropower plant (HPP), the shoal in the intake to HPP, the breast wall, design of coarse and fine racks, etc. Unsuitable design of these elements can very negatively affect hydrodynamic conditions in the intake area which usually lead to detachment of the flux from the face side of the pier, infringing the flux. Measurements conducted on completed water works have demonstrated a decrease in the efficiency of such an aggregate by as much as 30%. Research has proven that design of hydraulic structures can very significantly affect the efficiency of HPP, so it is of high importance to optimize their shape and dimensions.

This research is aimed in application of 3-D mathematical modeling technique to describe hydrodynamic conditions in intake structures where all thee dimensions should be considered. 2-D approach is based on the simple assumption of the constant vertical velocity which is not in the intake structure area usually satisfied. Nevertheless, 2-D models are suitable for design of the overall disposition scheme of the hydraulic structures. To describe flow conditions in more complex view a 3-D schematization is necessary.

Due to computational complexity a proposed approach recommends to divide solving into two basic steps. Firstly, the problem is solved in large scale of overall scheme with the use of 2-D model. This stage should consider sufficient length of upstream section to model flow condition more reliably. Outputs of this analysis are represented by velocity profile in small distance in front of the intake structure where assumption of constant vertical velocity is not more acceptable. Vertical velocity profile is then used as an boundary condition for 3-D hydrodynamic model of the intake structure, which is described in more detail by its 3-D geometry allowing to consider the real design of particular parts of hydraulic structures.

Mathematical modeling of turbulent flow uses the turbulent k-ε model, comprising modified Navier-Stokes equations with the Reynolds number, the continuity equation, transport equations and the diffusion of kinetic turbulent energy, and equations describing the transport and diffusion of the speed of the dissipation of the kinetic energy of the turbulence. Equations describing the turbulent flux introduce the time-averaged velocity.

The above-specified equations for 3-D turbulent flow were approximated by the Finite Element Method in the FEMLAB computing environment. The geometric limit conditions are given by the shape of the area of flux, and are based on the layout solution of the inlet to the

water power plant. 3-D model of the flux is based on assumption of horizontal water level in the area of the intake structure. This condition is sufficiently reasonable because water level is strongly affected by the weir construction.

The proposed approach was tested on the Malczyce HPP located in Poland on the Odra River. In this scheme the 2-D analysis was previously performed. Application of 3-D model has brought further improvements of simulating hydrodynamic conditions and allows more precisely optimize the intake structure design.

The methodology is intended to be used to optimize hydrodynamic condition in the intake structure of the HPP Děčín in 2006.

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Operative Management of Building Industries

J. Jakubše

jiricek@jiricek.cz

Department of Economics and Management, Faculty of Civill Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Internet capabilities in building industries

All companies using Internet as an integral part of their businesses activities are international. Successful Internet companies will achieve a benefit for owners, general and specialty contractors, architects – engineers, distributors and product manufactures. Shorter schedules and lower costs through project portals can be benefit for owners such us more detailed documentation being made at these portals can be helpful. Better information about the progress and better control of project costs can be profits for the general contractors. Wider exposure of general contractors and others are avails for the specialty contractors. Architects – engineers can be welfare in preparation and documentation of construction services and projects designs. Talented architects – engineers, developers and marketers located anywhere in the world can create a virtual better qualified teams collaborated on specific projects despite being thousands of kilometers apart and work more effectively while minimizing time, distance and organizational barriers. Distributors of manufacturer products are an integral part of the delivery chain via Internet and decrease cost of the products which are benefits to owners.

Process of the operative management of structures

In operative management project manager and project team have to perform multiple actions to execute project plan to accomplish work defined in project scope statement. There are actions like a expend effort and spend funds to accomplish the project objectives; obtain quotations, bids, offers, or proposals as appropriate; perform activities to accomplish project objectives; staff, train, and manage the project team members assigned to the project; select sellers by choosing from among potential sellers; implement the planned methods and standards; manage risks and implement risk response activities; manage sellers; collect project data and report cost, schedule, technical and quality progress, and status information to facilitate forecasting; adapt approved changes into the project's scope, plans, and environment; collect and document lessons learned, and implement approved process improvement activities; obtain, manage, and use resources including materials, tools, equipment, and facilities; establish and manage project communication channels, both external and internal to the project team; create, control, verify, and validate project deliverables. Process of operative management of structures is most directly affected by the project application area. Deliverables are produced as outputs from the processes performed to accomplish the project work planned and scheduled in the plan of project. Work performance information about the completion status of the deliverables and accomplishes, is collected as part of project execution and is fed into the performance reporting process.

Operative management of structures requires: implementation of approved corrective actions that will bring anticipated project performance into compliance with the project management plan; implementation of approved preventive actions to reduce the probability of potential negative consequences and finally implementation of approved defect repair requests to correct product defects found by the quality process.

Inputs

Inputs of operative management are project plan, approved corrective and preventive actions, approved change requests, approved and validated defect repair and administrative closure procedure.

Tools and techniques of operative management of building industries are project methodology and project information system. Project methodology defines a process that aids a project team in executing the plan of project. Project information system is an automated system used by the project team to aid execution of the activities planned in the plan of project.

Outputs

Outputs of operative management are deliverables (any unique and verifiable product, result or capability to perform a service that is identified in project planning documentation), requested changes (requested to expand or reduce project scope, to modify policies or procedures, to modify project cost or budget, or to revise project schedule are often identified while project work is being performed, requests for a change can be direct or indirect, externally or internally initiated, and can be optional), implemented change requests, implemented corrective and preventive actions, implemented defect repair and work performance information. Information on the status of project activities being performed to accomplish the project work is routinely collected as part of the execution of project plan. This information includes schedule progress showing status information, completed and not completed deliverables, started and finished schedule activities, extent quality standards, costs authorized and incurred, estimates to complete the started schedule activities, percent physically complete of the in-progress schedule activities, documented lessons learned posted to the lessons learned knowledge base and Resource utilization detail.

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Utilization of Tensiometric and Soil Moisture Data for Inverse Dual-Permeability Modeling

M. Dohnal, J. Dušek, T. Vogel, F. Doležal*

dohnalm@mat.fsv.cvut.cz

Dept. of Hydraulics and Hydrology, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

*Research Institute for Soil and Water Conservation, Žabovřeská 250, Prague, Czech Republic

Prior to modeling of solute transport in heterogeneous porous structures a reliable prediction of water flow in such media has to be accomplished. This effort is closely associated with the determination of the soil characteristics. Forward and inverse modeling of water flow in soils may help to address the question of trustworthy hydraulic properties of natural porous medium. The soil hydraulic behavior at the field scale is closely examined. Furthermore, we used three types of different measurements to estimate soil hydraulic parameters of the heterogeneous soil system.

A field experiment was conducted in Valečov in the Bohemo-Moravian highland region. The main objective of the field experiment was to optimize the drip irrigation and nitrogen fertilization of potatoes. The soil is a deep loamy Planosol, underlain by weathered paragneiss.

Soil suction was measured by Watermark porous matrix sensors at three depths (30, 45 and 75 cm below the soil surface). Tensiometers, measuring suction head, were placed at two depths 45 and 75 cm. In addition, to pressure head measurements, Virib probes were employed to measure volumetric water content. The position of the probes was 30 and 60 cm below the soil surface, respectively. In the present study, we limit ourselves only to the treatments without drip irrigation (variant I and V) in order to exclude the effect of irrigation heterogeneity on measuring sensors. Only sensors without obvious failure were chosen from each treatment for the following numerical experiments.

The soil retention characteristics were measured in the laboratory on core samples using standard pressure plate apparatus. In the field, saturated hydraulic conductivity (K_s) was derived from tension infiltrometer and pressure infiltrometer measurements. The resulting values of soil hydraulic parameters were used as a reference parametric set for the simulations. The hydraulic data examination suggests no apparent soil layering.

The dual-permeability model of soil water flow [2] was used to simulate the soil water regime in a one-dimensional vertical soil profile. The dual-permeability approach assumes that the porous medium consists of two pore systems, i.e. the matrix and fracture domain.

The initial condition was set equal to the measured suction profile at the start of the simulated period. Free drainage condition was utilized as a bottom boundary condition for the soil matrix and the fracture system at the depth of 150 cm. Atmospheric boundary condition, accounting for natural rainfall and evapotranspiration, was assumed for both pore domains.
Data from all three types of sensors used in this study overlapped only for a limited part of the vegetation season. Hence, the time period from June through July 2004 was selected for simulations and optimizations. Adventitiously, rainfall with the highest intensity occurred during the considered period.

Soil characteristics of the fracture domain were taken from the previous study [1]. The inverse modeling involved the estimation of only two sets of scaling factors [3] for each

sensor type scenario. Matrix domain scaling factors for pressure head and hydraulic conductivity were optimized using Levenberg-Marquardt algorithm. The scaling factors were assumed to vary linearly between their optimized top and bottom values. The parameters of the fracture domain were optimized separately. Several optimization scenarios were considered by including or excluding pressure head and/or water content data in the objective function.

The following observations were made by closely inspecting measured responses of the installed sensors to natural rainfall: The deeper sensors show close to saturation values; whereas the near surface sensors respond quite sharply and intensively to the changes in rainfall intensity. This may be caused by a strong reduction of the saturated hydraulic conductivity with depth and intense evapotranspiration forcing. To test this assumption, soil layering with substantial decrease of matrix K_s with depth was used in simulations. Alternative explanation for the measured differences in pressure responses would be the presence of the water table near the lower sensor; however this is not supported by any independent field observation.

The forward simulation results, using soil layers stratification, where K_s reduction of two orders of magnitude was employed, predicts closer agreement with all measured sensors. The highest correlation between modeled and measured responses is obtained with forward simulations based on parameters, which were optimized using tensiometric data. Conversely, the poorest forward prediction was delivered by "Watermark sensor parameters" for variant I. Interestingly, quite low objective function values were reached when the pressure head ($h = 0$ cm) boundary condition instead of free drainage for the bottom face was imposed. However, forward simulations using the pressure head bottom boundary condition lead to low correlation value and to considerably deteriorated sensor responses, i.e. all sensors in the soil profile show close to water saturation values.

Resulting sets of hydraulic parameters (scaling factors) for each treatment and sensor nests were evaluated. A similar trend of optimized scaling factor for hydraulic conductivity for all three sensors is achieved: hydraulic conductivity gradually decreases with depth of the soil profile. It is worth noting that such trend holds even for the cases with the preset K_s reduction. The scaling factors for pressure head, estimated from water content and suction data, exhibit identical tendency as the hydraulic conductivity scaling factor. In theory, a reciprocal relationship between scaling factor for pressure head and alpha parameter in the van Genuchten retention model is supposed. It means that for a fixed value of pressure the respective water content decreases with depth.

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Thin-Walled Steel Structures Exposed To Fire

Z. Sokol, F. Wald

sokol@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

Thin walled corrugated sheets are used for roofs of span up to 9 metres. Their fire resistance is usually evaluated by experiments. The load bearing criterion R, the integrity criterion E and thermal insulation criterion I are observed for roof structures. The mechanical load during the test corresponds to accidental design situation and the temperature follows the nominal temperature curve. The section factor of corrugated sheets A_m / V (m^{-1}) exceeds the value *1 000* m^{-1}, therefore the temperature of the steel sheet θ_a can be approximately taken equal to the gas temperature θ_g. The change of the material properties for thin-walled elements at elevated temperature can be found in literature and were introduced into European standard EN 1993-1-2. The reliability of the roof structure at fire is highly influenced by connection of the sheets to the supporting structure. The connection is loaded by forces induced by thermal expansion and contraction and the resistance is influenced by the temperature.

Experiments

Experimental programme was carried out in the past three years in fire test laboratories PAVUS (Veselí nad Lužnicí, Czech Republic) and FIRES (Batizovce, Slovak Republic). The test programme consisted of nine experiments where the corrugated sheets (supplied by th company Kovové profily) were used as the load bearing structure. The thermal insulation of the roof was made from mineral wool or polystyrene. One experiment was carried out on simple beam, for the other tests, beam with cantilever end simulating two-span continuous beam was used. Only the span of the beam was heated during the test. The gas temperature in the furnace θ_g followed the standard temperature curve. The structure was supported on rigid steel frame. Two self-tapping bolts E-VS BOHR 5 5,5 × 38 in every rib of the sheet were used to connect it to the frame. The mechanical load representing snow load and technology (air conditioning, etc.) was introduced by lightweight concrete block and steel plates. The experimental results are summarized in [1] and [2]. All the experiments were stopped when the resistance criteria were exceeded. The collapse of the structure was not observed. Local buckling was observed on the bottom surface of the sheet as a result of clamped support. Plastic strains and deformation of the cross section were observed at mid-span of the sheets.

Temperature of the connections was measured during the test C3. The ribs at the end support were filled with mineral wool to achieve thermal insulation of the bolts. No thermal insulation was applied at the cantilever support. The bolt temperature reached 135°C at the end support (insulated bolts) and 352°C (non-insulated bolts) at time t = 15 min.

Connection behaviour

The connection of the sheet to the support was subjected to experimental study at the laboratory of Czech Technical University in Prague. The tests were performed on steel sheets thickness 0,75 mm bolted to steel sheet thickness 10 mm using bolts E-VS BOHR 5 - 5,5 × 38. The tests were carried out at ambient and elevated temperatures. At the ambient temperature, three types of the connections were tested: the bolt without washer (bolt head diameter 7,2 mm) and bolt with the sealed washers diameter 13 and 19 mm. The

resistance, stiffness, deformation capacity of the connection and collapse mode were studied. In all cases the bearing failure of the sheet was observed [3].

Two types of the connection were tested at elevated temperatures, connection with the sealed washers diameter 19 mm and thick steel unsealed washers diameter 29 mm. The tests were carried at constant temperatures 20, 200, 300, 400, 500, 600 and 700°C. The resistance of the connection with the sealed washer was limited by bearing resistance of the sheet when the sealant burned at higher temperature. The thin and flexible washer does not influence the bearing resistance and the stiffness of the connection. When the thick steel washers were used, the stiffness of the connection increased and the resistance was almost doubled compare to the connection with sealed washers. The benefit of using the thick washers is related to different collapse mode, when the thin sheet was deformed and pushed in front of the washer [4]. However, at temperatures exceeding 500°C the shear failure of the bolt was observed. Because this bolt failure is accompanied by reduced deformation capacity it should be avoided by using sufficient number of the bolts.

FEM modelling

Finite element code ANSYS was utilized for the numerical simulation. Plastic beam element with three degrees of freedom at each node: translation in nodal x and y directions and rotation about nodal z-axis (BEAM 23 in the ANSYS element library) with multi-linear isotropic material was used for the trapezoidal sheet. Temperature dependent stress strain relationship (σ - ε) was introduced. The influence of the connections (stiffness and resistance and deformatrion capacity) was modelled by non-linear elements NONLIN 39. The force-deformation relationship of the bolted connection correspods to the experiments. Non-linear analysis with large strains and large deformartions was performed. The load was introduced in two steps, the first representing the mechanical and the second the thermal load. Contact element representing the auxiliary support at the cantilever end was used to limit its deformation. Three different connections of the sheet to the support were simulated: restrained connection (free rotation, no slip of the sheet on the supports allowed), unrestrained connection (free slip and rotation) and flexible connection (the force-deformation relationship corresponding to experiments with bolted connection and sealed washers diameter 19 mm).

Conclusion

The load bearing resistance of roof structure made from corrugated sheets can reach R 15 up to R 60. It is given by low stress in the corrugated sheets at ambient temperature which are usualy designed to meet the SLS criteria (deflection). Sufficient resistance and stiffness of the connections contribute to development of the membrane effect.

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Field Research Methods for the Assessment of the Specific Input Data in the RUSLE model

Alena Jakubíková

jakubik@fsv.cvut.cz

Department of Drainage, Irrigation and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

To decrease damages in landscape caused by surface runoff and water erosion is possible using measures such are erosion control practices. The first step is to quantify the degree of the soil susceptibility to erosion and accordingly, to propose efficient conservation measures. To determine the field soil loss, erosion equations that have been developed and intensively tested are used. In the USA, Universal Soil Loss Equation (USLE) was derived which employed the basic factors of soil erosion by water in the best way for the time being. USLE was adapted to conditions of the Czech Republic and factor values were defined in greater detail. In 1985 it was decided in the USA to revise USLE on the basis of new research and applied soil conservation technologies. In 1997 so called Revised Universal Soil Loss Equation – RUSLE was presented (Renard et al., 1991, 1997 in Jakubíková, 2004).

RUSLE model is an available tool for observing water erosion processes. This empirical model was designed to predict the longtime annual average soil loss caused by runoff from specific field slope in specific cropping system as well as from rangeland. The main problem within RUSLE using is to assess necessary input data for creating individual databases that contain information about growing crops and used field operations. The accurate field research method could solve this problem.

This paper deals with possibilities of obtaining the basic and specific parameters of crops and field operations by means of measurement in terrain. Theoretical experience (description and maintenance of input data) was already processed in Jakubíková (2004).

Mentioned specific parameters are basic input data for computing C factor, which is the most important erosion factor in RUSLE. C factor represents the conservation effect of vegetation. It indicates the effects of canopy covers on (decreasing) erosion and used field operation in relation to cover development (plant growth, height, and canopy cover), residues of preceding cover and tillage practices according to the frequency of rainstorms during the year. The height and canopy cover of plants reduce the energy of raindrops impact on the soil surface. It influences surface runoff and soil loss. C factor is also showing the ratio of soil loss by erosion in specific tillage conditions to soil loss from a bare soil on the USLE unit plot. In RUSLE so called soil loss ratio (SLR) is computed: it is the ratio of soil loss under present conditions of conventional management to soil loss under new soil-conservation management systems. The SLR value is computed for each time period for which some parameters are constant (type of cover, type of field operation and effects of rainfall erosivity). C factor can be computed for time invariant (pastures) or time-varying conditions (crop rotation).

Basic input data concerning the crops are: effective root mass (RM) in $lb.ac^{-1}$, canopy cover (CC) in % and fall height of raindrops (FH) in ft, and concerning the field operations the data are: effects of the operation on the soil - E, random roughness of the soil surface - RR (in), % of the surface disturbed - %P , % of residues placed on the soil surface - %A, and depth of residue incorporated – D (in); for more detail, see Jakubíková, Váška (2005). These 8 parameters were measured for selected crops (6 types) and field operations (12 types) at 4 selected research areas in the middle part of the Czech Republic, mainly the experimental plots of VÚMOP Praha in Třebsín area (Benešov district) was used. The measurements have

carried out in 2004 and 2005 (from April to September mostly) and will continue in 2006 and 2007. Individual plants were observed in 15-day periods in vegetation season when RM, CC and FH parameters were measured regularly. Particular field operation were observed at the beginning of the action and at the end of the action during the crop management when E, RR, %P, %A and D parameters were measured. See Jakubíková, Tippl, Váška (2005) for detailed plan of the measurements. Measurement was in cooperation with both, the Dept. of Landscape Engineering, FCE, CTU Prague and the Research Institute of Soil and Water Conservation Prague (VÚMOP), for more information, see Janeček a kol. (2004).

Results of the measurements and obtained data processing were divided into two parts: theoretical and practical. The first part contains among other things, detailed description of the methods used for terrain measurements of selected parameters with wide photo documentation. The second part comprises the review of obtained input data for each observed growing plant in 15-day intervals and for each observed field operation at the beginning and at the end of the action. These data were also used for the comparison with recommended values of the input parameters saved in RUSLE model databases for selected crops and field operations used in the USA.

Conclusions of the terrain measurement will be used for practical application of RUSLE model, above all for the filing the databases with data about plants (CROP database) and field operation (OPERATION database). The described research method is suitable for creating the data set that could serve for the computation of C factor and soil loss value in certain conditions at agricultural plots. In the future, the next research will be focused on the verifying the efficiency of canopy cover using model simulation at the selected experimental areas.

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Virtual 3D Model of Baroque Theatre at Český Krumlov Castle

R. Balík

radim.balik@seznam.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

The baroque theatre at Český Krumlov castle is one of two almost completely preserved baroque theatres in Europe; it is therefore a great monument of this kind. Its most interesting part consists of a complex wooden stage machinery controlling the scene, many effect machines, stage lighting etc.; up to 60 people were needed to control all the machinery during performances.

In 1996, a long-time cooperation between the Laboratory of Photogrammetry of CTU Prague, Český Krumlov Castle's Administration and the Baroque Theatre Foundation started. The project „Living Theatre" aimed to creating a computer model of the baroque theatre that could be later converted to a complex spatial information system of the site accessible via internet. According to its definition (see [1]), the infosystem will consist of three parts:

(a) **3D model** of the building in a format suitable for presentation of virtual models in the internet environment;
(b) **database** containing additional data such as images, text documents, sounds, animations etc.; the database and the 3D model will be connected by hyperlinks;
(c) **control application** serving the user for controlling his or her "walk" through the object, adjusting the environment according to his or her needs such as putting on/off layers, improving the orientation in 3D space or performing deeper study of the object (measuring distances…).

The infosystem will be placed on a web server and it will be possible to visit it using any computer connected to the internet. Simply speaking, the visitor will be able to "walk" through the virtual building and to display more additional data (such as historical pictures, flash animations of the machines' operation, text documents etc.) about the objects given by simply clicking on them.

In 1996-2004, a CAD model of the theare was made within several students' diploma theses. See [2], [3] for more information. The model is constructed in DXF vector format.

The CAD model created is static and special CAD software (such as ***Microstation***, ***AutoCAD*** etc.) is needed for displaying it. Displaying the model in such software is not very comfortable and it does not allow the user to „walk through" the building, not speaking about connecting the model to a database – in other words, the DXF model is not usable as an infosystem.

Another task is, therefore, to convert the model from DXF format to a format suitable for constructing virtual models (scenes) accessible via internet. From several formats available, VRML format was chosen. VRML is an open format created by *Web3D Consortium Inc.* Its specification can be found in [4]. VRML scenes can be placed anywhere in the internet. For entering the world, a VRML browser is needed. Companies that occupy themselves with VRML usually offer such browsers for free (e. g. ***Cortona VRML Client*** by *Parallel Graphics* or ***Blaxxun Contact*** by *Blaxxun Technologies*) as plug-ins to common internet browsers.

Of course there are applications capable of conversion between formats DXF (or other vector formats) and VRML; there are two types of them: exporters integrated to other applications (mostly CAD software) and stand-alone converters. However, none of tested exporters/converters corresponded with our needs for the following reasons:

(a) the applications converted quite complex model of the theatre to a virtual model with **too large data volume**; this would slow down the real-time performance of the model especially when working via internet;
(b) the user could not **influence the structure** of the final model, for example its dividing to layers;
(c) the final VRML model was „**raw**", it was necessary to complete it to the form of an information system.

For these reasons, many applications have to be used when creating a virtual model capable of quick and realistic display and of being used as an infosystem:

(a) an **exporter/converter** itself to get the "raw" model;
(b) a **VRML editor** to give the model the structure required (layers…);
(c) a **VRML optimizer** for reducing data volume (e. g. by simplifying triangle nets);
(d) **other applications** to convert the model into an infosystem, i. e. to create a database and connect it to the model.

It is clear that this process of creating a spatial infosystem would require quite wide software equipment and knowledge, which causes an increase in the amount of work and of course in costs. Our next aim is, therefore, to create an application capable of performing all the steps needed from the DXF model to the final spatial infosystem. This application called ***Virtual Builder*** is in the development process just now.

It will be a semi-automatic converter from DXF to VRML format. It is drawn as a shell application for ***AutoCAD*** software by *Autodesk*. It offers both the options of fully automatic and manual conversion. The user can set how the structure of the final model will look like. Additional data of various types (images, texts, animations, movies, sounds…) can be assigned to objects in the virtual building. This data are organized in a database that can be edited directly in the application. For users more skilled with VRML, the converter offers some other tools, e. g. conversion of a triangle net approximating a surface into various types of surfaces (optically smoothened net/NURBS surface of order 2), a tool for creating substitute representations of objects (LOD, level of detail) or for creating prototype libraries for objects often repeated in the model, etc.

The application Virtual Builder can be then used with any virtual model, of course.

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Material Properties and Modelling of Nonlinear Behaviour of Concrete Structures Reinforced with Various Fibres

A. Kohoutková, I. Broukalová

akohout@fsv.cvut.cz

Department of Concrete Structures and Bridges, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

A considerable progress in technology of concretes reinforced with various types of fibres has been noted in the last decades and there are great many producers who offer fibre concrete in commercial sphere. The most extended applications of fibre concrete are still industrial flooring, roadways and landing runways. Exploitation of fibre concrete in structural elements occurred as well, although not very frequently. Structural analysis of fibre concrete elements and structures is not well established; there is a lack of verified design procedures and in code specified procedures of analysis. That is in fact quite understandable, as fibre-reinforced concrete material properties strongly depend on the fibre type, i.e. material of fibres, fibre cross-section, ratio of fibre length and diameter and the amount of fibres in concrete mixture and general rules known for reinforced concrete (e.g. strengths specified for each concrete class) could be hardly established. A first step to solve this problem was already undertaken – an extensive experimental research resulted in recommendations of a RILEM committee for laboratory testing of steel fibre reinforced concrete. These one-track way should be extended for other fibre concretes and reassume in further recommendations for wide range of different fibre concretes testing and standardisation of procedure of structural analysis of fibre concrete structures and introducing in the Codes some basic criteria which can be assumed valid for all types of fibre reinforcement independently of materials and geometries, even though the knowledge for each type of reinforcement has not reached equally high level.

From the seventies, when researchers began with investigation of short randomly distributed fibres much work has been done: positive properties of fibre concrete were discovered and confirmed. Nowadays we know benefits of fibre concrete tensile behaviour, high residual strength and ductility and lately knowledge about micro mechanical behaviour and modelling which is a contribution for material engineering was extended but for a workaday designing there is still a great difference between material models and structural design of constructions. A simple way connecting material properties obtained in laboratory tests with structural analysis misses so far.

For a structural analysis material properties and a sufficient material model must be determined. Thus material properties identification and material model specification became a fundamental challenge.

To propose a generally valid routine for fibre concrete properties determination these principles were specified: designing of FRC elements have to be compatible to a common concrete structures analysis; benefits of fibre concrete should be taken into account; analysis should be simple and low-cost. Following these requirements a routine for material identification was suggested. Basic material properties (as compressive and tensile strength) are determined in common laboratory tests: compressive test, tensile tests (direct or indirect tensile test). Very important part of material identification is inverse analysis. An inverse analysis is instrumental in adjusting basic material properties, which were obtained in

laboratory experiments, and to determine other material characteristics needed in analysis. It starts from a load – deflection curve (or a moment – curvature curve) obtained from a laboratory flexural test. Three or four-point flexural test and specimen with or without a notch may be used of for laboratory loading. This experiment is simulated in a FEM analysis. Input material characteristics to numerical simulation are varied until acceptable coincidence of the load-deflection curve from laboratory loading and from FEM simulation is reached. Obtaining of material properties for the first run of computer inverse analysis is possible by several more-less sophisticated methods. The simplest possibility is estimating of inputs for the first run (trial and error method). Another way is to obtain material properties for the first run by means of an analytical method. The most advanced possibility is performing the inverse analysis by means of neural networks.

Material parameters in a structural analysis are represented usually by a stress-strain diagram or by any other effective diagram. This diagram is a curve of complex and general shape, for purpose of structural analysis simplified and reduced to an idealized form given just by several parameters according to complexity and demanded level of accuracy. There are two basic recommended formulations of functional dependence for fibre concretes. Model based on a stress-strain relationship and model based on non-linear fracture mechanics. In terms of these two approaches there are several possibilities for modelling behaviour after cracking and for modelling of tension softening. Tension softening might be based on fracture energy or exponential or linear crack opening law. Right choice of a material model influences pregnancy of structural analysis.

The aim of such research was to present a simple general routine of determining material properties for a fibre concrete which could be used in a further analysis of a structural element. It was intended to offer a simple low-cost method because influence of content of fibres on the resulting properties of fibre concrete may be very different. Recent technique of mixing “cocktails” of various fibres brings new fibre concretes with all sorts of behaviour and sometimes also of unpredictable properties. If these new materials shall be used in a structure, engineers must have an elementary tool to verify load bearing capacity and service behaviour of the fibre concrete structural element.

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Performance of Fibre Reinforced Concrete with Proper Material Characteristics in Practical Applications

A. Kohoutková, I. Broukalová

akohout@fsv.cvut.cz

Department of Concrete Structures and Bridges, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Fibre reinforced concrete (FRC) has been used only for industrial pavements and, as sprayed material, for excavation supports until recently. Its toughness and post-cracking behaviour are now opening in the construction industry new applications in tunnelling, in pre-casting, in structural rehabilitation and in defence in many European countries. Conception of innovative structures is also motivated by the market needs and encouraged by the increasing amount of standards, whose contents derive from the experimental and theoretical results of the research activities carried out worldwide by private and public institutions. Fibres are discontinuous and are generally distributed randomly throughout the concrete matrix. Fibres can be used in structural applications with conventional reinforcement, but references are very few. Because of the flexibility in methods of fabrications, fibre reinforced concrete can be an economic and useful construction material, e.g. precast glass fibre cladding architectural panels but generally applications are not widely spread. In slabs on grade, mining, tunnelling and excavation support applications, steel and synthetic fibre reinforced concrete and shotcrete have been used instead of concrete reinforced with welded wire fabrics

In structures fibre concrete is preferably used in reconstructions. The full advantage of structural fibre concrete can only be achieved in new construction, where design solutions are not limited to the geometry of an existing building. Fibres could substitute stirrups, using of fibres in a mixture benefits in higher load bearing capacity, higher ductility, enhance triaxial acting of a structural element, inhibit looses of stiffness at loading, enhance interaction of classical steel bar reinforcement and concrete. Significance of enhancement in fibre reinforced elements leads to possible reduction of transverse reinforcement in earthquake regions.

With proper design of a mixture a fibre reinforced structural element has favourable behaviour comparing to a classical reinforced concrete element both in service life and in ultimate loading. High residual strength increases resistance and behaviour in failure. Also in analysis of serviceability limit state fibre concrete has opportunities comparing to common concrete. Among main positives of fibre concrete is mentioned tensile behaviour. However also in compression fibre reinforced element has better load bearing capacity for combination of compression and flexure thanks to better triaxial behaviour. Present codes forbid designing of beams without stirrups. Experiments show, that in fibre concretes with volume content of steel fibres 0,5 ÷ 2% fibres act as sufficient shear reinforcement. Members with fibres have more ductile and thus safer failure. To enable design of beams without classical links (or to decrease amount of links – increase spacing of links), proper quantification of contribution of particular fibres of different materials, shapes, types interaction of fibres and concrete and content in a mixture to shear resistance is necessary.

Experiments and some practical applications proved that fibre concrete elements have bigger load bearing capacity and ductile fail mode comparing to comparable concrete element. Realisations of flooring systems are exceptional they exist as a unique effort to

introduce advanced technology and material. Es an example of such innovative structure might be illustrated by attempts of SIMCON frame structure fabrication. SIMCON (Slurry Infiltrated Mat Concrete) is made by infiltrating pre-placed short, discontinuous fibres, or continuous stainless steel fibre-mats respectively, with a specially designed cement-based slurry. SIMCON exhibits high strengths and ductility. Due to its fibre-mat configuration SIMCON is well suited for casting thin elements such as retrofit jackets or stay-in place formwork. The result is a markedly increased flexural and, shear capacity, ductility and overall seismic response.

Durability is influenced by permeability that is affected by cracking and porosity. Thus for better permeability of structures cracking must be avoided. Thanks to favourable spacing of cracks and smaller crack width, which has been proved by experiments permeability of fibre concrete structures, is preferable. Even now demands on durability and satisfying of serviceability limit state were solved successfully by using high performance fibre concrete. In fire design polymer fibre are profitable. At high temperatures these fibres escape and created cavities enables expanse of gas and avoid spalling. Thereby the fire resistance is increased and repair after eventual fire is easier and cheaper. There is a broad range of fibre concretes nevertheless research of fibre concretes still advances. There are developed new fibre concretes with new fibres and cocktails of fibres that are used at present. A new term is hybrid fibre concrete – it is a fibre-reinforced cementitious composite where combination of more types of fibres in a mixture shall take advantage of both (all) fibres. To prevent cracking in different stages of loading fibre of different types, length and modulus of elasticity are used.

Further new term used in connection with fibre concrete is HPFRCC - high-performance fibre-reinforced cementitious composite. Properties of these materials resemble behaviour of metals. Description of materials with so differing properties is impracticable. Lately a new classification of fibre concretes occurred – according to behaviour of material in tension there are two basic types: materials with tensile hardening and tensile softening; the second category has two subcategories according to behaviour in bending - materials that exhibits softening and materials with hardening in bending. These hybrid materials seem to be very effective at improving the material performance. The use of fibre reinforcement in the cement industry will increase as understanding of the material improves.

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Water Regime of the Soils of Small Watersheds with Different Forest Cover

H. Pavelková, T. Vogel

pavelkovah@mat.fsv.cvut.cz

Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Outflow of watersheds, particularly in respect to extreme hydrological conditions, is one of the most investigated phenomena in hydrology. Hydrological methods using solely precipitation to predict runoff do not incorporate soil processes. However, monitoring the water regime of the soil is essential to understanding of the outflow response of a watershed. Our study evaluates the water regime and focuses especially on transformation of precipitation into outflow from the soil profile. The water regime is examined in respect to the possible impact of the type of vegetation covering the watershed.

The water regime was monitored at four experimental watersheds (Stolec, Doupě, Kout and Liz) located in the Šumava mountains. The elevations range from 800 to 1300 m above sea level. All four watersheds differ with vegetation cover. Liz and Stolec are covered by mature deciduous forest, Kout with damaged forest and Doupě is deforested. The changes in the type of forest cover at the watersheds Kout and Doupě was caused by catastrophic bark beetle damage in the 1990's.

Because of climatic conditions and measurement limitation, only data from vegetation seasons 1998 and 2002 is available for the watersheds Stolec, Doupě, and Kout. At Liz, data measured from 1998 to 2000 and in 2002 is available. Precipitation and stream discharge were measured at each watershed and automated tensiometers were installed to obtain pressure head data. Missing precipitation data for Stolec, Doupě, and Kout were completed according to Liz. Transpiration was calculated from meteorological data using the method of Pražák [1]. Saturated hydraulic conductivity and retention curves were determined. Each of the measured retention curves was fitted by van Genuchten formula in combination with Mualem capillary model. Based on the sets of fitted curves, a reference retention curve for each soil depth was specified using the scaling method [2].

Due to frequent failures of the tensiometers, the obtained pressure head data is by itself insufficient to examine the water regime of the soils. To obtain more information about water transport in the soils simulations were run using the program S1D [3]. Water transport in this program is described by Richards' equation. The model was run for the atmospheric data based on one day time steps for four vegetation seasons. Soil profiles 70 cm deep at Stolec, Doupě, and Kout, and 110 cm deep at Liz were modeled. Free drainage was applied as a bottom boundary condition. This boundary condition describes properly highly permeable bedrock at the studied watersheds. The models consist of four layers and were verified by comparing measured with simulated pressure head.

Precipitation infiltrates fast into the subsurface at all four watersheds. Surface runoff was neither observed in reality nor predicted by the model. At Liz and Stolec, while top layers respond distinctively to precipitation, the deeper layers of the soil profile dry out. A significant portion of water is extracted by roots before reaching the bottom layer. The process of drying-out is interrupted by high precipitation when water propagates through the complete soil profile. At watersheds Kout and Doupě, the simulated pressure head in the soil profile closely corresponds to precipitation. Less water is extracted from the soil profile by vegetation. According to the model, even small precipitation induces changes in pressure

head at the deepest layer. At the studied watersheds, variations in pressure head in soil profiles are caused not only by different transpiration rates, but mainly by diverse hydraulic properties of the soil layers.

Increased outflow from the soil profile is recorded at all watersheds when precipitation exceeds roughly 20 mm in a short time interval. At Kout and Doupě, the simulated outflow from the soil profile behaves analogous to the measured discharge in the stream - outflow peaks correspond to peaks in the measured stream discharge. The hydrographs are characterized by a rapid rise, sharp peak and rapid recession. Outflow from the soil profile contributes directly to the runoff; only in dry periods, discharge is generated from groundwater resources. At Liz and Stolec on the other hand, the hydrographs exhibit lower and broader peaks with steep rising and gentle recession limbs, the recession proceeds over several days. Discharge at these two watersheds is generated mainly from groundwater resources inside the bedrock. The groundwater is supplemented by infiltrating precipitation from the soil profile into the bedrock. Slow discharge recession is a consequence of increased groundwater levels. Only during extreme rainfall events, shallow subsurface runoff contributes to stream discharge.

The water regime of the soils is evaluated in relation to precipitation in four vegetation seasons during which extreme hydrological conditions were observed. Comparing deforested watershed and watersheds with mature and damaged forest, the difference between minimal and maximal values of discharge is smaller for the watersheds with mature forest. Watersheds Kout and Doupě have lower retention ability under standard conditions. However, for these four particular watersheds no proof was found that this is caused by the difference in the land cover. The difference in the hydraulic properties of the soils at the studied watersheds seems to be of greater influence to the outflow regime. For extreme situations, measurements and model prove that retention and accumulation of water at all studied watersheds are limited. The difference in vegetation cover and difference in hydraulic soil properties are not significant in respect to the outflow regime during extreme rainfall events.

To attribute the variance in water regimes solely to the different forest cover of watersheds would be oversimplification. Data analysis shows that the concerned watersheds differ also in other hydrological and pedological characteristics, particularly hydraulic properties of soil layers strongly influence investigated processes. So far, no transparent evidence was found that the difference in water regime of the four studied watersheds is caused by a particular vegetation cover.

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Properties of Fibre Concrete with Structural Synthetic Fibres (SSF)

J. Vodička, J.Krátký, A.Kohoutková, J.Vašková, H.Hanzlová,

jan.vodicka@fsv.cvut.cz

Department of Concrete Structures and Bridges, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

This paper deals with solving and results of the research project " Exact Formulation of Properties of Fibre Reinforced Concrete with Special Fibres Based on Experimental Results" supported by Grant Agency of Czech Republic. The main scope of the project was to prove that there are not differences in the Fibre Reinforced Concrete (FRC) between the Structural Synthetic Fibres (SSF) or some types of Steel Fibres (SF) by the results of extensive experimental program resulting in specified conclusions evaluating the possible impact of composites with SSF on material characteristics, durability, ductility and safety of structures. Part of the research is also a development of mathematical models of FRC and calibration of the models. On the basis of these models, the calculation algorithms have been developed and methods for practical design of FRC structures recommended.

The centre of solving the research should be execution and interpretation of experimental results. The results of tests carried out in the framework of a broad experimental program on the basis of research cooperation contracts between the following laboratories: CVUT Prague - Faculty of Civil Engineering and Klokner Institute, VUT Brno, VSB TU in Ostrava and Warsaw Polytechnic. The reason for the broadly based cooperation in testing was the effort to get the objective results of tests of the selected properties of FRC.

In the research project checking of SSF Concrete (SSFC) material strength and deformation properties with two volume ratios of SSF in comparison with plain concrete were used. Tested properties were compresive strength, splitting tensile strength, flexural strength (measured on specimen 100/100/400 and 150/150/700mm with various set-ups of test), modulus of elasticity (in flexure and in compression with various mode of loading) and density. Testing was also focused on post-crack behaviour of FRC.

Results of tests show next conclusions and notes.

Fibre dosage up to 0,5 % of volume (4,55kg/m^3) has nearly negligible influence on the strength characteristics of concrete but has a significant effect on the composite ductility and changes the brittle concrete into a tough FRC. Higher dosage of 1% (9,1 kg/$m^{3)}$ measurably reduces (approx. 10%) the compressive strength of concrete and the module of elasticity. The same trend of results was observed at the FRC during the long-term measuring of the volume changes caused by permanent loads (strain). The effect of this dosage on first crack tensile strength is not significant but the increase of post crack residual strength is significant and increases the ductility of the composite. The explanation of the stated facts needs to be found in the relatively low specific mass of the fibres that in our opinion create in the composite "quasi-macropores" the effect of which can be measured at higher dosages. This is observed above all on the samples subjected to compressive forces. This fact (reduction of strength characteristics) is confirmed by the measured volumetric weight of test samples showing the reduction in relation to the fibre dosage.

The values of density measured on the test samples show a good FRC homogeneity achievable by the use of these fibres. The homogeneity of FRC is a basic requirement for the practical use of FRC. This must be true in cases of the use of FRC in weight carrying structures. The structure reliability is a basic condition of the protection of human lives.

The ratio of compressive strengths measured on cylinders (Ø 150/300 mm) and cubes (150/150/150 mm) is in the range 0,92 – 0,98. The ratio of 0,8 between stated strengths (cylinders vs. cubes) introduced by the European Standards was not confirmed by these tests even for the plain concrete. That leaves open the question of the reliability of structures or the economic efficiency of concrete mixtures at the situation where the concrete suppliers can prove the concrete classes´ properties by both types of tests.

The values of measured tensile strengths differ significantly and depend on the type of the test.

For the static calculation of the structure using FRC the statistically guaranteed tensile strengths must be known. For a specific type of FRC at least the first crack strength and so called equivalent post-crack strength must be known for the required post-crack tensile ductility. This way the real stress/strain diagram of FRC can be characterized. The stress/strain diagram can be used not only for the ductile areas of structure but also for the expression of joint effect of FRC and rebar reinforcement or eventually the pre-stressed reinforcement both at the ultimate strength of FRC structure. The results of the tests indicate that still a lot of work (measuring, expert discussions etc.) needs to be done before the FRCs are classified into exactly defined strength classes as for the plain concretes without fibres.

The results of research project shall be applied for design and execution of selected appropriated members in FRC with co-operative firms (eg. Lias Vintířov a.s., SMP Praha a.s., Division 1).

The results confirm that Structural Synthetic Fibres can replace Steel Fibres with smaller strength and can be used for structures in plain, reinforced (by reinforcing steel bars) and prestressed Fibre Concrete.

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Sustainable Construction of Building and Sustainable Development of Urban Space

P. Hájek, J. Růžička

petr.hajek@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The urgent need for actions towards sustainability presented at Sustainable Building Conference in Tokyo in October 2005 in the SB05Tokyo Declaration "Action for Sustainability" is becoming to be more and more recognized by more and more professionals as well as public. The doctoral project 103/03/H089 "Sustainable Construction of Buildings and Sustainable Development of Urban Space" represents one of actions intended to speed up the process leading to sustainable development of built environment.

A doctoral project 103/03/H089 "Sustainable Construction of Buildings and Sustainable Development of Urban Space" supported by Czech Science Foundation GAČR is running already 3rd year (since October 2003). During this time a professional platform has been developed, where various special problems and research results related to sustainable development in construction of buildings and development of urban space are continuously discussed.

The main target of the project is to support and co-ordinate scientific activities of students in doctoral study programs whose themes of dissertation works are focused to specific problems of sustainable built environment. The goal was to integrate in the doctoral team students oriented to technical aspects of construction and operation of buildings, students focused to social, sociological, functional, urban and architectural aspects of built environment and students engaged in development of methods for assessment of environmental and social impacts, and economic efficiency. There are involved doctoral students from two faculties – Faculty of Civil Engineering and Faculty of Architecture. Taking into account the multicriterion character of the problem of sustainable construction, the project is organized "across" different departments of CTU in Prague. The aim was to involve into the team students and supervisors working in different segments of the research in this specific field of investigation. This integration of professionals from different branches has developed the chance to exchange experiences and knowledge in much more wide range. All members of the team together with their supervisors and other guests meet regularly once a month at thematic "working discussions" focused to specific problems and research themes.

The educational activities of Doctoral Team are planned and performed on three levels Working Discussion Meetings, Seminars and Workshops. During the year 2005 there were organized following actions:

- 10 Working Discussion Meetings focused to following scientific topics: airborne sound insulation in buildings, public space and quality of life in town, climate facades, relationship between urban space and urban greenery, industrial conversions in city blocks, BIPV systems and solar skins, double-skins facades, optimization methods in structural design, prefabricated reinforced concrete frames in industrial estate, heating and cooling in office buildings.

- 2 Seminars: Low Energy Buildings, Technological Park Skoda Pilsen.
- 2 Seminars/Lectures: Quality of Public Space given at CTU by Prof. Catherine Semidor, Laboratoire GRECO, Ecole d´ architecture et de paysage, Bordeux, France; Emerging Sustainability Issues in Architecture given by Wojtek Kujawsky, iiSBE Canada, Carleton University School of Architecture, Ottawa, Canada.
- Workshop W2-510: held at Czech Technical University in Prague in November 11, 2005. Participants of the workshop could watch 13 presentations grouped into 3 thematic sessions: A) Energy in Buildings, B) Environment and External Relations and C) Building Structures. Poster session was in the entrance hall of the Faculty of Civil Engineering.

The proceedings book from Workshop contains contributions of student members of the doctoral team and guests presented in oral and poster form. These presentations are mainly focused to the main topics of thesis of PhD students involved. The Workshop was again an ideal opportunity for all participants and guests and visitors to exchange experiences within implementation of sustainable principles into different kinds of building a well as urban design processes. This year also foreign guests took part at the workshop with oral contributions which are contained in this proceeding.

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Tomography of Moisture Field of Building Structures and Materials

J.Římal, D.Chren*, B.Sopko*, V.Sopko*, L.Samek*, T.Horažďovský*

rimal@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Thákurova 7, 166 29 Prague 6, Czech Republic
*CTU, Faculty of Mechanical Engineering, Technivká 4, 166 07 Prague 6, Czech Republic

Introduction

The moisture field and temperature field are basic imaging of state of building structures. Tomography refers to the cross-sectional imaging of objects from either data transmission or data reflection collecting by illuminating the object from many different directions. For the illumination, X-rays, high frequency electromagnetic waves or fluxes of neutrons can be utilized.
The dynamic state of moisture field and temperature field is the imaging of the transport mass and heat in the continuum of construction materials.

Moisture field in building constructions

Measurements.
Parameters of moisture and temperature fields are obtained by collecting the reflecting or transmitted data from tested structures. The measurements media are beam of neutrons or high frequency electromagnetic waves. The size of detectors and the intensity investigated rays following the density and volumes of samples or real constructions.
There are the data from investigated the bridge structures which we obtained during last time. The ones will be scaling and compare with models.

Imaging.
The tomographic imaging deals with reconstructing an image from its projection. The projection at a given angle is a integral of the image in the direction specified by the angle . The data from models of bridge or other construction must be scaled and applied as data for tomographic imaging. Data for modeling are obtained from samples of investigated mass and really constructions.
The results of imaging will be in presented in 2D and 3D form.

Conclusions

The tomographic imaging of dynamic and static moisture fields give us the possibility to see the real situations of more-layers of building constructions. The numerous results from tomographic imaging of moisture fields can be the reason for correcting the state of arts models.

This project has been carried out with the participation of undergraduate students Veronika Březinová and Jakub Římal.

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The Application of the New Methods of Assessment of Potential Flood Damage and Risks

M. Horský, L. Satrapa

martin.horsky@fsv.cvut.cz

Department of Hydrotechnics, Faculty of Civil Engineering, CTU Prague,
Thákurova 7, 166 29 Prague 6, Czech Republic

The research of assessment of potential flood damage started on Department of Hydrotechnics in 1996, even before the big floods in The Czech Republic in 1997 and 2002. This question was yet more interesting after the big floods in 1997 in Moravia, Eastern Bohemia and Silesia and in 2002 in Bohemia and Southern Moravia.

The methods for calculation of potential flood damage are based on application of loss functions [1][2] for many kinds of objects. Generally we distinguish these kinds of objects and damage on: buildings, homes hold equipment, equipment of municipal facilities, infrastructure, roads, railways, bridges, industry and agriculture. There are three levels of methods in this time according to detail of site investigation and input data. The first method (I) is based only on basic input data (ZABAGED-The basic base of geographical data, RSO-The Register of adding circuit). Method I is created for first focus on larger river-basin areas and for selection of the most risks areas. The second method (II) use same input data and in addition to RES –The register of economical subjects, orthophoto maps. The third method (III) use same data as method II and it can use more accurately data from DMT- Digital model of terrain. The method III is based namely on site investigation of detail information about all objects in inundation area. The sensitivity analysis has shown that inaccuracy between method I and III is in the extent of 15% and depend on accuracy of all input data about objects and hydraulic data. The all 3 methods need maps of inundation and maps of depth and velocities (result of 1D or 2D modeling or maps of real flood situation) typically for flood flow Qmax, Q100, Q20, Q5.

The all methods use basic formula:

DAMAGE = S . L . P [CZK]

where:

S Size of object in measure unit – area, length, count [square meter, meter, count,…]
L Loss function – percent of damage from purchase price [%]
P Purchase price of object [CZK / measure unit]

The loss functions are the result of detailed research of interaction between flood and their activity on each part of a construction of an object. Some functions depend on depth and velocity of flood water (e.g.: loss function for buildings) and some do not. Each loss function is defined in interval of values, which represent uncertainty in assessment of damage. The group of loss functions consists from around 200 functions for detailed method III, 20 for method II and 10 aggregated functions for primary method I. The purchase prices are derived from standard public statistics (ČSÚ, URS Praha, JKSO) and they are continually updated. The result value of potential flood damage is in interval of the calculated values with probability, which depend on quality of input data.

The next part of the research is focused on the use GIS for mass data processing for assessment of flood damage. There were created new tools for GIS (especially for GIS software ArcView version 9.1. by ESRI), which allows quick and comfortable data

processing. The created tools subserve for calculation of potential flood damage, for assessment of risks of exposure of property and people and for visualization of damage and risks represented by raster maps.

These methods have been supported by grant: The design of methods for assessment of risks and damage in inundation area and their verification in Labe river-basin. Within the frame of project were created methods I and II [2], which was derived from the detailed method III, and were calculated damage for the river Labe from Brandys nad Labem to country boundary with Germany for flood situation Q20 and Q100 by methods I and II. For this area were created the raster maps of risks of damage in units CZK per year and hectare. The resolutions of maps were chosen 10m. The method III was used for verification of results in the pilot areas Děčín and Litoměřice.

These methods can be use for method of analyses of costs and benefit [3] for criticize of economic effect of flood-protection projects. For example it was used for 96 criticizes of flood-protections projects for Ministry of agriculture of The Czech Republic in 2005.

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Scale Model of the Římov Emergency Spillway

L. Satrapa, M. Králík

satrapa@fsv.cvut.cz, martin.kralik@fsv.cvut.cz

Department of Hydrotechnology, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

During the flood in August 2002 appeared some troubles with safety of the Římov dam as for the peak flood discharge passing the dam. Main troubles concern the capacity of the spillway, flow regime near the intake to the spillway, obstacles to the flow near intake during extreme flows, the capacity of the spillway channel during extreme flows and the hydraulic behaviour of flow in the spillway channel.

There is no possibility to investigate the general behaviour of such structure like emergency spillway with mathematical analysis. The flow inside the spillway structure is transient and three dimensional. The only possibility to understand basic characteristic and to find improvements for the spillway in to observe the real behaviour during floods or to use physical scale model study constructed in appropriate scale in hydraulic laboratory.

Two flood waves passed the Římov dam in August 2002 during the very short interval measured in ours. Parameters of both waves were as follows:

1. flood - peak discharge Q = 445 $m^3.s^{-1}$, volume W = 45,5 mil. m^3 ,
2. flood - peak discharge Q = 476 $m^3.s^{-1}$, volume W = 60,3 mil. m^3 .

Both floods seriously exceeded the design flood Q100 which was 282 $m^3.s^{-1}$ (theoretical peak flow). Some troubles appeared after the flood during the back analysis of the volume of out flow and consequently the analysis of flood hydrograph was effected by some uncertainties:

- damage of limnigraph station downstream the Římov dam,
- uncertainties in consumption curve for spillway,
- uncertainties in water level measurement in the Římov reservoir.

Nevertheless it was obvious that the real flood exceeded the design flood and that is necessary to analyze the effect of this fact to safety status of the Římov dam.

The basic knowledge which is necessary for the evaluation of the safety of a dam is precise information about the spillway capacity and about the effects of hydraulic behaviour of spillway affecting the consumption curve. It was decided in the consensus with responsible specialists of headquarter of Vltava water board that the scale model is the only possibility how to obtain representative information about the extremes in the operation of the Římov spillway.

Hydraulic scale model of the Římov spillway (intake, gate section, channel, part of the dam body) is constructed in the scale 1:40. The model is constructed mainly from PVC. Three forms of PVC were used form the model construction: hardened PVC, foam PVC and transparent PVC. Construction joints can be done with glue, screws or rivets. Some parts of the model are sealed with silicon mastic to achieve the complete water tightness of the model and consequently the as highest preciseness as possible. Important parts of the model (gates, original structure, new structures designed to improve the situation etc.) are painted by different colours to visualise them for documenting (foto, video).

The model was painted by following colours:

- gray - intake, gate section (piers), channel, energy dispersion baffle,
- green - gates,
- brown - technological houses, service houses, storage place of stop logs,

- red - changes in model geometry - new design possibilities (right pier, highening of channel side walls, changes in spillway bottom, changes in left contact between the dam and valey) , wave breaks.

Main questions for model investigation and tests were:

- which are the values of main characteristics of the spillway - discharge coefficient, peak capacity, shape of the consumption curve for extreme flows,
- what is the behaviour of water flowing inside the downstream spillway channel - problem of side walls overflowing,
- what is the effect of floating debris to spillway capacity,
- what are the possibility of dam profile during very extreme floods - left side flow,
- effect of designed construction changes to spillway capacity,
- what is the shape of consumption curve for low discharges.

It was analysed that interval of the preciseness of results is approx. between 3-5 % in values of flow or water levels. This is much more better in comparison with theoretical calculations based on deterministic formulas. Such calculation can be effected by subjectivity of designer with error up to 30 % in discharge.

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Laboratory Set-Up to Determine Entrapped Air in Undisturbed Soil Cores

M. Sněhota, M. Císlerová, V. Jelínková

michal.snehota@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Irrigation, Drainage and Landscape Engineering
Thákurova 7, 166 29 Praha 6

Introduction

Predictions of the water flow and contaminant transport generally assume temporal stability of the soil hydraulic properties. However, there are evidences that the properties of heterogeneous soils can change significantly during the infiltration experiments. The change of soil hydraulic properties is often reversible and does not have to relate to the changes in soil structure.

It was shown experimentally in literature that the saturated hydraulic conductivity could depend on the initial water content of the wetting event. The reported irregularities in field and in laboratory were related to the effects of air entrapment, or to microbiological activity. Reviews of the flow instability related to the air entrapment effects were given in [1], [2], [3]. The mechanisms of entrapping the air in soil pore system are not well understood. The flow instability caused by air entrapment is likely related to the preferential flow.

The goal of the current project is to evaluate the effect of air entrapped in the pore system of undisturbed soil to the function of hydraulic conductivity. Experiment comprises series of downward ponding and suction infiltrations and slow saturation of the column from the bottom. Columns will be held at different degree of saturation before the infiltration begins. Aerated and degassed water will be used as flowing liquid. Combination of the previous will form number of scenarios with different amount of the entrapped air presumably induced in the soil column. The differences in volume of the entrapped air supposedly affect resulting hydraulic properties of the soil, the retention curve and function of hydraulic conductivity, which are obtain for each infiltration separately by inverse modeling.

The Experimental Set-Up

The experimental set-up has been designed to allow performance of long lasting infiltration experiments with minimal human intervention. The main requirements for the proposed experimental set-up were: (a) a capability of sensitive and continuous measurements of total soil columns saturation by weighing, where actual weight of the column enable us to calculate the entrapped air content in quasi saturated column, (b) ability to separate and to measure the water and gas cumulative fluxes entering and leaving the soil column, where water fluxes are the major inputs to the objective function of the inverse model.

Design of the proposed set-up is similar the one of apparatus built earlier at FCE CTU [4] for hydraulic characterization of large undisturbed soil columns. First main feature of the newly proposed set-up is a capability to separate liquid and gas water phases at the bottom of the soil column. The custom made aluminum assembly is sealed to the plastic outer ring of the soil column by a pair of o-rings. Any water leaving the soil column is collected in the funnel-shaped bottom part of the assembly and is directed to outflow measurement device. As the water infiltrates into soil, air escapes from the bottom of the column. The air is collected into the outlet placed inside the funnel assembly and, which is protected from the water intrusion

by roof-shaped thin metal plate. The water outflow is measured electronically in tipping bucket, where each tip is recorded by the magnetic switch closure sensor. Gradual increase of the water volume in tipping bucket between each tip is recorded by bending beam load cell (LCAE-1KG, Omega Engineering, Inc.). The amount of the venting air is quantified in a gas flow-meter. The flow-meter is a Mariotte bottle in which the air inlet is mounted at the same height level as the water outlet. Then any amount of air entering the bottle cause the release of equivalent amount of water. The water level in the bottle is continuously recorded by the differential pressure sensor (PX170, Omega Engineering, Inc.). For the case that any amount of air is attracted into the soil column the water trap in installed between the Mariotte bottle and the funnel assembly. The mariotte bottle has to be refilled and the water trap has to be emptied at the beginning of each infiltration. Second important part of the set-up is the newly proposed double layer infiltration disc assembly. Its main feature is the ability to separate water and air at the top of the soil column during the tension infiltration. The disc assembly consists of a standard tension infiltration disc [1] and of sintered glass plate which serves as an interconnection between the tension infiltration disc and the soil pore system. Sintered glass plate is grooved at the side which faces to the soil surface. The purpose of the grooves is to allow the air to escape or enter the soil pore system. Air entry value of the glass disc is approximately 14 cm of water suction pressure head. Since the suction pressure head at the top of the soil column is scheduled to be only in the range of 0 to 6 cm during the experiments, the glass disc will saturate completely soon after the beginning of the infiltration and will act as the impermeable barrier for gas during the infiltration. In this case the air released from the soil pore system can flow solely through the grooves in the glass disc. The glass disc is tightly attached to the plastic tube containing the soil sample. Released air is directed to the vent and the air flux can be quantified in time using flow meter analogous to the one used for the funnel assembly. The proposed set-up is equipped by the electronic monitoring system based on CR23X data logger (Campbell Scientific, Inc.). Data acquisition system is similar to the one presented in [1]. The individual parts of the proposed experimental set-up are currently being tested at FCE CTU.

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Reliability of Timber Members and Joints

P. Kuklík, A. Kuklíková

kuklik@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The European harmonisation of timber building codes, the determination of design values for loads and materials is the purpose for this study. Safety factors in building codes are traditionally based on long-term experience. Also, Eurocode states that, as the most common method, numerical values of partial safety factors can be determined on the basis of calibration to the long-term experience of the building industry. As an alternative, the use of statistical evaluation based on probabilistic reliability theory is mentioned. An international model code for probability-based assessment and design of structures is under preparation. However, it does not yet include information concerning timber and wood-based products resistance.

Structural reliability analysis

This study on the use of probabilistic methods in the development of timber building codes, which is a part of the Czech COST project, covers a study with a special emphasis on Eurocode 5, an analysis on material strength data to which CTU has access, and some reliability analyses to demonstrate the effect of selected distribution types and parameters on calculated failure probabilities. Also, a calculation is performed to demonstrate the dependence of safety factors on the coefficient of variation of strength.

When the number of experiments allows, determination of the 5% fractile of strength should be based on the function fitting on the lower tail of the strength values, for instance 10%. All smooth functions fitted to tail data gave good estimates of the 5% fractile. When the 5% fractile was determined from a function fitted to all data, up to 5% error occurred when compared to a non-parametric estimate. Three-parameter Weibull distribution gave, in all calculated cases, the 5% fractile within an accuracy of ±3%.

The result of structural reliability analysis depends strongly on the load and strength distribution types used. When fitted functions are used in reliability analysis, it is essential that the fit is good in the lower tail area, the lowest values being most important. When fitted to the same data, a two-parametric Weibull distribution being next, and lognormal and three-parameter Weibull being the most optimistic. In an example, a two-parameter Weibull gave a failure probability 10 times higher than that of a three-parameter Weibull.

Reliability analysis with a permanent load and a variable load gives an interesting result: constant reliability level can be obtained by the same value of material safety factor γ_M, when partial load factors are γ_G = 1.2 and γ_Q = 1.6 and COV of lognormally distributed strength is not more than 20 %.

Evaluation of structural timber

Methods of transverse and longitudinal vibrations were applied with the help of which three values of the elasticity modulus $E_{edge,}$ $E_{flat,}$ and E_{long} were determined. During the tests the dimensions of the respective samples and their masses were measured.

With the help of the ultrasound method an “ultrasonic” elasticity modulus was determined for structural timber parallelly with the grain E_{us}. This method is the simplest and “the most convenient” as regards its realization.

One of the main problems limiting the transfer of the ultrasound method to industrial applications was historically the coupling between transducers and material specimen. For quite a long time, high frequency transducers were used, together with a coupling paste. Both coupling material and attenuation level were limiting the performance of the method, at least for industrial size material.

Because attenuation is proportional to the wave frequency, and because the industrial applications have to be developed without additive coupling material, new piezoelectric transducers, low frequencies have been set up. The reduction of the attenuation function have been solved by using low frequencies, in the range of 20 kHz, together with a high vibration energy obtained by using an excitation function similar to a condenser.

From the point of usability of the methods tested we are most interested in the dependence of strength on the elasticity modulus. The correlation coefficients between the strength selections and the elasticity moduli range from 0,75 to 0,88. This may testify to the fact that the elasticity modulus can be a suitable indicator of the bending strength of structural members.

It also follows from the results of experimental measurings that to some extent the density shows a better correlation with the elasticity modulus (0,69 - 0,89), than with the strength (0,54 - 0,71).

Joints with steel elements

Thin-walled steel shaped elements are an alternative to carpenter's joints. They are moulded from galvanized sheet steel of 1-3 mm in thickness. For their fixing, special nails with a profiled shank, are used. The objective of this study is to complexly analyse the behaviour of joints in timber structures.

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Experimental and Numerical Analysis of Timber Concrete Composite Structures

P. Kuklík, A. Kuklíková

kuklik@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In the last several years an increasing amount of timber-concrete composite structures has been used mainly for the strengthening of existing timber floors. The benefit of this type of structure is also improvement of sound insulation and fire resistance of floor systems.

Finally, the cost of a composite timber-concrete floors is always competitive when compared with an all-concrete floors.

In the reconstruction of old timber structures an important role is played by a good knowledge of the properties of timber. The estimation of the properties of timber by means of the visual grading method is not entirely reliable with respect to a series of factors influencing the mechanical properties of timber and, further, with respect to the influence of the human factor in the grading proper.

Basic behaviour of timber-concrete beams

Basic behaviour of a timber-concrete beam with semi-rigid connections is following. Cross sections do not keep their planarity. Concrete layer is under compression and bending, timber beam is under tension and bending and fasteners are under shear. The strain distribution has the same slope because the section parts keep the same curvature; stress diagram is the result of compression-bending and tension-bending stresses.

Calculation models

Analytical model is based on the following general assumptions and conventions:

- The vertical deflection is equal for both elements and is given by one function. This means that a gap will not occur between the concrete and the timber in the model.
- The single cross sections remain plane, shear deformations within the two elements are not considered.
- Compression strengths and stresses should be entered with a negative sign.

The model can only be used for elements subjected to bending, so external axial loads are set to zero.

In the FEM model, the following assumptions are introduced:

- The member, the applied loads, and the deformations lie in a plane; the plane of the loads is the plane of symmetry of the member;
- Material properties of each layer are constant along the length, but they can differ from one layer to the other;
- No separation occurs between layers at any point along the member;
- There is no friction at the interface between the two layers; the interaction between the layers follows the connector load-slip characteristics;
- For each layer, a geometrically nonlinear Reissner's beam theory is assumed with small interlayer slip; geometrical (displacements and rotations) and deformation (membrane, bending) variables are finite;

- Materials in all layers and the load-slip characteristics of the interface are assumed to be nonlinear.

Recommendations for design and construction

Do not use wet timber. If it is unavoidable, use timber without pith or be sure that fissures will not affect fasteners lines. Leave the propping in place for more than the time allowed for all-concrete elements.

Use corrosion-free fasteners: passivated steel or zinc-coated steel or stainless steel.

Reinforce the concrete especially if thick concrete sections are being designed, in order to ovoid loss of stiffness due to large cracks on the concrete tension side.

When casting try to protect the timber from moisture, i.e. using plastic layers or using concrete with additives in order to reduce the water/cement ratio (that also allows smaller concrete shrinkage). This is not crucial for timber but for appearance undemeath. Pay attention to timbers that do not allow the concrete to harden (e.g. in the case of larch, due to sugar extractives).

If the spans are long prefer the use of soft connections in order to minimise eventual constraint actions, and, when possible, prefer a structure where the concrete layer is mainly important for reducing deflections rather than for reducing a lot of the stress values in the timber.

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Risks of Decisions Making in LCA of Housing Structures - Principle of Downward Sloping Demand

D Čápová, Z. Prostějovská, L. Kremlová

dana.capova@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, CTU in Prague, Thákurova 6, Prague 6

At the present, the price level in property market mismatches with the real purchasing power of inhabitants. Especially in Prague and Brno is the situation considerable. Research is focused on monitoring trends on housing markets, influencing indicators and its impact on market level in housing development in Prague. Sources for study are easily approachable in journals (e.g. Reality, Mag Real) and on Internet. Currently, we are monitoring executed sales of flats in new built houses. The current situation on the real estate market in Prague is an excess of supply over demand. Increasing offer of flats does not correspond to purchasing power of inhabitants.

The most important indicators influencing the housing market with flats are:

- Demographic trends in the Czech Republic;
- Income level of Czech households;
- Availability of mortgage;
- Developers profit level.

Demographic trend in the Czech Republic shows sloping new flats requirements in the future. Increasing number of retired people signifies growing needs of accessible housing for senior citizens and old people's home. Even now there is long waiting time for lodging in old people's homes. Senior citizens will gradually vacate larger flats and demand smaller and cheaper flats because they will economize their living.

Simultaneously, Prague is being gradually depopulated. People move outside the city limits and only commute to work. People who commute to work from further distances will probably try to rent a flat rather than buy a new one. Therefore, they will not have a major influence on the real estate market.

In 2003, the actual price of a new flat was 8.1 times higher than an average annual income of a Czech household. In other EU countries are the costs of acquiring a flat just 1.8 – 3.5 times higher than the average annual income of a household [ČSÚ]. Simultaneously, from the year 2000 the prices in construction have increased by 18%. Disposable income of households has increased slower. High selling prices of new flats in Prague influence the real estate market. Supply exceeds demand and people cannot afford to buy a new flat.

From 2001, households extensively have been using bank loans, especially mortgages. The amount of mortgage that Czech banks granted to Czech households has been increasing from 2001. In the 3rd quarter of 2005 is this amount 26milliard. It is necessary to point out the fact that 30% - 40% of the total volume of the mortgages is used for reconstruction or privatization of already existing housing stock. The lower mortgage interest rate had also a positive effect on the demand for mortgages. Czech National Bank increased the discount rate from 0.75% to 1.0% at the end of October 2005.This fact had an immediate impact on mortgage interest rate, which increased as well.

A law about housing co-operatives was passed in 2005, which will be interesting not only for people but also for banks. According to this law, housing co-operatives can affect related building costs and flat acquisition will be more achievable with fiscal support. Twenty years maturity of loan is interesting for both parties – banks and housing co-operatives.

One of basic economic principles is the principle of downward sloping demand. Downward sloping demand curve shows how quantity of the economic good demanded are changed versus growing prices of economic good if the rest (disposable income and prices) stays the same. This principle can be used for Prague real estate market as well.

Demand is mostly influenced by buying power of inhabitants. For better understanding we can shows an easy example. One-person household would like to buy a new small flat in Prague. The average wage in Prague is 22,000 Kč before taxes, 18,000 Kč after taxes. A new flat will be around 50m^2 small. The selling price of 1m^2 is 30,000 Kč/m^2, and then the acquisition price will be 1,500,000 Kč. Monthly payment of mortgage with interest 5% p.a. and maturity of 10 years is 10,500 Kč per month. The remaining amount for the living is 7,500Kč, which is lower than the subsistence level. That is not sufficient. The result is that for one person household with an average income cannot invest into a new flat under these conditions.

There is an unwritten rule in the USA. Households apply for a mortgage, which does not exceed an amount, that is 3times higher than the average annual wage of the household. In case of applying this rule in the Czech Republic a four person household with an average monthly wage 50,000Kč – 80,000Kč has to purchase a new flat (area 80m^2) for a maximum price within the range 1,800,000Kč – 2,400,000Kč. In this model the corresponding price per 1m^2 would be in the range of 24,000Kč – 30,000Kč/m^2 including VAT dependence on the locality. The average selling prices exceed, however, 40.000 Kč/m^2. We have been talking about the market price in Prague so far. Market situation in the second largest city in the Czech Republic – Brno is diferent. The market is working better and the only reason is that the selling prices correspond to the prices created by the market.

In other regions of the Czech Republic are selling prices of new flats per 1m^2 even lower than the mentioned range. The prices of existing older flats in the country in district towns are in range of 8,000Kč – 12,000Kč/m^2, which is 640.000Kč – 960.000Kč per flat area of 80m^2. These prices are influenced by rate of unemployment and average wage in the regions.

Other influencing indicators are the rate of VAT for new residential houses after 2007 and deregulation of residential rent.

There is no doubt that the Czech housing market will react on the market fluctuation in other world property markets, e.g. the situation on the USA property market in autumn 2005.

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Flood Analysis and Mitigation on the Lužnice River in South Bohemia

P. Valenta, J. Valentová*

valenta@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Hydrotechnics
Thákurova 7, 166 29 Praha 6

*CTU, Faculty of Civil Engineering, Dept. of Irrigation, Drainage and Landscape Engineering
Thákurova 7, 166 29 Praha 6

During the last decade the Czech Republic was severely affected by a series of flood events that have stressed the necessity of numerous actions to be taken to improve general flood preparedness and prevention. The last catastrophic flood in August 2002 and its consequences led to the proposal of a new project FLAMIS (Flood Analysis and Mitigation on the Lužnice River in South Bohemia), which builds on experience from the previous FLAMOR project [1,3] and investigates important factors in the system of prevention, preparedness, control and management of extreme hydrological events. Both projects were supported by Swiss Humanitarian Aid Unit (SHA) – Swiss Agency for Development and Cooperation (SDC).

The Lužnice river, as a tributary of the Vltava in South Bohemia, together with several towns affected by the August 2002 flood, was selected as a suitable location for the case study for the FLAMIS project, after an analysis of several other localities on the territory of the Czech Republic. The main co-bearers of the project the Czech Technical University in Prague – Faculty of Civil Engineering and the Swiss Federal Institute of Technology in Lausanne closely co-operate with other Czech institutions, namely with the Czech Hydrometeorological Institute and with the Vltava River Basin Board in Prague, with a view to investigate hydrological and hydraulic problems in connection with prevention, preparedness and flood control topics in the framework of the project. The idea of the project was approved and supported by the regional authorities in the South Bohemian region and local authorities of the towns affected by the flood in August 2002 who have expressed great interest in a detailed hydrological and hydraulic study of the territory of the potentially endangered towns and of the influence of the reservoirs and ponds in the watershed of the Lužnice river. Project FLAMIS has following main objectives:

- To make a detailed evaluation of the flood of August 2002 in the domain of interest from the hydrological, hydraulic and social-economic points of view, and to collect the data with a view to studying measures against floods.
- To elaborate flood maps and analyze flood hazards in given areas by mathematical modeling techniques.
- To elaborate the vulnerability of areas and to estimate the risks. To identify the risk areas and impacts, to determine adequate measures to minimize the risks and to evaluate the efficiency of the measures. These measures may be structural and/or non-structural.
- To propose and formulate preparedness organization and an action plan in the framework of measures against floods in all stages (prevention, operational measures, dealing with after-effects, mitigation) and to propose legislative constraints for land and territory improvement.

For the first two objectives realized in the first phase of the project, data and specific

models were required. The study for the specified section of the Lužnice river was carried out with the use of 1D and 2D numerical models.

For numerical 1D modeling, the HEC-RAS one-dimensional model was used. The structure of the assembled one-dimensional model includes all important branches of the looped river system consisting of the main rivers Lužnice and Nová řeka, interconnected by the historical artificial channel Nová řeka. The main source of geometric data was the topographical description of the river and geometric data on the hydraulic structures and bridges based on the new land surveying exercise carried out in 2004 in the framework of the FLAMIS project by Geošrafo Ltd. Detailed 2D models were created for selected towns in the zone of interest, where the results of a 1D model cannot be reliably applied due to the complexity of the urban areas and the limitations of 1D modeling methodology. Two-dimensional model FAST2D was applied in selected sections in the towns of Tábor, Planá nad Lužnicí, Soběslav and Veselí nad Lužnicí, with the possibility of a detailed study of the situation in the flood plain and verifying the efficiency of existing or planned flood protection measures of the Vltava River Basin Board and/or local authorities, i.e. the town halls of the above-mentioned towns and regional authorities in the South Bohemian region. The terrain approximation in the numerical models was created with help of a detailed digital terrain model created on the basis of aerial photogrammetry.

The assembled numerical models were successfully calibrated using the observed water flood in August 2002 and other available data. Numerical outputs resulting from 1D modeling were evaluated in the graphical form used in the Czech Republic as flood maps containing flooding lines and an evaluation of the flooded areas, together with longitudinal water elevation profiles. Evaluation and analysis of extensive two-dimensional numerical hydraulic modeling results requires the application of special post-processing software used to create a synoptic graphical evaluation and presentation of the simulation results. A graphical evaluation of results calculated with the FAST2D numerical model typically includes several flood hazard maps, representing the spatial distribution of the primary flood variables (water elevations, water depths, flow velocities, specific discharges, flood danger zones).

The finalized and calibrated numerical models were used to simulate floods with peak discharges at various return periods. Numerical models and outputs resulting from numerical modeling and flood hazard evaluation are prepared for use as input for consequent flood risk analyses and flood mitigation efficiency evaluation.

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Radiation and its Influence on Behavior of Concrete

Vít Sopko, David Šámal*, Ladislav Samek

vit.sopko@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University Technická 4, 166 29 Prague 6, Czech Republic

*Department of Electrotechnology, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This project deals with changes of mechanical and chemical structure of concrete under irradiation. Concrete as a basic material for civil engineering structures is also used as a shielding in nuclear power plants and short-time storage of spent radioactive fuel. Influence of gamma radiation on water contain in concrete pores is well studied and already known results map out procedures occurring during irradiation [1]. However, concrete consists of hydrated cement that contains crystalline water. This type of water is indivisible component of cement stone and its decrease causes loss of mechanical properties of cement stone. The water bound in hydrated cement behave differently than water contained in pores during irradiation [2].

Experimental result shows that water irradiated in concrete voids is behaving according to formula

$$Ca(OH)_{2aq} + H_2O_{2aq} + 6H_2O \rightarrow CaO_2 \cdot 8H_2O \tag{1}$$

Equation (2), (3), (4) are explaining single aspects that are occurring in voids in concrete.

$$CaO_2 \cdot 8H_2O \rightarrow CaO_2 + 8H_2O \tag{2}$$

$$CaO_2 + H_2O \rightarrow Ca(OH)_2 + 1/2O_2 \tag{3}$$

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \tag{4}$$

At first the gamma radiation causes decomposition of peroxide octahydrate. The result of this reaction is calcium dioxide and eight water molecules. At second, reaction between calcium dioxide and water creates calcium hydroxide. Thirdly reaction between calcium hydroxide and carbon dioxide creates calcium carbonate which is so called carbonation. The calcium carbonate is decreasing significantly pH value. Declining of pH has significant effect on armature and starts decreasing its protection layer. Long-term reduction of protection layer of armature begins to display as its corrosion. Equations (5) and (6) describe origin free radicals of iron and hydroxide.

$$Fe \rightleftarrows 2e^- + Fe^{2+} \tag{5}$$

$$1/2O_2 + H_2O + 2e^- \rightleftarrows 2OH^- \tag{6}$$

$$2OH^- + Fe^{2+} \rightleftarrows Fe(OH)_2 \tag{7}$$

Equation (7) depicts compound of single radicals of hydroxide and iron when final product is ferrous hydroxide. Equation (8) describes creation of ferric hydroxide.

$$4\,Fe(OH)_2 + 2H_2O + O_2 \rightarrow 4Fe(OH)_3 \tag{8}$$

Equation (9) characterize formation of Fe_3O_4 which belongs to group of so called black oxide.

$$3Fe + 8OH^- \rightarrow Fe_3O_4 + 8e^- + 4H_2O \tag{9}$$

During corrosion shapes new compounds as for example Fe_2O_3, $Fe(OH)_3$ [7], which are in comparison with atom of iron from twice till six times larger and causing due to their size tension in concrete part of construction. When the armature is exposed to the atmosphere, its function declines in building unit and the corrosion continues. Neverless, progressive carbonatation of concrete is lowering safety and appearance of building construction.

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Moister Transport in Roof Structures

P. Slanina

petr.slanina@fsv.cvut.cz

Katedra konstrukcí pozemních staveb, Fakulta stavební, Thákurova 7, Praha 6, 166 29

Introduction

At present for the evaluation of the risk of moisture condensation in the interior of building constructions there are used simple calculation methods, described in the Czech and European standards ČSN 73 05 40-4 and EN ISO 13788. These methods are called Glaser´s Methods and they usually lead to correct designs as far as safety is concerned. These methods consider only one-dimensional transport of the moisture content and the qualities of materials as homogeneous.

In fact, however, the materials built in building structures are non-homogeneous the reason being their structural arrangement (i.e. linking of materials, mechanical fixing) or because of a negligence in a building.

Under the influence of originating non-homogeneities of materials the moisture transport is in more dimensions in the roof cover and thus the moisture content in the roof layers is raised. The calculation with the aid of Glaser´s Methods do not answer to the real state of the construction, the resulting roof cover designs are then not correct. Their function is lost, the life-service of the whole construction is shortened and the result will be expensive reconstruction.

Physic Description of Moisture Transport

Present broadest physical model of moisture transport was described by Krischer and Kyjov in the seventieths of 20th century. On based of their work was created simplest description of moisture transport the 1st Fick's Law. In this formula there is thermodynamic power only a gradient of a concentration. The 1st Fick's Law is pure process of diffusion without influence of heat and salt transport, pressure (gradient of pressure), electrical field, gravity, etc. Other current mathematical models of water vapour transport in porous material include also transport of head, soil, air and moisture, for example Grunewald's model.

In building physic and in Czech end European standards we can find different descriptions of moisture transport. According to these descriptions thermodynamic power is a gradient of water vapour pressure. For the evaluation of the risk of moisture condensation in the interior of building constructions there are used simple calculation methods. These methods are described in standards ČSN 73 05 40-4 and EN ISO 13788 and they are called Glaser's methods. The methods use for thermodynamic power only a difference of interior and exterior water vapour pressure that it is correct only for one-dimension construction. In fact, however, the building constructions are not only one-dimension and materials are with non-homogeneous properties these standard's methods lead to incorrect results. We have two other possibilities how to judge water vapor content in the building envelop constructions or value of water vapour diffusion-equivalent air layer thickness (sd-value) of non-homogeneous materials.

Numerical models of moisture transport

Two numerical models were used for the project. The first Area 2002 (Svoboda software) divides two-dimension construction into narrow stripes according to heat transport. Each stripe solve as one-dimension problems by using Glaser's method. As the water vapour content can transport among single strips of construction, the result can be very unclear so

that we decided not to continue using the model to determine diffusion properties of non-homogenous materials with high sd-value.
Second numerical model, which was used for the project, was Delphin4.5. The model was created by J. Grunewald from Dresden University. Numerical model uses FEM and it counts with dynamic influence of water vapour content in porous materials. At the same time model solves moister, head, air and soil transport. Unfortunately the model indicates inexact result at high value of relative humidity where it would occur to a condensation process. For that reason was stopped from using this numerical model.

Measurement of Diffusion Properties of Non-homogeneous Materials
Next possibility is measured diffusion properties of non-homogeneous materials especially with high sd-value (i.e. vapour barriers or waterproofing layers) where is significantly appeared multidimensional moisture transport. In the past these measurements were done at Civil Engineering Academy in Germany or in VUPS in Zlin, Czech Republic. The results of these measurements are a few with unclear solutions and thus the measurement of diffusion properties of material with high sd-value has been continuing at the Faculty of Civil Engineering in CTU in Prague. A few results that we've already had with help of wet cup method indicate a significant decrease of sd-value. For example the sd-value of perforate vapour barriers (foils) decreased in average on 5% of regular material. The perforation made 0,125% of the area of the specimens. In spite of the result corresponds to measurements of institutes notice above the result can not be take as satisfactory result because we measured only small amount of specimens. For higher-quality of measurement we built a new apparatus which allows to measure materials with larger area of specimen. Nowadays we are testing new apparatus and next results will be soon.

Conclusion
The results of measurements prove significant accrual of water vapour content which reaches into roof cover due to non-homogenous vapour barriers. Glaser's methods do not lead to real state of water vapour content in the construction if the materials for vapour barriers are non-homogenous. Then the resulting roof cover designs are not correct. Their function is lost, the life-service of the whole construction is shortened and the result will be expensive reconstruction.

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Optimization and Environmental Assessment of Floor Structures Using Recycled Materials from Municipal Waste

J. Mukařovský, C. Fiala, P. Hájek

jan.mukarovsky@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Praque, Thákurova 7, 166 29 Praque 6, Czech Republic

Optimization in the environmental context is becoming an important tool of integrated design of building structures at the millennium turn. Reducing the consumption of energy and structural materials derived from primary raw material sources is one of the most important tasks in the domain of sustainable buildings. The optimization of shape and reinforcement of concrete structures, additionally in combination with the use of recycled materials, significantly determine the total environmental impact of the designed structure.

A box RC cross-section effectively utilizes the material both from the point of view of structural behavior (pressed top slab + slight shear ribs) and technology (bottom slab forms a flat lower ceiling). This type of structure represents effective form (i) to the intent of consumption of structural material and (ii) self-weight that decreases the amount of reinforcement on one side and increasing load-bearing capacity on the other side. Additionally, lower self weight positively influences dimensioning of vertical load-bearing structures and foundations. Technological problem consists in a creation of hollows inside the reinforced concrete cross-section. The hollows can be created by application of permanent formwork using different types of fillers (to the intent of material or profile).

The goal of the optimization of box RC cross-section in environmental context is to decrease the environmental impact by decreasing (a) the consumption of non-renewable raw materials and energy sources, (b) the consumption of embodied energy, (c) the production of embodied emissions (of CO2 and SO2 above all), (d) the amount of waste at the end of a structure lifetime and all of that by improving the functional characteristics. In performed study six variants of fillers were used, specifically (1) concrete hollow filler, (2) fibre cement filler, (3) ceramic hollow filler, (4) polystyrene filler, (5) cellular concrete filler and (6) filler from recycled non-sorted plastic. A set of fillers represents contemporary possibilities in the field of lightening of RC floor structures. The predefined criteria in this study are environmental criteria (embodied CO_2, embodied SO_2 and embodied energy) and economical criteria (cost of acquisition). These criteria were applied in mono-criterion optimization of floor slab alternatives in the first phase. In the following phase these criteria were represented by the particular objective function in multi-criteria optimization model.

The optimization of the profile of box RC cross-section was executed by utilization of a special optimization algorithm. This algorithm was created in Microsoft Excel environment and utilizes a combination of discrete optimization and mathematical optimization (non-linear optimization code GRG2 – Generalized Reduced Gradient). Using “Solver” application several series of optimization loops were executed using four particular objective functions. According to the particular criteria volumes of concrete, steel and fillers were optimized so that the minimum of the objective function was achieved, i.e. concerning the environmental context the optimal dimensions of cross-section were found.

Together with the particular optimization of a structural element it is of an essential importance to quantify the environmental impact of subassemblies and of the complete structure in order to enable objective comparison with alternative structures. For this purpose several alternative structures to RC floors were selected which represent wood based and steel structures. This part of study is principally focused on the assessment of environmental criteria, specifically embodied energy use and embodied emission production of CO_2 and SO_2. However, basic technical criteria (total structural thickness, mass per square meter, etc.) are also quantified.

Within this evaluation part of study variants of bearing floor structure were selected which cover three groups of material and structural solutions. The first group – reinforced concrete floor slabs – is represented by the RC slab with constant thickness (standard-reference variant) and six alternative slabs with lightening fillers (see above). The second group represents floor structures with wood based beams where the first case is an experimental composite I-beam with timber flanges and a web from structural boards from recycled laminated cartoons. Next variants cover another I-beam with laminated timber flanges and OSB web, a plank truss, and a laminated timber girder. The third group – steel structures – is represented by a steel rolled IPE-beam. All of the floor structures were designed for identical way of utilization, i.e. identical span and effective load. Constant load was considered specifically for each variant, i.e. self weight of load-bearing structure, plaster ceiling respectively plasterboard ceiling, and heavy respectively lightweight floating floor. Design pursued the most effective structure utilization, i.e. the structures were oversized minimally, however to fulfil the deflection limits the majority of variants is oversized concerning the load-bearing capacity. For the final environmental assessment floor structure variants were completed with upper board (over the beams), floors (altogether 8 variants – from heavy floating floors to lightweight floating floors with boards from agglomerated timber respectively boards from recycled laminated cartoons), and plasterboard ceiling respectively plaster ceiling in case of RC slabs.

The results of this study show the importance of optimization in the environmental context and environmental assessment in general. It demonstrates the significant dependence of box RC cross-section shape and subsequent environmental impact and on the other hand the contribution of bearing structure in the total assessment of a complete structure.

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Reliability, Optimization and Durability of Building Materials and Constructions

J. Witzany, V. Blažek, J. Procházka, J. Studnička, J. Jettmar, F. Luxemburk, H. Krejčiříková, V. Vorel, I. Pultarová

witzany@fsv.cvut.cz

Faculty of Civil Engineering, CTU Prague, Thákurova 7, 166 29 Praha 6

Among fundamental objectives of the research project in relation to practice there is long-term reliability and durability, minimization of material and energy demands of buildings, protection of the environment and people's health. The solution of these problems involves a complex of issues in the area of design theory of buildings in terms of reliability and safety of buildings, optimization and material and energy savings, time-variable and time-dependent properties of building materials and structures in relation to their long-term reliability and durability, material engineering, computation methods, mathematical modelling and reliability theory. In keeping with the time schedule, the research in 2005 was focused on the following groups of topics in particular:

Solving the problems of multi-layer preconditioning of the numerical solution of partial differential equations. The constant estimate in the intensified Causchy-Buniakovski-Schwarz inequality for hierarchic bilinear conform finite elements was achieved. The problems of a numerical solution of stochastic processes in the theory of reliability, and derivation of conditions for a local convergence of certain two-level solution methods. The analysis of using the problem of linear programming with data set in intervals and its base stability. *(research workplace – Dep. of Mathematics)*

The numerical and experimental analysis of a design solution, including the in-situ monitoring of contact padding systems in terms of their durability and reliability. The monitoring, sampling from historic buildings with a special focus on the stone structure of Charles Bridge, the analysis of the impacts of moisture content and salinity on the degradation of sedimentary minerals. Research of the effect of soil mould and bacteria on the service life of asphalt and plastic damp-proofing systems. The development of a radiator producing very low gamma radiation dosages, and the development of a new measuring apparatus for determining temperature dependences of the radon diffusion coefficient in damp proofing materials. Verification of the methods of modelling the effect of time-variable temperature effects on the stress-state of multi-layer external claddings and external parts of buildings The analysis and evaluation of remediation methods for moist masonry. The analysis of a recycling potential and its subsequent use. *(research workplace – Dep. of Building Structures)*

The design of methodology of evaluation and appraisal of risks in the remediation of earth slopes and spoil heaps with regards to the reliability development in time. Further more, data was obtained on floods, the effect of landscape typology, flow parameters. The basic steps for decision-making on rehabilitation measures on buildings were described and illustrated using examples of specific historic buildings. Experimental measurement of selected physical and mathematical properties of steel-fibre-reinforced concretes. Verification computation models on specific structures, determination of the depth of the deformation zone in subsoil. *(research workplace – Dep. of Building Mechanics)*

Study of local stress of state of the bridge deck slab with an intermediate cable anchorage, statistic processing of existing loading capacity of masonry vault bridges with regards to geometric data, age and structure's condition.Comparative calculations of lean concrete

pillars with regards to reliability achieved, experiments aimed at determining the anchor length of FRP reinforcement glued into grooves in concrete. Development of a database of strength and deformation characteristics based on steel-fibre-reinforced concrete tests, parametric studies of the effect of residual strength of steel-fibre-reinforced concretes on the truthfulness of a material model. *(research workplace – Dep. of Concrete Structures and Bridges)*

Research of the use of trapezoidal arches in lean ceilings, the load-bearing capacity of defect bolted joints, the load-bearing capacity of friction joints of galvanized members, composite steel-concrete structures of high-strength materials, the design of chimneys and floating frames, thin-walled girders with corrugated webs exposed to fire hazards, fracture toughness of high-strength steels, composite trusswork structures, new coupling means, structures of glass, degradation processes in bridges, wooden roof trusses and composite timber-concrete structures. *(research workplace – Dep. of Steel and Timber structures)*

The analysis of design procedures and recommended methods of spread and deep foundations under EN 1997-1. For the usability limit state, the methods of settlement evaluation in accordance with the EC annex were compared with existing procedures verified in the Czech Republic. The analysis of interaction in solving sheeting structures was made – comparison of the properties of a bar model with rigid supports, a model with elastic supports, the finite-element method using contact elements. Based on the effects of random load by surface traffic acting on the underground structures' lining, the load due to non-rail and rail traffic acting on underground structures was specified together with its effects. *(research workplace – Dep. of Geotechnical Engineering)*

Research of the problems of mechanical, physical and rheological properties of compacted asphalt mixes, modelling of the effect of load on the relative service life of structures with a corresponding analysis of the traffic flow. *(research workplace – Dep. of Road Structures)*

The measurement and analysis of the track structure deflection (exploitation of Y-sleepers on a railway line section between stations Popelín – Počátky Žirovnice) under passing load, using geodetic monitoring methods of the total rail stability under changes in the static rail structure action. *(research workplace – Dep. of Railway Structures)*

Geodetic monitoring ensuring the reliability of buildings, the monitoring concept, verification of the measuring apparatus qualification and development of technological procedures of geodetic monitoring and points of a local reference geodetic net in measurements on bridge structures. Monitoring of shifts of historic buildings. *(research workplace – Dep. of Special Geodesy)*

The research results were presented in professional periodicals (or submitted for print) and in the proceeding of conferences and seminars. In total 96 papers were published in 2005, of them 18 abroad.

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Additional Hydro-Insulation Shield - Experimental Comparison of Infusion Agents Efficiency in Wet Masonry

M. Volf

volf@klok.cvut.cz

Experimental Department , Klokner Institute, Czech Technical University, Šolínova 7, 166 08 Prague 6, Czech Republic

The technology of creating hydro-insulated shields by chemical agents in masonry is possible to take for classical and common nowadays. Hydro-insulated courses are created by the impregnation of selected material in wet masonry. This material infiltrates in poruses, capillaries and scratches. It is supposed that this zone steeping protects and reduces capillary rise and serves as an additional insulation. The rules for infusions are specified for example in instructions WTA 4-4-96.

We can talk long time about technological processes (compressed and uncompressed methods of infusions, warming spirals, section and areal borings etc.) or material bases (silicate, silicone, polyurethane, oil, paraffin, asphalt etc.) but finally the key criterion for the infusion material and technology is the efficiency of material and the process of creating the protection or stopping the penetration of water in masonry. Although this technology is relatively old and well elaborated, it is very hard to find well-arranged, objective and systematically organized information about separating infusion agents. From this aspect there is unfortunately quite huge possibility of materials combination, wetness background of masonry and technological solutions which do not allow covering all possibilities.

In last years we were engaged in development of the relatively simple possibility of the efficiency comparison of separating infusion agents. In the meantime we are confronting the attained results with attested methods of comparison by WTA organization

The basic problem of infusion agents efficiency is the wetness of masonry in which is the infusion applied. Certainly it will be different result if we injects wet brickwork masonry with maximal level of wetness saturation about 18% of the weight, whose actual weight wetness is 7% in average, then wet masonry with wetness 13%. Problems with verification of the infusions efficiency are experimentally very difficult. For verification of the injecting efficiency process with regard to wetness and character of injecting masonry exist two basic approaches:

1. Completion of comparing experiment on the experimental walls (simulation of real construction)
2. Simplified monitoring of the chosen parameter.

We have started with the second above mentioned possibility in recent years in Klokner Institute, began the monitoring of infusion materials efficiency in burnt brick (brick shards) applying the uncompress method. Currently we are comparing both above described methods.

Summary of finished experiments until now:

1. Type testing of suitable brick shard, on the basis of bricks parameter determination (strength, absorptive capacity, capillarity attraction).

2. Methodical concept of experiment organization and methods of wetness progress monitoring.
3. Carrying out of primary experiment for four levels of wetness in brick shard.
4. Following experiment using more types of infusion materials and their comparison.
5. Building of 4 brick pillars according to the WTA methodology, holes drilling for infusion applying and selecting levels of wetness.
6. Injecting of brick pillars and their continuous measuring are carried out in Klokner Institute laboratories nowadays.

The data obtained from the previous experiment is indicating us possibility of quick comparison of efficiency and applicability for selected materials (using uncompressed inject). The result of efficiency for particular infusion agent is possible to obtain in relative short-term perspective. Our experiment results prove that efficiency of particular infusion agents is very specific for every infusion material. For this reason the range of infusion agents has been expanded and their efficiency has been certified on brick pillars in accordance with WTA instructions.

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Multiobjective Optimization of Steel Concrete Constructions

V. Žďára, J. Kalináč

zdara@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Building Structures
Thákurova 7, 166 29 Praha 6

Multiobjective optimization is a tool, which facilitates effective and balanced design of building. Our paper is dealing with multiobjective optimization of the hall buildings. We analyze the existing situation in designing and the approach to design of hall building. The paper also shows the new ways of multiobjective analyses used in design of loadbearing building structures.

Design of loadbearing structure of a hall is a part of the wider process of the building design as a whole. In current praxis, we can recognize two basic types of halls. Simple halls (rectangular warehouses, production halls etc.) can be produced repeatedly and manufactured in series. Design and production of the simple halls is prepared and that is why they are cheaper than the atypical halls.

Design of simple halls often uses the standardized structional systems produced by the individual manufacturers and suppliers. Design of more complex halls is influenced by the investor, architect, structural engineer or other specialists. The optimization of the standardized construction systems (ones which can be used repeatedly) is done by the manufacturer, in order to maximize his profit. The optimization is done systematically but without a concern for the environmental effects. Selection of the structural system is done on bases of the offers. The suitable tools necessary for multiobjective evaluation, are usually missing. Optimization of the structural system for a complex building is usually done by the architect in collaboration with design engineer. The selection of design engineer, specialized for the use of a particular material or technology, reduces numbers of possible solutions.

Design of the load bearing structure is usually done under great time pressure. Search for the options of possible structural solutions is often limited. The empirical type of experience of structural engineer is especially limiting for design of new structions. Structions are not properly evaluated. Multiobjective evaluation and simple optimization is not done.

The aim of this research is creation of a tool for the multiobjective evaluation and optimization of load-bearing structions, like roofing, ceiling constructions etc. Presented method is focusing on optimization of the most common structions with regular organization (orthogonal or radial multi-layer systems). Reason for examining these types of construction is their wide application in building.

Optimised structure is deemed multi-stepped. Model is written by the spans of the individual structural steps with used structural types. The aim is to find the best combination of spans and the structural types. Selected structural elements must fulfill the static load-bearing capacity, deflection and geometric requirements (span, placing of elements). Characteristics of structural types are described by the list of characteristics of their individual members or in form of algorithm. In view of the disparate source of information, are the structual types characteristics described uniformly by substitute approximate functions. For the given spans and loading are chosen characteristic properties (self-weight, parameters of

multiobjective optimization). At this stage is also given usability of individual structural types in relation to the span a loading. Advantage of such a approach is the optimization process acceleration, by use of the pre-calculated values.

Inclusion of the large number of structural types in the database lowers the efficiency of the optimization. It's uneasy to determinate success of structural members exactly, because at assembling time weight vector for evaluation is not known exactly. It's useful to assume this weight vector with specific statistical dispersion. Then it is possible to reduce database. Also is impossible to determinate exactly impact of self-weight of structural members, since its dependency on the ultimate constructions configuration.

Optimization is performed as a search in the "tree" of possible solutions. Tree of possible solutions contains combinations of geometry derived from attached geometrical arrangement of designed construction and available structural members. Optimization process begins on primary loaded construction stage and continuous to the elements on the higher hierarchical stage. For every hierarchical stage of construction geometry and load is known, so it's possible to choose most suitable structural member. Various possible combinations are compared using multiobjective analysis. Multiobjective analysis evaluates price of structural member and also its environmental effects, performance characteristic. Constructions with homogenous material are preferred.

Difficulty of this optimization task grows exponentially with number of number of structural members in database, so this variant of optimization method is useable only for limited number of structural members in database. Optimal solution can be found using one of well-proven optimization techniques like simulated annealing.

Size of tree of possible solution can be significantly reduced by clustering structural members along its relative densities into clusters. Effect of structural members in cluster onto structural members in higher stage is almost the same; therefore it's possible to choose the most suitable structural member from cluster. This decreases problems dimension. Efficiency of this method can be increased by application of heuristics (pre-reduction of unsuitable geometry and structural members' combinations).

Main advantage o presented method is its all-purpose usability for solving large area of similar problems. Structure of database allows unified access to various structural members. Major part of all necessary computations could be performed during assembling of database. This optimization method enables utilization of heuristics and also its enhancement.

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Specification of Fundamental Parameters of Environmental Compatibility Model for Road Structures

J. Valentin*

jan.valentin@fsv.cvut.cz

*Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The definition of environmental compatibility is based upon the principles of sustainability. EC further develops the principles and defines and specifies them for construction systems, structures, technologies and materials. In the past, permanent sustainability used to mean the management, that is, the utilization of resources, assets and managed supplies in such a way that ensured their maximum possible yield for the longest achievable period while regular maintenance and repair significantly contributed towards this goal.

Up to a certain degree, compatibility is affected and directed by the legislative framework, technical standards and scientific and engineering approaches that allow the further development of our understanding and what we consider a compatible structure to be from the environmental perspective. This definition and specification changes are depending on the nation, time and formulated development strategy. To a certain degree, the level of advancement in a certain society's way of thinking also has an influence. It is therefore necessary to state that we must understand environmental compatibility as a continually developing approach and a conglomeration of interconnected factors. Because of this dynamic character (time dependence) it is possible to create and define a model which allows further optimization with respect to fundamental principles of environmental compatibility. Elementary components of such model are EC parameters (characteristics), which are based on the specification of key environmental aspects. At the same time it is without doubt necessary to observe environmental compatibility of particular structures or entire systems from the life cycle point of view. In each stage of the life cycle potentials which lower negative impacts on the environment should be identified.

The questions we should today answer analyzing construction of pavements, the use of structural materials and technologies, especially production of hot-mix asphalt and cement concrete are following, as well as the issue of road pavement life cycle are as follows:

1. total energy consumption during road construction and possibilities for its minimization,
2. present total emission of CO_2 by road building processes,
3. exploitation of natural resources and production of structural materials and semi-finished products (material demand, energy requirement for the production, produced emissions of greenhouse gases and other harmful pollutants). From this point of view special attention should be paid to material and energy consumption at hot-mix and concrete plants,
4. design of road alignment and its location in the ground, including landscape treatment,
5. operation, maintenance and rehabilitation of particular roads during their lifetime (energy requirements, possibilities for recycling etc.).

The general concept of EC structures [1] addresses the proportional relationship between the quantity of released greenhouse gas emissions, energy consumed and accumulated in individual structures and the quantity of the consumed non-renewable resources that, at the same time, accumulate closed energy, as well as the mutually inseparable relationship between ecology and economy. From this assumption results an analogical proportional dependence between the volume of material and energy represented in such materials and structures, and the scope of their impact on the environment. Of course, for various material systems, there are obvious differences in the quantities of enclosed energy. EC is therefore inversely proportional to the total volume of the structural mass.

General criteria and prerequisites of environmentally compatible structures may therefore be summarized using as basic areas of parameters: structural systems, structural materials, optimization of location of each structure as well as their orientation and direction in the ground and development and utilization of structural technologies with low energy consumption within the life cycle of the construction. Besides the listed criteria, there is a whole range of economic and social factors that influence the impact of structures on the environment and can determine the degree of a structures' EC.

From the perspective of road construction, the crucial parameters could be considered to be the energy requirements ($\sum E_n$) of the individual construction materials, structures and technologies, the quantity of the emissions released ($\sum EMS_n$), which are not limited to greenhouse gases but also to the increased quantities of dust particles or the release of aerosols and hydrocarbon compound evaporations primarily when using asphalt technologies. No less important are the parameters relating to structural thickness ($\sum d_p$) which are directly proportional to the quantities of construction materials used, as well as the degree of utilization of reclaimed asphalt and other suitable recycled resources ($\sum R$) and the quantity of the construction waste generated and not used for the structure itself ($\sum W$). From the technical and economical perspectives, the crucial parameters are the structure durability ($\sum D$) and life cycle costs of the construction ($\sum LCC$), which may express, not only the costs of completion but also the maintenance and repairs but also the economic expression of energy consumption.

However the general EC concept will be not secured before we have understood each structure as a part of integrated system. We cannot solve problems of roads, highways and buildings separately, because construction of a road is meaningful only if an existing road will connect two building structures. On the other hand buildings without infrastructure, which provides their integration into the environment, are pointless in their being.

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Predicting Optimal Coagulant Doses During Surface Water Treatment Using Neural Network

A. Grünwald, P. Fošumpaur*, K. Štrausová, J.Jindra**

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering,
* Departement of Hydrotechnics
Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

**VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Coagulant dosing control is necessary to ensure stable treated water quality and to reduce chemical costs in drinking water treatment plants. The optimum coagulant dosis control is quite dependent on the development, availability and adoption of online water quality monitoring systems in the field. The main parameters in water treatment plants remain flow, pH, turbidity, alkalinity, colour, DOC, COD and UV-absorbance. The need for monitoring residual iron/alum has increased the awareness among plant owners and researchers for using it as a parameter in coagulation control. One of the major limitations of using coagulant is the pH of the solution. During coagulation this parameter must be within a specified range. In addition, the coagulation process depends also on other water quality parameters, such as alkalinity, colour and the concentration of dissolved organic carbon. In the absence of pH control, the addition of coagulant reduces the pH of the solution, which results in improved removal of dissolved organic compounds. However, higher residual content of aluminium or iron in the treated water can become an issue under such conditions. For example, the acceptable residual iron and also alumninium concentration stated in Czech Drinking Water Guidelines is 0,2 $mg.l^{-1}$.

Generally, optimum coagulant doses are determined using jar tests. Jar tests are relatively expensive and take a long time to conduct. The limitations can be overcome by using different models. The models can be either process or process inverse. In process models the inputs include e.g. raw water quality parameters and process control parameters e.g. coagulant dose. The model outputs the treated water quality parameters are used. In the process inverse model the inputs include the values of the process inputs, one of the process control parameters and the desired values of the process output parameters. Process inverse models can be used to predict the optimal coagulant dose directly, given values of the raw water quality and the desired treated water quality parameters.

Van Leeuwen et al [1] presented mathematical models for predicting ferric and alum chloride doses and pH control reagents that maximise removal of organic compounds and turbidity from raw waters, based on lab and pilot scale tests. Aguiar et al [2] studied the relationship among optimum coagulant dosage, organic matter content, coagulation pH and the raw water source in real water treatment plant.

In recent years artificial neural networks have found application in solving complex process engineering problems where it is difficult to develop models from the fundamental principles, particularly when dealing with non-linear systems.

Many papers have been published on the application of artificial neural networks to water treatment and also wastewater treatment systems. The use of neural network models has been suggested e.g. for the simulation the treatment of surface water by coagulation, the estimation of water quality for a rapid-gravity sand filtration, for the simulation of ammonium N concentration by the industrial wastewater treatment, control of the hydrogen peroxide and ferrous-chloride dosage in treating synthetic wastewater etc.

In this paper a feed forward (more commonly known as error back propagation) artificial neural network has been to investigate the simulation of the COD reduction which was achieved by coagulation the raw water from WT Římov. Raw data from WTP Plav (southern Bohemia) were pre-processed and used for training and testing the network. Artificial neural network with one hidden layer and 15 neurons was used. Model was calibrated using the backpropagation algorithm, as it has alredy been used for the prediction of coagulant doses.

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Ecological Evaluation of Trenchless Technologies

P. Šrytr, L. Nenadálová

srytr@fsv.cvut.cz

Department of Sanitary and Ecological Engineering , Faculty of civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The construction, repairs and reconstruction of utilities are the natural prerequisite for the maintenance and development of the territory. Every construction work, however, exercises a negative impact on environment. Therefore, the planning and implementation documentation of every project and the preparation of its construction must take into account, apart from technical design and economic requirements, also ecological criteria. Ecological impact of human activities is and will be even more strictly monitored in the future and the pressure borne at its elimination will continuously increase. This may be to the benefit of trenchless technologies (TT).

The principal objective has been to draft and offer a methodology providing a consistent approach to the evaluation of TT impact on environment in case of specific projects considering both public interest and the interest of all parties concerned and so prevent a "black-and-white" look at TT e.g. through the prism of contractor's interest only, but to consider them primarily as an integral, equivalent and useful applied engineering discipline.
The assessment of TT application to utilities, however, requires their systemization and classification. In the first place it is necessary to take into account ISST classification that is of official character.

The Graduation Thesis of Tomáš Kubát offered, in the first place, a critical analysis of this existing classification and tries to transform it into a consistently sector classification, incl. its supplementing with the technologies indubitably belonging to this category technically and technologically, but omitted so far.
The formulation of this entirely new methodology of consistent ecological evaluation is based on so–called stepped assessment. The ecological TT assessment is made in the following three steps.

1. The step of plain ecological assessment in the form of mutual comparison of individual TT types.
2. The step of ecological assessment in defined representative model situations.
3. The step of direct ecological assessment of specific examples.

Every step of ecological TT assessment is important, irreplaceable and significant for the final synthesis of result.
Plain ecological assessment: the principal prerequisite for plain ecological assessment is its application to a universal model situation, which guarantees relative assessment accuracy; all technologies are compared in identical conditions.
The objective of plain ecological assessment is to point out the mutual differences (advantages, disadvantages) of technological processes of individual TT and their environmental impact in a universal model situation.

Ecological assessment in defined representative model situations: the objective of this assessment step is to point out the ecological advantages and disadvantages of individual TT, i.e. in relation to the conditions of principal model situations and to find, whether and in what specific way the TT are ecologically applicable. The representative model situations are characterized by the conditions of municipal territories according to the category of municipality and the conditions depending on the location inside or outside municipal boundaries.

1. Territory inside municipal boundaries
   1.a Municipalities with a population over 2000
   2.b Municipalities with a population up to 2000
2. Territory outside municipality boundaries.

This step of ecological assessment is based on the same procedures as plain ecological assessment except that the individual criteria are weighted (weights 0.1 – 1, from less to more ecologically favourable).
Ecological assessment on the specific example of rehabilitation of feeders of the South Bohemian water supply system: the system ranks among the biggest in the Czech Republic. Together with age and high frequency of defects it must cope primarily with the problem of (at present) oversized feeders and related issues (relatively low flow rate, long intervals of water stay in the system, high secondary Fe content). In specific cases of ecological assessment of considered TT it is important to identify hazardous and problematic points in the rehabilitated water supply pipeline (sections crossing watercourses, sections in the proximity of watercourses and reservoirs, sections under ground water level, sections crossing or interfering with the protection zones of protected territories).
Also in this step of specific assessment of TT variant envisaged for application to water supply feeder rehabilitation the same set of purely ecological criteria was used as in the first and second assessment steps.

These results represent the first step in the consistent evaluation of trenchless technologies by ecological criteria. Further steps can be found in the dissertation thesis by Ing. Lucie Nenadálová dealing with the Methodology of TT Assessment by Ecological Criteria. The objective of this thesis is a detailed development of ecological TT assessment particularly on the level of specific application. For this purpose the author applies modern means of generation of variant solutions and their assessment (such as value analysis and others) incl. the drafting and testing of appropriate software.
The so oriented work may be of substantial benefit both to the firms- users of TT and for all other parties concerned (investors, operators and users of utilities etc.).

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Verification of Asphaltic Plug Joints for Bridges Characteristics

J. Hradil

jan.hradil@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

Road Laboratory, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

This project has solved problems of testing methods for asphaltic plug joints for bridges treated as warm in order to verification of their characteristics. Proposed testing methods come from testing methods for bitumen mixtures and are customized for asphaltic plug joints for bridges.

There were prepared three testing methods:

The test of repeatedly moving wheel – object of this testing method is to analyze resistance of asphaltic plug joints for bridges against permanent deformations from moving wheel. This test is simulating only influence of vertical forces. It is necessary to create two types of testing samples. The first type is created of substance for plug joints for bridges, the second type is combination of bitumen substance that is often used for wearing course and substance for plug joints for bridges. The complete samples have proportions 300mmx150mmx50mm. Combined samples are created from two parts with proportions 150mmx150mmx50mm, that are connected together. The objective is to analyze deformations on samples and influence of bitumen substance on substance for plug joints for bridges. In results we can determine influence of stiffness of bitumen substance on the value of deformation. The deformations on combined samples are lower than on samples from bitumen substance. Also, the influence of stiffness of bitumen substance on the value of deformation grows with the testing temperature. The source of load is moving wheel with strictly specified parameters, that traverses on surface of testing sample. The most important are deformations after 10 000 traverses and 15 000 traverses. The deformation after 10 000 traverses shows the ability to resist long term load, the difference between 15 000 traverses and 10 000 traverses is supposed to be very low, because in this phase of test the increase of deformation should be minimal. For comparison were used two temperatures – 25°C and 50°C and three types of substance for plug joints for bridges.

Shearing test of layers interconnection - object of this testing method is to analyze qualities of shearing interconnections between bitumen layer and asphaltic plug joint for bridges. The base of testing sample is used Marshall cylinder with radius 75mm. Theoretically can be used bores from the pavement construction. Testing sample consists of two parts – the firs is Marshall cylinder, the second is created of substance for plug joints for bridges. There has to be ensured perfect connection of these two parts of testing sample. Because it is necessary to determine reference between temperature, deformations and forces, during the testing of these samples were used three different temperatures : 20°C, 5°C, -15°C.

It is measured the force, that is needed to breach of sample and corresponding deformation. After analysis of results can be seen the influence of temperature. With temperature the deformation is growing and force is falling. Also, after look on results of previous testing method it can be seen dependence before these two exams. In fact, the higher the deformations in the test of repeatedly moving wheel are, the higher are deformations in shearing test of layers interconnection. This is not big surprise, but interesting is, that the difference between different types of substance for plug joints for bridges in deformations does not seem have effect on force, that is needed to breach of sample. This force is almost the same by all three samples.

Stretchability and adhesion of bitumen binder used in asphaltic plug joints - object of this testing method is to analyze stretchability and adhesion of bitumen binder used in asphaltic plug joints for bridges at low temperatures. It is used the testing machine for Rabe test. From bitumen substance are created blocks with proportions 300mmx150mmx80mm. Then it is necessary with diamond saw create bitumen tablets. Two identical tablets are put up into testing machine with interspace 15-17mm. Then is inserted in interspace metal bar. With this metal bar is created joint depth 30mm. The intersection is filled with substance for plug joints for bridges. The temperature of surrounding has to be 18°C – 28°C. Testing sample is inserted in fridge with constant temperature -20°C (-10°C). The we pull tablets from each other and measure the intersection after creation of rift. All three types of substance for plug joints for bridges had the intersection above 5mm (this value is specified as limiting intersection).

There were created three types of testing samples and used testing methods. The results were analysed and created findings. The most significant finding is influence of temperature and type substance for plug joints for bridges, that was used in testing samples. With the growth of temperature there can be seen greater deformations. In the opposite, the force, that is need for breach of sample grows with the fall of temperature.

Project used current equipment of road laboratory. It was necessary to define testing methods that can be used in all standard road laboratories in Czech Republic. In the future we presume the use of this methods in TP80 and specification of parameters for newly designed bridge joints. In the present the specifications are not regulated. The results were parallel consulted with experts on bridge constructions and road structures. The results were presented to public in articles and in presentations on sessions.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

Web Map Servers - Old Maps Internet Presentation

J. Cajthaml

jiri.cajthaml@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Cartography is a science with wealthy history. In fact, the first drawings of mammoth hunters were the first maps. With the coming of digital technologies, almost every branch of science is being changed, including cartography. Computer technologies, which were used only for cartographic research, have gained the control of cartographic production now. After establishing digital cartography to the practical production in 90's, internet comes as an ideal medium for map presentation in the beginning of new century. Contemporary technology allows more than only map browsing. Cartographic data can be shared on the different servers and user can work with these data interactively in the internet environment. This paper just deals with contemporary possibilities of map data publishing on the internet.

Maps are almost entirely made by computers today. Map drawing is mostly created as a vector file; with the old map scanning, we get a raster file. There are many possibilities of map production. I would like to enumerate basic groups of software useable in cartography: vector drawings programs (Adobe Illustrator, Corel DRAW, Macromedia FreeHand), CAD systems (Autodesk AutoCAD, Bentley MicroStation), specialized cartographic products (OCAD), geographic information systems (ESRI ArcGIS, Intergraph GeoMedia, MapInfo). Every group has specific advantages and disadvantages. If we scan old paper maps, we always get raster data format.

Maps can be published in two fundamental forms, analog or digital. Printed (analog) maps are mostly created from vector data. For final adjustments there are used various DTP applications. Finally, data are converted into print format (PDF, PostScript) and transferred to the printing works. Digital data can be published in various desktop application formats or in the internet. Practically every software product works with its own vector or raster file format. Therefore, data publishing should be done in open data format (instead of many proprietary formats). Internet also needs standard formats for data publishing. If we are going to publish data in the internet, data must be converted very often. For vector graphics, there are SVG and GML formats, for raster images there are JPEG and PNG formats suitable for internet publishing.

Concerning old maps publishing, we always work with raster images. Maps must be scanned in high quality and then modified for later publishing. If we want to use only static images and raw HTML, raster data should be only converted into JPEG or PNG and placed on the server. If we want to work with data more interactively (zoom, pan), some other application must be used. This application is mostly based on variable sending by the XHTML form. The application can only work with the raw image, without georeferencing (e.g. Zoomify). If we want to work with images in the coordinate system, we have to use powerful application called mapserver (UMN MapServer, ArcIMS, Geomedia WebMap, MapXtreme, and MapGuide). Mapserver also enables other data layers connection (either

vectors or raster images), even data shared by other servers (within the frame of Web Map Services). With this functionality, we have simple GIS tool operated through internet.

In the sample application, scanned maps of 2nd Military Mapping Survey of Austria-Hungary from the area of Czech Republic (1836-1852) were used. Data were georeferenced and are available in the internet in contemporary coordinate system S-JTSK (published by UMN MapServer). Data can be compared with the present state of the landscape by connecting other map layers (ortophoto maps, vector drawings, etc.)

The data are the heart of the application. The main dataset of my application consists of raster images of 2nd Military Mapping Survey of Austria-Hungary. These maps were created in the 19th century and the coordinate system of the maps is based on then cadastral survey. If we want to work with the seamless map, we have to prepare every map sheet. The following steps must have been done with every map sheet: crop the image behind the map frame, set the image transparency, save the image as a TIFF with LZW compression, georeference the image (transform to corner coordinates), save the image world file (TFW).

My created application represents simple form of interactive web mapping. It is based on the CGI program UMN MapServer, which communicates with the web server. Own internet page contains XHTML form. Using GET method, values of variables are sent from the form. Web server forwards these values to UMN MapServer. It reacts and sends back appropriate images. Finally, the whole internet page is sent back to the client. Because XHTML form enables only static application creation, I decided to improve it. I have programmed several functions in JavaScript for interactive coordinates reading during mouse movement. Then I have programmed functions for buttons for moving the map in eight basic directions. With the help of Java applet jBox, I enabled dynamic rectangle zoom.

Beside data of 2nd Military Mapping Survey of Austria-Hungary, I added some other data layers to the application. I also connected some data using WMS. Old maps can be then very simply compared with the contemporary state of the landscape. Data are valuable especially for landscape engineers and applications of the environment. The best way to make these data accessible is their WMS distribution. I am working on that implementation now.

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Czech and Moravian Architectural and Urbanistic Competitions in the Sixties – Their Specific Contribution to the History of Czech Architecture

Popelová, L.

lenpop@centrum.cz

Institute of the History of Architecture and Art, Faculty of Architecture, Thákurova 7, 166 34 Czech Republic

The subject of this dissertation, which falls within the discipline of basic research, is the collection, sorting and interpretation of materials connected with designs for the architectural competitions that were held in Bohemia and Moravia in the 1960s. The study concentrates on architectural competitions and focuses particularly on those projects that were ultimately realized and where it is therefore also possible to observe how the project evolved further and more generally to highlight problems that were typical for the 1960s in bringing the designs to life in real structures. The study covers the work of important competitions that had a more ideological or theoretical orientation, oftentimes drawing on nineteenth-century civil engineering tasks or addressing issues specific to the 1960s – standardisation, the industrialisation of civil engineering, new typological categories, etc.

Designs from architectural competitions in the 1960s have yet to have been dealt with in the history of Czech architecture. Only the most important competitions have received attention as part of monograph studies and newer interpretative publications (for example, the additional construction work in Old Town Square and the Letná grounds). This dissertation therefore bases its research on the published papers of planning institutes and primarily on articles published in the journals *Architektura ČSR (ČSSR)* (*Architecture of the Czechoslovak Socialist Republic*) and *Československý architect* (*Czechoslovak Architect*), which throughout the 1960s devoted considerable attention to these competitions. Another important source of information in the research is interviews conducted with contemporary figures, Czech and Slovak architects and urban planners who contributed unpublished texts, plans and designs, photographs, and other valuable materials. These interviews were completed over the course of 2005 and in 2006 they will be published in a volume (the publication of this volume is linked to the research agenda no. 214500027 of the Faculty of Architecture ČVUT in Prague – "The Transformations of Historical and Contemporary Architecture").

The amount and variety of tasks that architectural competitions in the 1960s addressed makes is possible to view them as a remarkable phenomenon. To a certain degree they represented an "ideological platform", where new trends in typologies and in the evolution of form took shape, clashed, and were pushed forward. Because the competition designs tended not to be encumbered by the compromises and limitations that the realization of such a project and the research sphere signified, architects from the socialist planning institutes had an opportunity in such competitions to create more freely. For this reason, the designs exhibit an exaltedness and progressiveness of design that considerably surpasses the realized forms. Such a situation was supported to some extent even officially – the competitions were intended to serve as a statement of the standard of Czech architecture and for designing projects comparable to work being done in the West. The confrontation with architecture abroad was ascribed enormous significance in the 1960s even from a political perspective, as the field of civil engineering served the publicity of the state. Competition designs were therefore frequently developed for special commissions, which often became even international award-winning works – the Czechoslovak embassy and pavilions at EXPO and

international hotels. But these designs were already beginning to reflect the significant conflict between their exclusiveness and the utilitarianism that predominated in mass construction projects. As part of this research a trip abroad was therefore also undertaken to study British examples of social buildings developments and public works in the 1960s, where no such rift occurred.

The purpose of the study is to evaluate the specific role of architectural competitions in the 1960s in the development of Czech architecture and urban planning (especially in relation to the renaissance of modern architecture at the start of the 1960s), to highlight the most progressive and breakthrough designs in terms of the development of typology and form, to assess the degree of conventionalism and typicality of the designs, to underscore the relationship of competition designs to progress in foreign architecture, to point out the prominent position of Prague with regard to the number of designs realized, and to evaluate the urban planning projects that constituted almost one-third of all competitions in the 1960s. The study includes a list of competitions covered (approx. 130), a catalogue of selected designs, and theoretical interpretations.

A number of competition designs testify to the 1960s as an important decade for the emancipation of Czech culture, as a search for a conception of modern architecture, and sometimes even as a period of somewhat vacuous reproduction of foreign models. Many civil engineering tasks that emerged out of the competitions were built in the following decades and provided some continuity with the important era of the 1960s during the period of normalisation.

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Railway Heritage in the Czech Republic

Michal Zlámaný

zlamany@vc.cvut.cz

Research centre for industrial heritage, Czech technical university in Prague, Pod Juliskou 4, 166 07 Prague 6, Czech Republic

"Railway heritage in the Czech Republic" is sub-project of main research project "Documentation and Assessment of Sites at Risk in Selected Sectors", one of research projects of Research Centre for Industrial Heritage at the Czech Technical University in Prague (VCPD ČVUT v Praze), also in co-operation with other parts of CTU in Prague thru doctoral students. VCPD is one of the most important participants in the development of the field of industrial archaeology in the Czech Republic. This project was announced last year in a few publications [3] and also on last years "Workshop 2005" [4]. Project was also supported by internal grant of CTU in Prague.

Main topic of the project in this year was informing about it, coordinating of research with other activities of VCPD, like filling, confirming and validating of central register of industrial and technical monuments on the territory of the Czech Republic, which is also one of the main projects of the VCPD, co-operating with other subjects, like for example National Heritage Office, National Technical Museum, or as an example from commercial sector with one of the biggest former locomotive factory in the Czech Republic, Škoda Plzeň, a.s. Another example of co-operation should be participating of employees of the VCPD in the preparation of commentary and opinion statements on planed rebuilding of first railway station in Prague, build in 1845, now known as "Masarykovo nádraží", based on deep research about this area, including for example technical analysis of buildings there together with Faculty of Architecture, or detailed photo documentation..

One of the most important parts of this project in last year was presenting it on 3rd International biennial "Vestiges of industry", action organised by VCPD in co-operation with other subjects. One part of many other activities during this biennial was also exhibition of works of doctoral students, which are actively participating in projects of VCPD, called "Industrial workshop". There were presented projects of research about brewing industry, sugar refineries, textile industry and railway heritage. The visitors of the 3rd biennial mainly also visited this exhibition, and all guests also received leaflet with information about this project. As the part of this biennial was this project also included in main publicity channels of this action, encompasses internet, press and radio and television broadcasting. The preview of exhibition will be also part of multi medial report from the 3rd biennial, which is in the end of preparation phase just in these days.

Parts of research from this project were also used during preparation of publications [1] and [2]. These publications are mainly oriented to usual customer or traveler, and just small parts of large research about this topic in related areas were used in final publications, but this is not decreasing the value of information collected during working on this publications. And these books are also good way of popularization of this topic and industrial heritage in general.

Thanks to support from internal grants there were possibilities of visiting well known examples of reusing and new using of industrial and railway heritage in foreign countries.

Excursion to Wiena shows how historical architecture of railway buildings can survive and prosper beside new one and with using new technologies and transport systems. The value of this information is also higher because Austria and Czech Republic have common history and historical experiences, and railway and public transport system in history was and today in general is almost the same in both countries. Another experience from Madrid, Spain and well known "Atocha station" there, could show differences, but also similarities in reusing railway heritage in theoretical and practical way, when behind this one example often presented in media and literature like ideal possibility is in real almost the same railway as in other European countries. The true is that this concept works and there is visible difference between usual and this modern station, especially when they are almost at the same place. Due to administrative and time problems it was not possible to visit Berlin and pure new "Lehrter Bahnhof" there, which should be good example of new way in building railway stations. The excursion to that place is still in the schedule for following part of research program. From the same source as research in foreign countries was also supplied large increasing of library with highly specialized literature from foreign and domestic sources, as well as with literature about general architectural theory and praxis or urban development. Theoretical part of research standing on these new sources as on these which are reachable usually includes unifying the methodology applied to working with historical artefacts somehow related to railway and for formulating options for the revitalisation or conversion of railway sites and buildings.

Same results as this year are in general also expected in next parts of this research program, mainly increasing of co-operation with other parts of CTU in Prague and other institutions, and also with foreign institutions and organisations. Continuing on theoretical part of research in addition to the project's collective results, the documentation and assessment of individual buildings and sites, should be the formation of a platform for the further development of research in this direction and should also prepare a base for publication of theoretical and presentation of practical results of this research.

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Organic Farms in Protected Landscape Areas (PLAs) in the Czech Republic

S. Losmanová

simona.losmanova@fsv.cvut.cz

Department of Architecture Design, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

Initial aim of this project was to estimate samples of existing buildings on organic farms in the Czech Republic and to obtain basic information about existing high quality and successfully working buildings on organic farms abroad.

On the study tour around organic farms in the Czech Republic, Slovakia and Austria I record the conditions of organic farming and how organic farms function and their use in the agriculture market. More than 11 farms were inspected, details and pictures were gathered, a brief overview was created and conclusions were set. The Czech Republic's main problems are selling organic products on the public market for their real price. One of the biggest problems is the lack of organic butchers. Obtaining financial aid from Czech government or EU funds through some grants seems to be very difficult because of complicated rules. Only a few new stables were erected and those only because of farmer's income from secondary activities, not mainly from farming. In Slovakia less organic farms can be found and farmers deal with similar problems as their colleagues in the Czech Republic. Not so many new stables were built in CR and Slovakia while on other hand in Austria a lot of reconstruction was done and new modern stables were erected. Some farmers created partnerships and found ways to sell their organic products in supermarkets.

In second step it was necessary to compare positive and negative features of existing farmhouses with input requirements for modeling simulation.

People living on organic farms cannot simply be told how to build their own houses because of farmer's budgets, municipality rules and requirements of various authorities and locations. But it must be highlighted that reconstruction of existing farmhouses and erection of new farmhouses should be done on account of permanent sustainable development and so energy efficient farmhouses are highly recommended. New stables should be designed without insulation because of money savings and a new system of breeding animals outside all year round. The stables should be considered carefully before building, in order to keep the possibility of changing them in the future for different usage (for example cattle stables can be transformed to barn - indoor arena for riding horses). The main negative features of existing organic farms are: insufficient or irregular maintenance, old equipment, unsuitable building materials inside the stables and disorder on the farm. The positive features that were found are: using metal supporting beams for the roof, wooden roof beams instead of glued wooden beams (because of cheaper price), insulated cladding, manually removable plastic sheets in the windows instead of glazing, high bedding in stables in accordance with welfare of animals, open effluent tanks, transillumination through roof top, using recycled materials, using overlapping part of roof for storing straw, hay or machines. Comparing and putting together all pros and cons will give us an idea about the ideal organic farm.

Next step of this project was to create a list of input requirements for simulation of placing organic farm into a Protected Landscape Area (PLA).

It is necessary to consider different factors when considering where organic farm should be set in PLA. The important factors are: to choose such a plot of land on the border of a PLA which insure the cheapest creation of sewerage and water systems as well as infrastructure network, to get permission from appropriate authorities, to find consumers in the neighborhood who will buy the products, to find a sustainable location so some supporting financial aid can be obtained from Czech government or EU funds and locations where tourists would like to visit. Two different locations were chosen as a sample to design a hypothetical farm. One of them is in the Protected Landscape Area Křivoklátsko and the other is in the Protected Landscape Area Beskydy. Those two places have quite different landscape profiles, which must be considered while choosing an appropriate scheme for farming and building.

Schemes of optimal alternatives for new organic farms in Protected Landscape Areas or reparative instruments for realizing reconstruction of existing buildings on organic farms were offered.

Throughout the study tour a lot of interesting new ideas, structure details and construction solutions were found. According to their results recommended solutions for new buildings were set. The findings were divided into 4 different groups: flooring, cladding including openings, roof and supplements for livestock breeding.

Finally options for obtaining financial aid from EU programs for building new buildings on organic farms in Protected Landscape Areas in the Czech Republic or for reconstruction of existing buildings, which is related to development of green tourism in the Czech Republic, were well researched.

There are not many options for obtaining money for organic farming in the Czech Republic. State subsidies for organic farmers are generally given to those farmers who run their farm in unfavourable conditions or whose livestock is marked as a non-production system. The main financial support is coming from Ministry of Agriculture of the Czech Republic and can be divided among Direct subsidy (Saps, Top-up, Lfa), National subsidy and Program of rural developing. The second main source for financing organic farming in the Czech Republic are Structural and Centralized funds of EU (Eafrd). If no financial subsidy is granted, improvement of economic situation can be achieved by joining ECEAT (European Center for Ecological and Agricultural Tourism), allowing greater tourist visibility. Farmers in the Czech Republic cannot easily obtain financial discounts from big energy companies, while farmers in UK can. For example big companies in Scotland support those farmers who install energy saving mechanisms on their farms. Buying this equipment can be discounted.

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Multimedia Assistance for the Education of Lighting Design

P. Bednář, O. Vinař, M. Průcha, L. Franěk, M. Lehmann

bednar@fa.cvut.cz

Institut of Interior Architecture and Exhibition Art, Faculty of Architecture of the Czech Technical University, Thákurova 7, 166 34 Prague, 6, Czech Republic

1. The project was aimed at developing a multimedia aid documenting the education-related use the PROLAB Space Light Lab. Its output is a document describing the use of the PROLAB Laboratory in following fields:

a) Perception of internal space and the phenomenon of light in the interior as the most important emotional element in modern architecture

b) Perception of virtual and real space

The document should reflect the development of the program as well as its subsequent practical application to exercises, seminars, and elective studio work. The program should be intended for bachelor and master degree students (within the Interior I exercises, elective studio, and seminars of the Multimedia course) as well as for postgraduate doctorate level students, particularly for the course of Theory of Architectural Design and the dissertations dealing with the theory of interior design. The selected topics are of interdisciplinary nature, with overlaps in the fields of psychology, psychiatry, arts, advertisement, and the development and application of virtual modeling environments. The Part C "Intermedia Institute" was therefore developed as a basis of interdisciplinary education at the Institute of Intermedia that is being created at the Czech Technical University in cooperation with the FAMU and VŠUP partner schools in the former Orlík Cinema building, Prague 6 District. The aid has been designed as open and can be further developed in cooperation with specialists in other professions, such as psychiatry, acoustics, etc., and used as a training aid for designers, investors and marketing workers.

2. Structure and Procedure:

The aid is divided into three sections describing the particular training stages.

A/ Introductory stage – Light in the Interior

This stage consisted in preparing the lecture and the tasks for exercises. Then, the topics prepared by groups of students were practiced in seminars. The basic knowledge thus obtained made it possible to proceed to the practical application in Prolab.

Seminar topics used:

- Scenic light, architectural lighting – common and different features.

Use of color light – architecture (interior) versus stage , detail illumination x washlighting – architecture (interior) versus stage, interaction between the spectator and the object observed (stage – sitting spectator, architecture – moving spectator), is it possible to change contrast, brightness, use multiple colors?

- Light designers and light design studios – principles of their work
- Light manufacturers with their own philosophy of lighting

This stage is documented by means of interactive images showing the role of natural and artificial light in the interior in perceiving the spaces and their interrelations, accentuating the spaces or details, creating a light-based or color-based atmosphere.

B/ Prolab

At the first part of this stage the students get acquainted with the design and the properties of lighting appliances forming part of Prolab's equipment. Focal Flood lighting appliances are presented – fluorescent RGB light, CP Color –metal halid light making possible the subtractive mixing process by rotating filters, Erco Eclipse spotlights with the possibility of using the Fresnel lens to increase the lighting angle or with color filters. All lights are controlled from the control desk via DMX protocol. To suspend the space-defining frames the Milos structure was used.

Subsequently, the students materialize in groups their ideas of light compositions within free tasks using the above facilities and other devices. The pictures of creative compositions are then recorded by a digital camera.

This part is documented in the aid by an interactive representation that makes it possible to test the additive and subtractive mixing process, and by a representation and description of particular light types. The exercise results recorded are professionally good; the limiting factors were, in particular, the spatial and layout features of the Prolab laboratory, which is simultaneously used for training in two school design studios.

C/ Intermedia Institute.

At the B stage, the Prolab Laboratory found out that to check the work with light as a means of modeling or articulating spaces and illuminating surfaces forming the space a variable space to a scale of 1 : 1 is required. Therefore, in the architectural study concerning the use of the former Orlík Cinema for the Intermedia Institute a method of solution was suggested that was open to checking the existing program and, simultaneously, to creating an interdisciplinary center of the partner schools using new technologies. This Mock-up Room makes it possible by means of pull-out frames and lowering ceiling modules to create a space of variable size. The exchangeable fillings of frame structures can be of different color, texture, can be transparent or translucent and exhibit different acoustic properties. Lighting integrated in ceilings, strip lighting as well as lighting in floor channels or grooves between surfaces makes it possible to create any type of architectural lighting. Scenic lighting on balconies further increases the application range by adding movement. The Mock-up Room can be used to simulate day lighting, including variable temperature and light direction in the course of time. Illumination of the internal space of different size through holes in the enclosing panels makes it possible to redesign the light of historical buildings and, simultaneously, check the lighting designs for the projects being planned. These projects may be prepared in the related computer centers using architectural and visualization software, and the perception of such graphic or animated outputs to the scale of 1 : 1 may be immediately checked. New solutions will be jointly developed by workers and students of the Faculty of Architecture and the Faculty of Electrical Engineering of the Czech Technical University, the School of Decorative Arts and the School of Cinematography with the use of the CAVE equipment to create virtual reality. This C Stage is documented by space visualizations with examples of potential use.

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Palliative Care Specificity and its Demands on Buildings

Naděžda Malkovská

nadezda.malkovska@fsv.cvut.cz

Department of Social Sciences, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The aim

The aim of the project was to specify providing of palliative care and its demands on equipment and character of buildings. The freestanding existing hospices in the Czech Republic were analyzed during the year 2005, and this new specific type of facility was described.

What the freestanding hospice is:

- a health care facility with health, social and spiritual services
- a separately operated non state health care facility
- a non barrier facility or at least a facility which has the certain parts wheelchair accessible
- a facility of successive after hospital care (as one of possible kinds)
- a facility where palliative care is provided (the care, which is focused on a symptomatic treatment, the aim is to keep a quality of patient last days)
- a facility for all, who need it (no matter what social status, political status or religions patient has)
- a house, where is guaranteed to the ill, that he or she will not suffer by a physical, social or other pain, and he or she will be respect with dignity
- a facility for the terminally ill patients (mainly oncology disorder), eventually for the pre-terminally ill patients
- a house which is open for visitors 24 hours per day

The freestanding hospices in the Czech Republic

There are just two newly built hospices and the rest 8 hospices are in the reconstructed buildings, which were adapted for the new usage, eventually there were built some additions or upper extensions. But it is not always possible to do a reconstruction of an existing object for hospice economically.

The localization of the freestanding hospices

On the basis of available information, there is possible to say, that for the location of a hospice in the Czech Republic now are important following relations [1]:

- a proximity of a hospital (staff, specialized investigations or other possible services)
- a proximity of a public transportation, traffic availability (it is important for older attendants or worse moving attendants)
- a central location in an administered territory (effectiveness, visibility, concept of providing care)

The architecture of freestanding hospices, interior

Since the illness and oldness mean for a man certain physical limits (mostly less kinetic possibilities), his or her world is much concentrated into smaller space compared to previous experience. Except of this space, much more attention is paid to all (mainly to all, what is living), what is in this space. The room, thought as a background, intermediates connection with surrounding world (there is a window and it is possible or not to see through it, to see sun lights, to have an idea about the time…), can makes patient, and his or her visitors, to have feelings of privacy or not.

The ill, if he or she is wheelchaired, can freely move out of his or her room too, and also he or she can be transported in a bed with the assistance. For these reasons is necessary to have all rooms, which are thought to by used by patients, without any barriers, to be accessible for walking patient even without assistance as well as for wheelchaired one.

Equipment of hospices

The basic part of freestanding hospice consists of patients rooms. This basic part is then connected with service, utility and technical complement.

An average bed capacity of Czech hospices is about 28 beds now. This average capacity is in the Czech Republic bigger than in abroad, and it could be caused by insufficient extended home care and partly by insufficient definition in law and support policy of Ministry of welfare and health care. There is 25 beds as recommended maximum in the USA [2] and it is even less in England [3].

A chapel is built in hospices as integral part for spiritual needs and it is mainly ecumenical, but there are some exceptions too, where the chapel has certain religion marks.

A lounge is rather universal room, which could be used for different activities during a day e.g. dining, reading, and learning. In this room could be some social activities for patients and staff, workshops or some home work.

Winter garden is much desirable place especially in winter time.

A kitchenette is sometimes place in the part with client rooms for standby cooking or preparing of food. It could by used by staff or attendant visitor either.

Generally, hospices have a pious room too. The place, where is possible to say somebody goodbye. Interior design and illumination, size of the room, an acoustic or the way of accessibility play an important role too.

Some hospices have their own central kitchen and laundry, for just for them or for other customers too.

Hospice rooms

The standard is one bed room, which has, except the special bed, an extra bed for attendant person. Further, the room has signalizing apparatus for nurse recall, a telephone, beside table, a table, chairs, a television, a commode etc. The bathroom is designed for wheelchair manipulation, eventually bigger for possible assistance too and it contains stump handrails, a closet, and a lavatory, a mirror, signalizing apparatus, a shower bath with a seat or a chair.

Sanitary facilities (bathrooms) at existing hospices are individual for each room or shared by two rooms. One bath for one room is preferred more for better hygiene and privacy. Only at one case is sanitary facility placed out of a room for all, but it is caused by very depressed historic object. This fact is offset by mobile aids there.

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Photogrammetric 3D Scanner Based on Binary Virtual Targets

M. Štroner, J. Pospíšil

martin.stroner@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Special Geodesy, Thákurova 7, 166 29, Praha 6

Application of the 3 dimensional scanners for documentation of the historic objects is a possibility, how to enhance the level of the documentation of often very complicated objects, which can hardly achieved by using of the different methods. The contactless technology of the 3D laser scanning acquires huge amount of the measured data automatically and in short time, describing the object's surface by thousands of the discrete points [1], [2].

Obtained data allow creation of the three-dimensional model and with use of the appropriate programs it is possible to view, rotate and make other virtual manipulations. In the first phase of the project there was designed a scanner using two mutually stationary cameras with known elements of the inner and outer orientation. Corresponding points on the pictures should be found with use of the cross correlation. But this principle did not prove to be reliable enough when using e.g. monochrome materials.

Therefore there was designed a different system based on projecting of the virtual coded targets [3], using one camera in more positions. The elements of the inner and outer orientation are determined with use of control points and simultaneously the position and the direction of the cameras' view can be selected considering the size and shape of the scanned object. At present virtual targets are generated on the object by standard data projector, which allows to experiment with the shape and color of the targets.

The key part of the scanner is the generating and after the image capture is done the identification of the projected points and its codes. For every projected point there is created unique numerical code, which transformed to binary system consists of the sequence of zeros and ones. To ones is a color, to zeros a different color and then the sequence of the images is projected on the object, creating needed code at the object. Decoding is being done by the following procedure.

To every pixel on every captured image is assigned value one or value zero. The zeros and the ones of the corresponding pixels on the pictures' sequence creates the code, which should be the same for corresponding spatial points photographed from the different position of the camera (projector has to be motionless). If there are known elements of the inner and outer orientation there can be calculated three dimensional coordinates of the signalized points.

The decision, if the pixel has the value zero or one if made with use of two calibration pictures (all points one, all point zero), the border value is determined for each pixel separately. There is more points with the same code, the point is considered to be at their average.

To capture the images there is a digital camera Lumenera LU 125 (1,3 MPix), directly plugged to computer via interface USB 2.0. The camera has one CMOS sensor and captures the Bayes data. To test the principle of the scanning the software for projecting and for evaluating was created. It can operate with maximum of 16383 points (sequence of 14 pictures, binary system gives $2^{14} - 1$ of points). Targets create square grid with the selectable spacing, the color of the targets and the color of the background is also selectable. Both program for image capturing and program for evaluating works fully automatically.

Providing, that virtual targets projected by the data projector do not change its position and whole system is invariable, the same points taken from different stations of the camera obtain the same code. To determine the elements of the inner and the outer orientation there has to be signalized and measured control points, the orientation is at present calculated by Direct Linear Transformation (principle and the mathematic fundamentals described e.g. in [4]). The minimal number of the camera stations is two, if there is more of them, results can be calculated more precisely by the least squares method.

Described photogrammetric scanner based on virtual binary targets is in the first stage of the development, it is planned the testing of the practical use and testing of the precision. The scanner is meant for contactless creation of the documentation of the not only historic objects of the lesser size and its development will continue.

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The Results of Development and Planned Innovations of the Laser and Optic Rotating Scanner LORS

B. Koska, M. Štroner, J. Pospíšil

bronislav.koska@fsv.cvut.cz, martin.stroner@fsv.cvut.cz, pospisil@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6 - Dejvice, Czech Republic

The actual information about the development of the 3D laser scanning system LORS (Laser and Optic Rotating Scanner) are presented in the paper. LORS was designed for scanning of small objects at the first stage. It consists of four basic parts. There is a calibrated digital camera, the laser module, which forms a laser plane, a rotating platform and a calibration cage. The rotating platform has a constant angular velocity. The laser plane crosses a measured object and creates a laser mark. The 3D point is created by intersection of the laser mark and an optic line which is defined by corrected image coordinates of the laser mark and by direct linear transformation (DLT) parameters. The DLT parameters are computed from 20 known points on calibration cage. The theoretical and software solution of 3D point computation was solved and tested. It is possible to add a real colour to each computed point.

The configuration of the whole system LORS (laser plane, calibration cage, rotating platform) was determined by spatial forward intersection from angles with using of the total station Topcon GPT 2006. The laser plane is determined by least square method (LSM) from 10 points. The position of the rotating platform is determined from one point which is measured in a few positions of one rotation. The period T is determined from camera pictures.

The system is composed of four hardware components. There was made a lot of hardware and software innovations during development of LORS (see [1] and [2]). Two digital cameras are used at the system LORS at present. The first camera is Lumenera LU120 (1280x1024/16 fps, progressive scan mode, connection by USB 2.0). The second is Panasonic NV-GS120EG (720x576/25 fps). This camera doesn't support a progressive scan mode. It is possible to get comparable results to camera Lumenera if a special treatment of recorded data is used (see [3]). The Laser module DPGL-3005L-45 (power 5mW, wave length 532nm) is used at present to form directly the laser plane. The width of the laser plane is changed to one millimetre by a precise iron diaphragm. The rotating platform has a constant angular velocity. The platform axle was taken from a theodolite vertical axle. The rotation period is 42.20s. The calibration cage is a new component of the system LORS. It contains 20 identical points. It is made of metal pipes and its size is approximately 0.5x0.5x0.5 meter.

The whole system consists of several programs which provide computing of all necessary configurations parameters, automatic scanning of image coordinates and finally computing of the 3D coordinates of the points on a scanned object. The first program provides computing of all configurations parameters (parameters of the laser plane and of the rotating platform). The library of classes "SPATFIG" is used for adjusting of these parameters (see [2]). The second program "DLT" computes the DLT parameters for the digital camera from identical points on the calibration cage. The next component is the program "POWOK" which provide treating images from the digital camera. It consists of two modules. The module "Základní vyhodnocení" (basic evaluation) provides automatic scanning of the image coordinates of the pixels which correspond with a preset RGB filter (the coordinates of the laser mark). The module "Podrobné vyhodnocení" (detailed

evaluation) provides the automatic line evaluation of filtered out pixels in accordance with a selected criterion. The following program is "DLTR2XYZ". This program computes the 3D coordinates for each point in global coordinate system from the DLT parameters, plane parameters and image coordinates of the laser mark. The last component is the program "TRANSFORM". This program transforms 3D coordinates from global coordinates system to local (rotating) system. The program "COLORADO" can be used for additional extracting of a real point colours.

The calibration model for accuracy assessing of the system LORS was suggested and created. It consists of six identical spheres. These spheres are fixed on duralumin poles. The method for determining of spatial accuracy was 3D Helmert transformation and assessing distance differences between spheres. The accuracy of the whole system LORS was tested by measuring of calibration model. The created point cloud was fitted with spheres with fixed radius by the library SPATFIG. The standard deviation a posteriori of Helmert transformation is σ_0=0.21mm and the scale coefficient is 1.0012. The result of made experiment is in accordance with our expectations. The accuracy of modelled figures seems to be between 0.2 and 0.5 mm (it means standard deviations in directions of coordinate axes). The present system LORS isn't able to scan any details smaller than 0.5 mm.

A several experiments with LORS have been done to verify the functionality of whole system, to get some more experience and to discover weak points of the system.

Some innovations will be integrated to the system LORS soon. The new digital camera Olympus E-300 with high physical resolution (8Mpixels) and Olympus Software Development Kit (SDK) have been bought recently. This software enables to write our own programs to control and synchronize our camera with rotating platform. The stepper motor with control card for controlling of rotating platform has been bought too. The new level of automation and accuracy will be reached by implementing of these new hardware components. The scanning of larger objects (human size) by reconfiguration of the present hardware is also planned.

The original system for 3D scanning of small objects (at present is max. size 0.5x0.5x0.5m) has been suggested and realized. The practical experiments have confirmed the functionality of the system LORS and allowed to estimate its real accuracy. The standard deviation a posteriori of 3D Helmert transformation of accurate sphere model is σ_0=0.21mm. Some innovations were suggested and will be realized soon.

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Library of Classes and Functions SPATFIG under Public Licence GNU GPL

B. Koska

bronislav.koska@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6 - Dejvice, Czech Republic

The actual information about the development state of the library SPATFIG is presented in the paper. SPATFIG is the public library of classes and functions for fitting of primitives in *n* dimensional space (2D, 3D) in accordance with the least square method.

There are a few reasons for creating SPATFIG. There isn't any suitable software in public area. The available commercial software has a several disadvantages. It doesn't consider the covariant matrix of measuring, it doesn't make accuracy analyses and a computing algorithm is unknown. The fitting of primitives is also very widely used (not only in land surveying but also in astronomy, computer aided drug design, particles physics, robotics etc.). SPATFIG is also used for the calibration of the laser scanner LORS (see [1]).

The problem can be defined as follows: A set of *m* points is given in *n* dimensional space. The type of figure (primitive) is known and the figure is described in implicit or parametric form. The problem is to find the best model parameters (form and position) of the figure in accordance with the least square method (LSM).

The basic dividing of the algorithms depends on the definition of "distance" function from given point to the figure. At first we consider an implicit form of figure. The first function is called "Algebraic distance". Algebraic distance is just the implicit function. The more suitable function is called "Normalized algebraic distance". The distance is implicit function divided by Euclidean norm of implicit function gradient. The best function is the geometrical distance between given point and the nearest (orthogonal) point on the figure. The shortest distance fitting is called geometrical fitting, Euclidean fitting, orthogonal regression or orthogonal distance fitting (ODF) in literature. ODF is position independent. The analytical and computational difficulties in using ODF led to use of some approximate determination of the orthogonal distance in the past. The fitting algorithms are presented and compared in [2] and [5].

There are some possibilities to divide ODF algorithms. The algorithms can be divided into coordinate-based algorithms and distance-based algorithms. Model parameters can describe form and position merged together or these parameters can be divided into two logical groups. Model parameters can be adjusted together with orthogonal distances in one iteration step or alone in inner and outer iteration steps.

The present demands on ODF algorithm are fitting of general geometrical figures in parametric and implicit form, robust and fast convergence, low computing cost and memory space usage and easy and uniform implementation of geometrical figures.

The algorithm called "Algorithm III" in [2] was chosen from algorithms presented in [2], [3] and [8]. It seems to be the best in the light of present demands on ODF. It is also the most suitable for future generalization of the library SPATFIG to incomplete ODF (see [4]). Some changes were made to the original Algorithm III.

Algorithm III is coordinate-based algorithm. Model parameters are divided into form and position parameters. The algorithm works in two iteration scheme (inner and outer iteration). It works in uniform manner with parametric and implicit form of figure. Computing cost and memory space usage are $O(m)$.

The public license GNU GPL (see [6]) and the object oriented programming language C++ was chosen for the realization of the library SPATFIG. The main library for matrix computation is "gMatVec" (see [7]).

Only a few geometrical figures are implemented in SPATFIG at present (2D: circle, line; 3D: plane, line, sphere, circle, cylinder and cone). Some constraints for these figures are also implemented (fixed radius etc.).

The library SPATFIG was basically compared with the most important commercial software Cyclone produced by Leica Geosystems and 3Dipsos produced by Mensi (owned by Trimble). The serious mistake was found in the software 3Dipsos. The algebraic fitting was used for some figures instead of ODF (tested for sphere and cylinder).

Some extensions are planned in SPATFIG in the near future: adding of some important geometrical figures in land surveying (ellipsoid, catenary, etc.), the generalization of algorithm to incomplete ODF (see [4]), the implementation of compound figures and deep testing with using of virtual measuring generator.

The actual information about the public library of classes and function SPATFIG is presented in the paper. There are pointed out the reasons for creating SPATFIG at first. Then the definition of problem is placed. In the next two paragraphs the methods for fitting of geometrical figures are divided and the best method "Orthogonal distance fitting" is introduced. Then the present demands on orthogonal distance fitting are presented and the chosen algorithm is characterized. The implementation and comparison with commercial software is also described. The planned extensions in the near future are introduced in the last paragraph.

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The VCPD Register

P. Vorlík, B. Fragner, P.Urlich, T. Šenberger, F. Štědrý, Z. Drahotušská, V. Valchářová, M. Zlámaný, L. Beran, L. Popelová, Š. Jirousková, M. Schusterová, L. Mašková, T. Kužel, L. Doležal

vorlik@fa.cvut.cz

Research Centre for Industrial Heritage ČVUT in Prague
Pod Juliskou 4, 166 34, Prague 6

A long-term project of the Research Centre for Industrial Heritage (VCPD) at ČVUT and the Institute of the History of Art and Architecture at the Faculty of Architecture at ČVUT in Prague has been the development of a register of industrial heritage buildings and sites. In the autumn of 2002, shortly after the VCPD was set up, it emerged with the idea of creating a methodically unified system of maintaining and processing the site data it works with (an idea that coincided with an urgent objective need for such a register).

The register is primarily used for the archiving needs of the ongoing research projects at the VCPD (e.g. Interwar Industrial Architecture, Sugar Refineries, Breweries, Railways, City of Kladno) and at the Faculty of Architecture ČVUT (The 1960s in Czechoslovak Architecture), and even at the VCPD's other partner institutions (especially the National Heritage Conservation Bureau and the National Technical Museum). It is also used for the purpose of recording, storing and working with data drawn from publications, specialised studies, "building passports", and other databases.

The register runs on the server of ČVUT and it is designed as an interactive Internet browser, which allows for the on-line creation of new entries and the ongoing updating and completion of these records. It is also designed to allow users to orientate themselves easily when studying the entries, and it has a multilevel filter that gives users a wide range of search options in their searches or when classifying records into thematically specified blocks. The stimulus and behind the development of the register is its usage for storing and working with records in a format that is easy to survey and structurally fixed. The development of a solid and unifying frame for holding data proved to be essential particularly because the information that the register stores is drawn from a vast variety of sources. The register's fixed structure means that the records are maintained in a considerably comparable format and that they can provide a solid foundation for further research work and subsequent interpretation.

The interdisciplinary focus of the long-term projects of the VCPD requires the involvement of a wide range of professionals from other fields and the participation of other cooperating parties, such as amateur enthusiasts, industrial heritage advocates, and especially students. For these collaborating researchers, who often have little or no previous practical experience with research on construction history, the register is a fundamental and essential methodological guideline. Therefore, only basic PC and Internet skills and an intuitive approach on the part of the user are necessary for mastering general use of the register in searches or to make new entries.

The register is at present composed of two interconnected parts – the building database and the author database. The building database maps the individual buildings and sites with the use of something like registration cards, which contain detailed information that identifies the particular building or site, its structural history, references to literary sources and archive materials, photographs, and documentation like plans or designs, etc. The building database has thus far focused mainly on industrial objects from the 19th and 20th centuries, but the structure of the database is suitable for much more general use. The database was set up and

began running in the spring of 2003 and today in contains more than 6000 records entered under the aegis of the VCPD and almost 4000 under the Institute of the History of Art and Architecture at the Faculty of Architecture ČVUT. The author database contains biographical information on individual architects, accompanied by photographs and an automatically generated list of buildings registered under the architect's name in the building database.

The register is currently used actively by about thirty users, including those people cooperating in the research externally; other contributors submit only their information, which we, in cooperation with the students, then process and enter into the database. There are three coordinators responsible for overseeing the register's operations: the technical side of operations is overseen by an external colleague, who is the author of the software; the second coordinator formulates the systemic changes and the further development of the register's conception; the third coordinator works directly with the users and contributors.

In 2005, as part of a developmental project of the Ministry of Education, the VCPD received funding for a project titled *"Implementing the Building Database in the Teaching Process"*. The aim of the project was to verify and enlarge individual records, make slight modifications to the structure of the registry, based on the two years of experience with operating it, connect the buildings database to digital mapping data (from GPS coordinates), and in particular make available to the public some selected records on the web site of the VCPD (http://vcpd.cvut.cz).

In the coming years we would like to expand the register and take it to another level – a database of industrial zones, which would make it possible to map industrial buildings or sites in a broader context (especially in the historical context of the development of the given region and spatial links, in relation to the figure of the industrialist, and with regard to its functional limits and possibilities).

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The Register is a pilot umbrella project of the Research Centre for Industrial Heritage at ČVUT in Prague which was developed in 2002 on the basis of an internal grant from the Czech Technical University in Prague.

Assessment of the Area for the Study of Land Cover Changes Development Influenced by the Highway Construction

L. Halounová, V. Tesařová

lena.halounova@fsv.cvut.cz

Department of Mapping and Cartography , Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The Department of Economics and Management in Civil Engineering of the Faculty of Civil Engineering was awarded a grant Sustainable management in micro economy and its socially legal aspects. The Department cooperates with other departments of the Czech Technical University – Department of Road Structures, of Social Sciences, Mathematics, and the Remote Sensing Laboratory and others. There are nearly 30 hypotheses which are being analyzed during the project. One of them is the road network as a presumption of land development and as a condition of the economical growth, where the growth is calculated according to the road network.

The goal of the project is to define relations among various civil constructions, their prices, life, maintenance costs and other features connected to constructions. Motivation of the project comes from different conception of benefit, usage, sustainability from the economic point of view and engineering point of view. Interaction of these two points of view is not unambiguous due to information loss in preparation and creation input data for resulting economical information.

The road network influence was changed after discussions with economists and civil engineers to highway influences. The Czech Republic owns about 400 km of highways. The first of them connected Prague and Brno as two largest towns of the country in 70ies. This highway is an exception among highways being constructed as a completely new connection route unlike other highways, which are copies of before existing roads. There are two periods – one of them represented by state planned economy (till 1989), the second one after 1989. It was decided to study only the period since 1989.

Data selection

The data choice was based on three level data sets – CORINE data, SPOT data and aerial photographs.

CORINE data were the first data sets. CORINE data are land use data determined by individual European countries according to the same list of hierarchical set of classes. Two time level data were used for change detections – data from the beginning of 90ies and 2000. The changes were determined in relations to highways. The relation was defined as the 15 kilometers distance from highways exits. The data represents 1:100 000 scale. The smallest mapped units are 25 hectares. If expressed as a square area, it is 500 by 500 sq. meters. Smaller object information is excluded from the result. This fact causes that the second step of the analysis will continue in other data – remote sensing data. Areas with important changes in buffer zones around highway exits will be applied for two time level SPOT scenes.

SPOT data as the remote sensing data will be used for the larger scale analysis. Colour data with 20 m/10 m resolution will be selected for the evaluation. Image processing for change detections allows choosing final areas with pre-defined conditions: distance from highway exits, land use change where the change is from agricultural areas or areas with vegetation to areas used for industry, business purposes or housing. The SPOT data will serve as a tool for the final data selection – aerial photographs/orthophotos.
Aerial orthophotos as more detailed remote sensing data will be processed for the final change detection and form the third, last and most detailed data level.

Methodology

The methodology comprises both GIS evaluation, and remote sensing image processing. The GIS tool was used for two time level CORINE data where changes were determined as overlaid areas. Resulting areas were areas whose change was from agricultural land use or vegetation land use to urban land use – economical objects or areas for housing. The second condition for the selected areas was based on their size which had to be larger than 25 hectares and therefore equal to the smallest mapped unit in CORINE data. The second condition was combined with the third condition limiting optional shapes to shapes whose minimal width had to be longer then 30 meters.
Image processing approach will be used for remote sensing data processing – satellite represented by SPOT image data and aerial ortophotographs.
The goal of the image processing is to detect changes between vegetated and non- or less vegetated areas.

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Possibilities of Laser Scanning Systems' Application for Geomonitoring

T. Křemen, J. Pospíšil, M. Štroner

tomas.kremen@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Special Geodesy, Thákurova 7, 166 29, Praha 6

New technology of direct 3D coordinate determination caught attention especially for its scanning rapidity and for the immense amount of the directly measured space points. This technology in its air version was originally concentrated on creating digital terrain model.

The laser scanning systems can be practically used especially in civil engineering and in related branches [1]. It is especially surveying of complicated technological units and constructions, determining real states of buildings or bridges, underpasses, dams and other objects or gaining data for construction, maintenance and reconstruction of line structures (roads, motorways or railways). Last but not least, the laser scanning systems are used for topographic mapping of tunnels, stone quarries, slopes and rock faces, mapping in mines and caves, mapping of dumps etc., they are also used for foundation engineering, for processing documentation of interiors and close exteriors of building objects and natural formations. They are specifically used in the area of architecture, monument documentation and archaeology.

Most terrestrial laser scanning systems [2], [3] enable not only to create and compare digital terrain models, but also to signalize particular points for observation (e.g. with retroreflective foils or spherical or semi-spherical targets) and to determine their position very precisely (by adjustment from many redundant measurings). These points can be used not only as identical points for georeferencing of the later created model, but also during placing in the deformation zone as points observed with the possibility of exact change vector determination between measuring stages in the single slide areas.

Researches and tests show that laser-scanning technology is very suitable for monitoring behaviour of slopes in extreme conditions, in extreme states and during investigation of their geometry. The aerial laser scanning system methods are profitably suitable to use for flood danger evaluation.

The testing was carried out for in order to gain knowledge of real possibilities of setting the laser scanning systems [4].

Testing of terrestrial laser scanners was carried out in the premises of CTU in Prague. Tested systems HDS 2500, LMS-Z360i and GS200 were lent by private companies, the last Callidus system is owned by the University. These systems use spatial polar method for determination of the point spatial place at a distance of 1 - 100 m and method of time of flight of the laser beam for measuring lengths. Testing of those systems was concentrated especially on verification of scanners abilities to measure in extreme conditions and to find out which of them would be suitable for more demanding measuring as e.g. exact documentation of buildings or observation of deformations. Especially distinguishing ability, influence of various reflectivity of the surface, influence of the laser beam's angle of incidence on the located object accuracy would be tested. These two experiments were carried out with the scanners: Verification of scanners possibilities to measure different materials under different angles and Object measurement under steep angles.

First experiment verified ability of the single scanners to measure various types of materials for various angles of incidence. Influence of various reflectivity of material surfaces

and influence of various angle of incidence were determined. Nineteen desks from different materials were measured under five angles of incidence from distance approximately 25 meters.

It is possible to judge from the results of the experiment that the tested terrestrial laser scanners are able to measure most materials even under wide angles of incidence (75; 90 gon). Certain difficulties can appear during scanning of dark, highly reflexive or transparent materials. This is stated by the results of scanning of black iron plate, mirror and glass desks.

Second experiment verified ability of the scanners to locate a level object under very steep angles of incidence and to determine edges on such located level objects. Especially it was necessary to determine the position of edge of the measured level which was situated in the direction of scanning further from the scanner. Three objects in the form of oblique flat oblong, a black, a grey and a white one, were measured under five very steep angles of incidence (75 gon to 95 gon).

The results of the experiments showed that the scanners HDS 2500 a GS 200 are able to scan objects precisely under very steep angles. Smaller inaccuracies appeared only during scanning of the black object and angle of incidence 95 gon. The point clouds measured with the LMS-Z360i scanner contained under these angles too much noise that was difficult to remove. It was also difficult to identify the determined edge correctly. Result point clouds from the Callidus scanner had too low point density to be able to achieve better results. The measured levels were caught here only by few columns that did not allow correct evaluation.

Accomplished experiments with terrestrial laser scanners showed some margins of using of these systems in practice. They were especially difficulties connected with location of surfaces with unsuitable reflectibility as dark colours, shining and transparent materials and scanning of objects under very steep angles. While in the first experiment with reflectivity of surfaces all the systems showed approximately the same abilities, the results in the second experiment were much more variable. Results of the experiment showed that for exact measuring, the HDS 2500 and GS 200 scanners are suitable, because we can expect very good results even under unfavourable configuration conditions of the scanned objects and therefore it is possible to use them without serious objections for exact documentation of buildings and prospectively for observation of slides and deformations.

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Research Centre for Industrial Heritage: Works of Architecture and Engineering and the Specific Methods for Studying them

P. Urlich, B. Fragner, T. Šenberger, F. Štědrý, M. Hauserová, V. Valchářová, P. Vorlík, L. Popelová, M. Schusterová, M. Zlámaný, L. Beran, Z. Drahotušská, M. Ebel

fragner@vc.cvut.cz

Research Centre for Industrial Heritage CTU in Prague, Pod Juliskou 4, 166 34 Prague 6, Czech Republic

The subject of this research is the building as a work of technology that emerges in and responds to the needs of specific historical circumstances and is a specific historical reference that must be approached with new procedures in order for its information content to be properly read and interpreted. This research concentrates on a thus far neglected sphere of structural work – industrial works of architecture and engineering – with the aim of formulating alternatives for their conversion to fulfil new functions.

The focus of the Research Centre for Industrial Heritage (VCPD) thus far – the development of an electronic database on industrial buildings and sites using specific methodology, fostering the VCPD's integrative potential as a platform for cooperation with other sections and parts of the Czech Technical University (ČVUT) (especially the Faculty of Architecture, the Faculty of Civil Engineering, the Faculty of Mechanical Engineering, the Faculty of Electrical Engineering) – has led to the creation of a complex study of structural works that encompasses not only the technological perspective but also takes into account other perspectives, such as the urbanist, economic, sociological and environmental aspects.

The research methodology has primarily involved searches for archival and bibliographic resources and materials in combination with field research. The principal resources used have been drawn from local building archives, archives of industrial enterprises, and specialised archives, especially the archives on the history of technology and industry at the National Technical Museum, which has a collection of company documentation and materials and a library with numerous archived professional and specialised periodicals and volumes dating back to the contemporary period. These resources were used to derive basic information on the architects, origin, and dates of the various structural works studied and on the technologies and production. Fieldwork has involved making a complete photo-documentation of the structures (or their remains), in some cases their localisation using GPS technology, and cooperation with specialists (e.g. the Institute of Urban Informatics in Prague provided the digital mapping materials).

The outcome of the research was produced on an ongoing basis and resulted in the development of professional conferences, exhibitions, and specialised and informational publications. In 2005, in connection with the project research, the VCPD organised the international biennial Vestiges of Industry. The VCPD summarised the results of the research on this occasion in a specialised scientific anthology devoted to Interwar Industrial Architecture, and in a catalogue compiled to accompany the architectural exhibition of examples of the conversion of technical and industrial buildings to new uses, and the results were also presented in informational guides designed to contribute to regional development through an alternative form of tourism, so-called industrial trails. As part of the biennial the Research Centre for Industrial Heritage also held a conference which involved the

participation of prominent foreign professionals in this field and focused thematically on defining the value criteria of industrial heritage buildings and sites and for their conversion to new uses, and it was organised with active reference to the European Working Heritage project. A digital version of the conference proceedings on DVD was published after the conference, containing a recording of all the accompanying events, lectures, presentations, texts, and information.

All the results and outcome of the research finds immediate and ongoing practical application as materials and documentation for use by the Heritage Conservation Department at the Ministry of Culture of the Czech Republic and as materials for the assessment of selected sites when they are proposed for heritage conservation status (expert opinions are drawn up at request on proposals for the heritage conservation of buildings or sites, and suggestions and notification of sites meriting heritage conservation are submitted, etc.). Making practical use of the accumulated data and the research results has been the focus of the cooperation that has been established with the bodies of state administration – Kladno City Council, and the Prague City Council (the culture, heritage conservation, and tourism divisions). This has also led, among other results, to the publication of collections of texts–guidebooks on evaluated technical buildings and industrial architecture. The research in 2005, focusing locally on Prague and the Central Bohemia region, continues in 2006 with the mapping and evaluation of works of architecture and engineering (with the accent on industrial heritage) at selected sites and buildings in the Liberec Region, the Jablonec Region and in Northern Bohemia (in cooperation with the City of Liberec, J.E. Purkyně University in Ústí nad Labem, the Technical University of Liberec, and the Czech–German Future Fund, and the Ministry of Industry and Trade).

The Czech Technical University operates an excellent specialised database on its server, which highlights in electronic format the buildings that have been studied and evaluated by the Research Centre for Industrial Heritage, and since 2005 it is accessible to the public, with the aim of facilitating the widespread application of its research results.

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Creation of Documentation of Charles Bridge and Old Town Tower

V. Němcová

veronika.nemcova@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

The project involved individual work phases of creation of Charles Bridge documentation. The first part describes exploratory works at Brno University of Technology – photogrammetric interpretation of images of Charles Bridge using the PhotoModeler software, the creation of a graphical presentation of the results, and the achieved results. The second part refers to a wireframe of Charles Bridge and its origin. The last part summarizes works at the Czech Technical University in Prague – new ways of creating documentation of Charles Bridge and the Old Town Tower with the help of Microstation and AutoCAD.

Exploratory works started in spring 2002 at the Brno University of Technology. The aim was to perform a photogrammetric survey of a part of Charles Bridge in Prague, to prepare drawing documentation, and to analyse the accuracy of the measurement.

Source data consisted of images of a part of Charles Bridge, used metric cameras' characteristics, the coordinates of control points and their sketch and accuracy requirements. For taking the images, two metric cameras were used: Pentacon Six (6x6 cm, wide-angle lens, 50 mm focal length) for lateral parts of the bridge, and digital reflex camera Canon Eos D 60 (6 Mpix, 35 mm focal length) for arch rings. For each lateral part, 5 images were taken, and for each arch ring 8 images.

The control points measurement was carried out from points of the geodetical network for monitoring bank wells. Slant ranges, zenith distances and horizontal directions were measured with Topcon GTS – TS 300.

For stereophotogrammetric interpretation of the photographs, the Photomodeler Pro 4.0 (Eos Systems, Inc.) was used – the measuring and modelling software. The result was space coordinates of crossing mortar joints among stones, and its joints. Points hidden behind trees or bushes were not interpreted. The documentation was prepared in Microstation software (Bentley Systems, Inc.) because of working with a dxf format.

The last step of exploratory works was to compare the theoretical and average attained accuracy. The result of this analysis was the fact that the attained accuracy matches the theoretical one and it meets the requirements for this project [1].

The creation of the wireframe of Charles Bridge was preceded by the works at Czech Technical University in Prague. This wireframe arose by the method of laser scanning made by GEFOS a.s. company. They provided it in a dwg graphical data format.

The first works on the documentation at the Czech Technical University in Prague started in autumn 2004. It was necessary to create a complete 2D vector documentation of the bridge, a 3D model of the whole bridge, a complete photographical documentation of the bridge, including the statues, and an intelligent 3D database for each stone.

Source data consisted of images and the wireframe. The images were taken by calibrated digital cameras Nikon D 100 (6.1 Mpix), Canon EOS 20D (8 Mpix) and a reseau camera Rolleiflex 6006 Metric, for documentation of the bridge and statues, for documentation of stones and statue damage, and for the petrographical analysis.

Detailed interpretation was performed in software AutoCAD (Autodesk, Inc.) and the Microstation (Bentley Systems, Inc.) environment. The bridge was divided into spans, piers and arch rings, and after that into individual plane surfaces.
The wireframe served as a source of control points in areas above the river, in other cases they were directly measured from the banks.
It was necessary to correct image distortion (with softvare Distortion PM), and to transform images onto the control point basis in the IRAS/C system upgrade of Microstation. Projective transformation was used.
The precision of laser scanning is approximately 4 cm, on the JTSK reference system 5–8 cm can be supposed. The measured control points have an accuracy of around 1 cm. Because of the points natural signalling (joints, spots on the stones, etc.) is it in fact worse. The mean error of image transformation to control points is 1 to 3 cm. If the surface could not be replaced by a simple plane (image had to be divided into several planes), the mean error was maximally 5 cm.
The joints interpretation was done through their tracing on a transformed image. The result was traced joints in a partial plane. In the case of arch rings, they were divided into modules of three or four stone lines. Each module was allowed to be plain.
The final 3D model was built as a "puzzle" of the wireframe and traced partial planes. The 3D model includes a special intelligent 3D database for each stone – tables with petrographical analysis data (type of material,...) and building-historical analysis data (localization, reconstructions,…) [2].
Creation of the Old Town Tower documentation was very similar. Approximately 20 control points were measured from interconnected and adjusted polygon. The electronic total station Sokkia was used with the help of a prism in the case of available points, in other cases forward intersection was made. The accuracy of the measurement is around 1 cm.
The photogrammetric survey can be divided into two parts. The single image photogrammetry method was used for the evaluation of planar elements, stereophotogrammetry then for the interpretation of stereometric elements (lancets, crockets, ball-flowers, statues, etc.). The images were taken by the metric camera Rollei 6006 with the help of older data from UMK (glass plates). The accuracy of a single image and stereointerpretation is (at control points) from 2 to 3 cm. The last step was data editing.
This project was made for the Municipality of Prague as a basis for an other survey – petrographical analysis, slight corrections, or large reconstructions caused for example by floods.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

The Road Safety Traffic in Dependencies on Traffic Terms and Constructional Form on Communication

J. Kocourek

kocourek@fd.cvut.cz

Department of Transportation Systems, Faculty of Transportation Sciences, Czech Technical University, Konviktská 20, 110 00 Prague 1, Czech Republic

Rapid growth of highway network, changing vehicle population, mix of vehicles on roads, number and age of drivers, economic constraints in road construction and technological advances contribute to an environment of increased accident potential.

To carry out road safety audit, it is essential to know the characteristics and risk by considering the fundamental elements that can describe road safety in a quantifiable manner. Risk index is an estimated score to rank the sites by using different road features to formulate the exposure, probability and consequence components. Development of risk index produces a technique to support road safety analysis and also for in depth study of road safety audit. The objective of my dissertation work is to show theoretically how risk index is useful in road safety audit and I will try to develop a new risk index, which is useful to prioritize the recommendations given by road safety audit. My Ph.D. work details are the road safety audit (definition, stages, step-by-step procedure and benefits); risk analysis (traditional); risk index (concept, terminology and techniques available); and suggested a theoretical approach with the required data for evaluating risk index to prioritize the road safety audit recommended safety measures.

The basic task in road safety is to describe the existing situation - the magnitude of the road safety problem. It is easy and too common to focus exclusively on the number of accidents, injuries and fatalities, which are the effects or consequences of the danger that characterize road traffic. However in order to compare and rank road safety problems it is also necessary to find out the magnitude, characteristics and risk by considering the fundamental elements that can be described road safety in a quantifiable manner.

Risk is defined as the potential for realization of unwanted, negative consequence of an event. The array of risks covers a wide variety of human experience involving risks - personal or societal, man-made or natural, with consequences ranging from financial involvement through premature death.

My research is focused on traffic conflicts as an alternative to accident data. Conflicts occur far more frequently in traffic and can include the whole range of incidences where the actual accident is just at one end of the scale. Techniques range from subjective to the more objective where conflicts are rated by measurements such as time to collision or post encroachment time. There are analysed two accident locations in my dissertation work. This research advances in research of Doc. Folprecht.

I applied traffic conflict technique to estimate the traffic safety at unsignalized intersections (Roundabouts) and an index measure was developed to summarize the conflict risk at intersections. This index provides an indication regarding the relative risk of being involved in a conflict at an intersection. These research efforts are further enhance the usefulness of the traffic conflict technique as a tool to evaluate the safety of intersections. Safety and risks are not only described in mathematical terms, when studying traffic safety, it is also important to obtain knowledge concerning human behaviour. Conflict studies are often combined with

other types of behavioural studies. In order to estimate the number of accidents from conflict registration, ratios between the number of conflicts and accidents are used, which means that conflicts can also be regarded as a measurement of exposure as well as an indirect estimate of the number of accidents. At intersections, observation or video-recording methods are used to estimate exposure database on the number of vehicles or pedestrians using the area. The exposure data can be based on traffic situations, either registered accidents or using traffic conflict techniques for the area. Combined with traffic counting systems, the accident rate or conflict rate can be expressed as the number of accidents per million vehicles entering the intersection. Traffic conflict technique enables to study hazards in traffic in an uncomplicated way. It used to be the number of reported accidents at a site that decided whether it should be rebuilt or not.

Risk analysis in road transportation is a complicated procedure and I propose a theoretical approach to use risk index in road safety audit to find the safety measures to the identified risk sections. The advantage of suggested approach is a two stage process and easy to handle when compare to risk analysis. Road safety audit is one of the road safety engineering programs widely used. Road safety audits are more specific to minimise the number and severity of accidents that will occur on the new or modified road; avoid the possibility of the scheme giving rise to accidents elsewhere in the road network; and enable all kinds of users of the new or modified road to perceive clearly how to use it safely. Safety audits are necessary cost, not an additional expense. Based on road safety audit, auditor list outs recommended safety measures to the identified deficiencies of different sections of the roadway.

A theoretical approach is described to determine which road features should be investigated and how each feature should be evaluated to estimate risk index. This process is flexible and can adapt to the needs of many users and different conditions. The validity of the risk index was evaluated by comparing the results of the subjective and objective risks. The spearman rank correlation can be used to determine the agreement level between the results of risk index. In suggested theoretical approach, limitation of risk index is the subjective nature of process and any process that relies on a subjective assessment can be susceptible to accuracy problem. However based on the risk index and risk scores it is easy to prioritize the recommended safety measures to the identified deficiencies obtained through road safety audit. To convert this theoretical approach in to practical applications also discussed the necessary data required for risk index and road safety audit.

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Trust Model for Embedded Cooperative Control Systems

M. Rehák

rehakml@labe.felk.cvut.cz

Department of Cybernetics, Technická 2, Praha 6, 166 27

Trust management model that we present is adapted for ubiquitous devices cooperation, rather than for classic client-supplier relationship. We use fuzzy numbers to represent trust, to capture both the trust value and its uncertainty. The model contains the trust representation part, decision-making part and a learning part. In our representation, we define the trusted agents as a type-2 fuzzy set. In a decision-making part, we use the methods from the fuzzy rule computation and fuzzy control domain to take trusting decision. For trust learning, we use a strictly iterative approach, well adapted to constrained environments. We verify our model in a multi-agent simulation where the agents in the community learn to identify defecting members and progressively refuse to cooperate with them. Our simulation contains significant background noise to validate model robustness.

The problem of trust in multi-agent systems is already a relatively well defined one, with many important contributions in the area. In our contribution, we extend the existing trust models with the use of fuzzy numbers for trust representation. Our model represents general trust - trust in an individual, suitable for embedded devices with specialized range of functions and goals.

We extend the current approaches by using fuzzy numbers and arithmetic -- a mathematical apparatus known from the field of fuzzy set theory and fuzzy control – to define, implement, and validate the trust model that is iterative, computationally efficient and in the same time robust with respect to considerable environment noise. Other crucial features are *(i)* automatic identification of the acceptable trustfulness using self-trust, *(ii)* domain independence and *(iii)* coalition cooperation representation, instead of simple client-supplier relationship.

The developed trust model is presented in [1], [2] and [3] captures the fundamental adversariality concept as outlined in [4] – the trust value we establish for each agent is a lower-bound estimation of its perceived adversariality.

In this research project, we have developed a general trust model that addresses properties that are crucial for most ubiquitous systems: *iterativity*, *computational efficiency*, *self-adaptation* and *team cooperation* representation. Another major feature of our model is *robustness* in a high-noise environment, where we have shown that the model works even with limited knowledge about the mechanisms of the environment, using only the cooperation result as an input. This also allows easy model integration with existing devices and algorithms, where it provides both the quantitative (trustfulness) and qualitative (decision) output.

The experiments conducted in the simulation environment with various (both systematic and random) noise influences have proved that the fuzzy-number approach is justified and is robust with respect to more than significant environment noise. We have shown that a general, non-situational trust can be sufficient even for complex ubiquitous environments, when the

agents are highly specialized - a typical case in embedded control or sensor networks. We have also shown that our mechanism autonomously adapts to the environment using the *self-trust* concept.

However, we expect to develop the presented model further to cover many issues not considered so far. The most important issue is the time variability of agent's behavior. The model will fail to detect reasonably soon the agents who start to defect after a big number of observations, and the use of the current decision-making process makes the exclusion of agent from the community an irreversible process, leaving no option for re-integration of the agent into the community. Therefore, two other extensions are possible - emphasizing the data acquisition time and extension with reputation management mechanism.

Situational trust is another obvious development path, where fuzzy rules and fuzzy control provide the well-developed apparatus for efficient decision-making. Fuzzy number representation of the trustfulness values also allows more advanced planning in the non-cooperative environment, as the risk management and game-theoretic approaches can benefit from the conveniently represented information.

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Noise Reduction of Land Transport in Urban Areas

A. Matoušek

xamatousek@fd.cvut.cz

Department of Economics and Management Transportation and Telecomunications,
Faculty of Transportation Sciences, Czech Technical University in Prague,
Horská 3, 128 00 Prague 2, Czech Republic

Overexposure to excessive noise is, similarly as air pollution, the most serious factor affecting health of inhabitants of large cities. Long-term affecting noise nuisance may result in hearing impairments and disorders yet also cause a number of other diseases as stress, neurosis, pathological changes in blood pressure, etc.

Road traffic is the major source of noise in urban environment and especially the heavily growing automobile transport. Exceptions are the vicinities of airports, railways, or even construction sites. Adverse effects of noise are reinforced due to highly concentrated population on relatively small areas. Prague is the worst affected area of the Czech Republic concerning noise affects on inhabitants.

Legislation established criterion for environmental noise assessment is the equivalent sound pressure level L_{Aeq}. It is average energy of momentary sound pressure level values A over a certain period of time expressed in decibels (dB).

The most important source of excessive noise affecting the largest portion of the City population is automotive traffic. The number of automobiles and transported volumes has been ever increasing. Road pavement condition in many cases contributes to the noise level increase, noise prevention barriers have been implemented along a small portion of the road network only. In the most roads of Prague with intensive traffic the equivalent levels of acoustic pressure reach up to 80 dB in daytime, as in Veletržní, Legerova, and Sokolská Streets, and so on.

The alternative solution of the traffic noise in urban areas requires modification of the input parameters (traffic volume, traffic composition, road surface and car speed).

Within the grant solution Anglická Street was chosen for simulation. For this street the calculated noise maps of automotive and tramway traffic Anglická 2000 and Anglická 2004 were developed for both the daytime (6 to 22 o'clock) and night-time (22 to 6 o'clock). One calculation point was assigned for each of the houses (a total of 30 calculation points). All calculations for the automobile traffic noise map Anglická Street were obtained using version of the HLUK+ software. Calculations results are related to points located at 3 metres above ground and 2 metres from facades of premises, which face the roads and for which input data necessary for the calculations of the L_{Aeq} values were known. Data for the calculations were prepared in a GIS environment using digital map background materials of the City.

For daytime (6 to 22 o'clock) and night-time (22 to 6 o'clock) these situations were simulated:

- Actual situation Anglická 2000 (Reality Year 2000),
- Actual situation Anglická 2004 (Reality Year 2004),
- Anglická 2004 – Full speed 30 km/h,
- Anglická 2004 – Traffic volume reduction by 30 %,

- Anglická 2004 – Freight – free,
- Anglická 2004 – Road surface – asphalt,
- Anglická 2004 – Road surface – asphalt – full speed 40 km/h,
- Anglická 2004 – Road surface – asphalt – full speed 30 km/h.

The summary of basic results obtained is given in Table below.

	Calculation points (1-30):		1	6	7	12	15	20	25	27	30
Reality	**Year 2000**	**day**	70,8	70,5	68,5	72,2	72,0	68,6	72,5	73,0	71,7
	L_{Aeq} [dB]	**night**	58,7	59,2	59,8	60,4	60,2	56,8	60,6	61,0	59,8
	Year 2004	**day**	70,5	70,4	68,7	72,4	72,2	68,8	72,7	72,8	71,4
	L_{Aeq} [dB]	**night**	58,9	59,5	60,1	61,1	60,9	57,5	61,3	61,3	60,0
Year 2004 – simulation	**Full speed 30 km/h**	**day**	69,9	69,7	68,1	71,8	71,6	68,2	72,1	72,2	70,9
	L_{Aeq} [dB]	**night**	57,9	58,7	59,7	60,4	60,1	56,7	60,5	60,6	59,2
	Traffic volume reduction	**day**	69,0	68,8	67,2	70,8	70,6	67,2	71,1	71,2	69,9
	by 30 %, L_{Aeq} [dB]	**night**	57,4	58,3	59,4	59,6	59,3	55,9	59,8	59,8	58,4
	Freight – free	**day**	69,3	68,9	67,6	71,1	70,9	67,6	71,4	71,4	70,1
	L_{Aeq} [dB]	**night**	58,4	59,0	59,8	60,4	60,2	56,8	60,6	60,7	59,3
	Road surface - asphalt	**day**	70,4	70,1	65,4	66,8	66,7	65,9	67,1	67,2	66,1
	L_{Aeq} [dB]	**night**	58,8	59,3	58,7	55,8	55,5	54,7	55,9	55,9	54,7
	Road surface - asphalt	**day**	70,2	69,9	65,2	66,5	66,4	65,7	66,9	67,0	65,9
	full speed 40 km/h, L_{Aeq}	**night**	58,5	59,0	58,6	55,5	55,2	54,4	55,5	55,5	54,3
	Road surface - asphalt	**day**	69,8	69,5	64,7	66,0	65,8	65,1	66,3	66,4	65,3
	full speed 30 km/h, L_{Aeq}	**night**	57,8	58,5	58,4	54,8	54,5	53,6	54,8	54,8	53,6

The analysis of the set of calculation points revealed that optimal solution for Anglická Street would require modification of road surface, eventually speed reduction to 30 km/h., by which we could achieve a more beneficial acoustic environmental impact.

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Measurement Analysis of Bioparameters of Human Operators in Critical Phases of Flight with Emhasis on Accident Prevention

J. Bláha, J. Krása, J. Rajnoch

xjblaha@fd.cvut.cz

Department of Control and Telematics, Faculty of Transportation Sciences, Czech Technical University, Konviktská 20, 110 00 Prague 1, Czech Republic

In the project it was concerned to prediction of pilot mistakes in the critical phases of the flight - start, touch-down and measurement, evaluation of rate, rightness and adequacy response at the different flight regime. Further we was concerned with in the human operators in generally non-standard situation, system theory with increasing immunity in face of sudden changes, possibilities of prediction diagnostics of complicated system in detection of the causes failure of the human factor on the plain board, numerical analyses EEG record and problems reliability the interaction of the human operator with the artificial system.

We are sometimes the witness of accident, which they leave many casualties every day on our road and big material damage. Experience and statistics reflect that only minimal percent of accident is caused by sincerely technical causes and the absolute majority of these extraordinary incidents are caused by insufficient functional reliability of human operator with the artificial system. It is many examples, from traffic accidents over air accident when after catastrophes in road tunnels or accidents of military operations.

The causes of failure human operator are often mental character e.g. aggressiveness, hothead behaviour of the human operator (drivers, pilots etc.) behind by operation of incidence stressful situation or tiredness and monotonic scenes, that it can be cause fall attention of operator.

So that we could find out fall attention operator in interaction with system we have to watch the most significant bio-parameters i.e. electric brain activity, breath frequency, heart-beat frequency, movement eyes (eventually lids). These information it is possible use to development methods for diagnosis and detection stress symptoms in the human operator.

One of the first aims our project was determined the measuring philosophy of bio-parameters with reference to following points:

1. Critical flight regimes (prevention fall, fall, spinning - rate selection, high loss),
2. Parameters in above-mentioned points inquire into and depending on the training phase (by retraining to the new aeroplane type / as compared to quiescent value)
3. Test instructor in-flight
   - test instructor at flight with pupil, which absolved successfully programme AK MOT-AKRO (certified by Office for Civil Aviation)
   - test bio-parameters of instructor with pupil - beginner on the plain board
   - contemporary test of both two - comparison of the influence instructor stress at flight with the pupil and the pupil stress pupil „novice"
4. Test in Quasi-emergency modes
   - at security touch-down

- at simulation of the emergency touch-down (pupil / instructor / both). At first will be practised this measurement from safety reasons after training of emergency touch-down first without gauging probes).

In both above-mentioned of measurement, it will be compared: 1. value of individual bio-parameters, which were measured behind normal flight and further with those, measured at boundary regimes, 2. level correlation of bio-parameters.
Next our aim it was the functional testing according to schematics: subject (proband) -> EEG amplifier is registering the cerebral biological potentials -> analysis EEG e.g. by means of the Fourier harmonic transformation -> results are processed by logical circuits -> signalling system – Yes/No. It exists an other physiological symptoms of vigilance, sleep and stress, among it belongs the heart rhythm measurable by the means of EKG, movement of eyes (electro-oculogram – EOG), muscular activity (electromyogram – EMG), changes of skin galvanic conductivity, breath activity, etc.
Resulting EEG record, which it is measuring on the operator brainpan, it has very small energy and then the electric potential is in μV. Therefore it is used the electrodes, that are encased in plastics and the conductive gel (lowers impedance) provides the signal transmission from the brainpan surface on electrode and it is used the electrodes Ag/AgCl, where the conductive gel is the carrier medium. Result record EEG will be processed by means of the Fast Fourier Transformation (FFT) and creation of the frequency spectrums. Among main frequency brain spectra are: delta (0,5 - 3,5 Hz), theta (4 - 7 Hz), alpha (8 - 13 Hz), beta (14 – 30 Hz). Comparison of spectra in different phases of the human brain it is possible to determine characteristic distribution and substitution individual frequencies for the give phase.

It was measured of selected bio-parameters and their connection with suitable of components EEG signal operators and elaboration of exemplary classifier levels of attention inclusive of operator diagnosis. It were solved the problems of interaction of human operator with artificial systems (especially possibility of detection, analysis, predicate and prevention fall attention).

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Measurement Analysis of Air to Earth Transmission as a Search and Rescue System Support

J. Bláha, J. Krása, J. Sadil

xjblaha@fd.cvut.cz

Department of Control and Telematics, Faculty of Transportation Sciences, Czech Technical University, Konviktská 20, 110 00 Prague 1, Czech Republic

Project is concerned with monitoring of objects and sending of visual data (photos of surveyed area) together with navigation data (obtained from receiver GPS) from the board of the plane to the Earth e.g. to the Coordination Rescue Centre (CRC) or to the Control Air Services of the Police. Present CRC is missing the subservience of the efficient monitoring of the developing situation, state and character of the natural catastrophic process, e.g. high-flood-water wav, fire of the great wood complex. It will be possibility to predicate the presence and speed of catastrophe movement and to determine the suitable precaution tend to rescue of persons, protection of property, etc. Project is concerned with the problems of the connection air-Earth, realized by various devices on different frequencies or the system realization of the optimum data connection.

In order to recognize of position in time (e.g. rate or range of the high-flood-water wav or fire of the great wood complex), it is needed possibility timely of the impendency recognition. Furthermore it is important, to information on this danger reached in time to the needed places, like e.g. Coordination Rescue Centre (CRC), fire service or water service. In the sequel by high water in 2002 in the Czech Republic, the question of timely warning and possibilities of catastrophe monitoring, it was very underestimated. It is important for the warning-monitoring system to transfer the actual and precise information.

In first phase of the project it was created the measure philosophy and the data transmission analysis to the ground station. Partial purposes it was divided into the main sections: 1. visual data scanning by device VC-H1, 2. visual data transmission by means of device TH-D7E to the Earth Control or Coordination Centre, 3. received data depiction on the Earth display unit, 4. obtaining the position aeroplane information from the receiver GPS (GPSMAP 196), 5. sending the positional information in the suitable intervals to the Earth, 6. regular evaluations of navigation date from the points 4 and 5, 7. scanning of the selected area, 8. transmission of instructions by data evaluation data on the Earth to the plain board, 9. completion of the precision scanning of the selected area according to air rules and instructions from the Ground station.

In next phase our project will tend to test connection air-Earth by means of different devices, working in different frequency bands with emphasis on transmission of positional information (from GPS) and visual data (catastrophic area photos). GPS is the passive telemetric system, which it is consisted from the three parts: 1. space, 2. control, 3. user. Presently GPS is for needs of the air navigation certified as the additional system – GPS is extended about verification integrity and accuracy and it can be alone (without comparison with data from other system) using for plane navigation. However it must be installation the prime navigation system on the plane, which it will be used in GPS defect. Over his excellent GPS properties, GPS isn't suited for civil aviation abilities on accuracy, availability (ability to ensure the sufficient number of satellite signals for positioning) in all flight phase. The accuracy it is possible to improve by using DGPS or wide area DGPS-WADGPS. Higher availability and

accuracy it is possible to ensure by system completion about geostationary satellites INMARSAT or connection GPS and GLONASS. The problem of integrity system is in case of the defect of some satellite. The integrity problem is guaranteed by methods: 1. Receiver Autonomous integrity Monitoring, 2. GIC GPS integrity Channel. In the legislature of the Czech Republic is licensed using GPS as the additional navigation system on the route ATS (Air Traffic Services), on the routes of Air Traffic Control (ATC) and for device approach.

The Project was concerned with the measure philosophy and the data transmission analysis air-Earth. In next phases we'd like to test above-mentioned devices and software for verification parameters. In real conditions we'd like to concentrate dependencies on mentioned parameter on used flight levels, situation of ionosphere (dependence on the day-time, intensity of solar radiation) and next influence quantities. Further we'd like to develop the method for comparison of the positional information with the photos of the certain area definite and their mapping.

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Monitoring of Objects and Moving Vehicles on the Earth Surface

J. Bláha, J. Krása, J. Sadil

xjblaha@fd.cvut.cz

Department of Control and Telematics, Faculty of Transportation Sciences, Czech Technical University, Konviktská 20, 110 00 Prague 1, Czech Republic

Project is concerned with monitoring of objects and sending of visual data (photos of surveyed area) together with navigation data (obtained from receiver GPS) from the board of the plane to the Earth e.g. to the Coordination Rescue Centre (CRC) or to the Control Air Services of the Police. Present CRC is missing the subservience of the efficient monitoring of the developing situation, state and character of the natural catastrophic process, e.g. high-flood-water wav, fire of the great wood complex. It will be possibility to predicate the presence and speed of catastrophe movement and to determine the suitable precaution tend to rescue of persons, protection of property, etc. Project is concerned with the problems of the connection air-Earth, realized by various devices on different frequencies or the system realization of the optimum data connection.

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Analysis of Conditions for Cycling and Pedestrian Traffic at Junctions

Z. Sperat

zbynek.sperat@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, CTU in Prague
Thákurova 7, 166 29, Praha 6

The fundamental problem of a bicycle as a means of transport in the Czech Republic (which was, however, known when this project was launched) is the access to the cycle traffic while redistributing the street area. Differences among the cycle traffic intensity values in the Czech Republic and Western Europe are brought by a different approach to cycle traffic. In spite of many political declarations and proclaimed "pro-cyclist" territorial planning programs of towns, the cycle traffic is still considered as a minor type of transport, non-equivalent to motor traffic. A cyclist is in Czech towns degraded to be a roadblock which is necessary to separate from traffic lanes and mainly from junctions. Investigations and questionnaire-completing, revealed the fact that a cyclist in town looks for the fastest way of reaching the destination; time, needed energy and safety are the most important facts for him. If the cycle infrastructure is not designed with respect to these conditions, cyclists often do not use it, choose other routes, avoid junctions where they spend much time waiting at the traffic lights or ride on the red light. That is why the junctions are the most problematic places in the cycle infrastructure. In the Czech Republic about 45 -60 % accidents with cyclists´ participation happen at junctions.

A serious problem, which slows down cycle development concerning factual designs in the street territory and junctions, is the absence of input dates – cyclists´ accidents frequency and intensity of cyclists appearance at junctions (movements in junctions). At the same time it is important not to overstress the importance of cycle traffic intensities in street profiles, because potential cyclists often use cars or public transport just because there are no cycle paths on the streets. The demand for cycle traffic is always in proportion with the quality of the offered cycle infrastructure, which is reflected by the experience from Rotterdam in Holland, where the cycle intensity rose by about 70 – 100 % after constructing a high-quality cycle network. While designing new cycling paths in the Czech Republic, there is a tendency to increase safety of cyclists at level crossings by leading them into an associated traffic range and then the cyclists use separate crossing legs through separate cycle crossings. This separation of cyclists from motor traffic seems to be logic and safe but it is necessary only at major crossings with a high amount of traffic. At smaller ones, this way of solution requires a longer time for riding over the crossing and brings a risk of breaking the traffic rules, or choosing of an alternative route by a cyclist. In addition, the accident frequency is the same in both forms of leading cyclists through junctions. In intravilans of towns, at all types of level crossings with a lower amount of motor traffic, it is preferable to design cycle leading in the main traffic range. The safety of cyclists is increased for example by reduction of driving speed in crossing areas to 30 km/h. If cyclists are strictly separated at all junctions which cycle paths lead into, car drivers get a feeling of superiority and the problem appears at next junctions, where cyclists have no reserved territory and they have to share traffic lane with cars.

The form of leading cyclists through crossings should be connected with the form of cycle traffic organization in street profile; if cyclists are in profile led in main traffic range, they should not be directed to an associated traffic range before a crossing. In case of

transversal crossings with small amount of motor traffic, there is preferable to lead cyclists into main traffic range with queuing before a junction in reserved cycle lines, or into a forward "stopline" (in this case cyclists enter the junction first – before the car drivers, who can easily check their movement in the crossing territory). There is an illusion that this form is dangerous not only for cyclists passing junctions, but also for cyclists appearing in front of these junctions when it is necessary to enter the reserved cycle lines. Foreign statistics show, however, that only 10 - 25 % of all accidents at junctions happened in this places. In addition the cyclist, who is led through the junction in the main traffic range has the priority on the direct route through the junction against cars turning right, which is not the case of the associated traffic range, where the cyclist has no priority at the junction. In crossroads controlled by traffic lights (in case of an associated traffic range), there is problem for cyclist with the signal location, which is often situated before the crossing just next to the place where such a cyclist is waiting (0,5 m on the right, 2,1 m over the pavement level). It is more preferable and more transparent to situate signals behind the crossing leg, similarly to signals for pedestrians.

The form of leading cyclists across circular crossings is again preferable to be chosen with the view of the importance of the crossed roads. The size of the circular crossing is not the major issue, but the intensity of motor traffic and driving speed are the most important factors. At important crossings with a high amount of traffic is preferable to lead the cyclist in an associated traffic range parallely with pedestrians (the cyclist has to give priority on all crosses), at other circular crossings it is more efficient to design the cycle traffic over the circular zone (traffic line) on reserved line for cyclists. In the Czech Rebublic there is only one circular crossing with this form of traffic organization available (with priority for cyclists before cars entering and escaping the circular crossing). It is in the town of Šumperk, the reserved cycle line is of red colour. In conditions of the Czech Republic it is not possible to follow the recommendation given by Dutch researchers who advise an absolute priority for cyclists to motor traffic at circular crossings with leading cyclists into an associated traffic range, even if the cyclists ride on the two-way path across crossing leg clockwise. Crossing for cyclists is raised about 10 – 15 cm higher over the road level.

Summarizing, it is possible to claim, that cyclists´ problems in towns and especially at junctions are necessary to be solved in complexity, globally considering the arrangement of the street territory with a concrete definition of priorities and needs. If cyclists has no priority on roads and at junctions, it can be expected, that general opinion will consider cycling as the second–rate type of traffic. A suitable chosen strategy in the town cycling network planning and the integration of cyclists into the traffic flow can lead not only to the improvement of the environment. Another positive fact is that cyclists can be fairly considered as a natural element in traffic the flow, which can lead to a positive traffic modulation.

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Innovative Education of Quantitative Methods

O. Pastor, P. Novotný

pastor@fd.cvut.cz

Department of Logistic and Transportation Processes, Faculty of Transport, Czech Technical University, Horská 3, Praha 2, 128 03 Prague 2, Czech Republic

Fast development of computer sciences, easier communication with computers, a very large offer of software products focused on decision making as well as growing quality of information systems are gradually removing obstacles which prevented from wider usage of scientific methods. Students of the transport faculty at CVUT are coached to be prepared for such changes.

A new course called Economical mathematical models has been launched from academic year 2005/6 in a newly accredited bachelor's study program „Technics and Technology in transport and communication"- major „Management and economics of transport and telecommunications". This new course replaces currently finishing course „Operative analysis" with aim to react on a European trend, when tough sciences like operative analysis (research) are replaced by courses and publications type of „quantitative methods in management" (Management Science). The main objective is to highlight a phase of models creation and their analysis.

Main objective of the project was to create for students of full-time and combined studies study materials, which would in the field of transport and logistics gradually shifted from one sided approach emphasizing mathematical solution to approach focusing on creating models, their analysis with standard software products and interpretation of obtained results.

Outcomes of the whole project are divided into 6 study blocks.

0. Introduction
1. Linear optimization models
2. Models of network analysis
3. Models of mass operation
4. Models of stock management
5. Localization methods
6. Computer simulation

In the introduction block, there are treated specific features of approach to analyzing decision-making problems, determination and definition of a problem, construction of a suitable type of model as well as interpretation and implementation of the chosen solution.

In the first block a linear programming is presented as a fundamental optimization method, typical cases of linear programming are analyzed, a general and standard format of a linear programming case is formulated together with types of linear programming problem's reports, and graphical interpretation of the solution. In this block there are described also linear cases with special features, so called distribution cases, and methods of their analysis.

Second block treats project modeling by network charts in order to obtain numerical characteristics of the project and ensure optimal management. The evaluated characteristics and connections are time, cost and resource related.

In the third block process of Mass Operation is analyzed by mathematical models with aim to get numerical characteristics of the Mass Operation systems, which are in this case seen as a foundation for suggesting efficiently functioning systems of Mass Operation and for its optimal management.

In the fourth block, significantly simplified stock models are debated as they should serve for understanding fundamental principles and approaches for constructing mathematical models of a stock flow whose massive implementation in the current situation can be explained by emphasizing logistics principles in managing companies. This block shows that logistics is becoming a domain for applying model approaches and the same can already show successful attempts to optimize in real conditions stock flows within enormous logistics networks, starting from final customer and ending with raw material suppliers.

The fifth block focuses on the most suitable placement of one or more entities towards existing entities, thus on the localizations models. It proves that their analysis usually leads to a case of linear or nonlinear programming whose generally specific structure is used in the special effective algorithms. There is a part dedicated to complex business-like problems with usage of heuristic methods.

In the sixth block a method Monte Carlo is introduced as an effective counting procedure, belonging to the class of numerical methods. It is shown that its essence is a simulation of examined system using artificial probability model, whose probability characteristics relate to a solution of the problem.

In each block it is highlighted that quantitative methods are essential for analyzing repetitive, standard problems, where it is possible to link algorithm of the solution with an information system of a company.

On the other hand, students are lead also to awareness that quantitative methods are not the only way for making decision in a real business. In many cases, decisions are outcome of intuition and experience of managers together with support of quantitative methods.

All blocks are available for students in a written form. As a next step it is foreseen to complete them with test questions, solved cases using standard software and cases for individual work. We assume further extension of materials to software available on the web sites of different publishers and companies.

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Analysis and Subsequent Optimalisation Disposition of the Railway Stations

M. Jacura

jacura@fd.cvut.cz

Department of Transportation Systems, Faculty of Transportation Sciences,

Czech Technical University in Prague, Konviktská 20, 110 00 Prague 1, Czech Republic

The railway stations in Czech republic and his disposition mismatching needs of the passangers and the railway traffic. One problem is a form of the platform, which are usually accessible only across the track. This solution is unfortunately use in a large number of czech stations.

The big railway junction are not conforming too. In the city center lie freight station, the “city railway” is not implementation, vestibules of the station buildings are “empty”. When is writing empty, it is meaned empty for passanger. Extensive surface effuse emptiness, vacation of service premises aren't exploitation. Separate chaps is exploitation railway for town and suburban personal transport. In this area stay Czech Republic far beyond by all the mature Western European country.

However, also the other related rail transport systems have to be considered, i.e. municipal high-speed tracks (e.g. metro, S Bahn) in large municipal agglomerations, and the network of traditional railway lines, which are with the systems in question in close relationship, both direct (vehicles transitivity) and indirect (interchange points). However, nor the rail transport as a whole is isolated form the other transport means, therefore the linkages to trackless haulage must be also reviewed; i.e. above all to road car traffic in the Czech Republic conditions. There is linkage between those two means of transport in traffic and transport market.

In conditions of Czech republic must be arithmetics with construction of modern terminals for public mass transport. It very markedly creates attractive system for standard travellers. Undoubtedly must do arithmetics with expansion system dual tram too. It is traffic system for passenger transport, the vehicles of which can be used both for the railway and tram line, and consequently to use advantages of both kinds of transport, is called tram-train (or dual tram).

In frames analysis grant was fulfilment inquiry opinion traveller. From they implication next findings:

- more than a half number of passangers demands edge of platform 550 mm
- majority of passangers prefer byu the ticket in the cash desk
- passangers request these services: refreshment, press shop, chemist´s, station restaurant
- passangers think fit these serveices: bookshop, coffee-lounge, internet coffee
- more than a half number of passangers require modern information system (optical und acoustic)
- all pasangers wish in station a suitable information office

- dividing the streams of arriving and departuring passengers is useless, because they don´t usually abide it.

- it´s be of ineterest, that many people want a „tall“ platform (550 mm high edge of platform) and they don´t want go by subway too. It isn´t possible realize these conditions (all at once)

Findings of these grant will may be using for revision standard specifications of the disposition of railway stations and its station bulidings. These exits wil be one from many basis for the dissertation thesis „Traffic Service of Territory“.

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Quality Management System and Its Implementation into Company Structure

David Šámal*, Vít Sopko, Sergio Pinto***, Pavel Mach***

xsamal@fel.cvut.cz

*Department of Electrotechnology, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic
** Department of Physics, Faculty of Mechanical Engineering, Czech Technical University Technická 4, 166 29 Prague 6, Czech Republic
*** Department of Materials Engineering, Instituto Superior Tecnico, 1049-001 Lisboa, Portugal

This project deals with implementation of ISO standards into company management. ISO 9000 represents an evolution of traditional quality systems rather than a technical change. ISO 9000 is a system quality standard that provides requirements and guidance on all aspects of a company's procedures, organization, and personnel that affect quality—from product inception through delivery to the customer.

Quality management system

Determination of term: Quality management system to conceptualise a component of company management system as guarantee customer satisfaction at optimal costs. There are many different types of management conceptions in the world [1]. Only two predominate:

- Conception ISO
- Conception TQM

Conception ISO is based on application requirements defined by ISO 9000 family.

Quality management principles by ISO 9000 [5]:

- Customer focus
- Leadership and management of employees
- Involvement of employees
- Process approach
- System approach to management
- Continual improvement
- Factual approach to decision making
- Mutually beneficial supplier relationships

The ISO 9000 family has become fundamental part of the company's quality system since 1987. The revision of standards was made in 1994 and in 2000 [1]. ISO 9001:2000 standard in comparison with ISO 9001:1994 innovate the quality management system - Applying the principle of Process Approach to Quality Management Systems.

General requirements in accordance with requirements of International Standard [5, 6]:
To implementation the QMS, the organization shall:

- Identify the processes needed for the QMS
- Determine the sequence and interaction of these processes
- Determine criteria and methods required to ensure the effective operation and control of these processes

- Ensure the availability of information necessary to support the operation and monitoring of these processes
- Measure, monitor and analyse these processes, and implement action necessary to achieve planned results and continual improvement.

Additional requirement is establishment a process to review the QMS by top management and continuous improvement

Quality management tools

Widely used management methods and tools for quality planning:

- Seven Basic Quality Tools (SBQT)
- Seven New Management and Planning Tools (SNMPT)

Seven Basic Quality Tools (SBQT)
An important group of methods and tools used in QMS consists of Seven Basic Quality Tools. These methods and tools were developed in Japan especially by K. Ishikawa and W. E. Deming. The SBQT is used especially in solving problems of quality operative management and in solving of quality continuous improvement.
The SBQT are: Flow chart, Cause and Effect Diagram (Ishikawa or fish-bone), Data - collection form, Pareto Diagrams, Histogram, Scatter Diagram, Control Chart [2, 3].

Seven New Management and Planning Tools (SNMPT)
The SNMPT is used especially in solving of quality continuous improvement. Not all the tools were new, but their collection and promotion were. The tools promote innovation, communicate information and successfully plan major projects.
The SNMPT are: Affinity diagram, Relations diagram, Tree diagram, Matrix diagram, Matrix data analysis, Process decision program chart, Arrow diagram [2, 3].

Steps for ISO Certification

An organization must plan and integrate into own quality management system a comprehensive strategy to comply with family standards of ISO 9000 requirements. Preparing for registration involves creating essential documentation starting with the quality manual, identifying areas that require improvement, and ensuring quality processes and work instructions are in place [7, 8].

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Basic Approaches to Measuring Economic Benefits of Transport

F. Lehovec, P. Karlický

lehovec@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University,

Thákurova 7, 166 29 Prague 6, Czech Republic

European countries usually incorporate certain procedures of economic assessment in their transport strategies. It is, however, a well-known fact that the socioeconomic aspect is not the only way of expressing the feasibility of various projects in the public sector. Policy discussions prior to decision-making cover a wide range of areas, and several different criteria for the assessment of public benefits may be identified in present-day research.

The following survey specifies different approaches to establishing the criteria in the infrastructure sector. This survey may also be interpreted as various approaches to establishing the benefits of transport based on various research disciplines. The approaches preferred in each country differ both historically and politically.

1. *The engineering aspect* is based on the application of technical standards for the transport network capacity. As a method studying the needs for investments into infrastructure, the engineering aspect is highly important, but in no way is it sufficient on its own. It would be wrong to build a transport system on the basis of technical standards without considering e.g. the factors of the actual development of the demand for transport.

2. *Political measures based on the results of voting* as a standard and inevitable criterion is applied in each democratic country. A political discussion on what objectives are most important for national/regional governments is necessary, but discussions will be irrelevant unless the arguments result from an economic and technical assessment. Political decisions tend to be oriented on short-term solutions, and benefits of long-term development are often insufficiently emphasized.

3. *Regional development* includes the effects of investments in terms of localization. It is, however, not clear where the principal benefits of the new investment into transport will show up – benefits for one region may turn out to be to the detriment of the other. This can be avoided if investments into infrastructure are preceded by analyses of their implications concerning increased numbers of new jobs and larger production capacities.

4. *An economic estimate of the impact on productivity* is a macroeconomic criterion for the evaluation of returns on investments. Economic analyses of inputs and outputs are used for establishing the productivity growth within the respective region or country. Their results, in turn, may be used for the assessment of the benefits of transport and other activities.

5. The *regional planning* criterion focuses on the structure of municipalities and cities. The importance of a transport system in this relation should not be underestimated. Accessibility by means of the newly built infrastructure leads to the growth in the city population, which, of course, creates a certain positive effect for individuals as well as enterprises.

6. *Economic assessment of the return rate*. The cost-benefit analysis (CBA) consists of a series of microeconomic instruments interpreted in transport applications in such a way to include both direct and some indirect costs whose changes may be compared against

investment costs. Cost-benefit analyses based on technical and economic properties of various modes of transport are a key approach for a society searching effective solutions to problems caused by drawbacks in the existing transport system. This microeconomic approach requires estimates of future changes in the demand for transport and transport infrastructure by using additional data such as transport forecasts derived from macroeconomic data. As a result of difficulties in the assessment of some criteria, the cost-benefit analysis must be always complemented by other types of analyses (see points 1-5 above) to achieve a basis acceptable for decision-making.

We cannot say that there is only one optimum criterion which should be applied on its own in the development of efficient policies in transport. It rather seems that the design and the level of a transport system must be adapted to numerous factors present in the society. In order to be able to select such investments that would prove efficient, however, economic estimates are vitally important. The methods of economic assessment allow combining various types of benefits, comparing these benefits with investment costs and carefully comparing the efficiency of investments in different public sectors.

Transport systems of regions and countries always have been considered as important for development, and investments for different transport modes have been made to facilitate mobility for the public and for different enterprises. The increased awareness of environmental issues and the knowledge of the negative environmental impact of transport have gradually led to a more critical attitude towards transport. The transport field is crucial regarding the efforts in making society environmentally, socially and economically sustainable.

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Process Dependability and How to Measure It

R. Flegl

flegl.radim@isq.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 128 03 Prague 2, Czech Republic

Generally it is possible to state that process dependability characterizes process behavior from dependability point of view. Unfortunately it is not possible to solve process dependability as a simple analogy to dependability of technical objects. It is necessary to think of essential mission of process and which parameters mean its regular function.

The first problem is to define process dependability. One possibility is to define process dependability as "output achieving". This approach sources from idea that process means transformation inputs to outputs. Process dependability is represented by probability of this transformation in specific time period in specific condition. If the outputs do not meet requirements it is the process failure. In such case it is necessary to repeat the process or its part. Special case of process failure is process delay. If failures are critical or systematic it means that process has achieved limit state and it is necessary to redefine the whole process or its part.

Another approach to process dependability is "customer" approach. This approach sources from idea that process provides certain "services" to internal or external customers. Process dependability is defined as service dependability. The process dependability has three main parameters: process availability, process continuity and process integrity.

Process availability means process ability to provide specified service (to carry out certain activities) in required quality under specific conditions when it is required by internal or external customer. This ability is dependent on properties of objects by which means is the service/activity carried out.

Process continuity means ability started service/activity carry out in specific condition required time period, i.e. during carrying out the process will not fail.

Process integrity means ability to carry out specified activities without fall-of in quality. From this point of view it is especially important to define output criteria of quality. Achieved outputs are then compared with these criteria to judge if process achieved the specified quality.

Solving the problem of process dependability is based on evaluation of dependability - expressing loss of ability to carry out specified functions i.e. appearing of failure, critical failure or limit state - for specified operating conditions. Process dependability is given by set of stochastic influences affecting the process. For solving the problem it is necessary to identify causes of failures and fault states in process, define failure types, investigate failure dependence, identify appearances and consequences of failures, find possibilities to prevent failures or rectify consequences.

The main terms in the field of dependability are the failure and the fault state. For technical objects these terms are defined in international terminology standard IEC 50(191). For purpose of process dependability evaluation it is necessary to modify these terms.

Process failure is phenomenon consisting in process loss of ability to carry out specified function. Process after failure is in fault state.

Fault state of process is state of process which is possible to characterize by its inability to carry out specified function except inability during preventive maintenance of process technical components or other planned activities or caused by lack of external means e.g. energy supply.

Process dependability evaluation is based on dependability indicators. For dependability indicators definition is purposeful to divide processes into three groups: continuous processes, repeated processes and unrepeated processes.

In the sphere of continuous processes it is advantageous to use methods and dependability indicators known from technical systems dependability theory. Continuous process dependability it is possible to evaluate as renewed objects using renewal theory - to evaluate so called renewal flow - i.e. sequence of periods when the process regularly works, failures and process renewals.

In the sphere of processes which are regularly or irregularly repeated it is possible to use methods and dependability indicators known from technical systems dependability theory as well. In this case in consideration of working periods and non-working periods changing it is difficult to evaluate theoretical renewal flow. Availability indicators and operational availability indicators are more acceptable for practical evaluation. It is possible to use reliability indicators and maintainability indicators as well.

In the sphere of unrepeated processes it is useful to evaluate dependability of long-term and complex processes which has e.g. character of projects. In this case it is purposeful to divide failures into two categories: critical process failures which mean stopping of process and non-critical process failures i.e. less important process failures which mean some complications during running of process or process delay.

For critical process failures evaluation it is possible to use method Reliability Block Diagram (RBD), which derives probability of failure of process as a whole from probability of failure of relevant subprocesses and partial activities.

For non-critical process failures evaluation it is possible to use method Program Evaluation and Review Technique (PERT). The method is based on similar network graph as Critical Path Method (CPM). The main difference between the methods is stochastic character of PERT method. Time periods of partial activities are represented by stochastic variables. The method makes possible some probability calculations which lead to ascertaining of time period of project as stochastic variable with known probability distribution.

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Benefits of DOE Method in Industry Practice

J. Král, L. Hanzlík

kral.jan@isq.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 128 03 Prague 2, Czech Republic

The basic material for mathematical statistics is data that gives information, which can be elaborated and used in a suitable manner by methods of mathematical statistics. Obtaining data in practice is a very important part because wrong data cannot give reliable conclusions even using the best statistical procedures. One of possibilities how to collect reliable data is the method of design of statistical experiments. It is a part of statistics that is devoted to methodology of an effective design of experiments (DOE), which give objective results about watched variables. When process obtaining information about observed variables is influenced by random errors then an elaboration of data using the methods of mathematical statistics is in fact the only tool giving an objective approach to evaluation of information hidden in data.

The design of statistical experiments is composed of two main parts. The first part is a plan of experiment; the other part is devoted to the evaluation of experiment and is strongly dependent on the plan of experiment.

The design of experiments is based on two principles, called by replication a randomization. A replication of experiment is a repetition in a random order prescribed by a randomization. This repetition of experiment brings to the experimenter very important information on the behavior of random errors. A randomization reduces the impact of possible side effects, which could bring systematic errors into the experiment. It is supposed that single runs forming a suggested experiment are mutually independent and a randomization supports also this demand. The evaluation of experiment is finished by a conclusion about the existence or nonexistence of the impact of studied factors on observed variables.

At the beginning it is necessary to create the list of all possible factors that can influenced observed variables and determine also their versions. Brainstorming of the whole team is the best solution for obtaining such a list of factors. In the second step the team must choose those of them that must be included in the plan of experiment and simultaneously determine the corresponding versions for each factor.

The main goal of a screening design is to choose those factors of the factor set that are most important and should be analyzed in the next step in which full analysis of chosen factor will done.

For analysis of experiment results it is used software e.g. Design-Expert. Evaluation is based on the standard methods, mainly on ANOVA analysis. ANOVA suggests mathematical model, which describe influence of factors and intensity of their influence, further implies if the proposed model is statistically significant and the main effect of factor or the interaction between factors is dominant.

Sort of savings are direct - reduction of non-conform production; stabilizing the manufacturing process enables reduction of check frequency and indirect - together with the suggested solution of situation in the manufacturing process indirect savings are connected, which can improve the image of firm, a situation of firm on the market and bring a better position for the defense of quality systems in firm according to standards ISO.

At the present time very complicated setting of competition and mainly in the automotive industry that firm can be only successful that applies modern methods in control. Among these methods we can also consider those based on mathematical statistics as e.g. method DOE, which is presented. Application of modern methods in control of manufacturing processes together with use of information obtained from data can very often brings large savings even in such processes that are for a long time under control and up to this time quite sufficient. The system of never ending improvement leads to a more effective production, reducing costs, modern products and enlargement of production together with a higher qualification of workers and their loyalty to firm.

Example from our praxis: a sticking process of mirror and rain sensor holders is performed at the workstation of extrusion, where a worker sticks and precisely puts a holder on a prepared glass. According to the technological procedure a glass is treated first by Betawipe, which is wiped by a paper napkin off and then treated by Betaprime 5001. A holder is treated by Betaclean and Betaprime 5402 and then a layer of polyurethane cement (PUR) is applied on the holder by a robot. After applying PUR the holder is stuck using a suitable tool with meeting demands for minimal pressure and location. Such a performed connection between a holder and a glass is getting hard 5 days on the stock for the unfinished production and then each connection is tested for a prescribed minimal screwing moment by a digital moment wrench.

The loss caused by insufficient stronghold of a sticking connection was 3-5%, which presents in average 650.000-700.000 Kč per a year. For this reason the solving team was established to reduce this loss and using DOE method to optimize the sticking process of holders.

In connection with this project different technological procedures for sticking mirror holders and rain sensors holders were discovered. These procedures at present time are unified and unambiguously defined. Every responsible worker has got acquaintance with the new technological procedures for sticking both the types of holders in details. Impact of these new technological procedures is evident from the course of the number of repairs in months during 2005. The application of corrections has begun in March 2005. At the beginning percentage of repairs was about 3%. At present the level is 1.15%, but the goal is 1% of repairs in future.

Saving from new working instruction in year 2005 was 322.000 Kč.

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Costs Comparison of Casting Mg and Al Alloys

L. Zeman, B. Košetická, K. Macík

lukas.zeman@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering,
Czech Technical University, Horská 3, Praha 2 128 03

The aim of this research project had worked up the costs structure of the casting production process of Mg alloys and determined under what conditions it is suitable to take the advanced of the chosen casting technologies. The exploiting of magnesium alloys is not widely spread and that's why it had been necessary to find their equivalent. This equivalent served as the base for costs determination of the casting process of magnesium alloys. As the most similar materials for magnesium alloys had been chosen aluminum alloys.

In the first part of the research project had been determined costs of castings for chosen technologies. The technology centers had been defined. This technology centers secure the realization of partial activities. Inside the technology centers had been identified the costs items. The identified costs items had served as the base for comparison of the production process of magnesium and aluminum alloys.

Within the frame of the research project had been concretized costs items which are linked with the castings production process of aluminum alloys. These costs items had been allocated to the costs groups. Consequently the analysis of costs level had been processed for the production of magnesium alloys castings. The comparison had showed that the production costs compositions are similar. The composition of production costs of aluminum castings are: overhead costs and cooperation 50%, material costs 39,9% and pay-roll 10,1%. The composition of production costs of aluminum castings are: overhead costs 53%, material costs 38% and pay-roll 9%.

Also the deviation of magnesium and aluminum production processes had been necessary to be identified. These deviations had served as the base for determination of the impact in relation to the size of some production costs.

This research study had set the advantages of exploiting products of magnesium alloys and set economics benefits which are globally of great extents.

The comparison of production processes of magnesium and aluminum castings had detected the specific deviations with positive impacts to the production costs of casting magnesium alloys.

Material of magnesium alloys castings is one of the basic inputs into the production process. These magnesium materials have a higher price then aluminum materials but magnesium materials have a lower density. When the production process is perfectly under control then we could assume that the utilization of magnesium alloys instead of aluminum alloys have positive impact into the materials costs. The magnesium alloys will be cheaper because the new more productive methods will be exploited.

The casting process of magnesium alloys has a two times faster casting cycle. This advantage has a positive impact on productivity or more precisely on fixed costs. The tools have longer operational life and that's why the unit costs of renewal and unit costs of tools are lower. The analysis had showed that costs of production process of magnesium and aluminum

alloys castings are similar. The positive impacts into the global industry could be determined awkwardly, nevertheless the impacts are huge.

Then research project had proved that the production costs of magnesium alloys castings are not the obstacles which impede the expansion of their production. The important step to expansion of production magnesium alloys castings is the enlightenment between the users of final product.

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Analysis of Machine Industry and Time Trend in Last Years

M. Vaněk

dragonek@email.cz

Department of Economics, Management and Humanities, Faculty of Electrical Engineering, Czech Technical University, Zikova 4, 166 27 Prague 6, Czech Republic

In these days it is not easy to define or to determine term machine industry. We can define it for example by using categories of industrial products and services. In my paper I describe position of machine industry in our state. Further I show production in these categories of machine facilities. Development trends of import and export in selected groups of products follow.

First chapter shows definition of machine industry in the Czech Republic. We have few categories, which contain machine products. These categories are divided into:

- Practice in foundry (code 27)
- Metalworking products and repairs(code 28)
- Machines, equipments, facilities and repairs (code 29)
- Two-track vehicles, trailers and semi trailers (code 34)
- Other transport machines (code 35)

For deeper illustration I describe main categories of machine products, which can be divided in several subgroups. In the first category with code 27 are following products – casting of iron, casting of steel, casting of light metals and casting of non-ferrous metals .

The second group of products (code 28) contains – metal constructions and prefab unit for building industry, tanks cisterns, holders, radiators and furnaces, boilers, press forging, cold forging, closed die forging, stamping, cold extrusion, metal ceramics, heat treatment, metal finishing, cutlery, iron goods and other metal products.

The third part (code 29) includes machines for production and usage of mechanical energy, machines and facilities for general purposes, machines for agriculture and forestry, machine tools, pressing machines, similar machinery, components, installations, mountings, services, machines for specific branch of industry, weapons and munitions, parts, installations, mountings, services, equipments for household.

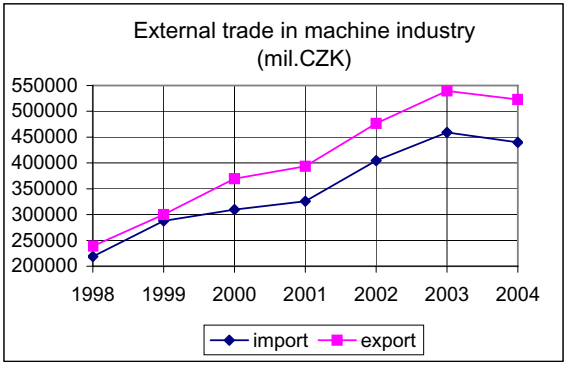
Next (code 34) are two-track vehicles and engines, auto bodies, trailers and semi trailers.

The last group (code 35) is composed of crafts and small crafts, services, rail locomotives, car for tram, metro, rail traffic, parts, services, airplanes and spaceships with satellites, parts, services, motorbikes and bicycles, wheelchairs, parts, other transport machines.

In my research I analyze development trends of these facilities production and their components. For such work I obtained data from Czech Statistical Office. See the table below:

Year	1998	1999	2000	2001	2002	2003	2004
Code 27 (mil. CZK)	2144,8	2083,3	473,1	406,2	17817,1	19338,4	16696,9
Code 28 (mil. CZK)	25839,1	31896,2	40849,9	49705,5	49371,0	82237,8	83276,1
Code 29 (mil. CZK)	39342,1	56074,9	64382,7	65568,8	55413,4	70512,8	78108,5
Code 34 (mil. CZK)	9676,9	17344,2	33448,4	50182,7	52513,3	66215,6	86635,0
Code 35 (mil. CZK)	10065,1	10065,1	10206,0	10975,1	9462,7	13713,8	12821,1
Total (mil. CZK)	**87068,1**	**117463,6**	**149360,1**	**176838,3**	**184577,4**	**252018,4**	**277537,7**

I have data about both production values and import and export of these facilities. At the end of my report I mention time series of these data, which are in the following graph.



Conclusion of my paper: machine industry in our country is very complicated. This term does not exist and must be defined by various categories of products. Main groups are composed of practice in foundry, metalworking products and repairs, machines, equipments, facilities and repairs, two-track vehicles, trailers and semi trailers and other transport machines. These groups contain several subgroups of products, their description is changing in time, because the production is changing.

To imagine there are mentioned values about import and export in these groups of products. Comparing import and export we can see that the export is larger than import. Time series demonstrates development of import and export, which increase during the years.

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Life Cycle Cost Analysis of Various Road Pavements

F. Hanzík, F.Lehovec

lehovec@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, CTU in Prague,
Thákurova 7, 166 29, Praha 6

Non-solid pavements with asphalt layers are nowadays the most common road constructions, not only in the Czech Republic, but also in many developed countries in the world. In spite of the fact that using asphalt brings some problems, it is obvious that this sort of pavements will be hardly replaceable. Asphalt pavements differ according to their layout structure. Each layout has different characteristics – price, physical and chemical properties, thickness or preparation and placing method. Layout structure depends not only on the application purpose of the road, but also on price and investors' funds. Therefore, it is very difficult to decide which construction is the most suitable. Furthermore, in practice the selection process is often based only on finding the alternative with lowest purchase costs, but this kind of selection seems to be insufficient.
The main goal of this work was to compare some selected road constructions. The comparison included not only the purchase costs, repair and reconstruction costs during their life cycles, but also a comparison of time costs calculations.

To ensure the comparison was carried out correctly, it was necessary to consider the same conditions for all the variants; it means:

1. To choose constructions used for the same purpose, loaded by similar traffic intensity.
2. To consider the same lifetime of constructions and set the technological interventions with regard to it.
3. To compare the constructions on the same road section (with typical dimensions).
4. To select and use appropriate comparison and evaluation method (NPV).
5. To calculate technological and time costs correctly and do not prefer any of the selected alternatives.

For the comparison was selected (for simplification) a new project or a base repair of a half-part of a four-lane-road with following characteristics:

- Main road
- Section's length 2000m and width 8m
- I. Class of traffic intensity
- Distance from the construction site to an asphalt mixing plant 15km and to a dumping site 20km
- Road is partially closed for traffic when repairing works proceed

According to the suggestion of revised edition TP-78, nine construction types – six basic and three alternatives – were selected for the comparison. Basic types included pavements with stone mastic asphalt as a surface course. Alternative types included pavements with mastic asphalt surface course. Binder course was made with asphalt concrete for all the constructions. Base course structures caused the main differences among the constructions. They were compounded by various asphalt and non-asphalt layouts in different thickness and combinations (high modulus asphalt, asphalt coated materials etc.). Protective course was made with gravel for all the constructions.

The economic lifetime of constructions was determined as 36 years. Then, on the basis of empiric experience of road experts were set some technological principles, which were necessary or suitable to keep during constructions' life cycles.

For the comparison of solid or non-solid pavements can be used several computer models. All these models usually work on the same principle. They enable to compare purchase, maintenance, repair and reconstruction costs of selected constructions, considering various factors. The methodic is not unified in the Czech Republic and so it was necessary to find out from miscellaneous alternatives the most suitable method, how to solve this problem.

After thorough investigation of all accessible models we selected for the purpose of this work AB-CB program. This program was not used in all its details; some principles were changed or completed and essentially a new model was created. Some changes were based on principles of HDM4 program; the others were made after consulting the problem with experts.

The calculated values were arranged into a summary table with following figures:

- Purchase costs
- Repair and reconstruction costs (according to selected discount rates)
- Time costs (with working schedules)
- Total costs

The final outcome of this work should be not only a comparison of construction costs, suitability assessment of selected constructions and layouts, but also a brief suggestion of some recommendatory data for bidding bonds from the investors', contractors' and road providers' points of view.

The results demonstrated that the lowest purchase costs were achieved by the constructions with stone mastic asphalt as a surface course, high modulus asphalt and asphalt concrete as a base course, all made with a high volume of recycled asphalt material. The lowest total costs were achieved by constructions with mastic asphalt, especially because of the small amount of technological interventions during their life cycles. The constructions with cement-consolidated aggregate as a base course were the less appropriate not only because of the high technological costs, but also because of the high amount of construction working days.

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Sustainable Management in Microeconomy and its Social and Legal Aspects

J. Šafránková,

jana.safrankova@fsv.cvut.cz

Department of Social Sciences, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In the Department of Social Sciences of the Faculty of Civil Engineering of the Czech Technical University and within the research objects No. 5 The management of sustainable development of the life cycle of buildings, building enterprises and territories. We deal with the topics of economical, social, philosophical, legal aspects of civil engineering impacts on the environment and the problems of social conditions of technological innovations, which belong to the necessary targets of the program of sustainable development in the European Union.

In 2005, we concentrated on the problems of sustainable developments in terms of utility, philosophical, legal, social, ethical and economic aspects utility, on the conception of externalities, communication with the general public.

In our approach to this issue we draw from the conclusions of international UN summits, especially Agenda 21 (adopted on the summit in Rio de Janeiro in 1992) and the 16th summit in Johannesburg in 2002 under the title „People, Earth and Prosperity“ that defines three buttresses of permanent sustainable development, i.e. social, ecological and economic ones. The aim of humanities is to study these individual fields and their interrelations at global and national levels.

The building industry, the architecture and the urban space have an important role for a human being and further, there are sociological and psychological influences to mankind, to our well – being. Sociology analyse a role of the architecture in the conscious shaping of an urban space in the 21st century. This dilemma is very important for a sustainable development, as well as for the knowledge of civil engineering graduates and for the urban sociology too.The sociology of the settlement, the city and the housing is, among others, concerning in buildings' (or let me say the architecture) action to the man, his perception and needs. At the same time, the interpretative sociology is dealing with this dilemma too. However, the concerning on those problems in sociology is relatively low in Czech Republic. In these problems, which have a direct impact on the formation of a social and spatial urban structure, we can count the residential segregation, the suburbanization of cities periphery, the depopulation of downtowns, the revitalization of habitation, the revitalization of industry areas and integration.

In the relationship of the interpretation of territory causation to an individual, We was captivated by the theory of Norwegian historian and theoretician of architecture Ch. N. Schulz, at his book Genius Loci assigned: „All works are connected by an identical view, that the architecture is a resource, which provides „existentional support“ to a man. He indicated: ...That is why, the book does not deal with economical and social problems. Existentional dimension is not „determined“ by socio-economical conditions, even though they can make realisation of specific existentional structures easier or harder.“In the contrary of the Ch. N. Schulz, we presume the buildings, the architecture, urban planning is strongly determined by social and economical conditions and they directly symbolize a socio-economical status of the owner, no matter if building is public or resident. During the long period of monitoring

building symbolism in Bohemia, there was showed, that buildings always strongly symbolize their owner.

The topic of sustainability is approached in its general theoretical and historical levels, in two different points of view. In the first one, more stress is put on the origin and the history of the concept, nevertheless in both contexts the concept of sustainable development is proclaimed to be a concept with rather ambiguous content, not a closed and a static one. It has been subjected to many debates since its definition in Brundtland Report in the 1987, its interpretations being based on different philosophical backgrounds. To make a meaningful debate possible, it is necessary to identify the multidisciplinarity of the concept, especially both its factual and normative aspects. At the same time, it is based on the anticipation of the future development with the aim to eliminate the potential crises. Hence, the factor of potentiality is quite strong in it, and on these grounds, it is sometimes blamed for constructivism. However, both extreme concepts of social development, e.g. not to work with any forecasts and strategies on the one hand, and to follow some theoretically constructed models on the other hand, have been impaired recently. Sustainability is both the scientific concept and social strategy.

Economic approaches to these issues are connected with the area dealing with the crisis solution from the economic and social perspective, and with the issues of transactional costs of the firm in our context with the specification of a construction firm. An important role in these approaches is played by the conception of externalities, which integrates economic and social approaches.

The participation of the Department of Social sciences at faculty of Civil Engineering in the research objects is interdisciplinary and transdisciplinary, the results bring contributions to the development of philosophy, sociology, ethics, aesthetics, psychology, law and economy. We consider the interconnection of these human sciences and their methodology for studying social phenomena and the technically oriented disciplines to be the most important aspect of such studies. The construction outputs and the construction as such influence deeply the environment in which we live, and therefore the interconnection of both approaches and perspectives is highly beneficial. The study is related with internationally observed topics of connecting social aspects with technology (science, technology, society). The outputs are connected with the future realisation of the environment and with the EIA procedure.

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The Nature and Scope of an Aggregated Approach to Evaluation of Engeneering Products Utility with Long - Term Life Cycle

Th. Beran, K. Macík

beran@karnet.fsih.cvut.cz

Department of Management and Economics

The principles to be maintained in aggregation can be expressed as follows: The basic organizational unit is always an enterprise. For each enterprise, deliveries into the enterprise must be stated in great detail, while deliveries from the enterprise can stated only in their sum total (from the practical fact that it is impossible to know in the producing enterprise how its products will be used). In getting detailed input data from all enterprises, we can, even without detailed output data, construct a system of aggregative partial models, since the statistics of outputs are from the point of view of the national economy nothing but a double entry of inputs. For better understanding of the idea of this paper the hierarchy of the national economy on which it is based, is stated here. The whole national economy is divided into ministries, each dealing with a large group of economic activities. Each ministry is divided into general directories, each dealing with a group of products or services, called "branch."

Production and servicing are organized in enterprises, each of which is reporting to a particular general directory. Some enterprises consist of a number of factories. The research on which is reported in this paper, is aimed at the development of methods to automatically integrate structural models for the lower units into an aggregate model for the whole national economy, with a feedback procedure for adapting the partial models to changes emerging from the use of the aggregate model as a tool for economic planning. Ministries, general directories, enterprises, and factories are considered to be lower economic units. Theoretically, it is possible to develop a model for one single workshop of factory, when its internal cooperation relations are relevant enough.

It is very important to choose correctly the structure of inputs in enterprise models. The main principle of aggregation in the system lies in the fact that each higher unit will integrate the lower inputs in its main quadrant. The model of the whole national economy will then integrated all inputs (equal to all outputs which have been omitted). If, for instance, we consider enterprise models, which must be gradually aggregated into a general directory model and a ministry model, the lowest enterprise models must be constructed by the following roles: This form makes possible (a) the automatic aggregation of enterprise models into a general directory model, (b) the aggregation of general directory models into a ministry model and (c) the aggregation of ministry models into the inter – branch national economy model. The models of higher units shall then have a more and more narrow structure of input and finally the national economy model will have the classical structure.

In practical use of these models in planning, the following range of calculations shall be made:

1. Aggregation of all models from the lowest units (enterprises) to the national economy model; here the technical and other coefficients will be calculated as well as the inverse matrices of all models. 2. Calculation of the new variant of the economic plan, which now represents the task for the lower units. These units receive their tasks simply in the form of the final use vector **Y.** This process can be indicated as "segregation." The lower units can receive as their task other variables, e.g. the **X** data, i.e. the total amount of production (vector of production), or even the **Z** data, i.e. the matrix of primary costs, or finally the possible

combinations of **X, Y, Z. 3**. After segregation a new check aggregation can follow: through the new aggregation, the new variant of the economic plan must be obtained. In this way, all tasks could be transmitted from the highest planning centers to the lowest economic units through this system of aggregative partial structural models, and planning techniques could be substantially improved by well implemented data processing.

We must, however, always keep in mind that the system must necessarily be supplemented by many other planning and analytical techniques. On the other hand, it can be hoped that after the system is realized and properly put to work in practice, the experience of all workers in this field will bring about a lasting improvement mainly in the dynamic and optimizing aspects.

Finally we must discuss the very important question of collecting the necessary data. It is well know that up to now structural models have been constructed on data acquired through special statistical investigations. Considering that the system could be threatened by the difficulties of data collection, we decided to choose quite a different way. In our economy, accounting and statistics are completely unified and standardized. Enterprises must regularly send in their reports, which are numerous, but which are often exploited much less than would be desirable.

After analysis of the present system of accounting we have come to the conclusion that with comparatively little adjustment in the accounting of inventories, production, and sales for creating the system of aggregative partial models, not only balance sheets and other reports, but also models the given enterprise could be made automatically at the and of each month. This structural model, constructed directly from normal accounting data, just as every other accountancy report, is the base of the system of aggregative partial models, which are then available every month as a by-product of accounting work, without special investigations needed. A method has been developed for entering the accounting data into the models. It is obvious that it was necessary to solve numerous problems, for instance the allocations of costs, the problem of different “indicators”, different meanings of “final use” in different sphere of economic life – e.g. our research subject – long life product cycle.

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The Chances of CTU Graduates on the Labour Market

J. Šafránková, D. Dubnová

jana.safrankova@fsv.cvut.cz

Department of Social Sciences, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

There are a growing number of discussions about further development directions of the Czech Technical Faculty and its component faculties in the context of the transformations under way in the Czech society and with regard to the accession of the Czech Republic into the European Union. One of the sources of information is also the knowledge about the chances of the graduates from component faculties of the Czech Technical University on a labour market. In 2005, for that reason, survey gathering information about graduates from 1985 to 1993, 2001 to 2003 of all the six faculties of the Czech Technical University was realized. The subject of this survey is connected to five representative surveys realized within the Czech Technical Faculty, namely, the survey of students in the 2nd to 5th year of their program in 2001, 2004, students in the 1st year of their program (2001) and students who did not enrol after they had been accepted in 2002 and survey of the problematic of CTU graduates fro 1993 –2000 realised in 2003. In these surveys, the opinions of existing students as regards the instruction, motivation to study, and identification with a selected course of studying, etc., are being uncovered.

The survey information about the graduates describes their chances on a labour market, for example, what kind of work they prefer after graduation, how many of them work in leading posts, or work independently, in what kind of companies they are mainly employed, etc. What is very important is the feedback information about the instruction, assessment of the relevance of completed courses for the practice, and simultaneously finding out required knowledge and skills, which the students are missing in the instruction.

The target of the university is to pass on the theoretical foundations of their disciplines to the students and inform them about the future development directions of their chosen specialty. In spite of this, it has to response to modified conditions within society, of course, with the aim to secure as good as possible chances of its graduates on a labour market.

In the case of the position of graduates of the Czech Technical University on a labour market, 64 per cent of the graduates are employees, and almost 21 percent are entrepreneurs. At present, 2 per cent of the respondents are without any working position (on a maternal leave). Nobody is unemployed, however, 23 percent of the graduates state that they had been unemployed for a certain period. In terms of the company's size, one third of the respondents work in a small company up to 25 employees. Two fifths of the respondents work in the middle sized companies and almost one third of the respondents work in large companies.

In companies according to the type of ownership, one third of the graduates work in the Czech private company, another one third in a foreign company, 18 percent of the respondents have their own firm, and also one tenth of them work abroad. The graduates hold very different positions. Most of them perform organisational and managing work (one fifth of them) and projection work (one fifth of the respondents). 51 per cent of the respondents hold leading positions. More than two thirds of the graduates of the Czech Technical University work in the same or related field, which they studied.

In terms of the type of working position, two fifths of the graduates changed an employer after they had finished their studies. For a part of the graduates, the main reason for their finding a new employer were the organisation changes in their company, the need of a

higher salary, and a lack of good prospects in the company. 84 per cent of the respondents are satisfied with their current job. Three quarters of the respondents renewed their qualification after the end of their studies, more than one half of them in firm seminars.

The graduates show relatively high identification with a faculty and a field of study. 63 per cent of the graduates of the Czech Technical Faculty would study the same faculty and the same specialty, 11 per cent would study a different specialty; that means that 77 per cent of the respondents would study the Czech Technical Faculty. Next, the respondents evaluated, according to their experience with the practice. 81 per cent of the graduates value most the acquired ability of technical thinking. Three quarters of the respondents assess the theoretical preparedness as very good. 70 per cent of the respondents evaluate positively the orientation in a chosen field, and 56 per cent conception abilities. Practical knowledge from the field got a lower positive assessment only from one fifth of the respondents. In terms of the knowledge of foreign languages, the knowledge from the area of work organization and management, only one tenth of the respondents gave a positive assessment. In terms of the practice and preparation for a future profession, the graduates assess as best those forms of instruction in case of which they can actively participate; that means the projects – diploma and complex projects and exercise. Excursions and professional practice got the worst assessment. The majority of the respondents (30 per cent) had to complement their language skills after finishing their studies, 19 per cent had to improve the knowledge from the area of management and organization of work, 10 per cent the knowledge from the area of computer technology, and then the knowledge from economy, law and legislation. This is the reason why the graduates do not assess positively the knowledge acquired at the faculties from the area of management, work with people and the knowledge about a today's society, which are important for a good performance in practice.

The analysis of this sociological survey results brought a large set of valuable information about the position of the graduates of the Czech Technical Faculty on a labour market. In the first place, considering the needs of the Czech Technical University, relatively detailed evaluation of the instruction in terms of the knowledge utilisation in the practice is specifically important. The knowledge acquired in the survey reveals that the students go to study the Czech Technical University for the reason that they want to study in a university with a professional technical specialization. The graduates are satisfied with their original choice of the field of study. In terms of their future work, the graduates acquire a very good theoretical and a good professional training within their specialty. They miss practical experience and professional practice in firms however, this is insoluble for the time being. For above stated reasons, it would be good to concentrate more on the independent work of the students, on their skills to present and justify their work and on teamwork.

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The Life Cycle Costing Methodology of the Building Object

J. Ttománková, D. Čápová, L. Kremlová, R. Schneiderová - Heralová

tomankov@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, CTU in Prague, Thákurova 7, Prague 6

Life cycle costing (LCC) is a method for analysing the total cost of the acquisition, operation, maintenance and support of a product throughout its useful life, and including the cost of disposal. This LCC analysis can provide important inputs for the decision making process, especially in

- evaluation and comparison of alternative investment strategies;
- assessment of economic viability of projects;
- evaluation and comparison of different maintenance or reconstruction concepts;
- choosing between different building materials, components and systems,
- improvement in or change of operation.

LCC can be applied to any capital investment decision. It is most relevant when high initial costs are traded for reduced future cost.

In order to estimate the total life cycle cost, it is necessary to breakdown the total LCC into its constituent cost elements. These cost elements should be individually identified so that they can be distinctly defined and estimated. The identification of the elements and their corresponding scope should be based on the purpose and scope of the LCC study.

One formal approach, often used to identify the required cost elements, can best be illustrated by the use of a three-dimensional matrix. This matrix involves identification of the following aspects of the product:

- breakdown of project product into individual subsystems or group-work activities;
- breakdown in life cycle phases (development, planning, acquisition, operation service,…);
- breakdown in cost category of relevant resources (investment, operational, overheads, …).

This kind of approach has the advantage of being systematic and orderly, thus giving a high level of confidence that all relevant cost elements have been included.

Once all the relevant cost elements have been identified, one has to find or estimate the cost parameters for each element. In general, there are three basic methods that are commonly used to estimate cost. They are:

- engineering cost method – involves the direct estimation of a particular cost element by examining the product part-by-part. It uses standard established budget items,or for example firm engineering and manufacturing estimates,
- analogous cost method – involves cost estimation based on experience with a similar construction, product or technology in the past.
- parametric cost method - uses significant parameters and variables to develop estimates which are usually in the form of equations. A parameter reflects a conversion factor from one system of units to another.

Once the costs have been estimated the present value of all future cost and incomes have to be calculated by “net present value”.

The benefit of using LCC in building practice is the possibility of determining annual costs of a building or engineering work already in the planning phase as well as providing minimal annual costs at the selected quality or optimalization between costs and quality.

There is a lot of known or ascertainable information about technical and economic condition of the building objects. These inputs spring from more or less reliable sources, they have various significances, various exactness and they are variable at the time. Responsible decision about business

financing (especially maintenance and repair) based on this casual mixture of information is very difficult, as we did not know the inaccuracy rate of our decision.

It is possible to create the information system by the assembly and layout of all relevant data on the technical and economic condition of a building object valid to the fixed date into the unified input data scheme. This information system [Tománková-Macek, 2005] will allow building object owners (managers) expertly and effectively to take control of the object costs and revenues and its method of utilization.

The model of LCC analysis of building objects is based on the principle of fixed algorithm input data processing by means of a building production reference database. An essential part of this model is also the assessment of mutually interacting relationships between particular construction elements and works [Čápová-Kremlová, 2005].

Within contemporary public procurement there are often left out criteria connected with the life cycle costs of buildings. Public competitions are often based only on the principle of lowest price quotation without considering if costs of improvement, maintenance and demolition in future will be more than average or not. Nevertheless, it is necessary to consider all costs that are connected with the life cycle of a building when looking at submitted offers.

A lot of projects, which are being carried out abroad especially in housing construction, illustrate the possibility of building designed for decreased environmental damage - close to the guaranteed quality of the internal environment with little or no increased cost of investment and with much smaller costs in the whole life cycle of the building (LCC).

A number of LCC/LCA tools have been developed and these tools are limited to evaluate some specific choices on a particular problem. Into the model go a number of assumptions and pre-set data in order to simplify the input for the user and to reduce flexibility (which is equivalent with complexity when one makes and uses the tool). It is assumed that users of the tool are familiar with the problem area described so that long explanations are not needed. With less experience of LCC, a more structured model is necessary to identify the required cost elements.

The LCA methodology has been developed extensively during the last decade. Moreover, a number of LCA related standards (ISO 14040 - 14043) and technical reports have been published within the International Organization for Standardization (ISO) to streamline the methodology.

On the other hand, no general standard for the Life Cycle Cost (LCC) method is available. There are some standards for LCC in specific application areas e.g. IEC 60300-3-3:2004: Dependability management - Part 3-3: Application guide - Life cycle costing.

Currently, there are the representative projects under the auspices of EU (e.g. within LCC Refurb) whose outcome is to be an integrated European methodology of life cycle assessment of building objects. This methodology should serve as a basis of legislative terms in this area and simultaneously as one of the basic decision factors.

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Brownfields Redevelopment: Pros and Cons

L. Jilemnická

jilemnic@fsv.cvut.cz

Department of Languages, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Brownfields are abandoned, idled or underused industrial and commercial facilities where expansion or redevelopment is hindered by real or perceived environmental contamination that can add cost, time or uncertainty to a redevelopment process. Brownfiels sites have become all over the world a persistent problem that cannot be alleviated by the normal process of modernizing the built environment. In our country brownfields can be divided according to their origin and/or location into a few categories. Nevertheless, there are many transitions among them.

- brownfields originated after a decline in the coal or mineral mining, further in steel, textile or other industries. These regions are usually very large and require extensive rehabilitation and decontamination work;
- brownfields in urban areas may include abandoned industrial properties, the sites previously used for large-scale railway or harbor infrastructure facilities, idled technical facilities, derelict housing complexes and civic amenities, warehouses;
- brownfields in rural areas, which may be represented by the sites previously mainly connected with primary economic activities in agriculture, forestry or mining;
- various brownfields in the former military areas, derelict barracks, abandoned areas around borders, waste sites, dumps, derelict historical monuments, etc.

In this distribution I present results of the initial literature search on pros and cons of brownfield redevelopment. Brownfield redevelopment is widely acknowledged as one of the major tools to achieve sustainable development. Unfortunately it is complicated by the fact that it usually requires the participation and coordination of multiple public and private entities, as well as expertise in a variety of disciplines including environment and economic development, infrastructure, planning and financing and community development. Local governments have historically controlled brownfield redevelopment because of their responsibility for land use decisions, but often lack the expertise or financial means to carry out complicated site assessments, toxicological studies and clean-ups that are needed. In addition, brownfield communities often face other problems such as unemployment, substandard housing, or outdated public infrastructure.

The main barriers of brownfield redevelopment are following:

- unclear and complicated ownership relations;
- potentially higher costs at remediation of contaminated land;
- brownfields pose health and safety risks to surrounding communities;
- presence of brownfields can create a negative spiral of mutually reinforcing processes that eventually lower the vitality of a city as a whole, as firms and people relocate to suburbs thus increasing urban sprawl;
- developers prefer cheaper and quicker construction on greenfields, which means consuming farmland and pristine lands.

Advantages of brownfield redevelopment are as follows:

- redevelopment of a region, removal of contamination and aesthetic eyesores in a landscape;

- reducing urban sprawl, preserving open space and farmland or greenfields;
- reuse of existing city infrastructure, utilities, roads and services;
- restoration of old urban centers, revitalization of a neighborhood;
- increasing of incomes and stimulation of region economy.

Brownfield redevelopment significantly contributes to the sustainable development of cities and regions. There are some key concepts associated with brownfield redevelopment. Smart Growth is a movement focused on reducing urban sprawls being typically active at the local level, getting involved in the planning and zoning processes. Target of New Urbanist developments is smaller, more densely arranged housing with a mix of apartments, townhouses, and stand-alone houses in a design that is pedestrian friendly, linked by transit and set in a larger open space framework. Other objectives may include the use, aesthetics and environmental impacts of surrounding areas, availability of jobs, recreation or entertainment opportunities.

While the developed countries started to deal with brownfield redevelopment in the seventies of the last century, in our country this problem has been perceived since the nineties of the last century. Investors and developers in our country still prefer greenfields to brownfields for new housing development or construction of shopping and administrative centers. This state can be eliminated solely by directive and economic measures. Therefore, there is an insistent demand for system legal, administrative and economic tools of short-term and long-term character to create conditions for using brownfield for construction as a matter of priority. Those instruments may be applied in two models. The first model represents the clean-up of contaminated land that should be an initiative of governmental authorities. The other model is based on cooperation of public and private sectors and their financial means. This cooperation should be supported by tools of regional development, economic instruments as well as by control and repressive role of the state. This model leads up to foundation of specialized redevelopment organizations supported by the state and municipalities public budgets.

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Utility Simulation in MDM 2005

V. Beran, V. Berka, P. Dlask, R. Schneider-Heralová, J. Tománková

dlask@fsv.cvut.cz

Department of Economics and Management in Civil Engineering,

Faculty of Civil Engineering, CTU in Prague, Thákurova 7, Prague 6, Czech Republic

The Modified Dynamic Model with risk usage is the basic version of the Risk Modified Dynamic Model (RMDM). This version of the MDM supports

a) Managers influences
b) Interventions of interactions
c) Influences of the risks.

In the application environment it is possible to checking the hypothesis of the sustainable development of the single model elements. The results are the standards and the differences between standards of the model elements. In the transferred meaning it is possible to regard the standards as calculated utilities defined in the model structure. The advanced section of the MDM is a module for the utility calculation. From this point of view is necessary to add some input information for the calculation.

The standard MDM sections are

1. Total Elements Model Database Creation
2. Elements Model Selection
3. Calculation Generation
   a. Input Data
   b. Interaction
   c. Interaction Matrix ***A***, ***B***, Starting Conditions
4. Basic Results (standards, differences of standards)
5. Model Outputs

For the utility calculation it is necessary to add costs of single model parts to the model and its *Life Cycles* (*LC*). These inputs are set up to the model by *User Forms* created in *Visual Basic for Application* (Microsoft Excel). New section for this calculating are

- Area definition for new inputs
- Modification of the project archives
- New project import/export in archives
- New inputs of the Life Cycle
- New inputs of the element costs
- The input weights modification

The procedure linked to a utility calculation is created by means of the integrated tool, which generated so-called *Rational Expectation* (*R*) output. This standard evaluates trend of the complete model structure. Every before calculated standards are multiplied by the weight evaluation. The weight is defined for every model element. The resultant trend of the *Rational*

Expectations approximates of the most to the trend of the element with the highest weight value. Formulas for
the $R(t)$, depreciation and good state are bellow:

Standard of element model $$X(t+1) = X(t)^{\phi(t)} \quad (1)$$

Differences of the standards $$\Delta X(t) = X(t+1) - X(t) \quad (2)$$

Rational Expectation $$R(t) = \sum_{i=1}^{NumElem} R_i(t) = \sum_{i=1}^{NumElem} X_i(t) v_i \quad (3)$$

The depreciation (linear) $$a_i(t) = \frac{ElementAge}{LifeCycle} = \frac{t}{LC_i} \quad (4)$$

The depreciation (non linear) $$p_i(t) = N_i e^{-\frac{t}{LC_i}} = N_i e^{-a_i(t)} \quad (5)$$

Good state $$h_i(t) = 1 - \frac{ElementAge}{LifeCycle} = 1 - a_i(t) = 1 - \frac{t}{LC_i} \quad (6)$$

$$h_i(0) = 1; h_i(LC_i) = 0$$

Where $X(t)$ … standard of the element model, t … actual time period, $\phi(t)$ … calculation parameter, $\Delta X(t)$ …difference between standards, *NumElem* … number of element in the model, i … counter, $R(t)$ … Rational Expectation, $a_i(t)$ … linear depreciation, $p_i(t)$ … non linear depreciation, LC … Life Cycle, N_i … element cost, $h_i(t)$ … good state of model element, $h_i(0)$ … good state for element i in t=0, $h_i(LC_i)$ … good state for element i in t=LC.

For the depreciation calculation we can use linear or non-linear procedure. The linear procedure has constant standard degradation rate. The non-linear degradation standard has increasing negative rate. The new constructions parts have high speed of the degradation. An old construction parts show lower speed of degradation (see formulas 4, 5).

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Dynamic Model of Energy Resources Consumption

D. Vytlačil

vytlacil@fsv.cvut.cz

Department of Engineering Informatics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic

The goal of the project is to develop dynamic model that describes the dynamic behavior of a complex system. The model will calculate a consumption of energy resources in a world or in the part of the world for certain time interval. Basic used methodology is system dynamics that allows us to simulate chosen parameters of the system [1, 2].

Description of a problem situation.

The implementation of new standards in some part of the world will influence the behavior of the rest of the system. E.g. new energy standards implemented in certain countries will decrease the energy consumption in these countries but simultaneously lower demand will influence the price of energy resources and therefore it will have the effect for other countries with market-price of fuels.

Methodology.

The used technique for the design of the simulation model is system dynamics. The system dynamics method uses the information feedbacks that ensure the real behavior of designed model in the virtual world [3, 4]. The model is created as the system of levels (important model parameters) and flows that connect the levels and auxiliary elements in the investigated system.

Model description.

The model includes these **subsystems**, flows and other *elements*.

Energy resources inventory [A] – influenced by producing (1) and consuming (2), connected to *comparison of desired inventory* and (4); connected to *exploring new resources* and (1).

Energy consumption arrangements (efficiency) [B] – influenced by changes in efficiency (3), connected to (2).

Price of resources [C] - influenced by changes (4), connected to *arrangements decisions, new standards development* and (3); connected to *economic decision of investors* (e.g. owners of new or designed buildings and facilities) and (3).

Political decisions connected to *new standards development* and (4).

Simulation.

The model was built in simulation program Stella. The program calculates all levels of above described subsystems [A, B, C]. The results are drawn in graphs where *x* axis is time. The initial level of "Energy resources inventory" is considered as known figure but the exact value is not important because we can work only with the changes of this level.

Tested hypothesis was: what influence on the level of the energy resources can have decreasing energy consumption in some part of the world or the territory.

Results and conclusions.

The results from the simulation demonstrate the fact that decreasing energy consumption only in same part of the system cannot have important influence on the level of the energy resources . It means, this arrangement (e.g. implementation of new standards) will encourage the consumption of resources in other economic subsystems because of the lower price. Typical example is the behavior of the consumers (and also governments) in Europe and North America. The speed of fossil fuel depletion will be lower but still significant. The solution can be introducing new standards in all the world, but the program can help to find also other solutions.

Other development of the model:

- to add the influence of individual investor decision making process concerning the implementation of the energy conscious solutions. Note – it is very difficult to find the border of the system and the model can be expanded every day by adding other subsystems, but the designer should think on the goal of the study and not exceed acceptable number of model elements in the system.
- the validation of the model for present data for the past period.

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Rollerquality for Belt Conveyor

P. Čamlík

camlik@razdva.cz

Department of Management and Economics , Faculty of Electrical Engineering, CTU
Horská 3, Prague 2, 128 03

What is a roller and what is it for?

A roller is defined as a rotating cylindrical component of a sleeper on a belt conveyor. It consists of a shell, shaft, front, bearing and sealing. Using the rollers in a bad way it can cause complicated disaster.

There are three principal functions of the roller:

1.support the belt

2.smooth move of the belt by rotating

3.work reliably in the hardest conditions, with low energy consumption as long as possible

It is our interest to deliver reliable rollers, which excess in the parameters current industrial standards for all of these three principal functions.

Why Tranza rollers?

They have been used for 35 years in countries as Russia [Siberia], Arabia, Canada and whole Europe.

They have gone through the hardest conditions from -40 to +60 C and through environment with a different aggression and abrasiveness.

They are watched, verified and validated in a standard practice in an internal and external way by experts and customers.

They are controlled by computer calculations using a net voltage analysis MKP

They compete in business in Hungary, Germany, Greece etc.

Due to experience and tradition Tranza can recommend and produce its rollers for the hardest conditions.

The ability to cooperate the running conditions with the customer is crucial.

Which parameters – factors proof the quality of rollers?

- Low vibrations,
- Low level of a noise,
- Min. 30.000 hours standard life time,
- Easy rotating of a roller with a low resistance,
- High reliability,
- Reduced energetic consumption,
- Competitive price.

Which technical solutions enable so high quality of rollers?

High accuracy of materials and single made parts > balance

Production of a front with an opening M7 for bearing, diameter of the shaft h6, alignment of a shell

- Accuracy of all parts and elimination of mistakes during formation of mono block of rollers,
- Formation of a mono block by either parts compression technology or by parts welding with airspace (patent),
- Roller Mono block built up with following high alignment and perpendicularity of components,

- Mono block punctuality and so for better bearing position establishment,
- Well-tried kinds of labyrinth like or stylus razor sealing,
- New technologies – machines for roller tooling – parts, also for direct roller welding, assembly, surface treatment etc.

Which cardinal findings – solutions – procedures influent the roller quality?

- Rollers monitoring in practice including competing business and theoretical dependencies
- Demonstration by calculation and by measuring of risk factors dependence on quality/poor quality for example,
- Theoretically featured roller deflection factor has 10 times lower weight than alignments errors,
- Assignment that by roller not alignment happens "tension" between parts, that
- The tension makes vibration, warming, following devaluation of lubricant, its desiccation,
- Lack of functional lubricant will cause following destruction of bearing and roller and so on,
- But accurate setting of bearing allows roller easy sinuosity,
- Easy sinuosity lowers a noise and vibrations and extends a lifetime of the roller heart – bearing,
- Recording of know-how and constant increasing of quality - getting better in Tranza a.s.

Conclusion:

The risk factors of a poor quality of rollers are inaccuracies, not alignment and angle of parts for bearing setting, and many producers underestimate it. The risk is also an insufficient defining of conditions of operation with a customer and their observance.

Tranza a.s. is aware of these risks of roller production and so for it is thoroughly treated with great care with a regard to a target to supply high roller quality to the customers – subscribers.

As a technician in quality I have monitored these characteristics for a long term.

In the year 2003 within innovations I suggested a solution, which is patented.

The solution allowed lowering the costs for production for 12 millions per a year, to reach the best world characteristics in a bearing setting and a roller alignment, and also to weld the whole roller with airspace without tooling. Consecutively it means a complex technology change in the company, what the appendixes document.

It also means logistic improving, reduction of machines and also the whole area for production.

Application of Magnesium Alloys - Market Research

B. Košetická, L. Zeman, J. Zahradník

barbora.koseticka@fs.cvut.cz

Department of Management and Economics , Faculty of Electrical Engineering, CTU
Horská 3, Prague 2, 128 03

Due to high strength properties and low density magnesium alloys are still more and more used for various applications especially in automotive and electronic industry. The consumption of magnesium alloys has been multiplied 4 times during last 10 years, whereas the United States is the greatest consumers of magnesium casts. It is supposed that the total magnesium demand will show out further growth – nearly 100 000 metric tons till 2010, mainly for die casting applications. Furthermore, Europe market of die casting applications is thought to progress the most.

The aim of this study consists in finding out actual applications of magnesium alloys in the Czech Republic. Moreover we had purposed to arrange contacts with companies interested in co-operation with Faculty of mechanical engineering on future projects in this field.

For achieving these aims a literature search focused on magnesium alloys properties and its applications had been firstly done. Then the concrete foreigner products made from magnesium alloys had been find out through Internet and different literature. These particular products had been ranged by its technology next.

Information about magnesium supply and demand had been also assembled. According to IMA market trends analysis an application forecast for die-casting industry is very favourable.

Based on this information market research aimed at application of magnesium alloys in the Czech Republic has been designed. Objective of this survey had been to map applications of magnesium alloys in the Czech Republic and thus to map actual and potential producers of magnesium alloys products. For this purpose Czech producing companies have been searched out via internet. These firms have been chosen from following branches of industry: automotive industry (producers of cars, automotive trucks, commercial vehicles, automotive components, producers of motorcycles), aerospace industry (producers of planes, aircraft structures, aircraft engines, ultra-light aircrafts), consumer and electronic industry (producers of garden equipments, electric and hydraulic tools, different instruments, sport equipments, bicycles, parts for communication engineering, cameras, notebooks, mobile phones).

Furthermore, for finding out potential producers among Czech firms which think of producing Mg parts and for arranging contacts with them, aluminium foundries had been taken into account. This consideration had been made for this reason: Die casting technology is forecasted growing the most in the future.

These assumptions for this marketing search had been formulated:

1. Only few producers of final goods in the Czech Republic use Mg alloys parts nowadays.
2. Producers of final goods in the Czech Republic consider about future use of Mg parts.
3. Only few Czech foundries produce Mg parts nowadays.
4. Czech aluminium foundries consider about future production of Mg parts.

As result of previous information, considerations and assumption two variants of questionnaires have been created – for each aim one questionnaire. One questionnaire destined for producers of final goods and one for aluminium foundries.

The first questionnaire with cover letter has been sent to 250 companies by electronic mail. The second questionnaire with cover letter has been sent to 55 aluminium foundries by mail.

From 250 sent electronic mails 27 responses have been obtained. 13 companies have sent positive responses at least to one question. It has confirmed actual applications of Mg parts for producing these final goods: aerospace industry (cylinder block, elbow and valve covers for ultra-lights engines), electric tools (lever, gear box, case with cover), grass cutter (Mg sheets). In majority cases these products are cast parts machined and surface finished. In future, companies plan these applications of Mg alloys: interior parts of aircrafts and cars, cutting of bodies of optomechanics assemblies, cast parts for grass cutter and other parts for electric tools. 9 companies were interested in possible consultations. From some responses it results that companies are not well informed about possibilities of Mg parts. 6 companies would like to cooperate with Faculty of Mechanical engineering CTU.

The rate of responses for the second questionnaire has been 51%. 28 responses out of 55 letters sent by post. 10 foundries have not envisaged the possibility of casting Mg parts at all. This questionnaire has awaken a great interest in the case of others foundries (18). Each of these companies would like to cooperate with Faculty of Mechanical engineering CTU. 15 of these foundries plan to start the production of Mg cast parts: automotive industry, aircraft industry (gear boxes and crankcase for aircrafts engines), optical industry, defence industry, textile industry (parts of textile machines), hand tools, parts for bicycles. Automotive industry has been mentioned for many times.

The results of this market search have confirmed preliminary assumption. Based on obtained results we can conclude that the rate of Mg alloys applications will grow even in the Czech Republic.

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Companies' knowledge of Competitive Intelligence in the Czech Republic

M. Marc

marc@karnet.fsih.cvut.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horska 3, 128 00 Prague, Czech Republic

During last year 2005 we realized a marketing survey with a title: Using external information by companies in the Czech Republic. The survey is a part of a project, which was founded by the Academy of Sciences of the Czech Republic and which takes a title: Knowledge base for searching and development synergistic entrepreneurial groups.

Marketing survey was realized by Internet form, in the very user-friendly environment. The survey is placed at the Internet page http://www.klastry.scip-czech.cz/. We formed so Internet application, which make possible to gathering information, answers from the respondents. Respondents answer to the questions, base on previous responds according to defined scheme. The survey is formed as a web application using HTML technology, for generate pages is used PHP technology and for saving data is used a FIREBIRD database. PHP Interpreter runs such a HTTP module of APACHE server, which at the same time provides static data. Web page is divided to the three basic parts – head, transactional part and bottom. The head is a static item and defines design of top of the page. The head is same for all pages in the survey. The transactional part is a main part of the page. Questions are dynamically generated in this part of the survey according to previous responds of the respondent. The bottom defines a design of the bottom line of the page; it is static item, which takes information about survey – information e-mail, scheme of the survey in PDF format and guarantees' logos. The bottom is same for all pages in the survey.

The goal of the survey was to map using of external information in the Czech companies, to define companies' knowledge of Competitive Intelligence in the Czech Republic and to find possibilities of potential cooperation with respondents. Main areas of questions were topics: external information gathering, external information analysis, problems pair with external information gathering and external information analysis and companies' knowledge of Competitive Intelligence and Business Intelligence. We addressed companies by e-mail form with the aid of members of project team and several organizations, with which we cooperate intensive. We concretely used a database of companies from the Economic Chamber of the Czech Republic, a database of companies from cluster Omnipack – members of cluster Omnipack and a database of companies from members of the project team.

We addressed more than 1000 companies by the cover note. Outs of the survey were worked up from 60 responds. It means about 7% backflow. Branches, in which companies do their business, are represented almost fifty-fifty in the survey; the greatest representation is from the banking, finance, services for company and consultancy areas. More than 83% of the interviewed companies have declared their interest in the results of the survey and would like to get more information about the area of Competitive Intelligence.

The sample of respondents in this survey has the following structure: 85% companies have more than half of the Czech capital, 15% companies have less than half of the Czech capital - dominate foreign capital. 57% companies with 49 or less employees, 14% companies from 50 to 149 employees, 10% companies from 150 to 249 employees and 19% companies

with 250 employees or more. 48% companies with average annual sales below 50 millions CZK, 8% companies with average annual sales of 50 millions CZK to 100 millions CZK, 44% companies with average annual sales over 100 millions CZK. Development of sales over the last five years: 67% companies have rather increasing sales, 24% companies are remained the same sales and 9% companies have rather decreasing sales.

In the following text, I am going to mention several interesting outs of the survey. At First I will mention answers to the question if the companies have sufficiency of external information. 88% of the companies have enough external information about competitors, 71% of the companies have enough external information about partners, 45% of the companies have enough external information about development of technology, 69% have enough external information about market trends, 89% of the companies have enough external information about customers and 69% have enough external information about products.

One half, exactly 51% of the interviewed companies, is not aware of the expressions Competitive Intelligence and Business Intelligence at all. On the contrary, 32% of the respondents know exactly the meanings of both Competitive Intelligence and Business Intelligence, 14% know only the expression Business Intelligence and 3% know only the expression Competitive Intelligence. Out of the half of the companies aware of Competitive Intelligence and Business Intelligence, 65% use Business Intelligence very often, often, or sometimes for their decision making. Competitive Intelligence is used very often, often or sometimes in 55% of the cases. In addition, 67% of the respondents aware of the Competitive Intelligence are confident that Competitive Intelligence can influence corporate strategy, and 14% are not sure; the remaining 19% do not believe Competitive Intelligence could influence it.

At the end I would like to say that companies' knowledge of Competitive Intelligence is growing gradually in the Czech Republic. Companies begin to come to realize that the Competitive Intelligence is able to notably and positive influence their corporate strategy. It is not by chance that in the year 2005 was established association SCIP CZECH, which groups members of international organization SCIP – Society of Competitive Intelligence Professionals in the Czech Republic and which deals with questions of Competitive Intelligence. More information about mentioned associations you can find at the Internet pages: http://www.scip.org/ and http://www.scip-czech.cz/. Thanks to survey, we could find very interesting contacts.

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Professional Equity of Men and Women in the Czech Republic

L. Dostálová

lucie.dostalova@pragonet.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 120 00 Prague 2, Czech Republic

Equity of men and women is a core principle of Acquis Communitaire established in the Treaty of European Union [1] and rooted in the legal practice of the European Court of Justice. Provisions of the Treaty declare, that equity of men and women represents "mission" and "goal" of the Community and sets its member states the positive duty to "develop" it in all its activities. One of the finding principles of this equity in the whole EC [2] is also equity of men and women at work, equal remuneration for men and women as well as non-discrimination among different nationalities at work. This is why a special grant was opened in the new member states to find out how the equity in business and professional life is followed and what kind of tools there are in the place to promote and ensure it.

I have acknowledged that situation of women in the Czech labour market is strongly influenced by their position and role in families and how men perceive their position. These perceptions, often described as „stereotypes", are lasting for a very long time and are very difficult to change. Among these stereotypes that has been shown in surveys belong for example that 80% of the Czech population perceives that women must take care of children, 76% of men and 87% of women think that men has better conditions for professional life... just 21% of the population thinks that women are able to cope with managerial posts etc. It means that discrimination is born out in the thinking itself of people. But a recent survey done by Median [3] shows that perception of men is changing – 62% in the CR and even 69% in Prague are willing to take care of children if women has higher salaries then they have, which was in the past something unthinkable.

It is true that the CR is just at the beginning of implementation of equity between women and men. But this question is not completely new – the basics for it were set already during the first republic by T. G. Masaryk, who was writing in his articles about this topic and also was fighting successfully for women to get their voting rights (they got it in 1919 while in many Western countries it was even 30-40 years later). During the era of communism a formal equity of women and men was in place. It was common that women work, but they often did inferior jobs and were not represented in managerial positions. The question of equity of men and women was brought back to light as far as in 1998 in connection with the entry into the EU. This mainly includes acceptance and implementation of EU legal system. However the changes do not depend just on a legal/institutional framework, but also on other factors like education, human resources, financial resources and control mechanism, which has been shown in my survey too.

Main transfer of the Acquis Communitaire in this sphere has been introduced into the Czech legal system by Law No. 155/2000 and by the Amendment to Labour Code valid since May 1st 2004, the entrance day of the CR into the EU. So how does the situation looks like?

Fight against discrimination between women and men

Remuneration of employees in the Czech Republic is regulated by Remuneration Act No. 1/1992 of Collection and Act on Remuneration in the Public Sector 143/1991. Both of them based on the Declaration of Human Rights and Freedoms, which also sets the right for a justified reward. Amendment No. 217/2000 of Collection has introduced the guideline about

equal remuneration into the Czech Law. Despite of that the average wage of women represents just 73,3% of the men ones (wage per hour) and this number has been levelling off for a longer period of time. Unfortunately, up to now, there are no legal prosecutions from those women, who can be considered as victims of inequity.
There is also another tool for "mainstreaming" which is a government decree, a yearly updated document. There is also Governmental Council for Equal Opportunities of Women and Men – established in accordance with the Order of Government dated 10/10/2001. The Council consist of 23 members, 13 of them being women – but since the beginning of 2002 till the end of 2003 just once the body reached quorum, which proves little interest of its members to execute their role, which is so desirable and important.
Equal treatment at work – provisions setting this principle can be found in guidelines No. 76/207, 97/80 and 2002/73 and were also introduced in the CR by many Acts (Labour Code, Act on Employment and Civic Procedure Act). The Amendment of Labour Code that entered into force in 2004 specifies what is direct and indirect discrimination, sexual and moral harassment. An employee, who has been harassed, has right to demand that such behaviour stops, results of it are cleared up or in more serious cases he/she also gets appropriate compensation including compensation for his/her moral harm.

Harmonisation of family and professional life

The goal is to increase number of fathers who are on a parental leave, currently about 1% (for comparison e.g. in Germany it is 5%, in France roughly 3%). Very positively were evaluated different subsidies and regulations (like the new possibility to get parental allowance and at the same time work without any limitations), which should lead into increase of birth rate, in the CR on a very low level of 1,17. On the other hand the Lisbon criterion to get women employment rate of 60% is almost fulfilled in the CR 56,3 i.e. deficit only 3,7%, which is positive. (Men employment rate is 77,6%, unemployment rate men 7,1% and women 9,7%, part time jobs women 8,5% and men 2,3% [4]).

To sum up, it is necessary to say that on the enterprise level the situation is far from satisfactory. Unfortunately, just every 4th company took part in this survey, so altogether just 13 companies responded. Among the most common reasons why the questionnaire has not been filled in were these: this topic is not their priority topic. Representatives of employees claim that more control, auditing and education about this topic would help to improve the situation in their companies. However, there was at least one positive result – even though majority of companies does not work on Equity of Genders, they follow Equity of Opportunities Equity (established mainly in their Ethic Code and other internal documentation).

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Utilization of the Business Intelligence in the Engineering Industry

Z. Jobánek, K. Smetana

jobanek@decision.cz, kamilsmet@centrum.cz

CTU, Faculty of Mechanical Engineering, Dept. of Economics and Management

Horská 3, 128 03 Prague 2

Business Intelligence (BI) is sometimes called as a MIS (Management Information System; in Czech: Manažerský Informační systém) or in general system for decision making support. Often is BI thought over as a complex of applications and technology focused on collection, storing, analysis and accessing of data. Broad issue of BI is focused on conversion of data from business systems in information. More precisely in information which can be used for strategic decision making or generally for improve the quality of decision making cycle.

When we talk about BI; it is collection of tools as are data warehouses, other management applications, analysis OLAP, working with dimensions, reporting, Data Mining and others.

Decisive for BI using is the way, how the company management wants to work with data. It is useful to define a suitable strategy. It is a question if management will see the information as a strategic source or not. BI does not mean only to buy a box of software and idea that it will works, but mainly it is philosophy and strategy how to work with data.

Within the companies there are many different systems which can be connected together, or not. The result is very great amount of data which are spread through a company. But it depends on a particular company situation.

BI systems can cover in the whole look and can access to company data. They can ensure look through company processes and data.

Important part of the BI is ability to store and process great quantity of data which are still cumulate in a company.

These systems can be widely used in all engineering companies. Thanks to BI; it can be achieved better competitive and complex sight on company. It is great advantage to use multidimensional sight on selected indicators which enables to change different views and sensation of data in different connections.

In brief, main benefit of these systems is to enable complete analysis of company data. Great hazard is an amount of manually processed data and impossibility to take advantage of Data Warehouse.

When we talk about BI implementation we must to mention the definition of strategy how to work with data. Then we can start thinking about software solving and about robust IT platform. It is important to know who will work with BI and how. Target is a state, when BI is widely used by entrusted employees and really helps to find answers on important questions.

Necessary condition is an ability to consolidate existing data warehouses and work with entire company data. Analysis contains both basic form of analysis, such as reports, queries, and advanced analysis as OLAP, Data Mining for example.

In fine we have to say, that BI can not replace the human decision making, but in ideal state it can help to make quality and fast decision making and globally improve effectiveness of the company.

Application Software for Project Risk Evaluation

V. Beran, Z. Prostějovská, P. Dlask, E. Hromada, J. Frková

beran@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, CTU in Prague, Thákurova 7, Prague 6

The technical project processing is a rule at the end of the solution selection. The criterions for evaluation can be utility, economic, ecology, strategy in-groups, etc. The quantitative evaluations of the single construction parts are available from the project processing. Aggregated value, which evaluates complete project, is not always available. The designer has neither static nor dynamic values, nor the one describing the risks of the proposed solution available.

The question of the engineering (technical) reliability conception [2] and economic view [3], [4] concerning risks, uncertainty, indeterminateness, reliability differs both in conception and methods. The connection is not directly portable from the view of the theory availability, but as regards of loosing information when establishing aggregates for final economical information. The technical disciplines have a more definite way to access data. They solve exercises with explicitly defined inputs; create solutions without links to higher aggregate parameters.

The modern project documentation process is being practiced in the environment of efficient CAD application systems. Its architectonical and technical outputs are on the high level. Economical resumes are on the level of the quantitative parameters and its financial analysis. Application tool evaluating the quality of respective construction parts and their risks are not processed with for the concrete solution above.

The realization software (such as Microsoft Project) sufficiently provides information about terms and balance sheet of sources. Currently, it is not possible to obtain reliable values of the terms and balance sheet of sources from risk calculation otherwise then using the Monte Carlo method.

In the risk and reliability evaluation process 2 project phases are recognized:

1. Project solution
2. Realization solution

The project solving suggests project decomposition into individual constructional parts in required details. The realization solution divides the project into activities and defines links among these activities. Every attribute (constructional element in project, activity in a progress chart) is complemented by a risk interval, in which will the actual value in realization process appear. In the frame of this interval, possible disturbances by technical processing or final realization process are simulated.

Every evaluation level has its evaluation weight (v_i). By aggregating a lower simulation level, we can get a higher evaluation level. After aggregation all lower levels we obtain final evaluation of the complete project including statistical and especially value-reliable data (e. g. reliable termination of realization processes).

Except the project risk investigation, it is suitable to also create parameterization studies. The parameterization of changes engaged into exercise presents an area in which the solving can/should be carried out. The question of reliability of given questions has a key meaning. From time perspective, the future data are negatively influenced:

- Probable occurrence of changes in the primary propositions of the project,
- Risks,
- Uncertainty,
- Indeterminateness.

Their sources can in the initial stage be calculated and evaluated. From this point of view, reliability questions mean important information. In technical disciplines, reliability definition [2] is generally accepted as follows:

The reliability equals the probability that system fulfills its function in the time defined and given specified conditions.

In the economic disciplines, we mostly are working with risk evaluation, to which the preconditions of the exercise economic setting are exposed.

We can write $R(t) = \sum P_{fi} C(t)$, where P_{fi} are disturbance probabilities of presumptions connected with penalty parameters C(t).

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Methods and Software for Reliability Estimation of Risk Evaluation

V. Beran, Z. Prostějovská, P. Dlask, E. Hromada, J. Frková

beran@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, CTU in Prague, Thákurova 7, Prague 6

Risk analysis is new a discipline that determines the success of technical economic projects. We can divide *Risk analysis* into two branches

- construction and design risk analysis,
- economic risk analysis.

The development in construction and technology carries new *hazards,* which endanger construction projects. The adoption of new construction production technologies involves some degree of hazard to project developers. This is especially true when new knowledge is not tested at technical or commercial scales. In these situations project hazards are difficult to analyze. In economical risk analysis, the entire project through wide risk scale and its influence on efficiency and commercial attractiveness is analyzed. In these analyses, it is essential to use time value calculations because all hazards are usually classified through their time dependent influence on costs and benefits of projects.

According to [1], [3], risk is defined as potential harm that may arise from some present process or from some future event. It is often mapped out to the probability of some event, which is seen as undesirable. Usually the probability of that event and some assessment of its expected harm must be combined into a believable scenario (an outcome) which combines the set of risk, regret and reward probabilities into an expected value for that outcome.

In professional life we can encounter many kinds of risks (e.g. constructions risk, production risk, technological risk, inflation risk, economic risk, mortgage risk, liquidity risk, market risk, opportunity risk, income risk, interest rate risk, prepayment risk, unsystematic risk, business risk, event risk).

Risk analysis is a part of the entity's risk management beside risk management planning, risk identification, risk response planning, risk monitoring and controlling. Risk analysis is an integrated process and all of its partial processes must be calculated.

A range of approaches and techniques to risk analysis exists.

- *Tree analysis* – it can be used in the model of consecutive decisions, appropriate for construction and production design;
- *Sensitivity analysis*;

Standard deviation – the risks are identified with a standard deviation σ related to the expected value.

Distinct approaches to risk analysis are basically broken down into:

Quantitative Risk Analysis (*QRA*) approach employs two elements; the probability of an event occurring and the likely loss should it occur in (1), calculations are accomplished by simulations. If *QRA* is calculated as the *Annual Loss Expectancy* (*ALE*) or the *Estimated Annual Cost* (*EAC*), losses are multiplied by the probability. SW products related to are e.g. CRAMM, @RISK, RiskPAC, MDAP, and UMRA.

Qualitative Risk Analysis (*QLRA*) is by far the most widely used approach for risk analysis. Probability data are not required and only the estimated potential losses are evaluated. These methods are more subjective than *QRA* and the results depending on the concept of risk preferences.

The proposed application software carries out simulations of the time and cost schedules of building activities. The simulation of the building process (building activities) makes it possible to monitor the reliability of expected time schedules and total costs depending on such input parameters as production speed, scope of work, time schedule, bonding conditions, maximum and minimum deviations from scope of work and production speed.
In the first year of research there has been created a version 1.0 of the application software for reliability estimation and risk evaluation of development projects. The application is able to carry out simulations of simple building processes. In the next year of research the application is going to be markedly extended (e.g. a module enabling selection of any bonding condition, compatibility with standardized file formats, etc.).
The application software for reliability estimation and risk evaluation is possible to use at many levels of project management.
The application software carries out time and cost simulations of building activities from input parameters. On the basis of a statistical evaluation of enacted simulations a program algorithm calculates the assumed cost and time frames of particular building activities.

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Integration Features of Scenarios Application in Enterprise Control

B. Garajayeva

bahar.garajayeva@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering,
Czech Technical University, Horská 3, 120 00 Praha 2, Czech Republic

Integration was and remains the central objective of the enterprises of large and average scale. The consequence of the highest extent of integration is the situation when the enterprise control (system) functions effectively with the results which are more closer to the planned results, and when the number of critical situations into the enterprise management is reducing. The management tools play a major role in providing the integration in the enterprise control. Unfortunately, nowadays little attention is paid to the researching of this integrative role of the management tools in the enterprise control, especially to the role of such tool as scenarios.

The scenarios are the stories about how the future might turn out. It does not mean that the Scenarios are the quasi-forecasts but the perception devices. Scenarios are set of reasonably plausible, but structurally different futures. These are conceived through a process of causal, rather than probabilistic thinking, reflecting different interpretations of the phenomena that drive the underlying structure of the business environment. Scenarios are used as a means of thinking through strategy against a number of structurally quite different, but plausible future models of the world. Scenarios are the management tool, which are relatively simple in comparison with other tools, so they are not so interesting from the theoretical point of view. However, their significance for providing the integration in the enterprise control system is high.

The subject of my research effort is to investigate the integrative role of scenarios in enterprise control.

During my research I am considering these major integrative features of the scenarios:

Technical - economic integration. Scenarios are essentially a form of modeling of the future; in the same way Scenario planning can be use as a "wind-tunnel" analysis for designing success strategic. Enterprises during that analysis can design some techniques of behavior in different situations, what can help them to react quickly to changes in environment, thereby to improve their economical results.

Integration of plan and actual values of indicators. Scenarios are the strategic tools, they helps to determine and set the targets, indicators, which are necessary to achieve and the objectives and initiatives that lead to that achievement. It is possible to determine the plan values of indicators, which can be compared later with their actual values. It is allow to calculate the deviations and to make arrangements for correction.

Integration strategy into all levels of plans. . Thereafter Using the Scenarios allow the Enterprises to follow the deviations on all levels of plans and accordingly to correct the strategy or plans.

Time Integration. During the Scenario development is researching past and current issues in the enterprise, which is help to discover when and why changes had been experienced. It helps an organization avoid repeating mistakes.

Integration with enterprise environment. At the same time, there is analyzed the enterprise environment. In contrast to forecasts, which are based on the assumption that the

past can be extended into the future, Scenarios, during modeling the future, takes into account the uncertainties and ambiguities. It helps to see more objective picture of enterprise environment. As it is well know, the organization needs a good fit with its environment if its aims are going to be achieved.

Personal integration (Vertical and horizontal integration)**.** Scenarios are written by not one person but by a group of people, which are completed by the employees of enterprise from the different levels, from the different departments. Scenarios are the managerial tool, which bring people together towards a shared understanding of the situation.

Data integration is actually realization phase of foregoing integration features, because data are the elements, with which is worked during the economic activity of enterprise. Thus the data integration is necessary for functioning of the enterprise control system.

The aim of this article is to describe main feature of integration, which are covered by Scenarios, and to afford a wider view on potentials of this managerial tool for the enterprise control. The Brief description of the integration features of Scenarios show their significant integrative effect in spite of the notion that this managerial tool is not interesting from the theoretical point of view.

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Information and Expenses for a Decision

J. Dřevo

drevo@fsv.cvut.cz

Department of Applied Informatics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

When managing a firm, it is necessary to make a lot of decisions. The decision-making process (decision-making) means selection of a single option (variant) out of several options. The individual who makes the selection is called the subject of decision-making (decision maker, participant in a decision-making situation). The set of mutually dependent elements and conditions which determine the decision shall be called the decision-making situation. The solution of the decision-making situation is called the set of options that were selected in decision-making.

A correct decision is considered to be selection of the most advantageous variant. A rate of advantageousness is usually formulated as a certain function of a yield and invested expenses.

When making intelligent selection, participants in the decision-making situation must assess individual options. An assessment shall stand for determining the difference (distance) of consequences of an examined option from a certain required value. A quantified set of objectives which are to be achieved shall be called a norm in this context. Let us make an observation that a norm understood in this manner need not be achievable, a decision-making situation need not include an alternative whose selection leads to achieving the norm.

The subject of decision-making makes an assessment of alternatives by means of a single or multiple criteria (characteristics). Making an assessment according to a single criterion is called a mono-criterial decision-making situation or a decision-making situation with a scalar assessment of results. Making an assessment according to multiple criteria is called a multi-criterial decision-making situation (multi-criterial decision-making situation with a vectorial assessment of results).

According to the succession of consequential decisions, decision-making processes are divided into single-stage and multi-stage ones. A multi-stage decision shall refer to the decision-making process in which the decision maker disposes of information on consequences of his or her previous decisions and utilizes them for improving his or her decision-making.

Typically, a decision-making process proceeds in the following stages:

- description of the decision-making situation and of its environment
- recognition of a set of alternatives
- ascertaining and assessing consequences of individual alternatives
- selection of the best alternative

Benefit and Preferences

In order to describe a decision-making situation precisely, it is necessary to assess consequences of individual options. Let us assume that it is possible to find a real number which characterizes the consequence of a given decision maker's selection of each alternative. This number shall be called benefit. The function which transforms the set of alternatives into the set of real numbers shall be called the function of benefit for a relevant decision maker. The order in which the decision maker prefers individual results shall be called the decision maker's preferences. There are numerous methods of transforming preferences into benefit.

Multi-Criterial Decision-Making

The task in which we are supposed to assess options according to multiple criteria shall be called multi-criterial decision-making tasks. A solution of such tasks usually consists in transforming information available on individual variants as well as on a decision maker's intentions.

The task of a multi-criterial assessment of options is given by a set of decision variants, which shall be called A, and by a set of criteria. Concerning tasks based on the real world, the set A contains a finite number of elements. The number of elements in the set A shall be designated p. The number of criteria shall be designated k. Each variant is then characterized by a k-dimensional vector of parameters $a \approx (y1, y2, \dots, yk)$. A non-dominated variant is the variant for which there is no other variant with better values of all criteria.The variant univocally recommended for selection shall be called an optimal variant**.**

Expenses for a Decision

Decision-making itself also requires certain expenses. Attempting to achieve better recognition of a decision-making situation and, consequently, to achieve a decision of higher quality results in increasing expenses. A higher yield is usually obtained, but at the same time expenses are raised.

It is even possible to come across an event in which we find out after including decision-making expenses in expenses for a selected variant that a less perfect decision or even arbitrary but low-cost selection could have been more advantageous.

Decision-making expenses consist of expenses for finding information, for recording them, for storing the information, and of expenses for processing the information. When attempting to achieve higher accuracy, especially the expenses for finding the information rise steeply. It is then practical to estimate useful accuracy and refrain from further examination of conditions.

Strategy of Approximate Selections

Let us imagine a model decision-making situation of selecting a device which is supposed to satisfy a certain need. Offers differ in price, in operational cost value and in various probability of defects. A maximum yield of a correct decision shall then be the difference between an (expected) price of the most expensive and the cheapest variant. Provided that selection procedure expenses exceed this amount, the better decision has actually resulted in our loss.

In such a situation, it is suitable to use the strategy of approximate selection. For example, we can examine only a part of a set of offers and select the best one of those. We cannot suppose that the best variant has been selected but we are certain that the worst one has not been selected. It is probable that an above-average variant will be selected in this manner.

In the event of repeated selections, a similar decision-making situation being repeated, variants are described by means of identical criteria, it is possible to ascertain which parameters correlate to the greatest extent with overall quality of a variant; therefore, a heuristic decision can be made (only on the basis of certain parameters).

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Structure of Planning Model PP

M. Plachý

Plachy.m@tiscali.cz

CTU in Prague, Faculty of Mechanical Engineerign, Institut of Enterprise Management and Economics
Horská 3, 128 00 Praha 2

1. Introduction

Enterprise management in a turbulent age requires the application of new managerial tools. One of the new managerial tools is the approach "Activity Based Management (ABM)". The annual enterprise product sales structure planning is one of the effective ways of the application of the ABM. For the efficient ABM application IT support is needed. In case there is no special software on disposal, excel application can be developed to support planning and plan evaluation.

2. Model solution

The Model software support has been prepared for a manufacturing enterprise, which produces working machines (rollers).
The company is split into eight centers.
Manufacturing centers
- Assembly, Machines, Welding and Components

Non-manufacturing (overhead) centers
- Development and Administration

Service centers
- IT and Maintenance

The company makes up annual plan in the production groups:
- Pneumatic roller – basic
- Pneumatic roller – electron
- Pneumatic roller – platform

Each production group consists of the variant types:
- Small pneumatic roller – basic
- Medium pneumatic roller – basic
- Large pneumatic roller – basic

It is possible comply each type with particular customer requirements.
The costs are split into two groups (direct costs and indirect costs)
Direct costs
The product manufacturing in manufacturing centres develops these costs and they are allocated to products. They are not accounted in manufacturing centres.
Direct costs of the product are defined in this structure:
- Direct material, Direct cooperation, Direct components and Other direct costs

Indirect costs
These costs are linked to the centers, because they are actually centers-costs. They are accounted in the centers (cost centers). These costs are determined by the cost capacity and facilities.
Indirect costs are in structure:
- Labor costs, Depreciation, Energy, Tools and Other costs

Costing
The costing system is based on two methods:
Hour overhead tariff (HOT) method - the HOT is calculated for each centre as the rate between the total overhead cost of the centre and the total capacity of the centre. This HOT may be calculated for each centre except the Administration centre. In the Administration centre, it is impossible to allocate the activities (the costs) to the products.
Multistage contribution margin - for determine the product profitability the contribution margin is used. In this model the contribution margin is split into six stages (sub-margins). The biggest managerial advantage of multistage contribution margin is its transparency in costing system. Each stage of CM is useful for managers in their decision-making.

The model is determined for simulation of product sales structure in relationship to profit (product contribution margin).
In the Costing part of the Model is possible to fluctuate the quantity of the products and the prices of the products. For each alternative the Model calculates the total company profit using the multistage contribution margin and capacity utilization in each centre. The Model also calculates the particular contribution margins for the product groups.

IT support for the Model
The Model software solution is built in Microsoft Excel Environment. Even only, the standard program tools are used. To the greatest advantages of using standard spreadsheet programs belongs: availability, general knowledge, possibility to link with other excel application, using excel facilities (graphs, etc.) and easy use.

3. Conclusion
Working with the Model is useful for the understanding (comprehension) of relationships and consequences of basic factors influencing costs, capacity utilization within the capacity limitations and therefore the product contribution margin and profit. Every decision about products (technical parameters, design, manufacturing, etc.) has a consequence to costing and capacity utilization. To balance product sale structure according to the customer orders belongs to the important features of the enterprise management.

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Different Approaches to Risk Analysis

J. Klvaňa

klvana@fsv.cvut.cz

Department of Applied Informatics, Czech Technical University, Thákurova 7, 16629 Praha 6

Definitions of risk, classification of decision making situations

Risk is usually defined as
- danger of wrong decision
- danger of loss (which can be measured not only in monetary units)
- danger of undesirable deviation from planned objective

Of course all these characteristics ("definitions") of risk are little bit indefinite and many times hardly transformable into exact form. Nevertheless they enable to bring to the risk analysis definite order and rules.

The decision maker furthermore distinguishes between decision making under risk (in that case we usually suppose, that risk can be somehow measured, see below) and decision making under uncertainty (in that case the decision maker has not any iformation about future situation, not even in the form of probabilities).

Assessment:
This approach to risk analysis can be indicated as
- verbal
- classifical (taxonomic)

It is more pragmatic than scientific aproach. But we can't refuse it, because it makes the problems of risk analysis more transparent. At the same time it is the first step to risk management.

Measuring of a risk

The first possibility is the verbal ordinal scale.
Example: Risk none (zero risk), slight, low, medium, high, considerable (very high), total (certainty of failure).
Assessment:
The same as before.

The second (more frequent) possibility of measuring of a risk is application of approaches and concepts used in probability theory and in mathematical statistics, which are founded on features and sense of probability, probability density function, probability distribution function, correlation coefficients, dispersion and standard deviation respectively.
Assessment:
This approach is exact and objective regardless if it is used objective (classical or freqency based) or subjective definition of probability. It is also the first necessary step to risk management.

Risk management

Elementary methods

Elementary principles for succesful risk management are known from many commonly accepted rules as:

- don't risk too much for a few
- don't risk more than you can afford to loss
- in any situation plan the future
- always analyse the resources as well as the conseqencies of risk
- consult with proffesionals
- distinguish the controlable and noncotrolable risk factors

Assessment:
This approach to risk analysis can be again indicated as more pragmatic than scientific. But we can't again refuse it, because it is the first step to systems of risk management (SRM).

Systems of risk management (SRM)

This is more exact and rational approach to risk management, which consists in designing and implementing of SRM, which can be decomposed e.g. as follows:

- identification of risk
- classification of risk
- risk analysis
- controlling interventions

Assesment:

Approach contained in SRM is not only verbal. It is structured and results in designing and implementing of SRM, as in designing and implementing of information systems.

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Industrial Competition in Market Mechanism

T. Peterka

tomas.pet@seznam.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 120 00 Praha 2 , Czech Republic

Czech Republic turned to market mechanism in 1989. Czech economy has changed from directive economy to functional market mechanism of valid EU member in the last 15 years. Competition and especially its protection is dynamic sector with very quickly changing conditions [1-3]. The topic of the day for me is the way how the participation on economic competition influences particular company economies. I would like to dedicate my piece of work to direction; the Office for the Protection of Competition (OPC) goes in.

Main aim of competition law is to secure that markets in the Czech republic stay competitive while compliance of acts of competition subjects with the law leads to profits of not only consumers but also concurrent users. These, who respect the law would avoid to disfavourable results that could possibly, if law's not respected, happen. These results may be quite serious involving e.g.:

- Investigation of OPC including checking some very important private information
- Penalty up to 10 per cent of the last accounting period turn-over
- Deals between companies, not respecting the law, will be not valid and observance of such deals not compulsory and unforceable
- Reversed ad, loss of image and a good will
- Possibility of being judged by those who sustains loss by such acting.

OPC is the main factor affecting environment of competition in our country and its new chairman (M. Pecina) has notified complete change of atmosphere by preference of consultations in cases of possible corruptions of competition with participators to strictly repressive way, used until now. With such a policy corresponds Compliance program and a little bit also Leniency program [4].

Compliance program

It is absolutely necessary that the content of each program must be optimised to specific needs of each business and should include at least these basic principles:

- Support of program from management
- Suitable procedures and methods
- Advanced competition law education of employees
- Classification and controlling of program behaviour

The program shows basic frame securing that the law is respected by not only employees, but also by the all company. This program also helps with identifying problems with an unfair behaviour at the very beginning and let accept arrangements against it. Early unfolding of unfair acting and further cooperating with OPC can lead especially in case of cartel deals to applying moderate mode in punishment. (so-called leniency program). Formal

implementation of Compliance program to respect competition law by ordinary employees, managers and top managers is suitable especially for companies with a large market share. It is not a purpose of OPC to approbate Compliance programs of each participant company. Programs must be created and judged by particular competitors, who can easily react on changing needs, requests and aims of their organizations and therefore be responsible for usefulness and meaning of program.

Instrument used since 2001 called as **Leniency program**.

This programme is mainly focused on more effective fight with cartel deals, which are the most serious anti-competition delinquencies often leading to rising prices, artificial market barriers, limiting output and turn-out and usually turning against the consumer. That's the reason, why developed countries try to effectively unfold such deals. So-called Leniency program is the program of applying moderate mode in fine punishment according the law # 143/2001Sb., about the protection of competition for cartel deals. The first competitor coming with the evidence of existence of forbidden deal, not known to OPC and confessing being participant of such a deal can get reduced or canceled penalty. This program is applied by OPC since 2001 as the seventh country all around the world. OPC suppose obtaining crucial information and evidences from participants of illegal deals expecting less economically harmful impact as a fine. It needs to be pointed out that application of this program is tied up with fulfilling of condition of OPC, who is the only one who tells, in each period of affair.

Both of these programs, if applied, lead to clearer conditions and more effective behaviour of competition. This leads back to healthier and better prepared companies in competition mechanism.

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Work Restructuring and Labour Market

H. Pačesová

Hana.Pacesova@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering,Czech Technical University, Horská 3, 128 00, Praha 2, Czech Republic

This paper explores from different vantage points the interface bertween the restructuring jobs and the nature of the labour. It provides a theoretical assesment of the extent, to which manpower and economic parameters affect changes in the conditions of work. It presents an explicit analysis of major manpower and labour market transformations in industrialized societies and their influence upon the quality of working life. Finaly, it discusses the impact of the labour market on restructuring the workplace and the impact of selective societal trends.

Significant improvements with no quarantee-or even likelihood-of a proportionate increase in productivity. Nevertheless, since employers compete for labour, management may invest in improving the conditions of working life to the extend that it feels workers will see jobs in a better designet and better managed plant.

Most labour leaders are convinced that they have had a major influence upon improvements in the conditions of working life, although they have been peripherally concerned with the structure of production and styles of management. They have been influential in certain areas: moderation of the speed of assembly lines, limitation of weight-lifting requirements for people, rest periods, restriction in the power of foremen, procedures for layoffs callbacks.

Until the unions move, the speed with which individual employers will initiate new programs to improve working life is limited because of major constraints from the competetive market, the protection of managerial prerogatives and other demands of trade unions. Nonetheless, under governmental initiative the same forces that constrain experimentation can encourage it.

Modern gevernments have played a key role in strategic areas of work such as health , safety, amenities, hours, minimum wages, compensation systems, unemployment insurance-all of which have been broadly directed to improving the lot of workers.

A number of major trends in the labour market have a direct bearing on the quality of working life. It often has been observed that most social change does not result from policies and programs designet to check a particular danger or respond to specific opportunity, but is the consequence underlying forces which, individualy and in combination, alter the shape of things to came.

The first of this changes has been the shift from a goods – producing to a service – producing economy, a shift that warns against the use of the manufacturing prototype for analytical purposes, and especially warns against the assembly- line prototype,which currently describes the working environment. Although certain services, such as banking, communications, and insurance tend to be provided in large –scale enterprises with many of the characteristic found in manufacturing, a high proportion of all workers in the service sector are employed in small organizations.

A smaller number of workers remains in a working environment, in which output is strictly controlled. An increasing proportion of all workers earn their livehoods under conditions where the employer has difficulty setting norms, establishing the pace, and exercising close supervision.

A second major trend is the demand of modern economies for larger numbers of highly educated and well – trained personal. The growth of professional, technical and kindred workers has outpaced that of every other occupational group. Many of these workers are self – eployed, and some work without direct supervision. Others are employed in largr organizations, where they may be members of teams, whose work goals are set by team leaders, or they may even punch time clocks, as do many physicians, who work in clinics that dpend upon third-party reimbursement. Their assignments are often narrow and routine. Nevertheless, the conditions under which most of these service emloyees work differ markedly from those of production-line worker. Professionals, in particular, posses considerable orders of freedom from determine, how they work, when they work, and the quality of their output, and while all manpower projections are problematic, the odds favor a cotinuing absolute and relative growth in professional manpower.

A third change relates to women, whose participation in the labour forces of advanced industrial societies is increasing steadily. While the majority of female workers has tended to be employed less than full-time full – year, the career orientation of many of those, who are fully employed, particularly married women, seems to differ from that of the male prototype.

A fourth trend, whose influence and impact has not been given proper attention is the later entrance of people into the labour force and their earlier exixt from full-time employment. Little is known about the consequences of starting full-time work at age 24, instead of at age 14, but one may speculate that the longer the period of occupational exploretion, the higher one´s expectations. Similarly, with retirement benefits increasingly available after twenty to thirtly years of work, many workers in their early and middle fifties can change their life styles by shifting to a new type of work.

A fifth trend is a variation of occupational shifts because of early retirement toward the pursuit of second careers prior to retirement age. While still relatively few in terms of the total labour force, increasing numbers of workers are finding it possible and desirable to change their occupations in midstream. No longer satisfied with their first choice,they look around for new and more stimulating fields of activity. Sometimes they return to school or make other serious effort to prepare themselves for a carrer change. Earlier vesting of pensions, larger governmental expenditures for adult education and training, and higher personal incomes and savings will unquestionably accelerate this tendency.

A sixth trend relates to the steady decrease in hours worked per year. Total hours are decreasing because of more holidays, longer vacations, and paid absences to attend to personal affairs. In the long run there will probably be further reductions in the hours worked per year.

The trend toward second careers is enabling increasing numbers of workers to move out of fields that no longer command their interest engage their talents. Here again, it does not follow, that the choice of a second career will live up to expectation.

The reduction in working time also can be seen as a broadening of options. If workers find their work oppresive or uninteresting, the possibility of spending fewer hours on the job permits them to seek satisfactions elsewher. Despite its merits, however, this altwernative does not enhance the quality of life in the workplace itself.

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Business Cycles and Housing Development

A. Smejkalová, J. Frková, P. Dlask, J. Tománková, V. Beran

frkova@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, CTU in Prague, Thákurova 7, Prague 6

The three-year project "Research into Changes in Housing in the Czech Republic" (a grant financed by the GA ČR agency) will include an analysis of *Economic aspects of changes in housing.* In the part called "The macroeconomic housing context", an evaluation of the number of completed flats in relation to selected indicators was carried out. For the time period from 1919 to the present, the following analyses were developed:

- research of sensitivity of the number of completed flats in the Czech Republic to the amount of long-term interest rates,
- behavior of housing development in relation to the index of housing costs prices and the index of building materials prices,
- development of the average salary, the index of housing costs prices and the index of building materials prices,
- affordability of rented housing in relation to the average nominal salary,
- availability of commodities, such as bricks, cement, coal, gas, electricity, fuels.

The project involves the development of an application for the analysis of time-related series in the building industry allowing separation of selected variables and their graphic interpretation. The GRAC (Graphic Analysis o f Construction Data) is designed as a spreadsheet extension in the VBA (Visual Basic for Application) environment.

Further more, an analysis of Business Cycles and Housing Development was carried out from which the following extract is taken.

The analyzed time period from 1919 to the present has been subdivided into several shorter periods, which are characterized by various economic changes.

Period I Is the period of **expansion**. This period starts in 1919 and finishes by the year 1929. It is characterized by the construction of the new Czechoslovak economy and by post-war economic reconstruction, which was the most successful economic reconstruction in central Europe. The economic growth rate in the Czech lands was above the European average.

Period II The outset of the economic crisis, the economy falls into **recession**. The crisis lasts until the outbreak of World War II.

Period III The time of World War II for which no statistic data is available is not treated in this work.

Period IV This period is characterized by a dynamic, but unbalanced reconstruction of the economy and by a transition to centralized economy, which despite slight fluctuations, showed an enormous growth pace (the economy was in the stage of **expansion**).

Period V Another stage is the first half of the 1960s, which is characterized by stagnation to slight **recession** of the economy.

Period VI It is followed by another period of economic growth (**expansion**) starting from the second half of the 1960s.

Period VII In the second half of the 1970s, this dynamics of the economic growth is gradually fading, and the first signs of recession are manifested. In the 1980s, the indications of collapse grow stronger, and the economy gets to a standstill (**recession** of the economy continues). The period of centralized economy comes to its end in November 1989.

Period VIII It is followed by the last three years (1990 to 1992) of the common functioning of the Czech and Slovak Republics, which are still characterized by slight **recession**, even though not so strong as in the preceding period.

Period IX The last period starts around 1993 when the independent Czech Republic was formed, and lasts till the present time. In this period, there is a breaking point after which the economy finally starts to **expand**.

Relation of interest rate to housing development

We performed the relation analysis between the above-mentioned stages of the economic cycle in the Czech Republic and long-term average interest rates. The aim was to analyze to what extent the housing development in the Czech Republic is sensitive to changes in the amount of interest rates. When comparing the development of interest rates with the development of housing construction in the Czech Republic we find out that in each period the interest rate behaves in a different way than the development of the numbers of flats. As a successive step, a correlation between the interest rate and the number of flats was studied by means of the correlation coefficient.

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Using External Information in the CR - Survey Results Interpretation

M. Has

has@karnet.fsih.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horska 3, 128 00 Prague, Czech Republic

As a part of our project, we realized a marketing survey among Czech companies with a topic: „Using external information in companies". There were two parts of this survey. First was realized at the beginning of July, 2005 and the second round was proceeded at the end of September, 2005. During these two rounds we have collected 60 returns from 1000 responders, what means 7% backflow. We find it favourable, because it is typical for internet survey we used. We have established three goals of our survey: To map a using external information in Czech companies, Awareness of Czech Companies of Competitive Intelligence problems and to initiate a further cooperation with Czech companies. I will be briefly focused on the first goal: How do Czech companies use external information in business.

First question of this part is: „Do you gather information about area in which you run your core business?". Responder's aim was to choose most suitable answer (very often; often; sometimes; as an expectation; never) in six areas (Competitors; Customers; Partners; Products; Technology; Trends). The most requested area was marked customers; information from this area are gathered more then often; and the less asked area was technology; information from this area are gathered only more then sometimes. We had presumed these results. It is a trend of today's business and modern marketing, everything focuses on customer, and customer's needs are the most important impulse for a company. What we find very well is, that companies gather information in all categories more then sometimes and they do not want to stay in information isolation.

We obtain another look, whether we compare previous results of the information gathering with results of how companies analyze information. Especially we are interested in situations, in which is the minimal and the maximal difference. The smallest difference between information gathering and analyzing is in the Competitors area (information gathering: less then often; information analyzing: more then sometimes), which is obvious. Companies are aware of competitiveness and try to avoid it by gathering and analyzing information about competitors. I am very pleased with this situation, because Competitive Intelligence is a part of our grant and these results confirm necessity of having enough information about competitors. The biggest difference is in Partner area (information gathering: less then often; information analyzing: less then sometimes). This result represents opinion that companies do not find business partners as a significant source of threats. These two views showed situation with the biggest and lowest difference, but it could be also interesting to know, which information is gathered and analyzed at least. It is the area of gathering and analyzing technological information (information gathering: more then sometimes; information analyzing: more then as an exception) and I thing this is area of further potential cooperation; to improve using technological information for business e.g. effective using patents, white papers, conferences etc.

Next question of the questionnaire, I would like to present, is: „Which sources do you use mostly in these areas?". Responders were asked to mark used sources (companies' publications; databases; marketing surveys; internet; special papers; patents; reports and audits; special software; others) in areas mentioned above and it was possible to mark more

then one answer. In general look is the most used source special papers (47%) and internet (30%). I believe it is because companies are not able to find specific information on the internet. This opinion is supported by results of the next question: „What are the biggest problems assigned with information gathering?". Responders were ask to mark potential problems (It is expensive; information, we need, is not accessible; it is necessary special knowledge; it is necessary to have specific software; it is too time-consuming; it is not effective enough; others) and it was possible to mark more then one answer. The biggest problem is that information, which companies need, is not accessible (43%) and companies do not find information gathering effective enough (20%). I assume, that these results lead me to supposition, that companies do not have enough knowledge, which access information more easily and make the process more effective; but upon presented results, companies do not know they need special knowledge and they believe they are experienced enough. This situation I find difficult, because it will be hard to explain them they should educate themselves.

In the previous paragraph were mentioned sources and problems of information gathering and the same interest was applied to analyzing information. First question of this part is: „Which analytical tools do you use mostly in these areas?". Responders were asked to mark used analytical tools (competitor profiles; conjoint analysis; financial analysis; scenario development; simulation/modelling; war gaming; win/loss analysis; none; others) in areas mentioned above and it was possible to mark more then one answer. In general look is the most used analytical tool none (31%), win/loss analysis (17%) and conjoint analysis (16%). These results are very interesting (especially 31% of any analytical tool), because they boost previous supposition. I would like to present problems with analyzing information too. The next question is: „What are the biggest problems assigned with analyzing information?". Responders were ask to mark potential problems (It is expensive; information, we need, is not accessible; it is necessary special knowledge; it is necessary to have specific software; it is too time-consuming; it is not effective enough; others) and it was possible to mark more then one answer. The biggest problem is that it is too time - consuming (41%) and companies do not find information gathering effective enough (19%).

At the end I would like to write down a summary of this part of the questionnaire. Companies are looking for information quite often, but they analyze them only sometimes. The reason, why they do not gather and analyze them more often is, that they find both not effective and very time – consuming. My interpretation of this situation is that they do not have enough knowledge to be more effective.

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Toll - the Way of Congestion Elimination in the Centre of Prague

M. Oudes

oudes@fsv.cvut.cz

Department of Road Construction, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

One topic recently appears in most media often than before. Many special experts express their comments and public tend to bring some opinions as well. We are talking about problematic traffic situation in the centre of Prague. Prague is changing during early morning to the tailback of vehicles moving slowly until the end of the day. This situation is very alarming and it is necessary to start solving this problem. Some solutions can help but it is obvious that they will not be popular.

Nowadays there are around ten more or less practical ways how to eliminate traffic congestions in the center of Prague. A list provided below represents ways that can be apply in the real situation and implement in the practical use. The list consists of:

- Complementary of city bypass;
- Preference of a public transport;
- Toll installation in the center of Prague;
- Trucks exclusion from the center of Prague;
- Spread of the system P+R.

It is true that after finishing city bypass and transit bypass the central part of Prague would relieve. According to the newest information, we assume to complete and start using city bypass during 2014 – 2017. In this current situation of rising up car density and amount of people on monitored communications, it would be such a luxury only to wait for city bypass complementation. It is important to find another solution to help to get over the period.

One of the most important things would be to persuade people about public transport quality and advantages. An attractiveness of public transport and accessibility of Prague suburbs are problem solving. The only purchase of new and modern busses and trams will not be enough. We have to consider vehicle equipment. One of the gists is to transport as much people from point A to point B as possible. A comfort is important. Many of new vehicles, as obvious, do not really count with people taller than 1.85 m. Such a tall man does not have a chance to travel comfortable if he for all that finds a place to sit. There is another subject connected to it. It is required to strengthen every line in the morning and afternoon jams that the passengers will be able to find place to sit. Passengers can have even better comfort during traveling. Why do not passengers have a possibility to watch morning news on LCD screen? All these facts have connection to financing of public transport. It is luckily soluble as mentioned further.

A restriction for trucks to enter the centre of Prague is valid for six years. It is prohibited for trucks over 3.5 tons to enter the center of Prague. However is this restriction respected it is not easy penalize offence. Prague civic centre issued more than five thousands permissions for trucks to enter the center of Prague. City center objects that all issued permissions were only for trucks that provide delivery service. We can accept this objection but we can use a

model from abroad where trucks do provide delivery service during night hours. Of course, we cannot forget for some commodities using trucks transport during whole day.

P+R operating are significant for traffic congestion solution. A system how is presented nowadays needs to be improved and public transport requires many changes mentioned above. It is necessary to develop new P + R location. It is important to serve these locations in such a way that transfer and following final destination will cost minimum time loss for passengers.

The most effective implement for solving traffic congestion in the center of Prague is collecting toll when entering center, as we can see in London, Great Britain. Central part will be divided into zones of collecting fee and zones free of charge. This kind of regulation presents advantages and disadvantages. Collecting toll and decreasing vehicles entering the center of Prague is advantage. Not everybody will be willing to pay around one hundreds Czech crowns a day. This amount was consulted with many specialists. The other advantage helps to decrease number of parking spaces. We can also count on canceling parking zones in this area. Permanent residents living in mentioned area will have duty to pay toll as well but different price will be considered.

The question is how to enforce and control this toll. We can use more or less real solutions. One of the easiest would be cars equipped by identification device and this device would be monitored by GALILEO system. In this case, there is no need to built new infrastructure. It is only necessary to define zones requiring toll or zones free of charge. We do not find a system using cameras attractive because of algorithm manipulating with picture of car identification number. This system does not work reliably. A fact that in London after staring with toll there were many car identification numbers stolen. It is warning for our situation but collecting toll is not a subject of this article.

Most of collected toll should be return back to the system (toll – public transport – P+R). We can partly guarantee financing that helps to develop new P+R and transform public transport to be attractive for passengers.

As we mentioned, collecting toll itself will not solve problem and its implementation will be conditioned by city bypass complementary. It is necessary consistently inspect on cooperation of other parts in the system. We talk mainly about triangle consist of following parts: TOLL – PUBLIC TRANSPORT – P+R. Sophisticated control system guarantees effect that is expected and eliminates traffic congestion in the center of Prague.

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The Role of HR Branding in Recruitment

T. Šulcová

tereza.sulcova@fs.cvut.cz,tereza_sulcova@centrum.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 00 Prague 2, Czech Republic

Employer brand has been defined as the „company's image as seen through the eyes of its associates and potential hires" and is intimately linked to the „employment experience" of „what it is like to work at a company, including tangibles such as salary and intangibles such as company culture and values". (Ruch, 2002, p.3). The internal branding process, the means by which an employment brand is created, consists of creating a compelling employment image or promotion, communicating it to employees, convincing them f its worth and, in the rather evangelical words of one set of authors, linking every job in the organization to delivery of the brand essence" (Bergstrom et al., 2002).

Employer branding is a part of Human resources marketing. The main aim of employer branding is recruit, retain and engage the best employees (talents). Why the company should use employer branding? The employer with high level of employer brand becomes the „Choice Employer", which means following: during the candidates decision-making process when potential employees can choose their future employer, they choose the company with high level of employer brand. The "Choice Employer" gains the best candidates on the job market, which mean one of very important part of competitive advantage.

Employer branding (or Human resources branding) could be used not only by well known international private companies, but in public, voluntary and nonprofit sectors also. Brand management has been used for many years in marketing management, usually for core companies' brands with an aim to increase knowledge brands and influence purchase decision of customers.

Human resources marketing (including Employer branding) is relatively new tool in the area of human resources management in the Czech Republic. Personnel managers are focused for core human resources activities as benefits costs, staffing, learning and development, management of the most companies is not open for implementation of tools, which are not linked to the production or sales company function at this time.

According to Watson Wyatt theory, companies can use following competitive advantage of employer branding implementation: 1) Reducing recruitment costs because of higher level of awareness, loyalty, and commitment 2) Increasing bargaining leverage with unions and individuals since employees expect them to deliver on the brand 3) Demanding a higher level of performance than competitors because the brand promise has a higher quality 4) Offering some defense against fierce high performer poaching.

The impact of employer branding is evaluated by the employee satisfaction, motivation, retention, best-fit candidates' recruitment and reducing of hiring costs.

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Managerial Models as Integrative Tools in Enterprise Control

M. Zralý

martin.zraly@fs.cvut.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 00 Prague 2, Czech Republic

Enterprise control[1] has to reflect the growing complexity of products (and services) and processes linked with product development, production, market positioning and sales. Also growing complexity of environment in which the enterprise operates. The enterprise control has to be more integrated as a unit as well as in its particular parts. Under the framework of the project *Controlling and Management Accounting as Tools of Company Management* were developed two models to support managerial decisions making and to demonstrate how to approach integration requirements in enterprise control.

Model 3P - see also [1], [2] and [3][2]- is an interactive costing model, which supports cost decision-making in three phases of product life cycle: pre-production (P), production (P) and post-production (P). Three basic modules of the model cover a wide scope of activities and their costs, which are tightly linked to these three phases. The important role of the Model 3P is to deal with the levels of integration within the processes, which run during these three phases of the product life cycle. The following levels of integration of the model are considered: *The technical-cost integration*, *the integration of the three phases of product life cycle*, *the integration of the cost of processes (incl. departments, resources) and the cost of products*, *the methodological integration of applied managerial tools* and *the data integration,* that focuses on all kinds of the major input data, which influence the product cost-size. If a costing model is designed with regard to integration requirements, then enables to calculate product cost in dependency on processes, activities and resources and the conditions under which they are applied in all of three life cycle phases. Every change in the processes (e.g. any time duration or capacity utilization) resulted in a change of the product cost.

The significance of each level of integration is more in details explained in [2], [3], [4]. Let us to pay attention here only to the technical cost integration and managerial tools integration. What does it mean: *The technical-cost integration* in this Model 3P? The model links the technical characteristics of each *process* with its costs and technical characteristics of *the product* with the product costs. The costing model is created in a way, which enables to calculate the cost of the processes in these three phases depending on the particular technical product solution according to its basic and related attributes. The model also reacts to the cost consequences of the selection of the workplaces and changes in workplace selection or the changes in the conditions under which the process is running. The costing model is able to give an immediate response to the cost size of each particular version of the product. The result: the model demonstrates the technical-cost dependency for both, the process and the product. In the other words: the technical solution both, product and processes of the product

[1] Enterprise Control is on and on used instead of Enterprise Management, to stress even more strict character of recent managerial work.

[2] pp. 171-194

development, engineering, manufacturing, distribution and so on determines the level of the costs. The consequences: To manage costs of product means to manage the technical attributes of the product and *also* to manage processes including their conditions, which are linked with the product. Model 3P closely integrates the technical features of the new product design, development, manufacturing and etc. with the product cost size.

What does it mean: *Managerial tools integration* in this Model 3P? The key methodological concepts applied in the model are *Target Cost Approach* application, *Hour Overhead Tariffs Method* application and the *Variable Costing with Multilevel Contribution Margin.* Each of these tools has its important integrative characteristics. E.g. for the *Target Costing Approach* the major integrative characteristics are: (1) Direct *link* between the *customer's product attributes* and the *product price since the very beginning* of the product development process. (2) The link of customer's product attributes to product price implies in fact the link among the *customer's product attributes*, *attributes of the technical solution*, filling the customer's attributes and the *targeted cost size.* (3) Strong influence of the Target Costing Approach to the *achievement of higher level of consistency* within the steps and its activities in the new or innovative product development process.

Model PP were developed with the aim to support interactive enterprise planning on the product (product set, product group) basis, with respect to the integration relationships. The Model PP calculates the enterprise contribution margin and profit according to the product quantity, costs and price with regard to the processes, which are used in the particular enterprise. For each process (center) are planned and recorded its costs and its capacity utilization. These levels of integration are considered: *The time-cost integration*, *the functional integration between processes in the enterprise*, *cost-return integration in each product set*, *product cost and process cost*, *the methodological integration of applied managerial tools* and *the data integration.* More detailed explanation can be found in [4][3].

The knowledge of integrative characteristics of the managerial tools, including models contributed to the effective enterprise control in integrated environment.

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Trends in the Application of Technologies Based on Foamed Bitumen in Road Construction

J. Valentin*, P. Mondschein*, Fr. Luxemburk*

jan.valentin@fsv.cvut.cz

*Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The limited natural resources give and emphasize reasons for recycling of old construction materials, which fact on the other hand leads to the demand for an incessant innovation of current or modern technologies in order to fulfill requirements following from an advancing growth in traffic volumes and the expected increase of aggressively of wheel loading due to increase of the axle loads. No less important is the requirement of the most effective extension of construction life cycle including introducing of efficient system of controlled structure ageing and reconstruction. At the same time, the pavement structures designed on the basis of new technologies – such as foamed bitumen mixes – have to obey the basic economic efficiency principles combined with requirements for better quality and longer service life, i.e. effective recycling techniques instead of full depth pavement renovation with entirely limited or even without reuse of existing pavement structure.

The foamed bitumen technology has been used in road construction praxis since 1956, when the technology was developed in the U.S. Since 1990s there is an increasing trend in use of foamed asphalt (expanded asphalt, thermally reacted asphalt pavement) predominantly in Western Europe, Australia and South Africa; the US and Canadian road industry making up for quickly in the recent years. The foamed asphalt gains gradually on popularity in these countries with increasing demands for environmental protection and with sustainable construction principles receiving higher acknowledgement. The technology can be used foremost in cold recycling. By whatever name, most popular is a full-depth cold in-place recycling method for pulverizing asphalt pavements and reclaiming them in-situ using technically special modified recyclers by injection with bitumen foam and hydraulic binder for strength improvement or better adhesion. Compaction follows. The result is a stronger road base, for a lower unit cost, than other reclamation methods produce. Foamed asphalt, when used in cold-in-place recycling (CIPR) instead of conventional bitumen emulsions, results in a substantial reduction in cure time as well as a reduction in cost. As confirmed so far foamed asphalt requires very little moisture, it sets up more quickly, and thus can be laid more quickly than standard bitumen emulsions. Foamed asphalt also makes use of standard bitumen without special additives, which is less expensive than the emulsions that are conventionally used.

The foaming process converts a volume of bitumen into a large surface area, thin film bubble structure. Normally 2,0-5,0 % of dematerialized water are added at 15-25°C to hot bitumen (170-190°C) under pressure of 4-5 bar. Immediately after water comes in contact with the hot bitumen it explosively changes its liquid state and starts to evaporate. The bitumen expands its original volume with a very large surface area and extremely low viscosity making it ideal for mixing with aggregates. Foamed bitumen is then applied to a moist aggregate; the moisture enables the foamed bitumen to be effectively distributed within the aggregate fractions, particularly the fine aggregate fractions. The fine aggregate and bitumen matrix bonds the coarser aggregate fractions when compacted. The initial moisture

content of an aggregate is generally less than 85% of that for maximum densification of the aggregate alone.

The main parameters determining the quality of the final foamed bitumen product are expansion (ratio between the maximum achieved volume of the foamed bitumen and the original volume of the non-foamed bitumen) and half life (time taken for the foamed bitumen to reduce by 50% from its maximum achieved volume).

Another progressive production process based on foamed bitumen technology is called Warm Asphalt Mixture and works at temperatures between 80-120°C. It has attracted much interest because of the possibility to approach or even obtain hot mix quality. In this process, the binder is formed using two separate bitumen components in the mixing stage: conventional soft bitumen, with a viscosity below 0.3 Pa.s at 100°C, and hard bitumen in foam form. Such combination allows obtaining the right finished bitumen after mixing at lower temperature. The soft bitumen enables mixing with the aggregate in a first stage, taking place between 100 - 120 ºC. The hard bitumen is added whilst water is injected into it to create foam. This foam can then be mixed into the mixture at a lower temperature than normally required for such a hard binder.

Due to the lower energy consumption (in average by 40-50% compared to hot mix asphalt technology), lower manufacturing temperature with minimum release of volatiles from the mix and allowing recycled material to be used equally as standard aggregate, the foamed asphalt epitomizes the asphalt industry drive towards energy efficient, environmentally friendly and cost effective solutions for road building. Reducing asphalt production temperatures has significant benefits from both cost and environmental perspective. The hot mix asphalt industry has been aware of this for many years. The biggest challenge however has always been to achieve adequate asphalt mix quality at lower or ambient operating temperatures. In the Czech Republic, the first introduction of the foamed asphalt technology goes back to the end of the last century, however further optimization of the mix design as well as research of performance related behaviour of foam asphalt mixes is necessary.

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