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  - physics
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Section 1

MATHEMATICS

Obtained results about the free alternative nil-superalgebras on one odd generator of different indices

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As mentioned in previous articles [1,3], we try to obtain some general results in problematic of finding bases and the indices of solvability of alternative nil-algebras of different indices using the superalgebra method. This way, we constructed the bases of the free alternative nil-superalgebras on one odd generator of different indices, more precisely for the nil index 2 and 3 respectively (published in [1,3]). Finding of the base of the alternative nil-superalgebra of nil index 4 and 5, is in process. Zhevlakov's theorem establishes that in problematic of finding of the index of solvability is in characteristic zero every alternative nil-algebra of given index n solvable of index dependent on n. It would be fascinating to find better estimation of this Zhevlakov's bound, although only for the alternative nil-superalgebras on one odd generator. Our computations for nil index 2 and 3 state that the index of solvability for the free alternative nil-superalgebra on one odd generator is 2 and 3 respectively.

One of the most important and difficult problems in the theory of nonassociative algebras is the construction of effective bases of free algebras. Here by an effective base we mean an explicit base given in terms of a free generating set and accompanied by a multiplication table for basic elements or by a process of reduction of any element to a linear combination of basic words in a finite number of steps. There are not many classes of algebras where such bases are known: free non-associative, free (anti)commutative and free Lie algebras are the most well-known examples besides polynomials and free associative algebras.

A. I. Shirshov formulated the problem of construction of a base of the free alternative algebra. In fact, in his solution of the Kurosh problem for alternative PI-algebras, he constructed and used a pre-base (so called r_2-words) of this algebra. This pre-base was sufficient for his purpose, but it was not a base. Note that, contrary to the classes mentioned above, the free alternative algebra contains non-trivial nilpotent elements and zero divisors. Moreover, the free alternative ring has elements of finite additive order. This makes the problem of the base more complicated, and it seems natural to consider first some special cases.

Recall, that no base of the free alternative algebra is known. We use the base of the free alternative superalgebra on one odd generator constructed in [2] to construct a base of the free alternative nil-superalgebra of given nil index. This algebra is in fact the quotient superalgebra of the free alternative superalgebra on one odd generator and the ideal spanned by the homogeneous elements of special form. The index of solvability is easy to compute if the base is known.

The free alternative nil-superalgebra on one odd generator of index 2

The base of the free alternative nil-superalgebra on one odd generator of index 2 consists of the elements of the form:

$$x;\ t;\ tx,$$

where $t = 2\ x^{[2]}$. Finally, we counted possible products on these three base-elements, so obtained the index of solvability 2.

The free alternative nil-superalgebra on one odd generator of index 3

The base of the free alternative nil-superalgebra on one odd generator of index 3 consists of the elements of the form:

$$x;\ t;\ tx;\ t^2;\ t^2x;\ x^{[k]};\ x^{[k]}x,\ \text{for } k > 2 \text{ and}$$
$$u^{[4m+e]};\ z^{[4m+e]} \text{ for } m > 0 \text{ and } e = 0,$$

where

$$x^{[1]} = x$$
$$x^{[i+1]} = x^{[i]}\,x - (-1)^i x\,x^{[i]};\ i > 0$$

and

$$t = x^{[2]}$$
$$z^{[k]} = x^{[k]}t - t\,x^{[k]};\ k > 1$$
$$u^{[k]} = x^{[k]}\,x^{[3]} + (-1)^{\frac{3k}{2}}\,x^{[3]}\,x^{[k]};\ k > 1.$$

Possible products on these nine types of base-elements give the index of solvability 3.

The free alternative nil-superalgebra on one odd generator of index greater than 3

In case of nil index 4 we obtained only partially results, due to large number of equations to be solved. We hope to success it using the computer what may be probably applicable to solve the nil index 5 also. Nil indices like 6 or greater is not possible to solve even using the computers, because the number of equations and their largeness increase exponentially with respect to a given nil index. As the final result, we want to succeed in a generalization without these computations.

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Basis of Bol Superalgebra on One Odd Generator Spanned by Words of the Length from 1 to 12

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Recall that a Bol algebra is a vector space V equipped with bilinear $[a,b]$ and trilinear $[a,b,c]$ operations, and satisfying the following identities:

$[a,a,b] = 0,$
$[a,b,c] + [b,c,a] + [c,a,b] = 0,$
$[x,y,[a,b,c]] = [[x, y,a], b, c] + [a, [x, y,b], c] + [a, b, [x, y, c]],$
$[a,b] = - [b,a],$
$[a,b,[c,d]] = [[a,b,c],d] + [c,[a,b,d]] + [c,d,[a,b]] + [[a,b],[c,d]],$

for all a,b,c,d,x,y in V.

Notice that over a field of characteristic different from 2, the first identity $[a,a,b]$ is equivalent to the multilinear identity $[a,b,c] + [b,a,c]$.

Next, we say that an algebra A is a superalgebra if A can be expressed as a direct sum of subspaces $A = A_0 + A_1$, where it holds that $[A_i, A_j]$ lies in $A_{(i+j)mod2}$ and $[A_i, A_j, A_k]$ lies in $A_{(i+j+k)mod2}$ where i, j, k are from $\{0,1\}$. We call the elements of A_0 even and the elements of A_1 odd. For even and odd elements we define a parity function $p(a)=i$ if a is from A_i.

The Bol superalgebra is defined by following superidentities:

$[a,b,c] + (-1)^{p(a)p(b)} [b,a,c] = 0$
$[a,b,c] + (-1)^{p(a)p(b)+p(a)p(c)} [b,c,a] + (-1)^{p(a)p(c)+p(b)p(c)} [c,a,b] = 0,$
$[x,y,[a,b,c]] = [[x, y,a], b, c] + (-1)^{p(x)p(a)+p(y)p(a)} [a, [x, y,b], c] + (-1)^{p(x)p(a)+p(y)p(a)+p(y)p(b)} [a, b, [x, y, c]],$
$[a,b] = -(-1)^{p(a)p(b)} [b,a],$
$[a,b,[c,d]] = [[a,b,c],d] + (-1)^{p(a)p(c)+p(b)p(c)} [c,[a,b,d]] + (-1)^{p(a)p(c)+p(b)p(c)+p(b)p(d)+p(a)p(d)} [c,d,[a,b]] + [[a,b],[c,d]],$

Given a multilinear identity f we can construct a superidentity by the so called *superization* rule, see [2]. Simply said, this rule states that whenever the order of two elements x, y is changed the coefficient $(-1)^{p(x)p(y)}$ is added.

In general, to determine a basis for an algebra defined by identities is a difficult problem. We are particularly interested in free algebras on given set of generators X. It is known that such algebras are spanned by all words built up on X.

To get an idea how a basis looks like, a program has been developed. The program allows computing a basis for any free algebra (or superalgebra) with bilinear and trilinear operations defined by multilinear identities on given number of generators. The multilinearity of identities enables to consider an algebra A as a direct sum of subspaces A_i where every subspace A_i is spanned by all words of the length i. As all words span the algebra A, there is a subset of all words which forms a basis.

The program works as follows:

INPUT: defining multilinear identities with rational coefficients, for every identity it is marked whether it is a superidentity or not, the number of generators, and the length n of words for which we want to know the basis.
OUTPUT: basis for all A_i where i is from $\{1,..,n\}$.

Algorithm:

1. B = the set of basis words;
2. R = the map of replaced words, it means it maps a word to a linear combination of elements from B
3. we put the generators in B
4. *for (int i=2; i<=n; i++) {*
5. generate all equations by defining identities for words of the length i;
6. in all words in all generated equations we replace the factors that are not from B by a proper linear combination of elements from B and we add the replaced words in R;
7. we apply Gaus-elimination on the obtained system of linear equations;
8. by a parametrization we divide the words in sets B and R;
9. }
10. the set B contains the searched basis vectors;

Here we present the result of the program, that states the dimensions of subspaces A_i for the Bol superalgebra on one odd generator up to $i=12$.

i	1	2	3	4	5	6	7	8	9	10	11	12
dimension	1	1	1	2	4	9	19	41	94	220	512	1208

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Approximation of Dynamic Programming Algorithm for Dual Control Strategies

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The goal of all control strategies is to achieve a specified performance of the controlled system. Usually, this performance is expressed in a form of a criterion, which is to be minimized. When evaluating the control strategy, it is necessary to know the structure of the controlled system. The better the knowledge is, the more effective is the control strategy. However, if the knowledge is poor, identification must be done prior to applying control algorithms. In some cases, the knowledge about the system is also improved during the control process. Here, it must be ensured that the system is sufficiently excited, so that the identification algorithm has enough relevant data to improve the knowledge.

Stochastic adaptive control gives a possibility to deal with uncertainties in system descriptions. In contrast to other robust methods, it uses probabilistic description of uncertain system parameters and consequently, stochastic optimization methods are used to design the controller. It also uses identification methods to improve the system model and thus further improve overall performance.

Stochastic discrete time models are usual tools used for description of uncertain systems. AutoRegressive models with eXternal input (ARX) are used in our work, because such models enable simple estimation of parameters. There exist two basic optimal control strategies: cautious and certainty equivalent LQ optimal control strategies. In certainty equivalent control strategy all uncertainties in system parameters are neglected and only mean values are considered. On the contrary in the cautious control strategy all uncertainties are respected but these uncertainties are considered to remain the same during the whole control process as if no further identification was performed. In other words, each uncertain parameter is described by independent, identically distributed random variables with respect to time. In all cases the mean value of the criterion is minimized. In our work [3] we analyzed and compared certainty equivalent and cautious strategy in terms of theoretical criterion values and also by simulations.

It was shown by experiments that in case of cautious control strategy, the estimated probability distribution has the mean value close to the predicted one. Experiments also confirmed the assumption that the certainty equivalent strategy is suboptimal in terms of the criterion mean value. The predicted optimal value is nonrealistic, as uncertainties are not taken into account. For some choice of system parameters, the certainty equivalent strategy even failed to stabilize the system, which resulted in the criterion growing above limits, as the number of steps increased.

None of these strategies, however, take into account the fact that, after measurements of future outputs are available, the estimate of system parameters may be updated. This approach leads to a concept of dual control.

In stochastic adaptive control, the controller that achieves required control performance and keeps gathering information about the system at the same time is referred to as a controller with dual properties. The optimality is meant with respect to a given criterion. The optimal solution is generally described by Bellman equation for stochastic dynamic programming. As the optimal dual controller is computationally intractable even for very simple systems, approximations of the optimal problem are searched. In our work [1-2] we propose a control strategy for ARX systems with dual properties. This active control strategy is based on the well known cautious strategy, but takes the quality of identification in one step ahead into consideration.

The control strategy proposed in our work is based on a one-step approximate solution of the original problem. The biggest problem in solving the dual control problem is that it needs the computation of mean value and minimization of the criterion to be repeated many times. Finding analytical solution for these operations is generally impossible and numerical computations face the curse of dimensionality problem that often arises in dynamic programming. For this reason we propose an algorithm that only computes expectation and minimization once and for the next steps the assumptions are relaxed so that the solution can be simplified. It is based on the cautious controller, but takes into account the fact, that identification takes place in the first step of control. For the rest of the control process, cautious control is assumed. With this assumption, the controller keeps the dual property, as it optimizes the performance and identification, while remaining computationally feasible. The control strategy is derived for the ARX models.

The theoretical values of the criterion show, that the active strategy brings the biggest benefit when the initial parameter uncertainty is high. The control process of the active strategy was simulated and compared with the cautious strategy. Experiments show that using the active strategy leads to faster parameter identification than in the case of cautious strategy. However, after several steps of control, both strategies give very similar results. The experiments were performed on a discrete integrator with unknown gain, so only one parameter was estimated and quick convergence was expectable.

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Section 2

PHYSICS

Ferroelectric Nanocones Properties and Their Simulation in Structures with Size Distribution

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The dependence on size of ferroelectricity in ultrathin films and nanoparticles was a long time in the field of research interest. But the constant miniaturization of electronic devices and diversification of heir functions has poured the light on more sophisticated nanomaterials, namely nanocones, nanorods, nanotubes and nanowires. New features and possibilities have been widely discussed in recent papers: increase of the storage density by means of ferroelectric nanostructures [1] and Atomic force microscope (AFM) cantilever properties enhancement, enabling lower voltages and a higher sensitivity with use of ferroelectric nanotubes [2]. It is obvious that for approximation of the nanotip in AFM or Electron tunneling microscope a cone shaped body is more precise for simulation than nanorod shaped one, which was used before. To the best of our knowledge, this problem is solved for the first time.

We examine the ferroelectric size effect of cone-shaped nanoparticles (nanocones) for the second order phase transition. We consider a freestanding ferroelectric monodomain nanocone with h and α denoting the height and the cone half-angle (cone half-aperture), respectively. The axisymmetric polarization $P_z(\rho,z)$ and external field E_o are assumed to be parallel to the z-axis. To derive an analytical expression for the paraelectric-ferroelectric phase transition temperature, we have to solve the Euler-Lagrange equations, which can be obtained by variation of the polarization in the free energy functional. At the end we arrive to final equation for the modificated phase transition temperature for the cone shaped nanoparticle [3]:

$$T_{cl}(h,\alpha) \approx T_C\left(1-\frac{4Q_{12}\mu}{a_T T_C h\cdot\tan(\alpha)}-\frac{\delta\cdot k_1^2\left(16-3\left(\tan(\alpha)\right)^2\right)}{4a_T T_C h^2\eta\left(\tan(\alpha)\right)^2}-\frac{\eta\delta}{a_T T_C h^2}\left(\frac{9}{\eta}+1\right)\right) \quad (1)$$

The first term in eq. (1) corresponds to the bulk phase transition temperature, the second one to the coupling between surface tension and polarization via the electrostrictive effect. The third and the fourth terms describe the complex contribution of correlation effects and the depolarization field contribution. Obviously, the second term might increase or decrease the phase transition temperature, i.e. it might be positive or negative depending on the sign of Q_{12} [24]. For most of the ABO_3 perovskites, the electrostriction coefficient is negative, $Q_{12} < 0$.

Similar to nanowires [3], the transition temperature T_{cl} to the nonpolar state is enhanced for negative electrostriction coefficients Q_{12}. However, in nanocones this enhancement exceeds that of nanowires (T_{cl}/T_C increases up to 2.5 times compared to 1.5 times in an optimized nanowire). As a consequence, we also obtain a higher spontaneous polarization.

Albeit the shape of the cone nanoparticle requires special treatment to achieve sufficient increase in ferroelectric properties. To obtain the temperature, which is 2.5 times higher than

the phase transition temperature of the bulk material nanocone particle should have following sizes: for $Q_{12} < 0$ the optimized cone parameters (for $T_{cl}/T_C = 2.5$) are top half-angle $\alpha \approx \pi/7.5$ and volume of the particle $V \approx 1.33 \cdot 10^4$. And simulation of cases at the limits of our theory for nanowires (small cone half-angles α) and thin films ($\alpha = \pi/2$) perfectly coincided with results described in literature before.

Second part of our modelling was considered on performing an averaging of the phase transition temperatures by varying one of the geometric parameters (high of the rod and height of the cone, respectively) with methodology explained in [4]. The evaluation of the size distribution of nanoparticles in nanostructures is an important task for material characterization providing important additional information for the understanding of material properties. We have shown that nanocone fabrication tolerances must be very precise for realization of the full potential of enhanced ferroelectricity. The results were impressive: it was shown that distribution functions of geometric parameters of the nanocones and the nanorods must be extremely narrow. The deviation in their heights has to be less than ±5 %.

Limitations to our simulations were brought by approximations used during our approach: idealization of a cone particle, direct variational method, use of the first root of Bessel function and use of phenomenological expansion of free energy over polarization powers, which is not acceptable in some cases. But the influence of the limitations is small enough, even in the particular frameworks such as consideration of a nanocone in complicated structures and compound or nanocone with metal electrodes. Though these frameworks can require additional calculation of background permittivity of ferroelectric material and a description of variation of polarization on metal-ferroelectric interface by the effective surface energy, our model still delivers good results in perfect accordance with previous works.

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Fusion Neutron Production on S-300 Z-pinch

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Z–pinch belongs to one of the most fascinating objects in plasma physics due to its natural occurrence and variety of applications. A pinch is defined as plasma configuration in which an electric current generates magnetic field that tends to confine the plasma [1]. The prefix "Z" was added in the 1950s to denote the confinement driven by an axial (z) current. Today, Sandia's ZR machine is the most powerful laboratory sources of X-ray radiation (more than 500 TW). On the one hand, this naturally leads to detailed studies of EUV and soft X-ray radiation. On the other hand, however, there is a need for more experimental data about fast ions and we hope that fusion neutron measurements could help in that sense. For that purpose, the neutron production from a deuterium gas-puff Z-pinch were studied the S-300 pulsed power generator (4-MA peak current, 700-kV voltage, 100-ns risetime, 0.15-_ impedance) at the Kurchatov Institute in Moscow.

In our preliminary gas puff experiments at S-300 [2], the gas puff was driven by the burning gun powder similarly as on the Angara [3]. Recently, we have constructed the electromagnetic valve with the modest opening speed of the valve of 3 m/s. The next step was to design supersonic nozzle. In our experiments we aim at testing various nozzles for both the annular and the solid gas puffs. We started with de Laval (convergent-divergent) nozzle. When we calculated the steady state with the ANSYS FLUENT flow modeling software, we received the Mach number of about 8 and the linear density up to 80 micrograms per cm. The separation between the cathode and anode was 11 or 18 mm.

The time-of-flight analysis was enabled by 11 scintillators and photomultiplier tubes – 4 were placed axially and 7 radially. Neutron time-of flight diagnostics was used to give an insight into the acceleration of fast deuterons. The emphasis was put on the finding of (i) the energy distribution of deuterons which produced fusion neutrons, (ii) the anisotropy of neutron emission, and (iii) the time and duration of neutron production with respect to the general Z-pinch dynamics.

During our experimental campaign in 2009, we carried out 11 lower mass shots with the linear mass density between 5 and 20 micrograms per cm. In the case of 20 micrograms per cm, the gas puff imploded onto the axis before the current peak at about 100 ns. The implosion velocity exceeded the value of about 3×10^5 m/s. The implosion seemed to be without any significant zipper and with the diameter during the stagnation of about 2 mm. As

regards the time of neutron emission, there was a short neutron peak which started during the stagnation and correlated with the hard x-ray peak. However, the main neutron pulse corresponded to a small X-ray and hard X-ray peak. In all shots, the neutron emission started immediately after the voltage maximum and reached the peak 35 ns later. The neutron emission lasted for about 40 ns. At this time, we did not observe any significant voltage peak and also the X-ray emission detected by a silicon diode was quite low. The peak number of D(d, n)^{3}He fusion neutrons in one shot approached 6×10^{10}. The side-on neutron energy spectra peaked at 2.40 ± 0.05 MeV with about 500 keV FWHM. In the downstream direction (i.e. the direction of the current flow from the anode towards the cathode), the peak neutron energy was 2.6 ± 0.1 MeV. The average kinetic energy of fast deuterons, which produced fusion neutrons, was about 150 keV.

On the basis of our experimental results, we were able to discuss the neutron production mechanism. There were two important findings. The first fundamental result is the time of neutron emission because most of the neutrons were not produced during the stagnation. Instead of that, they were produced for a quite long period during the plasma expansion. As regards the anisotropy of neutron emission, it was quite low. So, the second important result was the radial neutron energy spectrum. If we calculated the equivalent Maxwellian temperature from this spectrum, the temperature is unreasonably high. all these facts imply that most of the neutrons were not of the thermonuclear origin.

Nevertheless, let's make some basic estimates of expected thermonuclear yield. If we calculated the ion temperature from the energy input, we obtained 1 keV, and for plasma parameters during the stagnation we receive 10^8 thermonuclear neutrons. It is on the order of one percent of the total neutron yield. Far more interesting, however, it is to calculate the number and energy of fast deuterons similarly as it was done for Z-machine [4]. In our experiment we measured the neutron yield, the deuteron energy and we could estimate the upper value of ion density and the path length of fast deuterons. From these experimentally estimated values, we obtained almost 10^{17} fast deuterons with the total energy higher than 1.5 kJ. In comparison with the input energy of 15 kJ, it is an impressively high value and we believe that such a result needs to be further researched and explained. For this purpose, we prepare future experiments in May.

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Prototype of Li-ion Thin Film Microbattery with Carbon Anode Produced by Magnetron Sputtering

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In recent stage of knowledge of secondary power sources, lithium-ion batteries are recognized as the most viable rechargeable battery system, since lithium is the lightest and the most electropositive element, producing the highest specific volume and mass capacity. Due to the miniaturization of consumer electronic devices there is growing demand for small-dimension, lightweight, and portable power sources. Multilayer solid-state electrochemical system, i.e. rechargeable thin film lithium-ion batteries, has the best potential to fulfill the increasing requirement for microelectronic energy storage devices.

Suitable research has been made in this field and it has resulted in microbattery system with metallic lithium anode [1]. Nevertheless, the disadvantages have appeared in this system. Because free lithium is toxic material and his contact with dampness has lead to some kind of explosion due to his very high reactivity, carbon has been examined as proper anode material for lithium-ion microbatteries to avoid safety and environmental problems.

$LiCoO_2$, the one of the lithiated transition metal oxides, is the most frequent cathode material for classical rechargeable batteries and it has been demonstrated that it is proper material for thin film configuration of microbattery [2], and although other materials, $LiNiO_2$ and $LiMn_2O_4$, have been examined for this purpose, $LiCoO_2$ has been chosen as the most suitable cathode material ($LiNiO_2$ and $LiMn_2O_4$ exhibit the lowest cost but they present an disadvantage of higher temperature of synthesis and slightly lower capacity, respectively). Another situation is in case of electrolyte. Classical bulk batteries use water-based liquid or gelled electrolytes whereas the solid-state electrolyte is required for thin film configuration. As fast ion-conducting glassy compounds, LiPON and LiBO, having high thermodynamic stability and a low electron mobility, have been examined. Despite the fact that these solid electrolytes have much lower ionic conductivity (~10^{-4}-10^{-6} S/m) in comparison with liquid materials (~0.1-1 S/m), when prepared about 100 nm in thicknesses, the internal resistivity of the microbattery is acceptable. Instead of using metallic lithium as anode, various materials has been investigated, namely, carbon, silicon, nickel, copper, titanium and titanium dioxide. While Ni, Cu, Ti, and TiO_2 thin films have low capacities (but very good thermodynamic stability during the charge/discharge process), carbon and silicon exhibit sufficient capacity. Nevertheless, silicon thin film has been unstable in all cases of charging process, and it has always peeled off after some time of charging. It is probably caused by tensions at electrolyte/anode interface while lithium ions intercalate into the thin silicon film and when its volume increases. Carbon thin film had the same tendency, but it has not been as significant as in case of silicon, so further research has been focused on carbon, promising the development analogous with classical bulk batteries where graphitic carbon is used as an anode.

In this study, RF (Radio-Frequency) and DC (Direct-Current) magnetron sputtering has been chosen as the technology for preparing of thin films, using argon, nitrogen and mixture of argon with oxygen atmosphere. Single layers of microbattery have been deposited on Si substrate covered by SiO_2 whereas thin layer of Ti (buffer layer) and Au (current collector) have been evaporated between substrate and cathode. In general the prototype of Li-ion microbattery contains $LiCoO_2$ cathode, carbon anode, both have about 1μm in thickness, and LiPON electrolyte with 100nm in thickness. An active surface of anode has been confined by dimensions of copper foil mask to the value of 52 mm^2. During the sputtering, a holder of substrates is heated up to 320°C in dependence which part of microbattery is deposited. It has been demonstrated that temperature of substrate has the most important influence on structure of carbon [3]. Electron transmission diffraction measurement indicates that the structure of prepared carbon films is not completely amorphous, but graphite-like with nano-sized crystallites. The average size of crystallites grows with increasing temperature. Such conclusion was also confirmed by later AFM measurements and by the measurements of the resistivity, which decreases with increasing temperature. In effort to achieve proper electrochemical and structural properties of single thin film components, the sputtering conditions have been determined.

Cycling tests (charge and discharge characteristics) of microbatteries were processed by Four-channel Galvanostat device upon constant discharge current density 20 $\mu A/cm^2$. The visible decrease of charging/discharging time is probably caused by tensions at electrolyte/anode interface. Consequently, a deterioration of the adhesion of carbon film on the LiPON electrolyte has been occurred during the charge/discharge cycles. During charging process of microbattery Li ions intercalate to the mass of carbon anode and structural changes cause the adhesion decrease. Additional inactive surface at electrolyte/anode interface occurs and it gives decrease of electrochemical capacity of carbon anode.
In summary, we have accomplished the functional prototype of thin film lithium-ion rechargeable microbattery with carbon anode using RF and DC sputtering method. Both electrodes and electrolyte have been produced by a dry process only. The compact microbattery has been realized in solid-state and thin film configuration.

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Developing of High-Speed Electromagnetic Deuterium Valve for Gas-Puff in Z-Pinch

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Studies of the mechanism of neutron production in the $D(d,n)^3He$ reactions are the main purpose of the experiments on Z-pinches at the CTU. In these reactions happen to fusion of two deuterium nucleuses. These reactions can proceed in two branches: D + D → T(1.01 MeV) + p(3.02 MeV) or D + D → He(0.82 MeV) + n(2.45 MeV). The great successes on USA's device ZR in SNL Albuquerque are inspiration for the development of this electromagnetic valve on CTU. ZR facility uses similar electromagnetic valve [1] like is in development on CTU. Maximal current peak of ZR device is 26 MA and maximum of stored energy in capacitor batteries is 20 MJ. The $D(d,n)^3He$ reaction record of neutron yield 6×10^{13} was achieved on this facility in 2005 with current peak 18 MA.

The gas-puff is the most effective load for Z-pinch discharges for neutron generation. In this case the chamber is evacuated and the gas is injected through the anode in the relative thin jet in the short time before discharge. So the gas does not expand to the whole volume of the chamber in this short time. Anode which is used for discharges in gas-puff must be porous. For this purpose is usually made from a cuprum ring with a wired grid in the middle. Injected gas passes through this grid towards to the cathode.

The Gas-puff valves for our experiments on the S-300 facility in RRC Kurchatov Institute in Moscow have developed since year 2007. Maximum current peak in the S-300 facility is 4 MA. First experimtens with gas-puff on S-300 was done with the valve, which wasn't opened electromagnetically but with the assistance of the gunpowder. The highest neutron yield 1.5×10^{10} was achieved with peak current 1.5 MA for this type of valve in 2007.

Development of the electromagnetically triggered gas-puff valve began in October 2008. The coil of this valve is made from 9 spirals of enameled cooper wire. Inductivity of this coil is about 2.5 μH. Pulse power supply for this coil is made from two 100μF-capacitors charged up to voltage 3 kV. These capacitors are connected with pneumatic spark gap. Coil current peak is about 20 kA for voltage 3 kV. This current is measured with Rogowski coil with integrating cell. A hammer made from conductive material is placed in the axe of the coil. The eddy currents are induced to the hammer and it is repelled from the coil. Accelerated hammer hits the rod of the valve and opens it.

Next improvement in comparison with old version of valve is the supersonic nozzle. Supersonic nozzle is designed for Mach number 8. The shape of the nozzle was designed in collaboration with Faculty of Mechanical Engineering, CTU in Prague. The shape of the nozzle is designed by manual calculation and the simulation is done in the program Fluent (Computational Fluid Dynamics).

Characteristics of the electromagnetically opened valve were tested on CTU on the PFZ-200 facility without discharge [2]. Characteristics of valve opening were measured for

overpressure 2, 3, and 4 atmospheres in comparison with vacuum inside the chamber. The measurement of temporary dependence propagating of the gas in the chamber was done with two probes working on the Paschen diagram principle. The probes are in coaxial spark-gap version. The voltage of the spark-gaps in the probes was 1 kV. First probe was placed inside the valve and the second one was in the chamber of PFZ-200 facility. If the gas comes to the probe the spark-gap ignites. The temporary process of the ignite pulse is registered on the memory oscilloscope. The oscilloscope is triggered by derivative of valve coil current. We know the times of pulses of these probes, therefore we know the times when the gas comes in the assigned places. This measurement was done for 6 positions of the second probe in the chamber and for overpressure 2, 3 and 4 atm. and for coil valve voltage from 1.6 kV to 2.6 kV. Several measurements with the same initial parameters (probe position, voltage, and pressure) were done for statistics processing of the results. Nevertheless the results show relatively big fluctuation in the sporadic measurements. The time when the gas will come from the first probe to the second one is about 200 ns for overpressure of 3 atm. and coil voltage of 2.6 kV. Another measurement is based on the recording mechanical motion of the valve with high speed camera. The high speed camera was borrowed from the Institute of Thermomechanics of the Academy of Sciences of the Czech Republic. This camera can take 100 000 pictures per second with exposure time of 5 μs, so we can record mechanical motion of the valve with enough time resolution. Motion of the valve was recorded for the same cases like the measurement with spark-gap probes. The temporary dependences of the valve position and velocity were determined from these records. In contradistinction to measurement with spark-gap probe, measurement with high speed camera shows very good repeatability of measurements. The maximum stroke of 2.5 mm was registered at the pressure of 2 atm. and voltage of 2.6 kV. Opening speed of the valve is in this case 2.5 m/s.

The main experiments with this electromagnetic valve were done in the RRC Kurchatov Institute Moscow in September and October 2009 [3], where the synchronization delay was estimated on the base of above mentioned measurements. There were done 11 shots with peak current of 2 MA with 100 ns rise time, the average neutron yield of these shots was 6×10^{10} neutrons. The Z-pinch discharges in the gas-puff seems to be the way for achieve very big neutron yields.

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Solid-state Lasers in the Visible Spectral Region with Pr3+ Active Ions

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In the recent period, materials doped with trivalent Praseodymium Pr^{3+}-ions have proved to be very prospective laser sources for efficient stimulated emission in the visible region of the electromagnetic spectrum. The Pr^{3+}-energy level diagram offers several laser transitions practically throughout the whole visible range up to the near infrared. Moreover, during the last years, significant progress has been made in the development of pumping sources - GaN laser diodes and optically pumped semiconductor lasers (OPSLs) - in the blue region corresponding with Pr^{3+}-absorption peaks. Additionally, in connection with high emission cross-section (of the order of 10^{-19} cm^2), the Pr^{3+}-doped laser hosts provide a great potential for realizing compact and efficient laser sources which can find use in different applications such as display technology, data storage, spectroscopy, fluorescence microscopy, and medicine.

Although the greatest attention is paid to the Pr^{3+}-fluoride materials (Pr:YLF, Pr:LLF, Pr:GLF, ...) due to their low phonon energy which is supposed to lead to a weaker non-radiative decay of the upper $^3P_0$ laser level, successful laser action at room temperature has been demonstrated also in oxygen-containing laser compounds, among which the $YAlO_3$ (YAP) crystal is of great interest because it provides the richest number of stimulated emission intermanifold transitions and simultaneously belongs to oxide crystals with relatively small phonon energy. Therefore, the rates of non-radiative decay of the $^3P_0$ level are relatively small. The Pr:YAP visible laser emission has been described under flash-lamp pumping, argon-ion pumping, and, recently, under the GaN laser diode pumping [1].

Concerning the Pr:YAP crystal advantages (in comparison with the fluorides) in terms of physical properties, it provides higher hardness (8.5-9 on the Mohs scale), thermal conductivity (not worse than 11 $W.m^{-1}.K^{-1}$ at 300 K), and mechanical and chemical stability. On the contrary, the Pr:fluorides are unique in the lower phonon energy spectrum and the greater number of possible laser transitions.

In this contribution we report on laser results reached by Pr-doped oxide and fluoride crystals under GaN-laser diode pumping at room temperature. As oxide and fluoride crystal representatives, $Pr:YAlO_3$ (Pr:YAP) and $Pr:LiYF_4$ (Pr:YLF) crystals grown by the Czochralski method were used and compared. The Pr:YAP crystal doped by 0.6 at. % of Pr^{3+}-ions was 5 mm in diameter and in length while the Pr:YLF crystal with 0.4 at. % Pr^{3+}-ion concentration was ϕ3 mm x 4 mm in dimensions. Both samples were of high quality, free of crack or twins, were b-axis oriented (according to Pbnm notation), had crystal facets perpendicular to the laser radiation propagation direction polished in laser quality, and were mounted on a copper heat sink.

As a pumping source, the GaN laser diode from NICHIA Corporation delivering output power of up to 1W was employed. Since the Pr:YAP and Pr:YLF absorption peaks (~447.6 nm and ~443.8 nm, respectively) are mutually shifted out of the GaN laser diode

tuning range, it is impossible to use one GaN laser diode for efficient pumping both the Pr:YAP and Pr:YLF materials. Therefore, to ensure the optimal overlapping of GaN-diode emission and the Pr:YAP (Pr:YLF) absorption spectrum, two GaN laser diodes designed for operation round 448 nm (444 nm) were used. The pump radiation was linearly polarized, so the both crystals were oriented for E||c to utilize the larger absorption coefficient.

As expected for laser diodes, the wavelength generated depends on the current passing through the active layer due to thermal effects. As a result, the amount of the absorbed power in the active materials differs according to the overlapping of the pump wavelength and absorption maximum of the laser crystal. In our case, the maximal absorbed pump power in a single pass was determined to be ~80 % and ~60 % for the Pr:YAP and Pr:YLF crystal, respectively.

Using the Pr:YAP crystal, more than 90 mW of continuous laser radiation at $^3P_0 \rightarrow {}^3F_4$ laser transition (747 nm) was generated with a slope efficiency of 45 % and laser oscillation threshold of about 600 mW [1]. Moreover, two wavelength generation of Pr:YAP laser at $^3P_0 \rightarrow {}^3F_4$ (747 nm) and $^3P_0 \rightarrow {}^3F_3$ (720 nm) laser transitions reached by employing broadband resonator mirrors and Lyot filter as a tuning element has been realized. In the case of Pr:YLF material, stimulated emission at $^3P_0 \rightarrow {}^3F_4$ (721 nm), $^3P_0 \rightarrow {}^3F_2$ (640 nm), and $^3P_0 \rightarrow {}^3H_6$ (607 nm) laser transitions have been demonstrated. The best results obtained were at 640 nm wavelength – 134 mW of the output power, 33 % of the slope efficiency, and 60 mW of the oscillation threshold. Spatial beam profiles of the emitted laser radiation were close to the Gaussian shape, for both cases. Besides, the results (for both crystals) are expected to be additionally improved by output coupling optimization and by employing beam shaping optics for the GaN laser diode radiation resulting in an almost circular pump beam.

In conclusion, room-temperature Pr:YAP laser operation under GaN laser diode pumping has been realized for the first time, to our best knowledge [1]. In our experiment, the Pr:YAP active material excelled in the slope efficiency reached. Its laser oscillation threshold approximately six times higher than that one for the Pr:YLF (in our experiment) was given inherently by the shorter lifetime of the upper laser level $^3P_0$ in Pr:YAP, and, furthermore, by larger pump-beam spot radius in the focus resulting in a greater pumped volume of the Pr:YAP crystal.

If compared with the best world results reached by using Pr^{3+}-ion doped fluoride materials (YLF, LLF, GLF) under GaN laser diode pumping, the Pr:YAP results obtained are comparable at the strongest laser transition in terms of slope efficiency. In connection with higher thermal conductivity – not worse than 11 $W.m^{-1}.K^{-1}$ (at 300 K) and excellent hardness – 8.5-9 on the Mohs scale of the Pr:YAP material, it appears that this crystal could be a worthy competitor with the Pr:fluorides in various applications in physics, industry, and medicine (display technology, data storage, spectroscopy, fluorescence microscopy, etc.), where visible laser radiation is required.

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Computer Simulations and Design of the Discharge System for Generation of Radiation in the Water Window Region

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Capillary discharge system is considered as possible candidate for the creation of a compact EUV radiation source, with high brilliance and relatively low cost. Most of the teams dealing with EUV (extreme ultraviolet) radiation sources concentrate on creating the source on the wavelength of 13 nm, useful for lithographic processes for microchips. Other teams are devoted on making the source in the water window range of wavelengths (2.4 to 4.4 nm) which is interesting for biomedical applications. The main benefit of using the "water window" wavelengths in biomedical applications is that a degree of natural contrast is achieved in cells. Within the water-window, there is a high absorption of the radiation by proteins, but very little by oxygen. In a living cell, structures with high carbon density, such as membranes, would be expected to absorb more of this radiation than more carbon-dilute areas such as cytoplasm and vacuoles [1]. This can be used for imaging of biological objects. However, the water window sources which have been so far accomplished do not provide ideal spectral and radiation output characteristics.

One way to generate EUV radiation is by capillary discharge system. Capillary discharge represents a narrow channel made of a solid insulator material ended in a longitudinal direction by the two electrodes. The channel is filled by gas. A high voltage between the electrodes is applied to form a short pulse of electric current through the cross section of the channel. The electric current heats both the channel wall material and the plasma inside the channel and its magnetic field causes plasma pinching and plasma radiation [2]. The kind and intensity of plasma radiation is specified mostly by the gas inside the capillary, voltage applied on the discharge and geometry of the channel and the shape of the electrodes.

To study capillary discharge we use computer simulations. The simulations are carried by the means of two-dimensional RMHD (radial-magnetohydrodynamic) Z* code. Z* is a computational code designed specifically to perform complete simulations in complex geometry of electrodes and insulators with ionization processes and radiation transfer in non-equilibrium regime. The physical model established in Z* is based on the quasi-neutral multicharged ion plasma magneto-hydrodynamic equations with self-consistent electromagnetic fields and the radiation transport in a 2D axially symmetric geometry[3]. This allows simulating the detailed processes of pinching discharge in the capillary so crucial properties of the hot radiating plasma, as electron temperature, electron density, emitted power, electrodes temperature, mean degree of ionization etc can be determinate. The model does not consider the ablation of material from the wall of the capillary.

In this contribution we present the results of Z* code simulations of the nitrogen capillary discharge. Our goal was to specify optimal parameters of the capillary discharge radiation source, in order to gain maximal radiation brightness and emitted energy in the water window range of wavelengths using the method of repeated computer simulations by Z* code. Simulations were executed varying geometry of the capillary (length, radius and a shape of the electrodes), voltage stored on the capacitors of the external electrical circuit and initial pressure of the gas inside of the capillary. The nitrogen filled aluminium-oxide

capillary was studied and simulated. Nitrogen gas was chosen, for the simulations, due to its high Einstein coefficient for the NVI nitrogen ion, on the 2.88 nm wavelength. Pressure of the gas was varied in the range 0.05-5 torr. Applied voltage was varied from 40 to 80 kV, while the values for the resistance, capacity and inductivity are R=0.7 Ω, C=15 nF and L= 50 nH respectively. The radius of the capillary was in a range from 0.8 to 2.5 mm and length of the capillary was in the range of 21 to 180 mm. Space time dependences of electron temperature and density, as well as time profiles of the current passing through the capillary are evaluated. Power of radiation from the capillary is also estimated as well as brightness of the source.

The results of simulated current, passing through the capillary shows that the peak of the current decreases and shifts in the time scale with the rising length of the capillary. The current peak goes from 18 to 30 kV, for different capillaries lengths (21-180 mm) and voltage 80 kV. This in accordance with the theory predictions because inductivity rises with the capillary length. The simulations have shown that the emission of the system is highly influenced with the pressure of the gas inside the capillary. The highest emitted XUV water window power (radiation between 2.1 and 3.1 nm in this case) is achieved for the pressure of 0.6 torr, for the stored voltage of U=80 kV. Peak of emitted XUV water window power for 0.6 torr initial pressure of the gas, and for the capillary length 180 mm is 11.05 MW in 4π radians. The evaluated space and time electron temperature and density distribution in the discharge channel confirm the high plasma radiation in the water window range. The electron temperature at the time of the peak of the emission is around 50 eV and electron density is on order of $10^{17} cm^{-3}$. This electron temperature ensures high enough degree of ionization (N VI), while the electron density ensures high number of radiation carriers [4]. The amount of XUV water window radiation for the optimal pressure rises with the length of the capillary, until the saturation occurs. Decreasing the voltage of the electrical circuit, lower emitted powers are achieved. However, decrease in emitted power is not significant when applied voltage is 60 kV, for initial pressure 0.4 torr. The simulations with 1.65 mm inner radius of capillary give the highest emitted water window powers, comparing to the amount of emitted XUV power when 0.8 and 2.5 mm capillary radiuses were used. The pulse durations of radiation are on order of couple of tens of nanoseconds.

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Material Dispersion Influence on Chromatic Sensors Measurement Accuracy

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The use of non-contact chromatic confocal sensors in industry is nowadays very widespread. These sensors are based on the dependence of longitudinal chromatic aberration of optical systems on wavelength and measurement systems based on this principle give very good and accurate results in the case of pure reflection of the measuring beam from the investigated object (e.g. reflection from metals etc.). In case we need to measure the thickness of transparent materials (e.g. plan-parallel glass plates) and simultaneously we want to measure the topography of tested object surfaces then chromatic sensor based measurement systems produce errors due to the dispersion of transparent media (e.g. glass) of measured objects. The work deals with a physical origin of these errors and analysis of the influence of these errors on the accuracy of measurement using chromatic sensors. Relations for quantitative evaluation of these errors are derived.

Chromatic confocal sensor

In an optical system for measurements of topography of surfaces using confocal chromatic sensor the polychromatic light from the source is guided into fibre and generates practically a point source of light at the end of the fibre. The light is reflected by semitransparent mirror (or beamsplitter) and propagates through the stigmatic objective lens with large longitudinal chromatic aberration (hyperchromat). The image of fibre end is formed by lens in different distances with respect to the wavelength of light. After reflection from the measured surface the light passes through the semi-transparent mirror and is then collected by the second fibre and guided into spectrophotometer SF which gives a position of the intensity maxima for different wavelengths during scanning of the investigated surface.

The intensity of light which propagates through the fibre will be maximal only for the light of a particular wavelength that corresponds to a minimum diameter of ray bundle in the plane of the second fibre end (for our case it is wavelength λ_1). For other wavelengths different from wavelength λ_1 the intensity of light will be very low. The accuracy of the described method is given by the accuracy of determination of maxima of the intensity corresponding to different wavelengths with the spectrometer.

Influence of plane parallel plate material dispersion on measurement accuracy

Now we will focus on the material dispersion influence in case of plane-parallel plate measurements. Using the Snell's law of refraction we obtain the following relation for the value of the shift between points A and A' (A is the place of beam incidence in case of infinitely small plane – parallel plate thickness, A' is the place of beam incidence in case of plate thickness d and diffraction index n)

$$\Delta = \left(1 - \frac{\cos\varepsilon}{\sqrt{n^2 - \sin^2\varepsilon}}\right) d = \left(1 - \frac{1}{n}\right) d + \left(1 - \frac{\cos\varepsilon}{\sqrt{1 - (\sin\varepsilon / n)^2}}\right) \frac{d}{n} = \Delta_0 + \delta s' \tag{1}$$

where Δ_0 is the paraxial shift and $\delta s'$ is a longitudinal spherical aberration of the plane-parallel plate and ε is the angle of incidence. For small angles of incidence ε ($\varepsilon < 20°$) we can expand goniometric functions and the square root in the denominator of the previous relation in Taylor series. If we restrict ourselves to the first two terms of Taylor series for the shift Δ caused by the plan-parallel plate we obtain an approximate relation

$$\Delta = \left(1 - \frac{1}{n}\right) d + \frac{n^2 - 1}{2n^3} \varepsilon^2 d = \Delta_0 + \delta s'_{III} \tag{2}$$

where $\delta s'_{III}$ is the third – order spherical aberration of plane–parallel plate and the angle ε is given in radians. As it's very well known the index of refraction *n* of the material depends on the wavelength λ i.e. $n = n(\lambda)$. Thus the shift $\Delta = \Delta(\lambda)$ is also dependent on the wavelength of incident light. By differentiation of relation (2) we get

$$\mathrm{d}\Delta = \frac{\partial}{\partial n}(\Delta_0)\mathrm{d}n + \frac{\partial}{\partial n}(\partial s')\mathrm{d}n = \frac{d}{n^2}\mathrm{d}n + \left(\frac{3 - n^2}{2n^4}\varepsilon^2 d\right)\mathrm{d}n = \left(1 + \frac{3 - n^2}{2n^2}\varepsilon^2\right)\frac{d}{n^2}\mathrm{d}n \tag{3}$$

If we denote the second term in the brackets

$$\alpha = \frac{3 - n^2}{2n^2}\varepsilon^2 \tag{4}$$

we obtain the following relation for the mean value of $\overline{\alpha}$

$$\overline{\alpha} = \frac{1}{\varepsilon_{\max}} \int_0^{\varepsilon_{\max}} \left(\frac{3 - n^2}{2n^2}\varepsilon^2\right) \mathrm{d}\varepsilon = \frac{3 - n^2}{6n^2}\varepsilon_{\max}^2 \tag{5}$$

where $\varepsilon_{\max}$ is the maximum angle of incidence. For example for $\varepsilon_{\max} = 20° = 0{,}349$ rad and for the refractive index of the plane-parallel plate material $n = 1{,}5$ we obtain value $\overline{\alpha} = 0{,}00676$ which is relatively small and can be neglected with respect to the first term. For practical calculation we can use the approximate relation

$$\mathrm{d}\Delta \approx \frac{d}{n^2}\mathrm{d}n \tag{6}$$

The following relation expresses the change of the shift Δ with respect to wavelength (material dispersion)

$$\mathrm{d}\Delta \approx \frac{d}{n^2}\mathrm{d}n = \frac{n_F - n_C}{n_d^2} d = \left(\frac{n_d - 1}{n_d} d\right)\left(\frac{n_F - n_C}{n_d - 1}\right)\frac{1}{n_d} = \frac{\Delta_0}{n_d V_d} \tag{7}$$

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Selected Mathematical Aspects of Non-Hermitian Quantum Models

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One of the most remarkable features of quantum mechanics is that during the last eighty years the original formulation of its basic principles survived virtually all its experimental tests and theoretical verifications. Also one of the recent attempts initiated by Bender et al and carrying the popular nickname of "PT-symmetric quantum mechanics" did not, in fact, succeed in changing the validity of the abstract first principles of this remarkable theory. At the same time, the sudden increase of popularity of PT-symmetric models during the last ten years brought new theoretical activities as well as a very visible progress in our understanding of many quantized physical systems, especially those which are considered in the kinematic regime of special relativity (controlled, e.g., by Klein-Gordon equation or Proca equation) or cosmology (cf. the Wheeler-de-Witt equation).

Inspired by the obvious fact that while the physical aspects of the new field are developing quite quickly (covering the phenomenological domains as remote as the so called interacting boson models in nuclear physics or the search for supersymmetric doublets of elementary particles in high-energy physics), numerous parts of the related mathematics are either far from complete (e.g., just a few authors studying PT-symmetric systems were able to make use of the theory of operators in Krein spaces) or entirely missing.

In this context, we stress the importance of a systematic return to several rigorous aspects of the currently quickly developing PT-symmetric quantum mechanics and of its various exciting immediate generalizations, which range from certain elementary schematic solvable examples (where either the parity P or the time reversal T – or both – are replaced by certain more general operators) to some more realistic models which still preserve exact solvability (multiparticle models of the Calogero-Moser-Sutherland type or some not too complicated phenomenological models in relativistic quantum field theory) and even to the models with applications out of the original domain of quantum theory (with the most successful attempts being made in classical electrodynamics and magnetohydrodynamics).

We summarize several results in this contribution. At first, we explore the relations between abstract classes of certain non-Hermitian operators [1]. Then, we focus on the scattering in the PT-symmetric Coulomb potential [2,3]. Further, the curvature effects for PT-symmetric models in defined in curved manifolds are described. Finally, Krein structures in de Sitter quantum theories are presented.

The basic question in the framework of PT-symmetric quantum mechanics is the relation between operators possessing an antilinear symmetry (e.g. PT-symmetry) and so called pseudo-Hermitian ones. It is well known that these two properties are equivalent for the operators defined on finite dimensional spaces. It is also known that this equivalence is valid

for particular (bounded) operators (spectral operators of scalar and finite type). However, for general bounded operators, the equivalence does not hold. The counterexamples, i.e. an non-pseudo-Hermitian operator with an antilinear symmetry and an pseudo-Hermitian operator without any antilinear symmetry, are constructed. Both examples are non-spectral operators with non-empty residual spectrum.

Scattering on the PT-symmetric Coulomb potential is studied along a U-shaped trajectory. This trajectory circumvents the origin in the complex plane from below, preserves PT-symmetry, determines the suitable boundary conditions, and allows the restoration of the correct sign of the energy eigenvalues. Scattering states can be written as a linear combination of the two solutions valid for non-integer values of the 2L parameter, which would correspond to the angular momentum in the usual Hermitian setting. The transmission and reflection coefficients are found in a closed analytic form. Analogously to other PT-symmetric scattering systems, the latter exhibits the handedness effect. The poles of the transmission coefficients correspond to the bound state energy eigenvalues.

The Laplace-Beltrami operator, defined in tubular neighbourhoods of curves on two-dimensional Riemannian manifolds and subject to non-Hermitian parity and time preserving boundary conditions, is analyzed. We are concerned with the influence of the geometry on the spectrum. After introducing a suitable Hilbert space framework in the general situation, which enables us to realize the Laplace-Beltrami operator as an m-sectorial operator, we focus on solvable models defined on manifolds of constant curvature. In some situations, notably for non-Hermitian Robin-type boundary conditions, we are able to prove either the reality of the spectrum or the existence of complex conjugate pairs of eigenvalues, and establish similarity of the non-Hermitian m-sectorial operators to normal or self-adjoint operators. The study is supported by numerical computations.

Experimental evidences and theoretical motivations lead to consider a curved space-time relativity. The only maximally symmetric space-time solutions in general relativity are (besides Minkowski space-time) de Sitter and anti de Sitter space-times. The invariance group of the former is the de Sitter group $SO_0(1; 4)$ or $Sp(2; 2)$. Quantum elementary systems are associated with unitary irreducible representations of that simple Lie group. At the lowest limit of the discrete series of $Sp(2; 2)$ lies a remarkable family of scalar representations involving Krein structures and related indecomposable representation cohomology which deserves to be thoroughly studied in view of quantization of the corresponding carrier fields. Possible extensions of an exemplary case, so called de sitterian massless minimally coupled field, are indicated.

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Aperiodic Rigorous Coupled Wave Analysis and its Applications

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Photonic and plasmonic structures (photonic crystals, photonic wires, dielectric and/or metallic guiding structures, diffractive structures, etc.), especially those with high-index contrast and sub-wavelength feature sizes, are very attractive in many areas of optics and photonics. Such structures, due to their specific properties and characteristics, have already enabled to develop many functional devices with new functionalities, and the research towards fully functional sub-wavelength high-contrast photonic structures successfully continues, also within our research group of Optical physics at the Department of Physical Electronics, both on national and European level (e.g. COST Action MP0702). In this contribution, we will concentrate on the latest improvements in the modeling methods and on the numerical simulations of selected nanostructures. Such a study is highly relevant not only for proper understanding of physical mechanisms but also for optimization and fabrication recommendations within the potential design process.

First, the attention will be given to the Fourier modal method, i.e. the modal method based on the Fourier expansions, namely the aperiodic rigorous coupled wave analysis (ARCWA) method [1-2]. Following the original idea [1], the modification has been achieved by introducing a virtual periodicity and incorporating artificial absorbers (perfectly-matched layers and especially the nonlinear coordinate transformation) at the boundaries of the elementary cells of corresponding periodic structures. Our ARCWA implementation has recently included all modern techniques and approaches (as e.g. the proper Fourier factorization rules, scattering and enhanced transmittance matrix algorithms) as well a range of other important algorithm expansions, necessary for an accurate effective modeling [2]. Naturally, for obvious simplicity and clarity, we have first concentrated on simulations of two dimensional structures, though our works on the fully 3D implementation of ARCWA, through the 2D periodic RCWA approach, have just recently started.

Particularly in this contribution, we will concentrate on the adaptive spatial resolution (ASR) technique [3] implementation, originally used for periodic structures (diffraction gratings). The theory of ASR will be presented, including various modifications, together with our implementation approach where is represents another nonlinear coordinate transformation (mapping). It will be shown how the proper implementation of this approach can effectively overcome the typical disadvantages connected with the application of the Fourier methods to real simulation problems: a large number of diffraction orders (wave harmonics) needed to achieve the desired accuracy, connected with the presence of the Gibbs phenomenon. The convergence characteristics and improvements for several types of structures of interest will be discussed. Also, some other further improvements of the algorithm (some of them rather technical but still significantly improving the numerical performance) will be presented.

As was found, in our particular implementation, the combination of original nonlinear coordinate transformations with the ASR transformation within the ARCWA algorithm behaves efficiently and numerically accurate. In this contribution, several interesting

examples of photonic nanostructure simulations will be discussed in more detail (waveguide diffractive element testing structure, photonic wire structure with a resonant cavity, surface plasmon sensor, various sub-wavelength apertures with the effect of transmission enhancement, including a s.c. slit-groove diffraction problem, and also photonic crystal based structures – namely PhC based waveguides). The convergence performance of our algorithm was also tested in a comparison with other methods, both modal based and direct numerical ones (e.g. finite difference time domain algorithm).

Apart from the ARCWA, we have also studied the complex Jacobi method (CJM) [4]. CJM is an alternative approach, based on the direct numerical integration. The standard Jacobi approach is the iterative method for numerical solving the Helmholz equation. The difficulties with the convergence have been overcome with the complex (two step) approach. The advantages of the CJM method include: general flexibility, rather easy implementation, even for the paralel computing. On the other hand, the disadvantages of the method come mainly from its background in finite differences: rather poor representation of curved boundaries and also a need for the connection with an external mode solver (to determine the source profile). We have implemented the method (also with the ASR technique), and used it both for the comparison purposes with ARCWA method, and also as a starting platform for the implementation of nonlinear optical interactions, namely the Kerr nonlinearity of the refractive index. Such nonlinear interaction is often applicable in practice. In modal methods as our ARCWA, since such nonlinearity is rather difficult to implement directly, it is typically implemented via the special iterative approach. Since the CJM is based on the iterative scheme itself, such implementation into the CJM is quite natural. Hence the CJM approach has been used as the first step to obtain preliminary experience with such nonlinear interactions.

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Design and Realization of Apparatus for Studying Pinching Capillary Discharge in Nitrogen

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The Z-pinching plasma proofed to be good way to obtain intense XUV radiation with devices reachable for most laboratories. Such device produces radiation with line spectra. Using filters, there is possible to filter out unwanted spectral regions such VIS and UV. When proper discharge conditions are set, significant amplification of certain lines in the sub region of interest can appear. In addition, when the plasma forms a uniform column with length exceeding diameter in two orders, and the pumping power is sufficiently high to ensure a high enough population on a meta-stable energy level, Amplified Spontaneous Emission (ASE) can be detected. ASE has the properties of a laser.

In the last two decades, XUV lasers are in forefront of interest of many laboratories. There are several possibilities to generate XUV coherent radiation. The brightest sources are free electron lasers – FELs. Accelerated electron beam passing through undulator generates Bremsstrahlung. This radiation backwards affects electron oscillations and by this way electrons becomes bunched in layers distant of multiplies of emitted wavelength and emitted radiation becomes coherent. Another approach is high-harmonic generation (HHG), generally done by non-linear effects in rear gases. In such a way, XUV coherent radiation with good beam properties, but low energy, is generated. Efficiency of the conversion is very small. Least but not last approach is ASE in a laser plasma column. Target is stroked by the high energy laser (or by the high-power fs laser). High temperature, dense plasma is generated. In such non-equilibrium plasma can appear high electron population on meta-stable highly-stripped ions energy levels. Radiation from these lasing transitions is amplified particularly by spontaneous, particularly by stimulated emission in direction of column length. High amplification has to be ensured, because no resonator in XUV region can be made. In 1994 J.J. Rocca et al. from Uni. of Colorado introduced first capillary discharge driven XUV laser at 46.9 nm of 3s – 3p transition of Ne-like argon. The active environment of Ne-like argon lasers is created by abrupt current pulse (~ 10 ÷ 40 kA with 10 – 90% rise-time of ~ 40 ÷ 60 ns) flowing through capillary of diameter ~ 3 mm and length 10 ÷ 30 cm. The plasma is heated by the current and compressed by radial magnetic pressure (Z-pinch effect).

We realized discharge apparatus able of producing laser amplification at 46.9 nm in argon with maximum of the current $I_{MAX} > 15$ kA and rise-rime of 48 ns. [1] We also used this apparatus for diagnostic of nitrogen plasma. Two spectral regions were gauged: Vicinity of 13 nm, and so called water window region – 2.4 ÷ 4.5 nm. The first region is attractive for industrial application, e.g. XUV lithography; the second has bio-medical application, e.g. nano-scale microscopy of proteins. MHD simulations for our discharge system done by P. Vrba predicted high intensity of radiation of $1s^2 – 1s.2p$ transition of N^5 at 2.88 nm [2]. We confirmed this presumption by experiment.

Our main aim is to build the capillary discharge nitrogen laser at 13.4 nm of 3 – 2 transition of H-like nitrogen. In comparison with Rocca's laser, which is pumped by the electron collisions in over-heated plasma, this laser is pumped by the three-body

recombination in under-heated plasma. Such condition can appear in the time of pinch decay, and are predicted by P. Vrba. The basic requirements for sufficient gain at 13.4 nm can be easy deduced. At the beginning, the electron temperature has to be sufficiently high, to obtain dominant abundance of fully stripped nitrogen ions N^{7+}. The temperature is $Te > 140$ eV for >50% abundance of N^{7+}. The electron density should be enough high – $Ne \sim 5 \cdot 10^{19}$ cm^{-1}, to ensure dominancy of the 3-body recombination process at collision limit between levels 2 – 3 of N^{6+}. Than the electron temperature *Te* should drop under 60 eV as a second condition of ensuring 3-body recombination to level 3 of N^{6+}. This *Te* drop has to be shorter, than the 3-body recombination rate for given *Te* and *Ne*, i.e. in time $t < 5$ ns. According to P. Vrba's 1D MHD and kinetic simulation of the capillary discharge in nitrogen, current with amplitude $I_{MAX} > 60$ kA and initial current rate $dI/dt > 1.5 \cdot 10^{12}$ As^{-1} is needed to obtain observable gain in the plasma column. Experiments at the discharge apparatus with similar current profile were made by S.N. Kampel, but no gain was observed due to weak abundance of fully striped ions (10 ÷ 20%). It is very cost and time consuming to build discharge apparatus with higher maximal current and current steepness as Kampel had at disposal. So, we tried to find another solution by changing the current profile from dumped sinusoidal to blumlein-type LR integrated square shape and evaluate the effect of higher speed of current drop to plasma cooling time. By higher plasma cooling, we could obtain higher gain. Our designed discharge apparatus based on marx-blumlein arrangement of commercial coaxial cables RG213 is able to produce 60 kA pulses with rise and drop time of 35ns into 60nH load at overall charging voltage 240 kV. Cables were tested up to 100kV DC without breakdown. Cables will be charged up to 80 kV in parallel and connected into series by spark-gap to increase the voltage on capillary ends. Our simulation of the discharge in 2D RMHD code Z* (S. Zakharov) shows influence of the discharge current shape on plasma cooling time. Simulations of several current shapes were performed and they were compared with the simulation of the same current shape as in Kampel's experiment.

The Blumlein-type current profile can really fasten the cooling of the plasma but at certain conditions and with some another affect on plasma parameters. One of these affect is electron density drop preceded the electron temperature drop. This is main drawback of using this scheme. The other drawback is a need of longer pulse, which leads to growth of instabilities in discharge plasma. On the other hand with sufficiently low cables overall impedance, and without switching cables in series, the cables can be used instead of ceramic capacitors due to their low cost and low inductance. But, such an arrangement is suitable only for lasers with lower electric power requirements, i.e. for lasers with $\lambda > 40$ nm.

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Improving Spatial Precision of 2D-imaging Color Filter Spectrograph with Wedged Optical Filters

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Spectrally-resolved imaging plays an important role in many areas of modern science, e.g., in astronomy, biology, medicine, and laser physics [1]. One of the simplest tools used for two-dimensional (2D) spectroscopy is a camera with a set of color filters. In such 2D-imaging color filter spectrograph, the analyzed object plane is image-relayed by an optical system to a photosensitive area of a camera. The color filters are placed in arbitrary position in front of the camera to select the required spectral band of the image. These filters, however, often have an optical wedge, deflect the beam, and cause a shift of the corresponding spectral image on the camera proportionally to the wedge angle of the filter and a distance between the filter and the image on the photosensitive area. After taking monochromatic images sequentially with different color filters, each image with different spatial shift, monochromatic images are numerically superimposed to obtain color image. Such color image will have unsharp details with unreal colors.

In this work, it is proposed to place the optical filters to a close proximity of the object plane or its image and then image-relay the filters onto the camera. It our setup, it reduced the distance of the filters and the camera from three centimeters to a millimeter. Accordingly, the image shift in order of 100 μm, caused by a common filter with the miliradian wedge, was reduced below 10 μm. The imaging compensates the shifts and unblurred image is produced.

To evaluate the beneficial effect of imaging, a spot on the image appearing on all spectral components of the original image was chosen and its position was measured for all spectral filters. Because of the filter wedges, the respective positions of the spot differ and the standard deviation of the average spot position is increased. By imaging the filters onto the camera, standard deviation dropped from 11.5 μm to 1.5 μm. Particular image shifts decreased 6 times from 65 μm to less than 10 μm. Further increase in precision was foiled by beam pointing instability caused by air-condition.

In broadband ultrafast laser systems, very short optical pulses are composed of spectral components. An important measure for such pulses is dependence of a direction of propagation of spectral components on wavelength. This dependence is called angular dispersion and influences the quality of the pulse, for example by stretching the pulse in time by several tenths of percent. Misalignment of optical systems that are used with such pulses influences the angular dispersion. Therefore, the angular dispersion has to be carefully monitored. So far, only more complicated instruments have been available allowing just one-dimensional angular dispersion measurements, e.g., a grating imaging spectrometer [2]. The spectrograph presented here enables a full 2D angular dispersion measurement with comparable precision.

The precision of the measurement has been tested by measuring angular dispersion caused by a thin optical wedge with the wedge angle of 3.9°. The data were measured with uncertainty of 10 μrad and then were fitted by calculated law of refraction curve. From the calculated curve, the wedge angle was estimated to be 3.85° ± 0.15° in the horizontal plane

and $0.0° \pm 0.15°$ in the vertical plane which is in a good agreement with the wedge parameters. The uncertainty of the wedge angle estimation is comparable with other non-goniometric measurements.

The presented simple 2D-imaging spectrograph is suitable for measuring wide range of spectrally resolved quantities where one has to compare relative positions among images obtained on different wavelengths. In ultrafast laser beam diagnostics, it can measure beam dispersions, wavelength dependent beam divergence, shape, etc. with 2D resolution and precision better than 10 μm.

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Arrangement of the Experimental Setup for Determination of Average Kinetic Energy of Reacting Deuterons in Fusion Z-pinch Experiments

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Neutron diagnostics, especially determination of the neutron energy spectra, could provide several pieces of information about fusion plasma. It can help us to understand how the ions are accelerated (beam-target mechanism, thermonuclear process, etc.). The kinetic energy of reacting deuterons is one of the important parameter of the fusion plasma where deuterium is presented in a load. The energy of deuterons is determined from the reconstructed neutron energy spectra which are obtained by extended time-of-flight (TOF) method [1, 2], where time-resolved neutron detectors are placed at several distances from the neutron source.

Provided that the deuteron energy is much smaller than the fusion Q-value, it is possible to show that the neutron energy is only a function of the component of the deuteron kinetic energy (and vice versa) in the direction of neutron detection [3]. Consequently, the side-on and end-on energy components of deuterons can be found on the basis of TOF measurement of neutrons in the radial and axial lines. Then the average kinetic energy of reacting deuterons can be evaluated on an assumption of radial symmetry of neutron production from Z-pinch plasma.

The sufficient number of lines of neutron detection (two lines) in the *Z*-pinch experiments was deduced in the previous paragraph. Another unknown is the number of detectors and their placement. The sufficient number of detectors could be determined from the numerical tests, where the reconstruction from 2 up to 9 detectors placed in both (opposite) directions of neutron detection were examined. The result is that 6 detectors are sufficient for the determination of one component of the deuteron kinetic energy. The recommended placement of the detectors is following: The nearest detector – as near to the source as possible (we are limited by the device vessel and by the duration of X-ray pulse). The most distant detector – as far as possible (we are limited by an experimental room and by intensity of neutron source). The rest of detectors – the detectors should be placed equidistantly at the angles of view not equidistantly at distances [1]. On the basic of other numerical tests, where the reconstructions from one or both directions of neutron detection were examined, we recommend the placement of the neutron detectors in both directions (two opposite directions within one line).

Consequently, total number of neutron detectors is 12 (3 detectors at 4 directions in 2 lines of neutron detection). Let's denote the placement of the neutron detectors in the real experiment, for example the experiment on the S-300 facility. The detectors are placed at the following distances in the radial line: –8.3 m, –5.17 m, –2.6 m, 8.3 m, 5.17 m, and 2.6 m.

Experimental setup in the experiments on S-300 facility placed at Kurchatov Institute in Moscow was arranged on the base of the above mentioned results. The reconstruction of the

time-resolved neutron energy spectra and the determination of the average kinetic energy of reacting deuterons in fusion Z-pinch experiments were published in ref. [3, 4].

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Characterization of VCSEL Diodes Emitting in Mid-infrared Range of Spectra

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Optical properties of many prototypes of Vertical-cavity surface-emitting laser (VCSEL) diodes were measured. VCSEL is in principle special type of PIN diode. Multiple quantum well forms active region of the laser (intrinsic area). This area is from both sides surrounded with Bragg reflectors, which forms optical cavity for defined wavelength [1]. Advantage of the quantum well lasers is two-dimensional density of states, because with energy going to zero density of states remains constant in contrast to bulk density of states where with energy going to zero also density of states go to zero [2]. Wavelength of emitted radiation should be tunable in range of few nm through change of electric current or through change of external temperature of the semiconductor structure. Emission wavelength has to stay constant at constant electric current and temperature. Main application of VCSEL diodes is in trace gas sensing, because spectral lines of many gases lie in the Mid-infrared range of spectra [3].

Semiconductor structures of measured lasers were prepared by Molecular beam epitaxy method and consisted of: GaSb substrate; 21 pairs of $GaSb/AlAs_{0,08}Sb_{0,92}$ layers (first Bragg reflector); Substrate and first Bragg reflector are Te-doped. Te is N type dopant, concentration of Te is 10^{18} cm^{-3}. 8 $Ga_{0,65}In_{0,35}As_{0,1}Sb_{0,9}$ quantum wells 10 nm thick embedded in 30 nm thick $Al_{0,35}Ga_{0,65}As_{0,03}Sb_{0,97}$ barriers (optical cavity); Semiconductor layers which forms optical cavity are intrinsic. 18 pairs of $GaSb/AlAs_{0,08}Sb_{0,92}$ layers (second Bragg reflector); GaSb contact layer 300 nm thick; Second Bragg reflector and contact layer are Be-doped. Be is P type dopant, concentration of Be is 7.10^{18} cm^{-3}. The composition and thickness of layers can slightly vary over individual samples.

The lasers are characterized by: (1) emitted radiation wavelength (laser can emit single mode or multi mode wavelength), (2) full width in half maximum (FWHM) of spectral line (3) optical power of the laser. Very important is to determine, how above mentioned properties change, when is changed electric current or external temperature. VCSEL diodes working in pulse regime were also measured. Pulse lasers were operating in quasi continual regime, which means that some specific electric current pulses are repeated with high frequence. High treshold current (around 20 mA) is a reason, why laser is operating in pulse regime, because so high continual electric current can cause thermal damage of semiconductor structure. The treshold current is in the range from 3 to 4 mA for continual working lasers.

The dependence of electroluminescence (EL) intensity on emission wavelength was measured for different values of electric current. The shift of emission wavelength was observed for increasing electric current. It was observed for all continual and for all pulse lasers. The shift of emitted wavelength is approximately 0,5 nm / 1 mA for continual lasers and less than 0,05 nm / 1 mA for pulse lasers. This effect can be explained by increase of the temperature of semiconductor structure. Obtained results for continual laser are shown in Table 1. The intensity of emitted radiation is increased with raising electric current, no saturation was observed. It is predictable, because increasing electric current means increase

in number of recombinating electrons and holes. Important is that FWHM remains approximately same for different values of electric current.

Table 1. Dependence of EL wavelength and FWHM on electric current for continual laser

El. Current [mA]	Emission wavelength [nm]	FWHM [nm]
2,5	2005,56	0,64
5	2006,72	0,58
7,5	2008,16	0,60

Also the dependence of EL intensity on emission wavelength was measured for different values of external temperature (for constant value of electric current). The shift of emission wavelength was observed for increasing temperature. The shift of emitted wavelength is approximately 0,2 nm / 1 °C. Measured results for pulse laser are shown in Table 2. Emitted radiation intensity decreases with increasing temperature. This effect appears, because recombine still same number of charges, but nonradiative recombination play dominant role with increasing temperature. The FWHM remains again approximately same for different values of external temperature.

Table 2. Dependence of EL wavelength and FWHM on external temperature for pulse laser (electric current was 40 mA, 1 μs pulse, 100 kHz repeating frequence)

Temperature [°C]	Emission wavelength [nm]	FWHM [nm]
25	2301,05	2,91
30	2302,20	2,82
35	2303,10	2,90

The shift of emission wavelength was not observed, when lasers worked at constant electric current (continual or pulse electric current) and constant external temperature. It indicates that lasers are stable enough.

The optical power is lower than 1mW for all lasers. Such value is not sufficient. The optical power higher than 10mW is required.

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Proposal of Ultra-High-Power Beams at the Kilojoule Iodine Laser PALS

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The iodine kJ laser PALS is widely used by users. To extend the scope of the experiments, a proposal of new ultra-high-power (UHP) beams was done in detail. The generation of ultra-high-power pulses is nowadays mostly based on Chirped Pulse Amplification (CPA) method. In CPA, femtosecond pulses are stretched 10^3 – 10^4 times prior the amplification to decrease the intensity of light to avoid undesirable nonlinear effects. After amplification the pulses are compressed to original pulse width and the pulse intensity is thus substantially increased. The gaseous iodine amplifiers do not support the broad bandwidth of femtosecond pulses. Therefore the CPA cannot be used to produce UHP pulse at PALS laboratory. However, UHP pulse is attainable with optical parametric chirped pulse amplification (OPCPA) of a signal pulse of a Ti:sapphire oscillator at a central wavelength around 800 nm if parametric amplifiers are pumped by a third harmonic of the iodine laser at a wavelength of 438 nm [1].

The model of the design is based on routine parameters of the laser PALS and on state-of-the-art of the ultra-high-power beams generation. Following assumptions were made in the model. Temporal profiles of pulses are Gaussian. The diameters of top-hat spatial profile of the pump and signal beams are equal in each parametric amplifier. The non-collinear interaction between the signal and pump beams is used in parametric amplifiers to enhance the amplification bandwidth. Transmission between amplifiers is approximately 80% and beams are image relayed. Front-end amplifiers achieve gain of about 1000 with repetition rate higher than 1 Hz for easy alignment and optimization. Power amplifiers are designed for maximum efficiency. The amplified pulses are compressed in the pulse compressor that uses commercially available metal coated gratings with 1200 l/mm. The efficiency of the compressor is 50 % for spectrum of bandwidth of 200 nm. The beam is focused by F/2 optics to 2× diffraction limited spot.

Using the OPCPA technique, we propose two new alternative UHP beams at PALS with powers of 100 TW and 1 PW, respectively, including a pulse compressor and new front-end amplifiers. The signal pulse generated by Ti:sapphire femtosecond laser with central wavelength of 800 nm and bandwidth of 100 nm is stretched from 10 fs to 310 ps. The pulse is amplified from 1 nJ to 30 mJ in 3 LBO crystals with lengths of about 11 mm and pump intensities of 3 GW/cm^2. These front-end amplifiers are pumped by second harmonic of commercial Nd:YAG laser with repetition rate of 10 Hz and pulse energy of 1 J. Fast Pockels cell cuts the pump pulse to reduce parametric fluorescence and to maintain high contrast of signal pulse.

The third harmonic of PALS auxiliary beam with energy of 30 J and pulse width of 500 ps is used to amplify the signal pulse to 4.5 J in KDP crystal of length 28 mm and pump

intensity of 2 GW/cm^2. The amplified signal pulse can be compressed to obtain 100 TW pulse with energy of 2 J and pulse width of ~20 fs. The 100 TW beam with the kilojoule sub-nanosecond terawatt PALS main beam (a wavelength of 1.3 μm or its harmonics) enables pump-probe experiments. The 1 PW beam utilizes the third harmonic of PALS main beam with energy of 300 J and pulse width of 500 ps to amplify the signal pulse to 65 J in KDP crystal of length of 21 mm and pump intensity of 2 GW/cm^2. Compressed pulse has energy of 28 J and width of ~20 fs. The repetition rate of UHP beams is the same as of PALS laser, i.e., 1 shot per 25 minutes. It can be switched between the two UHP beams by shift of three mirrors and both beams employ the same pulse compressor. To achieve good focal spot, the adaptive optics is implemented in the system. The intensities of focused UHP beam on target can be as high as 10^{22} W/cm^2.

The amplification chain was simulated using coupled wave equations for optical parametric amplification. The spectrum of the amplified pulse has a bandwidth of about 60 nm for both UHP beams thus the pulse is compressible to widths of 20 fs. Ray-tracing simulation and optimization of pulse compressor were made in Zemax software.

Layout of the two new beams in the existing PALS laser hall was also proposed. The front-end is placed on four optical tables that are placed in free space of PALS laser hall. The power amplifiers are placed above the contemporary laser chain. The cylindrical pulse compressor chamber with a diameter of 1 m and a length of 2 m is placed in the interaction hall of the PALS beside the present interaction chamber.

The proposed UHP beams will increase the available laser power at the PALS facility by two or three orders of magnitude and the intensity by five orders. This substantial enhancement will extend the range of possible user experiments, for example relativistic particle acceleration, relativistic optics, laboratory astrophysics, and tests of fast ignition schemes.

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Section 3

INFORMATICS
&
AUTOMATION ENGINEERING

Performance Analysis of Incompressible Viscous Fluid Flow Solver

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Introduction

FEMFLUID is an academic two-dimensional finite element method based solver for unsteady incompressible Navier-Stokes equations with the capability of fluid-structure interaction (FSI) simulation. It is mainly used for studying FSI problems such as airfoil vibrations and for studying numerical stabilization methods of FSI problems.

Within fluid flow simulation FEMFLUID iterates through computational time and for every time step it solves a non-linear problem. Linearization of this problem leads to nested non-linear iterative process and for every non-linear iteration a sparse unsymmetric system of linear algebraic equations is solved. As a linear solver the original FEMFLUID code uses UMFPACK – the software package for solving unsymmetric sparse linear systems using the unsymmetric multifrontal method [1], i.e. the method of direct type.

The FEMFLUID code suffers from high CPU and memory demands compared with simulation problem size. I tried to identify causes of these high CPU and memory demands and on the basis of my observation I proposed some changes in the code that should lead to its higher performance.

Test case

A laminar lid driven cavity problem case with simple unit square computational domain was established for evaluating the performance of FEMFLUID code. All measurements were performed for Reynolds number 2500. The computational mesh consists of 131072 triangular elements of P2/P1 type (Taylor-Hood) and 66049 nodes. The grid was refined by the boundaries of the domain to better capture assumed vortices and high pressure gradients. I setup the simulation to run for 60 seconds of computational time with time step of 1/100 second, which results in 6000 computational time iterations. A Galerkin Least-Squares (GaLS) stabilization was used.

Code performance

The number of non-linear iterations within time step varied through the computational time. The total number of non-linear iterations, i.e. the total number of UMFPACK linear solver routines calls was 12707. All simulation run took 1543 CPU time seconds and 78 percent of this time was spent inside UMFPACK routines. As for memory requirements, maximum allocated memory outside UMFPACK routines was 1.25 GB while maximum allocated memory inside UMFPACK routines was 4.29 GB. This high amount of additional memory is needed for factorization of the original sparse matrix wherein too much fill-ins occur.

Linear problems analysis

Through simulation run I stored linear systems with matrices in compressed sparse column format into binary files. Since storing linear systems for all 12707 non-linear iterations would take more than 3 terabytes of disk capacity, I chose only particular time steps

for further analysis. Finally, 320 linear systems from all over the simulation time range were stored and analyzed.

First result of my observation was that all stored linear systems were of the same size, particularly 592387 equations with the same number of unknowns. All matrices were square and sparse with exactly 15222353 number of non-zero entries, i.e. the filling is about 0.00434%. I also compared sparsity pattern of stored matrices and verified that it was exactly the same. This was expected because sparsity pattern relates to the structure of computational grid that does not change through simulation.

I also compared linear systems numerically. The main result was that the differences of matrices, right-hand-side vectors and solution vectors between two successive non-linear iterations decreased of several orders of magnitude during simulation run.

Iterative linear solver

Because direct solvers cannot exploit the decreasing differences between successive linear systems I tried to replace UMFPACK direct solver with an iterative solver. I chose the GMRES method from PETSC software package [2] and SOR preconditioner with Eisenstat trick [3].

Comparing both simulation runs showed much better solver performance when iterative linear solver was used. The CPU time of whole simulation decreased from 1543 to 312 seconds and the CPU time of linear solver routines decreased from 1209 to 21 seconds. As for memory requirements, the iterative linear solver needed 0.19 GB of additional memory compared to 3.04 GB needed by UMFPACK solver.

Conclusions

I have shown that using preconditioned iterative method instead of direct method for solving sparse linear systems may considerably improve CPU and memory performance of fluid flow solver based on finite element discretization of unsteady incompressible Navier-Stokes equations. For larger problems this may be the only option because of high memory demands of sparse direct linear solver.

However, my test problem case converged from the initial conditions to steady or nearly steady state fluid flow solution. It means that in the end of simulation time the solution between two subsequent time steps varied very slightly and such behaviour is suitable for iterative method. For unsteady flows, e.g. high Reynolds number flows around a cylinder or an airfoil or for FSI problems an iterative method may be much more time consuming and finding of efficient preconditioner is then crucial.

All my computations were only sequential. That was mainly because the FEMFLUID flow solver as well as the UMFPACK linear solver has no parallel capabilities.

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Anticipatory Behaving Artificial Life Agents

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Every creature or being uses anticipation should they be aware of it or not. This is already a known fact which is discussed frequently in past decade. I aim in this article to discuss what I consider overlooked in the research so far. My opinion is that anticipation is not matter of a single mechanism in a living organism. I will show on examples that anticipation plays important role on many different "levels". The first example showing a low level anticipation is the explanation of so called baroreceptor reflex, borrowed from the work of Nadin [1]. This mechanism affects the heart rate via the nervous system in order to maintain the blood pressure within relatively constant and safe limits. Nadin in his work described the anticipation behind. The point to be taken here is the involuntary internal regulation mechanism uses anticipation. Second example showing on the other hand higher level anticipation can be a sport player. While playing the opponent a one constantly estimates (based on "sensory inputs" and past experience) the opponent's action and also the result of his action. The past experience can be recorded as a model containing among other information the body physiology, the laws of gravity and physics. This model may not be expressed explicitly in term of equations but as input patterns and rules for reaction. These patterns and responses (i.e. the model) can be improved by training. It can be seen that above I have presented two different example principles with the common denominator which is predicting the future that helps to influence the current decision. This type of prediction is called anticipation. I presented these examples to show that anticipation is not just one function of the organism. The first example unlike the second has for example no note about improving through learning. This has led me to conclusion that anticipation is built in and applied on different levels. Then main point, already mentioned above for a good reason, for my work is to note from the examples above that the blood pressure regulation resembles anticipatory nature even if it is without any voluntary control. I already demonstrated on examples that are different types of anticipation. I'm not the first one to notice, Martin Butz [2] described four types of anticipation in his work. Even though I embrace this categorization of anticipation I was not entirely satisfied with it. I struggled to categorize the four types from the point of voluntary control (consciousness). As I already shown that this is an interesting point to me in the examples provided. I suggested enriched categories of anticipation by splitting in two each of the four levels defined by Butz. Each of these can exist on either conscious or unconscious level. In my work I call this 8-factor anticipation, in broader sense it can be called multi-level anticipation. The unconsciousness level helps when the information needs to be processed in quick and simple manner.

Unconscious implicit anticipation is the basic level and it represents behavior that was imprinted by nature or creator and that is also not consciously controlled. I understand the basic anticipatory reactions imprinted in the design falls into this category. Reactive behavior as such is not anticipatory in principle. In fact is very often used and understood as exact opposite of anticipation. Classical view of implicit anticipation, in sense of Butz's definition, would be satisfied with the fact that it contains the prerequisites given to the creature either by evolution or by the creative mind of designer. At this basic level there is only the set of inputs I and set of possible outputs O. The reaction base is typically in form of projection from

inputs to outputs $I => O$. The anticipatory approach would be to expect another input $I_t => O$ x I_{t+1}. The interesting question is if the same rule can be created by other level. The answer is yes, the same rule can be inferred by the consciousness of the artificial creature. It inference no doubt took some time also execution takes longer path so it is less likely to be executed in time critical situations. Even the simple model above can be improved. I suggested expectation not only of a new input but also the expectation of the next action as one of the improvement. I will demonstrate the reason for this on another example. Imagine the situation where two agents are in the vicinity of predator. These agents have to select a next step action which might be the same as previous one. This is exactly where I see chance for anticipation to expect that action and have it "prepared". The main area for implicit and unconscious anticipation besides the basic anticipatory reactions is in inner agent processes that represent the creature physiology. Conscious implicit anticipation is imprinted in the creature by design same as above but can be consciously controlled. This covers the attention focus mechanism. Unconscious sensory anticipation is represented by the sensory input gathering, filtering and pre-processing. The anticipatory sensors not only would provide the sensed data, but they could also calculate meta-values such as the speed of change, or keep history. Conscious sensory anticipation can abstract objects and predicts multiple sensory inputs that these objects may trigger. Unconscious and conscious reward anticipation is an area that almost every design and work operate with. The reinforcement is a simple yet powerful way to learning. There are several approaches and theories using reinforcement to create adaptive behavior. Anticipation together with reinforcement can generate emotions. On the conscious level of reward anticipation there is the advantage of the memory shared with other conscious levels so the possibilities are wider. This is a well explored area of anticipation and learning in general. To mention two of them then these are Reinforced Learning (RL) and also Anticipatory Classifier Systems (ACS) [3]. Unconscious and conscious state anticipation are the last two levels. These are most complex ones. Typically the problems solved on these levels are out of the scope of the ALife since they are more close to the classical AI approaches. At the unconscious state level all the state creations, manipulations, and estimation of next states that are not brought to consciousness right away have place here. The last most complex level of the suggested architecture is conscious state anticipation. All the classical AI approaches can find their place here starting from state space search through planning up to the reasoning about self beliefs and others. These two levels as mentioned are well developed within classical AI domain, and the anticipation can only benefit from them. I tried to describe all the levels of my anticipatory design, in my opinion the novel approach of my work is mainly in bringing in the consciousness point of view in the anticipation theory.

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Messages Management System

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Information is very valuable and strategic element. Information is more valuable sooner the recipient receives it. So it is important deliver information punctually to right person.
We lack for information system at Faculty of Transportation Science by which it could be possible to send information by message quickly and simply. The idea to make such information system comes into existence. Thank to maintenance of development programme MSM in the year 2009 we realized that idea and we made system that we named MMS (Messages Management System).
The central idea was made the information system with predefined groups of recipients which covered large scope of usage. So the user doesn't have to pick out individual recipient by hand which is time-consuming and for user it has not been simplification. There are two ways how send the message. The MMS provides to send the message via SMS on mobile phone for quick delivery. The second way how send the message is send it via e-mail.
The access to MMS couldn't be public to avoid to misusage of system to sending unsolicited message (spam). The user has to sign on and he use same login entry as for the others systems of CTU in Prague. For reason of security it is checked if user doesn't enter bad password for three times. In this case it is disallow to the user the access to MMS for a period five minutes.
The user sees a list of messages which were sent him by MMS after successfully sign-on. Every message has information about sender, date and time of sending and what group of senders the message was sent to. The user hasn't available the list of other recipient to safeguard of their privacy.
The user has available the list of all messages which he sent via MMS. The user sees a list of all recipients at every message. If the message was sent by SMS the user can see information about date and time of delivering to SMS gateway of mobile operator. MMS provides send SMS with advice of delivery so the sender should have true datum of delivery to recipient's mobile phone. But this function is not activated because advice of delivery increases price of SMS.
The user can send the message via four simply steps:

1) choosing groups of recipients – in this step it is available to user the list of predefined groups of recipients. This list of recipients' groups is like tree – in lower lever there are recipients' subgroups with more detailed structured. The tree of groups of recipients has four basic branches:
   - projects – this projects are component part of project's oriented education at the Faculty of Transportation Sciences, Czech Technical University in Prague. The user can choose students or/and masters of particular project.
   - subjects – subjects are divided by particular departments of Faculty of Transportation Sciences. The group of students of particular subject is divided by year of studies and study group.
   - students – this group of recipients is divided by all sorts of criteria – form of study, study programme, study profile, study locality, year of studies and study group.

- employees – the group of employees is divided by organizational structuring, particular departments, by roles of faculty (dean, vice dean, manager of projects, director of department, personal assistant and so on)

The user can choose any recipients' groups. If no recipients' group is satisfactory the user do not need to choose any recipients' group.

2) choosing individual recipients – in the second step it is shown to user the list of individual recipients of chosen groups of recipients. If user wants send the message to the other recipients, he can choose from list of other recipients which would not choose via recipients' groups in the first step.
   The list of individual recipients contains information via small icon with picture of mobile phone that recipient's phone number known.
3) choosing the way of delivery and writing of message – in this thirds step the user choose the way of message delivery at first. The way of message delivery is via SMS and (or) via email.
   If the way of delivery is via SMS, the user can type in one message only 160 characters so he can send only one SMS message. At the end of every message is appended full name of sender so the maximum of characters is deducted the number of characters of sender's name. The sender has summary about total number of recipients of SMS message.
   It is automatically checked off that to the user without known mobile phone number will be send so-called pseudo-SMS. It is means that the message will send them via email.
   If the message is send via email, excepting subject and body of email can be uploaded files as attachments also to the total limit 10 MB.
4) dispatching of message – in this step it will be generated SMS messages for individual recipients and they are delivered over commercial SMS gateway to the SMS gateway of relevant mobile operators.
   If the message is sent via email it is delivered over mail server whereas all mail addresses of recipients are in blind carbon copy (Bcc).

If user agrees with sending him messages via SMS he can enter his mobile phone number after sign-on. It is important that this number is never published – the sender see only list of recipients' names.
All mails are sending to the recipients via MMS with using his faculty e-mail address which user has configured as preferred. If user want to obtain messages also at his privacy email address he can entry this address in the MMS. Also this privacy address is never made available.
Every group of recipients is updated every day. There are used data from university systems as reference data.
The MMS application was programmed with using of language PHP, it was used AJAX elements and data are stored in the database system Oracle. The access to MMS is by HTTPS protocol.
MMS is starting to be used by member of academia of Faculty of Transportation Sciences and we have a many ideas to extension and upgrade.

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Supplementation of course "Interactive graphic systems" by multimedia educational material

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The course "Interactive graphic systems" is taught in branch of study Geodesy and Cartography at the Faculty of Civil Engineering CTU in Prague. The education is focused on software systems for processing digital graphic information, which are represented by maps, mostly in a large scale. The teaching consists of needed theory and in continuous elaboration of concrete practical exercises.

Current methods of teaching based on data projector presentations are relatively useful, but they have some limitations. If any student looses for any reason contact with teacher's presentation, he can find only with difficulty the way to continue the work. The compulsory attendance of students at presented processes is another limitation of mentioned type of teaching.

The disadvantages mentioned above can be removed by creation and using of suitable multimedia materials that can be available for students at any time on the internet. Web courses were created that consist of educational text and instruction to exercises as well as of animations for difficult parties of work with mentioned graphics systems. By this way, possibilities of individual study considerably increase no matter the limitations of time or places.

For MicroStation graphic system were developed these animations:

- System setting and configuration
- Using of workspace
- Using of drawing tools
- Cell creation
- Attachment of reference files

For Kokeš system were developed these animations:

- Operation of computing functions
- Computing of polygonal traverse
- Structured features of drawing
- Raster transformation
- Dividing of areas

Created animations are inserted to educational courses and according to students´ response they contribute positively to studying. Current education materials were considerably extended and completed. Complex web education courses were created for the courses "Interactive graphic system 1" (Kokeš system) and "Interactive graphic system 2"

(MicroStation system). Mentioned educational courses include all educational materials and created animations.
Educational courses are administrated in Moodle system, which offers comfortable tools for support of teaching (individual student's accounts, classification of exercises, etc.). Content of web courses is permanently available not only for subscribed students, but for all interested persons in these problems (account for guest user has no password). Of course, anonymous users have restricted rights (they cannot send exercises, review assessments etc.).
Authors of this paper are simultaneously administrators of Moodle system installation of our department and provide a support for other colleagues, who develop educational courses too. Educational courses are available on web site http://geo3.fsv.cvut.cz/kurzy/.
Cooperation with the leading company in the area of geodetic software development was increased during the actualisation of content of teaching. This year, two new exercises were included in teaching on the base of this cooperation: "Creation of digital technical map of city" and "Connection of draw and database". A software modulus for connection of databases was modified on base of our suggestions. Diploma project "Developing of user interface of GIS functions in MISYS system" is another example of cooperation with this company.
Successful cooperation is also established with "Institute of the Czech Language of the Academy of Sciences of the Czech Republic", that uses Kokeš system for graphic localisation of subject of interest. The project leader increases cooperation with "Institute of Archaeology of the ASCR". MicroStation system is used for the dimensional modelling of historical finding places. Some bachelors and diploma thesis were realised in this area.
We believe that created educational materials contributed to the higher quality of teaching and better knowledge of our students to prepare them successfully for studying and professional life.

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Web Based Portal for Structured Text Editing

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In today's world, every day we are meeting situations where structured text is playing a role. For every formal text we are pressed to use the well-formed standard of typing. Of course, it is necessarily and very helpful in major part, but sometimes it takes too much time to prepare document like this, especially when there are many of documents or there is plenty of text. In my work, I concentrated on a problem of editing bigger units of text with necessary of well-formatting in web based portal with possibility of conversion to postscript formats.

Just many years there are many of blogs and wiki portals, which work with templates that afford a kind of formatting of text. But, they are used either for small parts of changing text or afford only based formatting functions. My goal was to find a way to offer a possibility of simply editing of plenty of text (e.g. dissertation) on web sites. My result was a system of tree structure of templates and styles, which allows user to make own or use and edit existing template right for his needs.

In my system every template can own sub-templates with possibility of iterance and allowed styles. Style is a definition of font type, size, decoration, etc., which can user create and assign to templates. Template is a limitation of text, where can be used allowed styles. By assembling templates with styles we get a structure of document, where owner can choose, if some part of text will be whole template with one style or it will be only one of styles in one of templates. This concept allows editors to set a scale of variability of text editing.

Final text is stored as well-formed XML document where every element covers one template. Styles are covered in another element signs which allow element crossing. As late as the text is parsed for preview or format conversion, the style elements are divided into small blocks without element crossing.

Whole portal works with the template concept as with a form, where you choose a template to work with and then you fill the templates using allowed styles. If some template is multiple, you have a possibility to add a new template field directly. Conversion to postscripts format is executing through php class for generating PDF.

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Online Transcription Centre for Hearing-Impaired People

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Using telephony for hearing-impaired could seem like a nonsense at first sight. The project eScribe tries to show that it is possible. The goal of the project is to design and set up an online transcription centre for hearing-impaired. The technical background is based on IP telephony and online displaying voice transcription on the web pages. The transcription is currently done by quick typists and the future goal is to automate the process of transcription. The project is a collective activity of CTU and Czech Union of hearing-impaired.

The project eScribe enhances the project of Czech Union of hearing-impaired: Simultaneous transcription of spoken language. The contribution of the eScribe project is that there will be not a necessity to be physically on the transcripted action both for typists and users. The project offers transcription to anybody anywhere by using communications technologies and special application for transcription.

And how does eScribe work? The voice is transmitted by VoIP telephony from the venue of conference (or other action) for hearing-impaired to the online centre or anywhere to the transcriber. The transcription is done by special educated typists who use a large list of abbreviations which are expanded on all words or sentences. Typists are using in these days MS Word software, and we are not able to force them to use another software solution. Using MS Word as a text input was one of the basic conditions on developing the application for transcription.

The architecture of the system eScribe consists of several blocks. The core of the system which represents the communication part of the project is SW PBX Asterisk. The other very important block is the Transcription server which cooperates with the web server Apache. The access to the system is possible from ordinary telephones, mobile phones but also from HW SIP telephones and SW SIP clients. The easiest way how to access the system is using web phone which makes all the system available only from the web browser without the necessity of any installation or configuration which is very important especially for less experienced users.

The base of the communications system of the eScribe project represents SW PBX Asterisk. Like any PBX, it allows attached telephones to make calls to one another, and to connect to other telephone services including the public switched telephone network (PSTN) and Voice over Internet Protocol (VoIP) services. Asterisk supports a wide range of Video and Voice over IP protocols, including SIP, MGCP and H.323.

Within the scope of the eScribe project protocols SIP and IAX are used. It is possible to make free calls via these protocols from everywhere with Internet connection. To access PSTN and GSM network the eScribe system is currently connected via private VoIP provider. The system will be accessible from the ISDN and mobile network by using PRI connection and by using GSM gateways at an early date.

The other very important block of the system is the server and application for transcription. While open source SW Asterisk was used for communication solution, the own application for transcription was necessary to develop. There was a condition on the

application to minimize the changes of current work of the typists. The typists are used to use MS Word as a text editor. The MS Word document is therefore the input for online displaying transcripted voice on the web pages. On the background of the document runs a program code which sends a transcripted text to the server. The projection of the transcripted text on web pages is done by PHP scripts which are periodically connected to the server and updated the projected page.

The goal of the transcription is to provide real-time communication to hearing-impaired people. It means displaying text information character by character with possibility to make correction and use keys like Delete or Backspace. This is not possible with standard Instant Messengers. The developed application for transcription fulfills partly these conditions. Especially, it is possible the back-editing. The character by character transmission is unfortunately not possible due to nature of MS Word, because MS Word is able to send an event to the server only once per second. The next delay is caused by web page refreshing. Total delay is maximum 1.5 second and the text is transmitted in batches corresponding amount of text which the typist is able to type during 1 second.

The alternative to above-mentioned application is transmitting text character by character by using RTP protocol called as Text over IP. We have recently implemented RFC 4103 and T.140 into Asterisk in our test version. We use SW SipCon1developed by Omnitor as a Voice and Text over IP client. The future work will be focused on developing our own ToIP and VoIP client which will be totally web based without any installation requirements.

The widely accessible online transcription centre enables to provide services to many more hearing-impaired people. The remote transcription can offer this service with lower-cost than if the typist were present at the conference or other actions for hearing-impaired people. This implies the amount of "transcripted action" can be increased.

Thanks to the online transcription the communication barriers will be minimized and the cultural, educational, social or other events could be accessible for hearing-impaired people.

The online transcription could be also used for communication with authorities or courts where the inability to understand is one of the most significant problems.

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Electronic Voting System

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Electronic voting system allows users to use complex voting system which solves the problem of time consuming at voting card counting. It provides both local and global election. As a local election we can consider election events such as election at a congress of political party, council election, local plebiscite and so on. As a global election we can consider for instance the academical senate election or the national election.

Consumers of this system are institutions which arrange an election or a plebiscite. The election authority starts with the election creation in the system. The system delivers voting cards to voters who vote through the system in a secure way. Voters after the authentication fill a voting card which is sent afterwards. The end of the election is determined by the election authority such as a commission. Hereafter the system counts up the votes and provides the election result. The election result is accessible through the web interface.

In case of a local election the whole electronic voting system is deployed in a single server machine. The server is sealed and offline. Only one voting terminal is connected to the server. At first all voters are authenticated to the system by the help of the local identification or by the identity book. Consequently the commission is established which is the election authority who directs the election. Before every election event the commission sets the candidates and starts the voting process of the election event. Each voter votes through the voting terminal and votes for certain candidate or candidates. After voting of each voter the commission ends the election event.

In case of a global election the electronic voting system is deployed in more than one server machine. In this case the system meets the service oriented architecture to ensure the key security requirements for an election such as secret voting against the second person and secret progression of an election. The system enables voting through the internet. The system includes one separated and sealed server machine which is called the counter module. The counter module holds the self-generated cipher private key of the election and this module is the only subject which holds it. The counter module also provides the counting service and the public key. When an election starts the counter module generates private and public keys of the election. The system then operates like the correspondence voting in the USA. The voter is authenticated in the system. The system validates the voter to the election event if he is entitled to vote. Hereafter the system allows the voter to vote. The voter sends a filled in and encrypted voting card. The voting card consists of election information, voter information and voting information. The voting information includes the voted candidates. The voting information in the voting card is encrypted by the public key of the election. The voting card is sent to the validation module. This module holds posted voting cards until the election is finished. This ensures a repetitive voting where the last vote is applied. When the election is finished all voting cards without the voter information are sent to the counter module. The counter module decrypts the voting information from the voting card by the private key of the election. When votes have been accounted the private key is destroyed. Afterwards the counter module delivers the election result to the main module. The main module controls all system

actions and web container which provides the user interface and election information such as election result.

The system architecture reflects the key requirements given by the election law. There are several following requirements like secret voting, secret election progression or votes enforcement. The secrecy of a given vote is assured by the logical division and the asymmetric cryptography. The secrecy of the election progression is given by the use of cryptographic salt in the voting card. As votes enforcement is meant that someone can force another to vote certain option. This is avoided by possibility of voting repetitively. So someone who has been forced to vote in some way can change his vote without any notice.

The system also provides the security policy for the commission. The system doesn't allow to a single commissioner to do some election action. The election actions can be done only by more than one commissioner. This includes also the access to the system during the election. This avoids situtions when one person can influence the election such as premature ending of the election or changes in the database of votes.

In general the business process consists of the election creation, the nomination, the voting and the results generation. At the election creation the administrator sets the commission. Then comes the commission and creates an election event. When commission sets the election event to the nominating state then comes the nomination process where all candidates can nominate themselves and present their programmes. Then the commission ends the nomination and starts the voting. Next voters come to vote. After certain time the commission ends the voting and the system generates the election result.

The system is a three tier application and service oriented. As the presentation tier is the web container written in the framework JSF for J2EE technology with CSS and the java applet written in JavaFX. The application tier represents enterprise java beans which provide the interface or the service. As the database is used MySQL.

This application emanates from the Estonian pattern where citizens have electronic identity cards and use the national universal system for voting. This system also provides bank transactions and the whole communication with the governmental authority. In the Czech Republic there was signed on the 7th of April 2008 a memorandum about the cooperation between the Ministry of Interior and the Czech office of statistics to provide an electronic voting system in the Czech Republic. According to this it is obvious that eventually an electronic voting system will replenish the existing voting systems not only in the Czech Republic but also in another states in the world.

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Specificities, Risks and Potentials of the Cloud Computing - Software-as-a-Service

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IT society is going by changes. Old processes and technologies are replaced by their new versions. Existing main concept of IT using may be replaced by the Cloud Computing in a future. Some forms of The Cloud Computing are already on the run at the present time. It can be useful. This article will be about one form of the Cloud Computing - Software as a Service (SaaS).

Computers are used for works and entertainment too. As a computer we usually understand a full powered computing unit including software. The software is installed on the hard drive inside of the computer. Only own hardware of the computer is used for software run - it is mainly processor, memory and hard drive. It is isolated computing unit which is dependent only on a user and an electrical energy.

Computer network development allows using another concept - client server. An application is stored on the server and application run is possible with universal client which is stored on the user's computer. The computer conception is still classical how it was described, but have to be installed the client into it. Some companies are using a model when they install software on the server only. An user has to connect the server with special computer - terminal. The terminal has not own software but it allows run software directly from the server. Terminal is used only as in/out unit.

This second way is the nearest with SaaS form of the Cloud Computing. Only difference is that in SaaS is everything based on the big computer network - internet. So very fast connect to the internet is basic condition in this business. The Cloud Computing SaaS may be defined as a service which gives a chance to online use of software to users. The service is ensured by large software companies (Microsoft, Google etc.) whose primary offer their own software solution. The software is available to users only from server or servers of these services providers.

Other lines in this text will be about SaaS model and its specificities. It allows describe potentials and risks of this problematic. Firstly is necessary to identify actors in the model. Main actors in the model are: service providers, service users, local or union governments, small software producers and hardware producers.

Software is completely installed and available on the server for all of users without exception. The software means applications including operation system certainly. Computing, processing and saving of data are realized on the server too. The server's hardware is intended for it. So user's data are stored on the server too. User has only in/out terminal where he can see outputs and enter inputs. Connecting between the terminal and the server is based on internet network.

- Users can save their costs for hardware (but it can be irrelevant with costs decreasing), for software administration and for software too (this model can bring new types of licenses - using of the service can be based on purchase of input rights to specified quantum of software).

● Electric power can be saved with the fact that provider offers a sharable computing power for all users. Because shared computing power for millions people can be smaller than totals computing power of single user's computers. Hardware producers will have smaller demand probably. But users will have access to computing power of supercomputer. Peak time can brings lower computing power - but not when the data centre with computers (servers) will be one for all over the planet - peak time will be forever because day is somewhere still.
● Software companies argue with zero "warez", because there will be no needed installation software for users anywhere on the world. And stored data can be under control.
● As positive fact can be taken that data of users will be managed by professional companies including periodical backup.
● Cloud Computing allows sharing files and working on projects.

And now some facts and argues which are not so positive.

● Everything and user data mainly will be stored centralized far away. The meaning of centralization is strongly against main principle of the internet - decentralization. With computer centre blackout will be off line everything on the world. It can be generally considered as a security risk. Another disadvantage of far side is that the communication can failure or can be spied. Internet connection quality is need as important as good security.
● Extreme risk is on a protection of information. Nobody can guarantee security of saved data on the server. First condition of security is that the data must be protected before physical access of unauthorized persons. And now users should save their own data on the server as volunteer in this case! Data and information can be abused by mistake of service provider, hacker, purposely by service provider, government, police etc. Any law cannot help safe user's data. Paradox is the law can allow access to user's data for other persons.
● And with previous: data can be and will be scanned by government. The present day is full of the fighting against the terrorism and it is using for limitation of freedom. The government has needed to control everybody and everything and this is the step to better control of people. Privacy before government will be not. It will possibly store only right data - no matter what does it meaning "right data".
● Next problem is that user looses a possibility of choosing by selecting of concrete provider. He has to accept provider's operation system, package of applications and their version too. There is limited possibility of choosing software.
● User's data will be on the server and there is no place to save it elsewhere than to some alternative provider. User is obliged to pay for this service until he lives.
● SaaS model can give the chance only to big corporations and large software producers. Small software producers cannot probably. Middle software producers can outsource software solutions which are not in product catalogue of large software producers.
● Many problems can be made by individual and different laws of countries.
● SaaS model need not be suitable for graphics software where is request for quick reaction time. For example: games etc.

Definitely, it will be a good outsourcing for specifically group of users. But there are some security risks in this service. The services based on the SaaS model should be developed in future but only as an alternative to the existing concepts. The question is how position takes up the governments to this problematic. SaaS without alternative is a way to an information totality. Many specialists are against it. But it can be too little against the mass of usual user which cannot see bad aspects of SaaS model. There are alternatives for sharing files and works. These alternatives are based on various forms of Cloud Computing, but they are not so dangerous, mainly for their decentralization. Also small firm can have a server which can offer SaaS model as a local service - but this will not be classical as SaaS model of Cloud Computing as it was described by large software producers in their business.

Kohonen Self Organizing Map with Selection Based on Simulated Annealing

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Kohonen self-organizing map (SOM) is neural network created by T. Kohonen. It finds many applications in industry, especially in pattern recognition. It is based on topologically connected neurons that is randomly spread in the beginning of the computation and equally spread in their state space in the end of learning process. Learning process is based on selecting nearest neighbouring neuron from the given pattern and subsequent approach to the presented pattern. Its neighbours are less approached to given pattern according any neighbouring function (usually Mexican-hat function). After a few iterations neurons are probabilistically evenly distributed and forms topological grind.

Simulated annealing (SA) is optimisation heuristic that serves for global optimization. It accepts worse results, but it tries to converge to optimal solution. It is gradient based heuristic extended with probabilistic approach. Its affecting parameter is temperature that is decreasing in time. Temperature affects probability of accepting worse solutions. As temperature decreases, the probability of accepting worse solutions decreases as well.

Our goal is to reduce count of iterations to reach result for given data.

SOM is based on very primitive selection of winner. The nearest winner (usually with the smallest Euclidean distance from winner) is selected in competition of winner. We tried to select winner probabilistically according to probabilistic model of SA. Each neuron has own probability that defines its probability of selection for each presented pattern. And globally we defined temperature in analogy to SA. In each iteration (called epoch) we select winner neuron according to classic selection rule, and then winner is compared with random number, according to SA process. If the random number is smaller than probability of selection the neuron and its neighbours are accepted. The distance of neuron is always positive and the neuron is accepted with probability:

$$P(\overrightarrow{x_i}, \overrightarrow{p_j}) = e^{\frac{\|\overrightarrow{x_i} - \overrightarrow{p_j}\|}{T}}$$

Where $\overrightarrow{x_i}$ is current position of the winner neuron i and $\overrightarrow{p_j}$ is currently presented pattern j. The probability P always holds $H(P) \in \langle 0,1 \rangle$. If neuron is rejected then another one is selected and the primal one is prohibited until the end of competition in every iteration.

We reached our goal. The implementation in Java programming language has proved better results in speed of learning process in random data set.

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Digital Evolution in SVET

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Humankind deals with question of origin and evolution of the life from time out of mind. There are two main answers to the question: science based theories and creationist theories which are based on belief that life was created by a deity or extraterrestrials. Darwin and his evolutionary theory is very important in the area of the evolution of life but many people reject it (for details see e.g. popular book [4]). This is one reason for the make the digital evolution systems. The second reason is our ambition to better understand of the evolution [1].

However the evolution was discovered by Darwin in the area of biology, it may be realized not only by the real organisms like bacteria and others, but in the area of digital organisms as well. These systems enable the study of basic evolution principles on the computers. This evo-technology and artificial life may be used not only for the simulation of organic evolution but also for the fundamentals of evolution itself. The knowledge may be applied in the biology in the study of altruism and complex features. On the other side, the evolution principles help to find novel technical solutions e.g. new types of computer chips, antennas, and also in the concurrent area of high-tech [2, 3]. Computer systems are real experimental systems and shouldn't be read like the pure simulations, the obtained results should be interpreted like equivalents to the nature [2].

There are two most significant artificial life systems: Tierra and Avida. Avida is inspired by Tierra and is two-dimensional system. These systems are based on an array cells which can interact. Organisms are machine-language instructions which are running on the computer. The organisms can obtain bonus energy when it discovers something useful. The tasks learned by organisms are exactly defined. The task may be for example the addition of two numbers and its writing to the output. For each completed task get the organisms some extra processor time which may use to create more copies of its genotype in comparison with the concurrence. The process is able to learn due to mutations, which obtain by the copying or reading and writing to the memory. The most of the mutations are mortal, but sometimes some positive mutations may occur and the organisms may profit.

We want try to run our own digital evolution system. We give it name SVET which means “world” in Slovak and Czech language. The principles of this new system are similar to the previous systems Avida and Tierra (till this time the most important digital evolution systems) with the different definition of the organism. Organisms are machine-language instructions running on the computer. The SVET is written in C language. In this system digital organisms can live, replicate, die or evolve and sometimes mutations can run. Mutation is little error which is done near processing a instruction. There are two kinds of mutation in SVET: internal and external. Each is occurred with certain probability. Mutations bring new dynamic aspect to the system and cause the enhancement of the organisms. But sometimes it can have fatal effect and organism die due to it.

We made some opening experiments with system SVET to find best conditions for core experiment. We discover that minimum 10 000 B of memory have to be allocated for system. Otherwise experiment isn't suitable. Core experiment conditions were stated and experiment was ran for 50 times. Two scenarios appeared in the system. First: every organisms die very early. Second: organisms live and go through evolution period. Experiment was stopped when organisms converged to stationary state, they live but they haven't same ability to propagate like organisms in the beginning of the experiment. System converged to stationary state and there are alive organisms but they can't replicate. They will die of mutations by and by [1].

Work was successful. Evolution of digital organisms ran. Organisms became shorter by natural selection. But short organisms do not replicate as much as their ancestors. It is not fault because this form of existence is optimal for them.

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Applications of Methods for Identification Surface Microstructures

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Physical object identification is a field of high interest for many. In some sense every area of a human activity deals with identifying of physical objects - merchants, transport and logistic services providers, accountants, state institutions, libraries, archives, museums, research institutions, security services, even criminalists, just to name a few. The domain of physical object identification is also a topic of scientific research. In this paper we present the overview of current state-of-the-art approaches to object identification and specific implementation of a physical object identification system based on the object surface structure.

The current state of the art covers two approaches to object identification based on the object surface structure as depicted in [1]. One approach is to measure some *intrinsic characteristics* of the object and the second approach is *to add a tag* to the object.

Measuring an *intrinsic characteristic* of an object does not require any additional entities to be added or associated with an object. Well known and widely used methods of this kind are biometrical methods such as fingerprint, iris, or voice recognition. Another approach is scanning the structure of the object's surface as shown in [2]. These kinds of methods share one special feature – the *uniqueness* of the intrinsic characteristics. It is because of this uniqueness that it is almost impossible to create a forgery at the physical level. This is considered to be a significant advantage over the second (*tag*) approach.

Object identification based on methods involving *adding a tag* to the object is wide spread across many areas mentioned above. Well known are bar codes, rfid tags and numerous embodiments of surface marking (such as laser marking, minting, heat or chemical marking). The current state of the art in barcodes represents the High Capacity Color Bar Code developed by Microsoft [4]. Rfid tags are available in many versions such as plastic cards, thin films, or micro seeds (for tagging animals). Barcodes, rfid tags and other mentioned surface marking methods share one property – the tag is *defined* and then "printed" by a "printing device". This property makes these methods somewhat prone to forgery. There is always a possibility that a forger can get the "printing device" and create a counterfeit. Here we come to the approach of object identification which is our point of interest. As shown in [3] it is possible to create a tag with a random structure by spreading out particles on the surface of the tag. Such a tag can hold interesting properties.

We implemented a tag based on the principle proposed in [3]. We evaluated miniature retro-reflective glass balls and two kinds of fluorescent particles – line shaped and spherical shaped. The retro-reflective glass balls turned out to be somewhat instable according to the imaging needs. The retro-reflectivity is highly sensitive to the arrangement of incident light and direction of observation. Line shaped particles proved to be suitable because of their non-symmetrical shape which provided extra features for further image analysis. However, the line

shaped particles are very difficult to procure. The best results were obtained with spherical fluorescent particles.

A method for tag description and matching was developed. It is comprised of the following steps: *imaging* the tag using a common digital camera with a macro lens; *preprocessing* the image to obtain a representation of the tag (a set of points in 2D space); and *deriving* invariant *features* (set of lengths and slopes of the connecting lines between points) and an *algorithm* for tag matching.

There are two major areas for future work – the tag deposition system and the algorithm for tag matching. The current tag deposition system is highly experimental and the algorithm is not yet optimized for a large scale matching. Development of a more robust tag deposition system and the optimization of the matching algorithm will allow us to continue studying the abilities of the proposed tag system for possible applications.

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Experimental Base for a Biomass Burning Research

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Usage of a biomass for energy production has increased significantly over last years. Large part of the biomass energy source is obtained by combusting wood in a form of logs, chips and pellets. An abundance of wood in some regions makes this source of bioenergy inexpensive and easy to obtain even for heating in households or small firms.

It is generally harder to keep burning conditions optimal in small-scale biomass boilers. Poor control of burning conditions leads to a lower heat efficiency and a higher emission of harmful flue gases. Although it is not necessary to monitor flue gasses in boilers with power output lower than 1 MW, its ecological significance rises as using of small-scale biomass boilers continually rises in popularity. Control of burning process in small-scale is harder to accomplish due to many reasons. Small-scale combustion has more frequent fluctuations of combustion conditions. It is not manipulated by skilled persons and must be able to operate long time periods unattended. Used sensors and control equipment price must be held low to retain competitive price of a complete boiler. Thus only a few and lower price sensors must be used and control algorithm must be able to handle unreliable source of information.

For the research project we had a small-scale 25 kW biomass burning boiler. It is a standard factory product with its own control electronics set up for common day-to-day duty. As the factory electronics leaves no space for changes of control algorithm, we decided to replace original electronics with our own control equipment. Because mentioned boiler is also used for educational purposes unrelated with the research, we had to retain original control electronics and make possible to switch a control process back to it easily anytime user requests.

Because of higher complexity of the new control equipment, our own switchboard has been projected, manufactured and connected to the boiler. The switchboard contains control equipment power source, relays for pellet feeding, grate sweeping and fire starting, frequency changer for air blower speed control, emergency stop electronics and short-circuit and overload protection. It also allows connections of various types of thermocouples, limit switches and a flue gas analyzer. Although the switchboard is permanent part of the boiler, it is connected by flex cable with a plug. When a user decides to use the factory electronics for control of burning process, he simply disconnects the plug from the control unit and plugs it into the socket in a factory electronics case. The switchboard is constructed to be ready for data acquisition and control station RexWinLab-8000 – special experimental station developed for field experiments at authors department. This station consists of reliable industrial quality programmable automation controller (PAC) with custom control software developed by Institute of Cybernetics at University of West Bohemia in Pilsen. The station allows reliable real-time control of field process using high level development tools such as Mathworks Matlab.

Experiments were realized to observe and describe factory electronics behaviour. This behaviour was base of specification of new control algorithm. The control algorithm was subject of diploma thesis of a master degree student at authors department. The algorithm was

developed using Matlab/Simulink and realized in Rex Control development software application used for RexWinLab-8000 station programming. Initial experimental run based on new algorithm was realized and confirmed satisfactory function of the new algorithm.

The alternative control unit is finished and proved to be able to fully substitute function of original factory electronics. The boiler with the new control unit constitute as a flexible and easily programmable experimental base which will be used in following research.

Water heated during experiments had been taken from public water-supply and drained into sewerage. Because another boiler of higher heat output has been built in the laboratory, this routine became uneconomic. The Department of Fluid Dynamics and Power Engineering decided to build cooling circuit of original design which provided close cycle of cooling water.

The design of cooling circuit was based on steady state analysis which does not respect dynamic effects. Because dynamic effects have significant influence on used components, we have been asked to create dynamic simulation model. This model should be able to analyze transient states during standard and emergency cooling circuit operations. The model has been built in Matlab/Simulink development environment and series of simulations has been executed. Simulation experiments discovered some potentially unwanted situations which should be avoided during real operation. The experiments also helped with the right dimensioning of circuit components. For example a drive for a degasser control valve appeared to be slow inducing distinct water level fluctuations in a degasser during cooling circuit start-up.

Visualization of process has been developed in Geovap Reliance development software and this visualization has been connected to the simulation model. It allowed us to control virtual cooling circuit in the same way as a real cooling circuit. Visualization thus gives intuitive look at cooling circuit behaviour in real-time without needs of Matlab/Simulink knowledge. The visualization can be used for example for training service personnel for unusual or emergency situations.

We have been also asked to choose and provide suitable sensors, actuators and control unit for proper cooling circuit operation. Sensors and actuators parameters are based on the simulation model. They were bought and connected. The new switchboard was designed, manufactured and connected. Suitable PLC was chosen, bought and connected. The control software was developed and implemented in the PLC. The cooling circuit successfully passed initial tests and is now in partial duty.

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The Usage of ITIL for Information Security Management

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The most important objective of Information Technology Infrastructure Library (ITIL) is to help to ensure that effective information security measures are taken at strategic, tactical, and operational levels. ITIL think of the information security as it is a cycle process that must be controlled, planned, implemented, evaluated, and maintained. ITIL divides information security into four main parts [3]:

- Policies – policies define all objectives which organization has to achieve to establish an effective and efficient information security.
- Processes – processes define what has to be done to achieve the objectives.
- Procedures – procedures decompose processes into tasks and assign responsibilities. It also specifies when objectives have to be achieved.
- Work instructions - instructions describe specific actions for specific tasks.

IT Security Management has two primary objectives that fit perfectly with the information security management system (ISMS) goals:

- To meet the security requirements of service level agreement (SLA) and external requirements further to contracts, legislation and external imposed policies.
- To provide a basic level of security, independent of external requirements.

Information security process is defined as a complete iterative process with continuous review and improvement [1, 2, 3]. Despite organizations consider the implementation and monitoring as a one step process, ITIL looks at it within the information security process as a seven step process:

1. Using risk analysis, IT customers identify their security requirements.
2. The IT department determines the feasibility of the requirements and compares them to the organization's minimum information security baseline.
3. The customer and IT organization negotiate and define a SLA that includes definition of the information security requirements in measurable terms and specifies how they will be verifiably achieved.
4. Operational level agreements (OLAs), which provide detailed descriptions of how information security services will be provided, are negotiated and defined within the IT organization.
5. The SLA and OLAs are implemented and monitored.
6. Customers receive regular reports about the effectiveness and status of provided information security services.
7. The SLA and OLAs are modified as necessary.

The SLA is a vital part of any information security process which is based on ITIL. It is an agreement that defines (among others) the levels of information security, which IT has to

provide. The SLA has to include properly defined key performance indicators (KPI) and performance criteria. Typical SLA for information security should contain:

1. Permitted methods of access.
2. Agreements about auditing and logging.
3. Physical security measures.
4. Information security training and awareness for users.
5. Authorization procedure for user access rights.
6. Agreements on reporting and investigating security incidents.
7. Expected reports and audits.

In addition to SLAs and OLAs, ITIL defines three more types of documents for description of information security process:

- *Information security policies*: ITIL states that security policies should come from senior management and contain:
    1. Objectives and scope of information security for an organization.
    2. Goals and management principles for how information security is to be managed.
    3. Definition of roles and responsibilities for information security.
- *Information security plans*: describes how a policy is implemented for a specific information system and/or business unit.
- *Information security handbooks*: operational documents for day-to-day usage; they provide specific, detailed working instructions.

Information security as an organization process is still increasing in complexity and importance [4]. It can be hazardous, inefficient and expensive for organizations to base information security their proprietary processes. ITIL can enable these processes to be replaced with standardized, integrated processes based on best practices. Though some time and effort are required, by implementing ITIL organizations can better meet information security service expectations with internal and external customers by using standardized processes based on best practices.

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Information Security Based on Principles of ISO 27001, ITIL and COBIT

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ISO/IEC 27001 is the Information Security Standard. ISO/IEC 27001:2005 specifies the requirements for establishing, implementing, operating, monitoring, reviewing, maintaining and improving a documented Information Security Management System (ISMS). In addition, the standard specifies the requirements for the management of the implementation of security controls.

Concept of ISMS is an example of applying the management system conceptual model to the discipline of information security. In many situations, creation of an ISMS inspires and spawns complementary management systems in other disciplines such as human resources, physical security, business continuity, and more. The framework and management system principles transcend disciplines and tend to enhance multidisciplinary interoperation.

Unique attributes to this instance of a management system include the following: Risk management applied to information and based upon metrics of confidentiality, integrity and availability; Total Quality Management (TQM) applied to information security processes and based upon metrics of efficiency and effectiveness; A monitoring and reporting model based upon abstraction layers that filter and aggregate operational details for management presentation; A structured approach toward integrating people, process, and technology to furnish enterprise information security services; An extensible framework from which to manage information security compliance.

In the other side interest in and adoption of Information Technology Infrastructure Library (ITIL) has been steadily increasing throughout the world. The ITIL framework is typically implemented in stages, with additional processes added in a continuous service improvement program. Organizations can benefit in several important ways from ITIL: IT services become more customer focused; The quality and cost of IT services are better managed; The IT organization develops a clearer structure and becomes more efficient; IT changes are easier to manage; There is a uniform frame of reference for internal communication about IT; IT procedures are standardized and integrated; Demonstrable and auditable performance measurements are defined.

ITIL breaks information security structure down to: Policies (overall objectives an organization is attempting to achieve); Processes (what has to happen to achieve the objectives); Procedures (who does what and when to achieve the objectives); Work instructions (instructions for taking specific actions); ant it defines information security as a complete cyclical process with continuous review and improvement.

As a key part of the ITIL information security process is defining the Service Level Agreements (SLA). It is a formal, written agreement that documents the levels of service, including information security, that IT is responsible for providing. The SLA should include key performance indicators and performance criteria. In addition to SLAs and OLAs (Operational Level Agreements), ITIL defines three other types of information security documentation: Information security policies; Information security plans; Information security handbooks. In the ITIL framework can be further found a lot of processes, which are related to

information security, the first part is Service Support, which include following processes: service desk, incident management, problem management, change management, configuration management and release management, and the second is Services Delivery part: Service Level Management (SLM), capacity management, availability management, financial management, and IT Service Continuity Management (SCM).

By implementing ITIL organizations can better meet information security service expectations with internal and external customers by using standardized processes based on best practices.

The next approach to ISMS is Control Objectives for Information and Related Technology (COBIT), it was published by the IT Governance Institute and contains a set of 34 high-level control objectives, one for each of the IT processes, such as define a strategic IT plan, define the information architecture, manage the configuration, manage facilities, and ensure systems security. Ensure systems security has been broken down further into control objectives such as manage security measures, identification, authentication and access, user account management, data classification, and firewall architectures.

The COBIT framework examines the effectiveness, efficiency, confidentiality, integrity, availability, compliance, and reliability aspects of the high-level control objectives. The model defines four domains for governance, namely planning and organization, acquisition and implementation, delivery and support and monitoring. Processes and IT activities and tasks are then defined within these domains. The framework provides an overall structure for IT control and includes control objectives, which can be utilized to determine effective security control objectives that are driven from the business needs.

COBIT has some recognized weaknesses. Although IT governance is considered an enabler for business/IT alignment, COBIT lacks in the establishment of responsibilities and a methodological alignment with the business strategy especially when COBIT processes are used for enabling ISM. ITIL processes are not templates that can simply be forced onto an organization. They need to be selected, adapted and suited to each individual organization. In organizations that have the time to create an IT management infrastructure that is truly best in class, ISO 27001, ITIL and COBIT are likely to be combined in way that ensures IT really delivers business goals and performance.

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Large Scale Mobile Robot Navigation and Map Building

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The fundamental problem of mobile robotics is to autonomously navigate to a specified destination. To fulfill this goal, the robot has to know its position relative to the desired destination and positions of potential obstacles in its proximity. Positions of obstacles as well as position of the destination are usually specified in a form of a map. The map is either known a priory and the robot has to perform self-localization only, or it is created on the fly and therefore the mobile robot has to perform simultaneous localization and mapping (SLAM). The key problem of navigation, localization, mapping and SLAM is dealing with ubiquitous noise, which causes the knowledge of robot environment to be incomplete and uncertain.

Several methods based on probabilistic calculus [1] have been developed to deal with the noise, some of these are focusing on real time constraints and some on precision. These methods can be divided to two major groups, which are based on Extended Kalman filter (EKF) and Monte Carlo algorithms. The latter are capable to model complex, unstructured environments with moving objects and even keep several different hypotheses of robot position and surrounding. The main disadvantage of Monte Carlo methods is particle depletion, which is coped by maintaining several thousands of (low probable) hypothesis as well as unrealistic sensor models. This results in high demand of computational power and memory and low precision of these methods. On the contrary, the EKF methods are computationally effective, and the solid mathematical background of Kalman filter allowed the research community to build a good theoretical base for EKF-based SLAM. Proofs of EKF convergence and lower bounds on robot position uncertainty have been formulated. Unfortunately, Kalman filter optimality is proven only for linear systems and therefore the weakness of EKF methods is the linearization. Due to errors introduced by linearization, EKF methods might provide overconfident and inconsistent results. The linearization process poses a significant threat to the consistency of robot position estimation especially if the sensors do not provide bearing and range information simultaneously.

The theoretical solutions of bearing-only SLAM have gained importance as the computational power of nowadays computers allows real time image processing. The nature of visual information allows to build build sparse maps from well distinguishable landmarks, which are easy to register. However, range information is still missing in bearing-only SLAM. This can be solved by using stereo-camera systems or monocular-based methods based on structure from motion algorithms. However, due to the aforementioned linearization problems, monocular approaches remain computationally complex and cannot map more than thousands of landmarks while satisfying real-time constraints. For the purpose of navigation, this problem is overcome by methods, which do not perform SLAM, but rather build an environment map in advance and then use the map for localization. Most of these methods create the map during a teleoperated drive and then are able to repeat this learned path. Although these methods allow to map large environments, they are not truly scalable because their computational complexity depends on mapped environment size.

We have implemented a monocular navigation and map building system for a mobile robot, described the system mathematically and examined its fundamental properties. The system relies on

landmark recognition and is based on map and replay techniques.

The idea is simple: a robot is manually driven through an environment and creates a map of its surrounding. After that, the map is used for autonomous navigation. To minimize robot sensor equipment we consider the most available sensors, i.e. camera, compass and odometry. During mapping, the robot is guided on a path consisting of several straight segments. The robot measures length and azimuth of these segments by odometry and compass. Moreover, it performs recognition of salient objects in image from its on-board camera, estimates their position and records them in a map. During navigation, the robot establishes correspondences of currently seen and previously mapped landmarks and computes differences in their expected and recognized positions. The robot steers in a direction which reduces those differences while moving straight at a constant speed until its odometry indicates, that the current segment has been traversed completely. At the end of the segment the robot switches to next learned segment, turns into remembered direction and traverses the segment while keeping direction according to matched features.

The navigation algorithm is robust, simple to extend, does not require sensor calibration or structured environment and its computational complexity is independent of the environment size. Moreover, the method works while sensing only one landmark at a time, making it more robust than other monocular approaches. The aforementioned properties of the method allow even low-cost robots efficiently act in large outdoor and indoor environments with only natural landmarks. The basic idea is to utilize monocular vision to correct robot heading only and leaving distance measurements to odometry. The heading correction itself can suppress odometric error making the navigation error bound. We have examined the influence of map-based heading estimation and odometric errors on the overall position uncertainty. A claim that for a certain set of trajectories the localization error of this type of navigation remains bound is stated. This claim is defended mathematically [2] and by simulated and real-world experiments. This method was demonstrated in Robotour autonomous robot competitions, during which it has mapped and autonomously traversed paths more than 15 km long with localization errors lower than 0.5 m.

The method has been integrated in the Large Maps framework [2], where it serves as a map-building and navigation module cooperating with several modules in exploration and navigation tasks. Moreover, we have developed an FPGA-based device for fast image processing [4], which disburdens the main computer from image recognition task

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Motion Planning for Mobile Robots on Rough Terrain Under Differential Constraints

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In the motion planning problem the task is to find a collision-free trajectory for a mobile robot from an initial configuration to a desired goal configuration. The problem is usually studied in simplified planar environments. These environments can be described by polygonal map where both robot and obstacles are represented by polygons. Many methods have been designed to solve the motion planning problem on such environments [1] including geometric methods (e.g. visibility graph method, visibility-voronoi method) and cell-based decomposition methods (e.g. trapezoidal decomposition method). These methods are used mainly in indoor environments.

As mobile robots are expected to help man in difficult tasks, the motion planning must be solved in more complex environments. Example of such tasks is mining or extraterrestrial planet exploration.

The terrain can be described by an elevation map or by a triangular mesh. Each cell in an elevation map or particular triangles have assigned additional information like surface type or physical properties. This information can be determined using appropriated sensors or predicted based on camera data. The additional information helps a planner to make more realistic plans, e.g. to avoid sandy areas in order to minimize wheel sliding.

For robot moving on a terrain the robot's dynamics and physical robot/surface interactions have to be considered in order to make both feasible and executable plan. The robot's dynamics properties define its maximum acceleration and/or velocity and can be formulated as so called differential constraints. The above mentioned purely geometric methods cannot be used for this kind of motion planning because they do not consider the differential constraints.

To cope with differential constraints the sampling based method Rapidly Exploring random Tree (RRT) [3] was designed. The method maintains a tree of configurations reachable from the start configuration. Also each configuration holds information about its predecessor and input values that was applied to it. The core of the algorithm defines way how to expand the tree in order to reach the goal configuration. This is solved by random sampling of the configuration space and searching for the nearest state in the tree. The main advantage of the algorithm, beside its ability to cope with differential constraints, is that it can be used to plan a motion for a robot with many degrees of freedom. This is useful especially in case of legged robots with more than twenty DOFs, however the algorithm is mostly used in case of mobile robots moving on a ground. During last years several variants of the algorithm have been introduced for motion planing on a terrain [2],[4]. One team used it during the Darpa challenge for motion planning of an autonomous car.

During the planning the algorithm must be able to determine the configuration of the robot after a moving action is applied. The robot's configuration depends both on the kinematics and the underneath surface. The contacts between the wheels and the surface cause forces influencing the robot's pose. As the robot moves the contacts and forces must be determined.

This problem can be solved using a simulator of a rigid body dynamics. The robot is modeled by its physical properties (e.q. center of gravity, mass and mass density, joints between body

and wheel) and by geometric properties (shape) and their relation. The environment is usually modeled by heightfield or triangle mesh. The contacts between wheels and surface are modeled as contact joints and they are updated as the robot moves. All joints connected to a robot (wheel joints, contact joints) cause forces to particular bodies which consequently cause a movement of the body. Several simulators are available free (e. g. Open dynamics, Bullet).

The planning algorithm builds a tree of configurations reachable from an initial configuration. In each iteration a node in the tree is randomly chosen for expansion. The algorithm then applies several predefined input values to the robot's controller. The simulator is used to determine the response of the system (position of the robot, its velocity and stability). An action leading towards the goal state is then added to the tree. The differential constraints are known for the simulator. If a constraint is violated the simulator reports it and the planner has to choose another input for the controller.

To speed up the planning process we use a guide path for the planner. To compute the guide path a graph representing the surface is built. The guide path is found in the graph using the Dijkstra's algorithm. The guide path is thus computed without considering the differential constraints. Then the RRT algorithm generates random samples along this path. The result of the RRT is trajectory which respects the differential constraints. Generally the guide path can go through areas where the robot cannot move. This increases run time of the planning because the RRT tries to make trajectory through an unfeasible area. However in most situations the guide path speeds up the planning process.

The plan can be precomputed (if the environment is completely known) or it can be built and updated as new parts of the terrain are discovered. In the latter case a local map of the surrounding terrain is build, e.g. using laser range finder or stereo camera. The operator then enters new goal to be reached and the planner is used to find a path towards the goal.

Conclusion

The approach to the motion planning for a robot on a terrain has been described. The method uses sample based method Rapidly Exploring Random Tree algorithm for planing a path. To determine the response of the robot on a surface the simulator is used. The terrain can be represented by an elevation map or a triangle mesh. Due to physical robot/terrain interaction additional information about the terrain should be known to allow the planner make realistic plans. Such information can be obtained using sensors or it can be predicted based on camera data and records of movements on similar type of terrain.

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New design methodolgy for SRAM-based FPGAs using reconfiguration resources

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In the present time with growing complexity of FPGAs and digital design circuits we are in need of new testing methods and methodologies. Most of the systems which are needed to be tested are designed as Fault-Tolerant systems. To design such a system are used methods which are adding some redundancy into the circuit. Such methods are for example Triple-Modular-Redundancy (TMR), Duplex system or their modifications. Principle of these methods is to add units which have identical function as the original circuit into the system. Detailed description of the methods can be found in [1]. That gives us opportunities to use information from one unit to compare with information in others and make simple or more complex tests. Problem which we have to encounter in testing the Fault-Tolerant systems is that we can tolerate faults only until the count of erroneous units is lower then the count of fault-free units. That also influences the ability of using ensured fault-free results for testing, because if we wouldn't be able to indentify fault-free state, we wouldn't be able to make any tests. If we would be able to repair the erroneous units and bring to them the actual state of the system we would be able to significantly improve some properties of the whole system, like availability or dependability. Keeping the units repaired and fault-free would also increase the opportunities for testing.

To be able repair the erroneous units and transfer to them the actual fault-free state we need to create synchronization protocol and design and implement hardware necessary to do this. To design the hardware we have to analyze the kind of faults which can occur in the FPGAs and the possible solutions how to deal with them. Most of the faults in FPGAs are caused by so called Single-Event-Upsets (SEU). SEU is caused by the charged particles which impact the FPGA or by the other external electromagnetic interference. The SEU can have many ways how to affect the programmed circuit inside the FPGA. Effect of the SEU can be unrecognized glitch on some particular wires or it can lead to change of the configuration memory of the FPGA. The ways how are FPGAs influenced by SEU are discussed in [2]. It is obvious that different affects of SEU require different approaches for mitigating. Some faults caused by SEU can be easily mitigated by simple redoing the operation, others will need more sophisticated method to finish repair e.g. is the dynamic reconfiguration of the part of the FPGA or complete reconfiguration of the FPGA. Next issue, which needs to deal with, is the way how to send the important data from the fault-free unit to the just repaired unit. To be able do this it has to be created a special data transfer protocol with corresponding hardware support. The data transfer between two asynchronous domains is subject to some specific rules which ensure that data are transferred correctly and that we avoid metastability on the inputs of flip-flops. In [2] there are described the techniques how to design the hardware to ensure the rules.

In this contribution we present the analysis of the methods how to repair faulty units and transfer into them the actual fault-free system state in Fault-Tolerant systems implemented in FPGAs. In the contribution there are also discussed different kinds of faults which can occur in the FPGA and offered the solution for the particular cases with discussion about their advantages and disadvantages. Each disadvantage is also discussed with the goal to present solutions to eliminate or compensate it. Next there is presented experimental system design

which is implementing one of the described methods with the analysis of the experimental results. We have focused mainly on hardware overhead and maximal frequency of the circuits. The reference circuits which we have chosen for our experiments are blocks of railway station safety system, which implementation and behavior is described in [4]. For necessary data transfer between repaired and fault-free unit, the handshake communication protocol was designed, simulated and implemented.

The results gathered during the experiments with the experimental design were analyzed. The analysis focused on two main areas, hardware overhead and maximum frequency of circuit and the analysis of the communication protocol time consumption. The analysis has shown that hardware overhead was in the average about 200%. That might seem to be too much, but we have to take in account also the time overhead. By that we mean the decrease of the maximum frequency of the circuit after adding the synchronization hardware. The time overhead in average was about 30%. Now when we look on hardware overhead compared to time overhead we can see that it isn't causing too much problems to speed of circuit. The analysis of the communication protocol confirmed the expectation that the time needed for data transfer depends on the length of transferred data. The analysis of the experimental results also pointed out the parts which can be optimized to achieve lower time and hardware overhead and also the whole time-to-repair of the system. That means the time since the fault is detected in the unit until the unit is completely repaired and the actual fault-free state of the system is loaded. The ability to use standard test methods for Fault-Tolerant systems like a comparing outputs or internal states of units is increased by repairing and synchronizing units in the system.

The further work is going to focus on the optimization of the synchronization hardware and alternative communication protocol for comparing. We would like to add to protocol other functions which would help us make the tests between units not just by the comparing of outputs.

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Design of scalable structures with defined dependability for system on chip

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Systems realized by programmable hardware like Field Programmable Gate Arrays (FPGAs) are more and more popular and widely used in more and more applications due to several advantages, like their high flexibility in achieving multiple requirements such as cost, performance and turnaround time and the possible reconfiguration and actual changes of the implemented circuit, e.g., only via wireless connections. The FPGA circuits can be used in mission critical applications such as aviation, medicine, space missions, and railway applications. Many FPGAs are based on SRAM memories sensitive to Single Even Upsets (SEUs), therefore a simple usage of FPGA circuits in mission critical applications without using any method of error detection (and then correction or minimally safe behavior when a fault or an error happened) is impossible. A change of one bit in the configuration memory leads to a change of the circuit function, often drastically. These changes are not detectable by off-line testing methods therefore Concurrent Error Detection techniques have to be used. The self-checking (SC) structure is used to detect an occurrence of a fault in the tested circuit. Only one copy of the SC circuit is not sufficient to increase dependability parameters. Thus, we assume to use the Modified Duplex System (MDS) architecture [1, 2]. The self-checking circuit quality is determined by an area overhead and fault security (FS) parameters.

This paper presents a new technique of the safety device of a railway station design. Nowadays the widely used safety device of the railway station is based on relay blocks. This system is very popular due to its high safety factor. The safety factor is ensured by the structure corresponding with the physical structure of the railway station. But this system is too big. Nowadays some relay systems are exchanged by the new system based on processors. But processors based system does not keep high safety factors. The safety device of railway station rules are given by programmers not by the structure as in previous systems.

The new system based on FPGAs was investigated in our department in several diploma thesis, e.g. in [3]. The new proposed system uses the same blocks as a relay based system but the function implemented inside the blocks and communications between these blocks are completely different. New system is based on five blocks each realized by a finite state machine (FSM).

Our approach is based on the basic architecture of MOORE type FSM. There are two blocks of combinational logic. A set of flip-flops is assumed. The current state is stored in flip-flops and we assume its representation only as a data path in our approach. The current state is encoded by the select code (binary or 1-out-of-n code) and forms the code word. The code word is generated by one of combinational logic used to obtain the next state. Both combinational logics are designed as a self-checking ones and use an even parity code to detect a fault. An original combinational logic contains the predictor to predict parity nets on outputs from inputs. For architecture of MOORE type FSM have to be used two checkers for checking the correct function of the given combinational logic. The checker of the next state logic is situated behind the flip-flops and the checker of the output logic at the end to keep the

self-checking property for the whole FSM. This architecture is derived from original rules for connecting of small circuit to compound design.

All our experiments were performed for two error detection codes: binary and 1-out-of-n. Five basic blocks needed to design any safety device of the railway station are modified to ensure the self-checking property. All these five blocks were originally described by VHDL language and went through six seven, during which were used our design tools, some minimization and synthesis tools. Testing by our fault simulator was the last step [4].

The results of our experiments were processed individually for the next state and for the output combinational logic. These results show that 1-out-of-n code is proper for coding our safety device blocks. The parity predictor for 1-out-of-n code is only constant due to the fact that only one of "1" can by generated on outputs. It means that the predicted output is always "1". The code 1-outof-n causes that area of original circuit is bigger then for binary code. The binary coding has worse fault coverage than 1-out-of-n code. In overall score the area overhead of 1-out-of-n code is almost the same as a binary code but the fault secure parameters (FS) are better. Our results have proved, that our methodology is suitable to design the safety device of a railway station but due to the fact that FS is not 100%, the MDS architecture must be used to keep SEU detection. Therefore our methodology allows us to create any configuration of railway station safety device.

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Business Process Model Transformation

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The Unified Process (UP) methodology for software development recommends describing software from various views. These views can be divided into two basic groups - static views and behavioral views. There are several types of model in each group which are recommended to be used in different phases of software development. The models are transformed from one to another during the process of development so that a new model describes rising software in more detail and it describes its features depending on the implementation platform. This is called Model Driven Development (MDA). Models describing the software independently on implementation platform are called Platform Independent Models (PIM) and they are used more in the phase of analysis. Models describing software in dependence on implementation platform are called Platform Specific Model (PSM) and they are used mostly in the phase of design and implementation. The domain model, the requirements model and the business process model are recommended by UP as models for software analysis phase and the class model and the sequence model are recommended for the phase of software design.

We are interested in the transformation possibilities of business process models (BPM), concretely of a business process model represented by Object Managemet Group standard Business Process Modeling Notation (BPMN) [1] into other models especially into other models describing software behavior. The BPMN was selected as a source model because nowadays it is one of the most used representations of BPM.

Most of the notation used to represent BPM is based on graph representation of process, where oriented edges represents the process flow and nodes are used to describing activities, decisions and others. Thus we had to find a representation of this graphs suitable for automatic machine transformation. We decide to use another Object Management Group standard – namely XML Metadata Interchange (XMI) document format [2]. Because the XMI standard is based on Extensible Markup Language (XML) the tools for XML can be used also to work with XMI. Hence the Extensible Stylesheet Language Transformation (XSLT) was used for realization of a transformation from one model to another or if you like from one XMI document to another. In [3] there was presented XSL transformation which can be used to transformation from model in BPMN to process model in UML activity diagram notation and the possibility of backward transformation, from UML Activity diagram notation to BPMN was discussed. The transformation from BPMN to UML activity diagram notation is designated information-lost and vice versa the backward transformation has not enough information to create a full-value BPMN model. The BPMN has the highest information value among the business process model notations.

The transformation of behavioral model from PIM level to PSM, which we understand as transformation from BPM to UML sequence diagram can also be made by using XMI and XSLT. The main issue of this kind of transformation was to ensure that the process flow in BPM will preserve the transformation without any change. This was ensured by XMI hierarchical representation of sequence model which will store information about order of method calls – information about method calls order is stored in XML elements order in the XMI file.

We are also interested in possibilities of transformation of BPM into other static models, but we found out that this area is mapped very well. So far we are doing experiments with mapping between BPMN and other UML models, but it looks that in this area there will be no big research contribution.
Thus we get interested in possibilities of connections between static and behavioral group of models. We are interested mainly in analytic models. This interest is based on the fact that in phase of analysis information about the software and its domain are collected. We like to connect static and behavioral models together which will allow describing domain in complex. Another motivation is popularity of Service Oriented Architecture (SOA) and component based systems. The messages among services or components have to be modeled at PIM level and then at PSM level realized in XML format.
Our idea, how to help with messages modeling on both levels, is based on the extension possibility of BPMN. The link between business and domain model is created by extending the BPMN Data Object. The extension is called DataView and it is a subset of the application domain model. The extension was created in BPMN but it can be used in any business process describing notation where is no standard possibility how to specify data in detail.
The goal of our next research is to apply principles of MDA in the area of business and data modeling. We like to realize transformation from DataView to the XML Schema defining a message with a respect to the way how data are used in the services and how they evaluate during the process. This approach will allow better modeling of messages in SOA or component systems using XML and it will also allow maintaining changes in models and XML Schemas during the lifecycle of the software product. And the modeling approach combining process and data (or behavioral and static view) will allow better understanding of the domain. The validation and optimization possibilities of suggesting approach and transformation will also be in focus.

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GIS Modelling of the Relationship Between Rainfall on One Hand and Hydrogeological and Hydraulic State on the Other

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The aim of the project is to find relationships between rainfall and following floods and to create rainfall-outfall model based on measured meteorological data and information about a terrain, which will help to simulate outfall of water during a flood.

First step is to create a digital terrain model, in which every possible information about terrain properties and usage is put (type, slope, depth and roughness of soil, distance from stream; forest, agriculture). Second step represents GIS analysis of relationships between terrain properties, rainfall and water behaviour during a flood period in recent years. The results will be used in other catchments as well.

The project is planned as a free-stage project – first, useful data collection followed by GIS analyses and finally, creation of the rainfall-outfall model.

The project results should serve for antiflood precautions planning so as to minimalize life and/or property losses. The method should be then used for other catchments in the Czech Republic as well as abroad.

This project is supported by the Grant Agency of the Czech Republic (Exploitation of geographic information system for improving rainfall-outfall relation) with contribution of the CTU grant The catchments of the river Olše, Moravskoslezský region, and the river Bělá, Olomoucký region, have been selected for this project. The river Olše (Olza in Polish) belongs to water area of the town of Český Těšín. It springs not far from a polish village named Istebna in the Silesian Beskydy Mountains 840 – 880 meters above sea level. It empties into the river Odra near the town of Bohumín 195 meters above sea level. Its upper stream creates a natural boundary between the Silesian Beskydy and Moravian-Silesian Beskydy Mountains whereas its lower stream is a part of the Czech-Polish frontier border. The river Bělá (Biała in Polish) belongs to water area of the town of Jeseník. Its spring is situated near Praděd in the Hrubý Jeseník Mountains 925 meters above sea level. It leaves the Czech Republic in the town of Mikulovice and continues through Poland into the Głebinowskie Lake. The river Nysa Kłodzka flows out of this lake, which empties into the river Odra near the town of Lewin Brzenski.

Rainfall – outfall models represent an important part of antiflood protection as they help to predict progress of flooding, or else contribute to antiflood precautions planning. The aim of these models is to globally define water behaviour in the landscape from its initial contact with earth as rainfall until the time water leaves the area of interest. It is necessary to set a few factors in order to describe water movement in landscape, such as water movement on terrain or underground, soil saturation influencing these movements, amount of rainfall caught in the soil or infiltrating underground water. It is also significant to determine the rate of water

transpiring back to atmosphere from the ground or evaporating from the leaves surface. Evapotranspiration includes both phenomena. Its determination depends on regular and long-term recognition of water content. ERS-2.SAR.PRI satellite data may be used for this purpose. One has to know the drop angle of each photo pixel for calibration of these data. To calculate each drop angle from digital terrain model, a Matlab script has been created. The computation is based just on the effect terrain has on a drop angle, other effects are neglected. ArcGIS application is also used for the calculation. ArcGIS transforms initial TIN data into exchange format, whereas Matlab creates a raster to place each drop angle value into. The final raster can be processed either in ArcGIS or in Matlab.

Nowadays, GIS analyses can be found in almost every area of human activity. They exploit an immense amount of sources, which on the other hand might turn as undesirable on the occasion as it is often not the main problem to find the solution of a GIS analysis, but to determine proper factors entering it. In case of aforementioned analyses that detect moisture change dependence in a time period, they used terrain qualities such as slope, type, depth and roughness of soil, distance from stream; usage, e.g. forest, agricultural land; and climate during the period, e.g. rainfall amount, temperature. Water content change during 2 specific floods obtained from ERS-2 satellite pictures in 2002 and 2005 entered these analyses, too.

By analysing difference radar pictures that represent water content change in the river Olše catchment, it has been detected that land qualities separately have no or very little effect on the water content change. Each change interval contains all of these considered qualities in more or less the same rate. That means relationships between these qualities are very complicated and it is necessary to analyse various combinations of them. It might add to accuracy us not to use simplified land qualities, that means to use all slope intervals, all full land codes, more accurate rainfall interpolation model.

All this goes along with more accurate and global land information requests (accurate rainfall and temperature progress, morphology information and other).

In order to use results for other catchments, it is crucial to compare them with the ones gained in the river Bělá catchment, this being a part of the same grant. This way, the results will be excluded of a potential anomaly in the river Olše catchment that might distort them.

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Web Control of Mechanical System by Light Ray

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Papers [1-3] describe new method and conditions for web control of mechanical system by the light ray. Theoretical methods of image processing, i.e. color scheme RGB and histograms, are used to establish conditions for image processing using web camera and to carry out scientific analysis.
An IP web camera monitors a board of highly luminous LEDs. PHP web server processes color images generated by the ensemble of LEDs.
Problem of detection and processing the images from luminous LEDs for distinct day/night conditions was solved.
Mechanical system connected to the CTRL V4 webprocessor is controlled via internet and control variable is evaluated from the image detected by an IP webcam. No physical connection between the mechanical system and sensors is necessary to control the mechanical system. Mechanical system is possible to control from anywhere in the world via internet. As an aside, the optical transducer for wireless mechanical system control via internet is designed.

Imagine a factory with mechanical system which parameters we want to control. We can connect it to the internet via miniwebprocessor. How we shall control it?
We can create a LED panel and control the parameters according to the light of the LEDs.
What is new about it?
The control panel can be in remote building, remote city, remote country. We don´t need any operator, any person sitting by the control panel.
We can simply focus a web camera on the panel, monitoring the lightning LEDs and processing the images. Parameters of the controlled technology (or any controlled system) are automatically regulated according to the images.
We can regulate the remote technology or monitor its functions. There can be also the opposite process – switch on/off the LEDs according to parameters of the system.
To program the control commands, we can choose from different web languages.
PHP is the best-known, most widespread language, and therefore it is also useful for control via internet.

Designed Method
We have the board of highly luminous LED. The intensity of lighting varies and the light conditions depend on that.
If we want to find out how to switch-off or switch-on the LED, we need to have a robust solution. We can resolve day/night (light/dark) conditions, because the LED is shining differently at the various illuminated images from the webcamera.
Every LED will be checked on the board separately. Therefore, we crop the neighbourhood of every LED. The size of a neighbouring LED will be different in day and night, because the LED lighting varies. The neighbourhood of every LED is independent area (image). We solve

all these images when we process conditions of the LED activation/deactivation. When the LED is turned on, then the image is light. When the LED is turned off, then the image is dark.
We use the color histogram for conditions of image processing. We analyse every image in RGB model. We get five conditions to detect LED activation/deactivation in histogram. Conditions depend on the lighting of the LED, so results of every condition are not exact. These results are scale. Every condition has different importance. When every condition is fulfilled, it creates a greater probability, which means value in percentage. If sum of values of every condition is greater than 50%, then LED is switched on.
LED lighting is related to color. LED shining blue has different properties than LED shining yellow.
We use webcamera, which monitors image from a window, to establish conditions by day or by night (light or dark). These conditions increase probability of correct result in day/night.
Conditions are related to light source, therefore results value can change for various light source.

Example of Web Control of Mechanical System by Light Ray
We use miniwebprocessor CTRL V4 to control the mechanical system.
CTRL V4 is connected to internet. Rotation speed is related to LED activation and de-activation. Dependence is linear. Also, we can develop optical transducer. If 8 LED are ON the board, then we have eight-bit transducer.
The board of LED is also connected to miniwebprocessor CTRLV4 and the control can work contrariwise. Lighting of LED is in relation to rotation speed of the mechanical system.
If rotation speed is higher, then more LED are ON.
Webcamera can find out how many LED are turned on according to a rotation speed.
If the webcamera finds out, that LED is OFF, it sends a signal to CTRL V4 via HTTP header and LEDs switch on.

This method can control some system without manual action by internet from anywhere. We do not need any connection between the control place and the controlled system and we do not need any manual action (people). Everything is controlled automatically with help of image processing. The method is very useful without significant expenses. Detection conditions can change for some light source individually.

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Optimization of Compress Algorithm in Data Satellite Networks

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Data satellite networks have been developed for many years. At the beginning they offered voice services. Data services were not supported, or they were supported only for low bit rates. The Iridium satellite network provides 66 satellites in low Earth orbit above the Earth (160 – 2000 km). It offers a world-wide signal coverage, voice services and 2.4 kbps data transfer. This value can be increased up to 10 kbps by using compression methods. It is not suitable for file transfer with size about 1 MB and more, e.g. pictures. The Inmarsat satellite system operates in geostationary orbit above the Earth (35.786 km). Whole system consists of 10 satellites and ground stations. The Headquarters is situated in London. The satellites differ from each other. A type Inmarsat-4 satellite is a new one supporting higher bit rates. This type also uses new terminals called BGAN (Broadband Global Area Network) terminals, which support bit rates up to 492 kbps. The system does not offer global signal coverage. However, it covers most of inhabitable areas including James Rosse Island in Antarctica. The BGAN terminal called Explorer 110 (formerly Nera WorldPro 1010) is the smallest and the lightest one from all terminals of Inmarsat system. It offers constant bit rate 32/64 kbps (send/receive) and variable bit rate up to 240/384 kbps (send/receive). The Globalstar satellite network operates in low Earth orbit above the Earth and it uses 48 satellites and regional gateways, which enable voice and data services to take place between Globalstar's wireless satellite network and the traditional PSTN (Public-Switched Telephone Network). Most part of Africa continent is not covered by Globalstar. It offers voice services, SMS (Short Message Service) and data services, which can achieve effective data transfer speeds of up to 56 kbps.

The Czech Antarctic Station of Johann Gregor Mendel is situated on James Rosse Island in Antarctica. The base became operational in 2007. Since, Czech scientists have been working on branches of science, e.g. biology, geology, ornithology or climatology. The Inmarsat and Iridium satellite networks provide necessary communication. The Iridium offers suitable voice services, but not appropriate data services. Inmarsat can provide both services in good quality. The Explorer 110 was chosen for this purpose. It is consisted of two parts, so users can choose between indoor and outdoor use, with no need for an external antenna. This terminal is connected with computer, which ensures control functions. So, notebook is connected with Inmarsat terminal Explorer 110, which provides connection with satellite, placed in geostationary orbit above the Earth. The satellite communicates with the ground station, which ensures connection to the Internet [1].

A lot of sensors measure plenty of physical values and other data on the base. These sensors are connected with computer, which can download measured data from sensors and send them via Inmarsat satellite network to the Internet, i.e. server in Czech Republic.

Described communication system situated on James Rosse Island and Inmarsat satellite network are based on TCP/IP (Transmission Control Protocol/Internet Protocol) protocols [2]. It is possible to control devices localized in Antarctica remotely by SSH (Secure Shell), Telnet, VPN (Virtual Private Network), and MS RDP (Microsoft Remote Desktop Protocol) protocols. Downloaded data are based on plain text, which is coded in ASCII (American Standard Code for Information Interchange).

The main goal is to reduce data transmission time, which also leads to energy savings. It is very important factor because solar cells and wind powers are main power sources on the base. Protocols based on TCP/IP are optimized for wireless or cable networks with minimum error rate and good stability. A principle of satellite network is to overcome very long wireless distance between ground stations and satellites. It does not ensure stable bit rate or low delay caused by atmospheric effects. A throughput is also dependent on maximum capacity of satellite transponder. Connection loss or impossibility of connection establishment can occur in the extreme conditions.

The TCP protocol can ensure data delivery, which is important in the case of data transfers. The size of MTU (Maximum Transmission Unit) is dynamically changed depending on minimization of number of retransmissions. Authentication process is simplified by point to point connection. Measured data are sent by using compression methods. These modifications change transport protocol. It is not acceptable by firewall, which protects Inmarsat satellite network from undesirable attacks. It permits only specific content of transferred data and services, e.g. RDP (Remote Desktop Protocol), SSH, Telnet, HTTP (Hypertext Transfer Protocol), FTP (File Transfer Protocol), etc. Therefore this IP optimization cannot be used.

Next option of data optimization is to use FTP protocol, which is supported by Inmarsat satellite network. It enables MTU size optimization, point to point communication, data transfers based on ASCII format and compression methods. The source data block is compressed and ciphered. Compression algorithms based on Zip and Bzip2 are used [3]. GPG (GNU Privacy Guard) ensures ciphering. This operations use OpenPGP (Open GNU Privacy Guard) software package.

Considering MTU = 500 bytes and file size about 220 kB, the number of packets is 475. Compression method Bzip2 and GPG ciphering reduces this value from 475 to 24 in the case of IP optimization. However, it is not suitable to use it because of firewall. In the case of FTP protocol the number of packets of the same file is 493 and it is reduced to 42. The number of packets is reduced about 91%. A file size is about 10 kB in both cases.

The results show compression methods enable a great data size reduction, which leads to reduction of transferred packets and as a consequence data transmission time. On the other hand data compression increases assembling and disassembling packets. This operation requires suitable processor performance and bus system throughput. Zip compression method causes 20 ms delay of 800 MHz processor and Bzip2 80 ms delay of the same processor. This range of values is not significant in comparison of resulting bit rate because of data transfer character. It does not cause major time transfer increasing. As a result of all mentioned improvements the total transmission time is decreased. It increases energy savings, decreases financial costs and improves link quality.

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Scalable Multi-View Stereo

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Promising approaches to multi-view stereo reconstruction, which have appeared recently, get the degree of accuracy and completeness comparable to laser scans [1, 2]. Many of them demonstrated their performance on benchmark databases [1] which capture isolated and relatively small objects or on larger scenes captured in a relatively small number of images [2]. For instance, the largest data set in the Middlebury database [1] captures a single object, consisting of (only) 311 images. The largest dense multi-view stereo data set in Strecha's database [2] consists of 30 images.

In this work we extend previous works by presenting a method for scalable multi-view stereo reconstruction which can deal with a very large number of large unorganized images in affordable time and with affordable computational effort.

By “scalable” we mean that we can process very large image data with computational effort growing not more than necessary for obtaining the required accuracy. When dealing with very large data, we are more interested in an acceptable result in a limited time than in “the optimal” result in time which is not acceptable. Clearly, we often can't afford equal treatment of all data since this “linear" approach would eventually become infeasible. We consider large data in three particular situations when (1) a very large number of images covers a very large scene, e.g. a complete city, (2) an object of interest is covered repeatedly by a very large number of images, e.g. the dense ring of the Middlebury temple, and (3) a scene is captured by very large images in large resolution, e.g. 3072x2048.

Dealing with (1) calls for fast processing that does not need to load all data into memory at the same time. The case (2) calls for remembering already solved parts of the scene and avoiding unnecessary processing of redundant data which brings little improvement. Situation (3) calls for controlling the level of detail in space as well as in images.

We present a scalable multi-view stereo computation technique with the following properties: (1) the computational effort of our technique is a linear function of the surface area of the observed scene which is conveniently discretized to represent sufficient but not excessive detail. Our technique works as a filter on a limited number of images at a time and can process arbitrarily large data sets in limited memory; (2) scene reconstruction is built gradually and new image data are processed only if they noticeably improve the current reconstruction; (3) scene reconstruction uses variable level of detail, which is not greater than what can be reconstructed from images.

For very large scenes economically covered by images, the effort of our technique is proportional to the number of images (thus also to the total number of captured pixels). For scenes covered redundantly by many overlapping images, the effort is considerably smaller than the effort needed to process all pixels of all the images and is proportional to the scene surface area. For scenes captured in excessive resolution, the effort is limited by the resolution sufficient for reconstructing the scene on a chosen level of detail.

Unlike global methods, our method works as a filter on a limited number of images at a time and can thus process arbitrarily large data sets using limited memory. The main

limitation of all global methods is that they have to fit all the reconstructed structure into the memory, which is impossible for large data.

The most similar previous work is the method by Merrell et al. [4]. It can deal with large video sequences by working with a few neighboring frames in a small sliding time-window and fusing the depth maps on the fly. This approach is optimal for sequences that do not overlap and do not form loops but should the loops appear, the method will reconstructs the scene multiple times without noticing it. We avoid computation of already solved parts and solve unordered image sets by appropriate "serialization" of images. Thus we can reconstruct unlimitedly large scene and we improve over limitations of [4].

We demonstrate in experiments with Middlebury and Strecha's databases [1,2] that we achieve the quality comparable to other state of the art techniques. It is clear from our experiments that we can efficiently process redundant data sets, e.g. we used only 7% of pixels of the 311 images of the Middlebury temple and computed the reconstruction in 49 minutes with maximum 1 GB of memory.

A large scale experiment in which we processed 1000 images from the Google Street View Pittsburgh Experimental Data Set [3] in 183 minutes with maximum 1 GB of memory demonstrates that we can process very large data sets. Although the data set has been acquired as a sequence, we were considering it as unorganized. In another large scale experiment we processed 294 unorganized images in 92 minutes with maximum 1 GB of memory. These experiments demonstrate that we can process very large unorganized data sets with large images.

Here we report times for a non-GPU implementation of our method. We also work on a GPU implementation of our method which will considerably reduce the times.

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Planning and Decision-Making in Complex Dynamic Adversarial Domains

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Interactions of individual agents' plans in a shared environment are one of the main research topics in the field of multi-agents systems. Agents often need to collaborate on the tasks that are too complex to be solved by a single agent, coordinate to increase efficiency, or resolve conflicts that could make their individual goals unachievable. The algorithms and protocols for planning and decision-making in these situations can be used for supporting human decision-making or autonomous operation of artificial agents in number of real-world as well as artificial environments. Examples of these environments are various information and communication networks, social networking applications and multi-agent simulations, including models of societies, economies and/or warfare.

Research in multi-agent planning generally takes one of two approaches. The first one is centralized planning, where agents share their knowledge and capabilities to collaboratively search for a plan for all agents in the joined plan space of all agents. Centralized planning approaches are often able to find the optimal solution, but they are computationally intractable and they require absolute cooperation and full knowledge disclosure of all agents. The second approach is decoupled planning, in which each agent creates its own set of candidate plans and the agents coordinate/negotiate in order to choose a set of plans (one for each agent) that reaches the goals of the agents and possibly some common goals of the whole team. These approaches can be quite fast and allow the agents to share only part of their knowledge and intentions, but they rely on explicit cooperation and trust among agents.

In adversarial setting, the agents (usually called players) often do not share any knowledge, they are not willing to coordinate or even communicate and the goals of the players are strongly conflicting, making individual planning without consideration of the plans of other agents useless. Moreover, the goals in these situations are not fully achievable and the agents need to find at least partial solutions, i.e. optimize their utility function.

The approaches generally used in adversarial situations are based on the centralized approach, where each player is performing centralized planning for all players and the knowledge about the opponents is substituted by opponent models. Examples of these approaches are variations of the popular *minimax* algorithm. It can be generalized for more than two players and partial information, but each of the generalization makes the already prohibiting complexity of the search substantially higher. As a result, only relatively small games with few players such as chess can be currently successfully played this way.

The ultimate objective of our project is to enable adversarial planning in much larger and more realistic games, mainly multi-agent simulations of military operations and complex computer games.

The first challenge we deal with is the computational complexity of the centralized planning. Many practical application of single-agent planning currently use some kind of domain specific knowledge that allows them to search only a small portion of the search space. We generalized this idea to multi-agent adversarial domains. In Lisy et al. [1], we introduce a novel technique that utilizes procedural knowledge capturing how individual players tend to achieve their goals in the domain; the information is used to limit the search

only to the part of the game tree that is consistent with pursuing some set of players' sub-goals. We impose no specific requirements on the format of the procedural knowledge; any programming language or agent specification paradigm can be employed.

Another approach to reduce the computational complexity is to realize that, thanks to search space decomposition, the decoupled planning paradigm can save computational resources even if the whole process is simulated by single agent. Applying this insight to adversarial search, we have developed a method that decomposes the game into a set of smaller overlapping sub-games featuring only a small number of agents, solves each sub-game separately, and then combines the results into a global solution [4]. This way, the exponential dependence of computational time on the number of agents can be reduced to polynomial. This method can be used with a generic adversarial search algorithm. We have evaluated it in combination with the algorithm presented in [1] on a game, which is a model of humanitarian relief operations in conflict environment. The results show that the method often finds the same solutions as the complete search, but the search efficiency is significantly improved.

Computational complexity is not the only issue of applying AI methods in complex adversarial domains. An equally important aspect is partial information about the environment and it intentional manipulation by the adversary – deception. In [2], we employ a game theoretic model to analyze the expected strategy of the adversary and find the best response for a team of mobile sensing agents performing a surveillance task. More specifically we consider that the adversary deceptively changes the importance that agents assign to targets in the area. The opponent is expected to use camouflage in order to reduce the team's efficiency in target coverage. We represent a Mobile Sensor Team problem using the Distributed Constraint Optimization Problem (DCOP) framework. We propose an optimal method for placing a single sensing agent facing a deceptive adversary and this method serves as a heuristic for agents to select their position in a full scale problem with multiple agents in a large area.

The last issue we investigate is the possibility mutually beneficial cooperation among competitive or even adversarial agents. For example, a group of agents competing over a resource can coordinate and share knowledge in order to be more efficient against a common adversary that is consuming the resource [3], or they can simply agree on a course of action that prevents situations that are disadvantageous for everyone that may occur in shared environment with no coordination at all [4].

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Searching in Tree Structures

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Trees represent one of the fundamental data structures used in Computer Science and thus tree pattern matching, the process of finding all occurrences of subtrees in trees, is an important problem with many applications, such as compiler code selection, interpretation of non-procedural languages or various tree finding and tree replacement systems.

Tree pattern matching is often declared to be analogous to the problem of string pattern matching. One of the basic approaches used for string pattern matching can be represented by finite automata constructed for the pattern, which means the pattern is preprocessed. Examples of these automata are the string matching automata. Given a pattern P of size m, the string matching automaton can be constructed for the pattern P in time linear to m. The constructed string matching automaton accepts the set of words containing pattern P as a suffix, and thus it can find all occurrences of string P in a given text T. The main advantage of this kind of finite automata is that the deterministic string matching automaton can be constructed in time linear to the size of the given pattern P, and the search phase is performed in time linear to the input text T. A generalization of the above mentioned string pattern matching problem can be the string matching problem with multiple patterns. Given a set of patterns $P = \{p_1, p_2, \ldots, p_m\}$, the string matching automaton can be constructed in time linear to the number of symbols of patterns in set P. The constructed string matching automaton accepts the set of words having any of the patterns in P as a suffix, and thus it can find all occurrences of strings $p_1, p_2, \ldots, p_m$ in a given text T.

Although there are many tree pattern matching methods, they fail to present a simple and systematic approach with a linear time searching phase which would also be analogous to the basic string pattern matching method.

In our research we propose new methods for tree pattern matching which resemble existing string matching approaches. The computational model which we use is pushdown automata (PDA), which read subject trees in their prefix and postfix notations. The methods are directly analogous to the construction of string pattern matchers: for a given pattern, a nondeterministic PDA is created and is then determinised. We present a brief overview of our four most significant results:

In [1] we present a new kind of PDA for trees in prefix and notation called subtree matching PDA, which are directly analogous to string matching automata and their properties. A subtree matching PDA, constructed from a given tree s, can find all occurrences of subtree s within a given tree t in time $\Theta(n)$, where n is the number of nodes of t.

In [2] we focus on the problem of finding all occurrences of a set P of k subtrees in a subject tree. The presented method is directly analogous to the Aho-Corasick string matching automaton: a subtree matching PDA, constructed for the subtree patterns in P can find all occurrences of subtrees from P within a given tree t in time $\Theta(n)$ time, where n is the number of nodes of t. This is an improvement over the method presented in [1], where searching for k subtrees takes $\Theta(kn)$ time. Preprocessing takes $\Theta(m)$ time and space, where m is the sum of nodes of trees in P.

[3] is an extended version of [1] and [2] presenting subtree matching PDA for trees in their prefix as well as postfix notations.

Finally, [4] proposes a method for tree pattern matching by introducing nondeterministic versions of tree pattern matching PDA. These types of PDA are constructed from tree templates. Tree templates are tree patterns with their form not being specified precisely as some nodes can be marked to represent arbitrary subtrees. However, tree pattern matching PDA are not input-driven as their transition relation may contain conflicting pushdown operations for transitions originating from the same state, and thus cannot be determinised in the same way as the subtree PDA presented in [1], [2] and [3] (which are input-driven). In spite of the fact that the determinisation of a nondeterministic PDA is not possible generally, tree pattern matching PDA can be determinised when constructed over tree templates in their postfix notation, but cannot be determinised when constructed over tree templates in their prefix notation. The proof to this claim and the method for determinisation of tree pattern matching PDA will be presented in a future paper.

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Semantic Web Access Prediction by Means of WordNet

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Due to the rapid development of the Internet usage and the exponential growth of online information, the Internet has become one of the most important information sources. The usage of World Wide Web (WWW) as a data source has increased as it provides quick and easy access to a tremendous variety of information in remote locations. The wide range of sources' locations is the benefit as well as the drawback of the WWW. Users often suffer from long delay time when they access Web pages – so-called Web access latency. With the rapid growth of Web services on the Internet, users are experiencing access delays more and more often.

Document pre-fetching is an effective tool to improve the access to the World Wide Web. In comparison with caching, pre-fetching aims to pre-retrieve Web documents (more generally Web objects) to the client side even before they are actually requested. The efficiency of this is mainly limited by the accuracy of Web page access prediction. The accuracy affects the performance of prefetching in two ways: Firstly, evidently bad guess does not reduce the latency. Secondly, bad guess means extra bandwidth burden that subsequently means even longer delays in Web documents transfer.

Knowing the user's browsing history provides us with extra information like the type of the user or his/her preferences. This information about the user can help to improve prediction accuracy in prefetching process [1] [2]. Xu and Ibrahim in [3] demonstrated that client surfing is often guided by some keywords in anchor texts of URLs. They use this observation to design algorithm that monitors client's web surfing behaviours and dynamically establishes keyword-oriented access preferences. The authors also observed that the anchor text usually gives a truth picture of the linked Web document and used that as the semantic descriptor of it. As well as the authors [3] I used keywords in anchor text of Web objects for web page description. For further processing and, hopefully, with no loss in precision I took into account just nouns that can be found in WordNet lexicon (so called synsets).

As one web page can be, and usually is, linked from many documents there can be found many different keywords while browsing the web. The keywords can be synonyms or can have different meanings and altogether creates the semantic description of the document.
To distinguish different importance of different keywords I established a weight on keywords. The weight, in general, represents the number of occurrences of the keyword and also the occurrences of the keyword's hypernyms/hyponyms in sense of WordNet's definition. Further, the weight is normalised to balance its range. The final algorithm generates the database of Web pages and their semantic description based on the set of weighted concepts (nouns in anchor texts) found in WordNet. The description is represented by a set of strings – WordNet synsets. The database is being built using crawler. There were attempts to enrich the semantic description with headlines used in the web document (marked by H-tag in HTML source code). But the headlines do not always contain descriptive information and their processing added extra burden. Thus, they were not included.

The prediction of user's next step is based on monitoring user's activities taking into account also previous steps. This leads to building user profile. It assumes existence of

primary database of web pages and their semantic description as described above. This database is "alive" and is stuffed and updated also during the prediction process. Prediction of next page is described in following steps:

1. For each required document, the predictor tries to find the site in the prepared database and get its description. If it is not present, the site is added and if possible the description (set of n strings) is computed.
2. The description of the required document is added to user profile. By computing semantic distances among concepts already present in the profile and fetched ones we re-evaluate the weight w_p of profile concepts to embody changes in user interests. Concepts under determined threshold weight w_t of importance will be omitted.
3. Further the predictor examines hyperlinks in the document. The predictor computes semantic distance between concepts in user profile and concepts describing every link presented on current page using the weights associated with concepts.
4. URL links with preferences higher than the threshold are prefetched to the cache. The threshold must be determined by experiments to minimize overhead and refine the accuracy of prefetching.
5. With database filled with sites and their description, we can also find other page(s) of user's interest and offer it to him /her as additional source of information.

As the semantic distance in comparison of synsets (see 2.), we could use the number of nodes (synsets) in the tree structure of WordNet that were crossed in shortest path between compared synsets. But this approach does not distinguish between the case, in which one synset is a hypernym of the other one, and the case in which the synsets are siblings. In the first mentioned relationship (hypernyms, hyponyms) between synsets, the synsets are considered closer each other from my proposal's point of view because I need to find pages with similar meaning. The recursive semantic distance defined in [4] reflects this demand.

The second application of this link predictor could be system aided web navigation. The link prediction could be used to build a navigation agent which suggests (to the user) which other sites/links would be of interest to the user based on the statistics of previous visits (either by this particular user or a collection of users). The predictor is being implemented to test its accuracy and compare with other web access predicting approaches. The raising drawback of the predictor is its computation demands.

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Data Compression of Natural Languages

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The quantity of information is rapidly growing up. The data compression is the main technique of reducing loads of the space needed to store the data or reducing the time needed to transmit the data. The efficiency of data compression algorithms can be compared by many factors: compression ratio, time of compression, time of decompression and size of used memory. Each of these consequences unfortunately mutually interacts. The data compression algorithms can be divided into lossless compression algorithms and lossy ones. Lossless means that the compression process is fully reversible and decompressed data is identical to the original data. These algorithms are best-suited for the data where the loss is unacceptable.

All of texts in natural languages have a specific structure. They can be divided into sentences which can finish by a period, a question mark or an exclamation mark. Each sentence consists of words separated from each other by a space and/or a punctuation mark. Word-based text compression is a novel approach to text data compression proposed by Horspool and Cormack in 1992. The algorithms based on word-based approach take advantage of the strictly defined structures, repetitions of sequences of words and spaces, repetitions of whole sentences. These algorithms consider the text as a strictly alternating sequence of *words* (sequence of alphanumeric characters) and *non-words* (sequence of non-alphanumeric characters) to split the input data into single symbols of the input alphabet. The words in natural languages are not created as a random combination of characters. They contain a possible coding redundancy in the text. This redundancy can be eliminated by the usage of compression methods of Markov model of higher order or by the raising the approach from character-based to word-based. Moreover the set of words related to the certain context is very limited, which implies that the redundancy can be easily eliminated by more space-saving word representation than the sequence of characters [1].

Nowadays compression algorithms use the adaptive or semi-adaptive compression model instead of mostly non-efficient static compression model. The static compression model quotes that the coder and the decoder use the same model which is prepared before the compression process and do not depend on the input data. The semi-adaptive compression model is also prepared before the compression process itself. This model is eligible for the input data from which is made. The semi-adaptive model must be included to the output data on the other side. The adaptive compression model uses some positive features from the models above. The model is built during the data encoding by the coder and during the data decoding by the decoder. This model is eligible to the input data and it is not a part of stored/transmitted data too.

In this contribution we present the new data compression schema for natural languages compression. We use two-part compression model in this schema: the static part of the model

and the adaptive part of the model. The adaptive part of model is similar to the common adaptive model. The best-suited compression algorithms for the adaptive part with respect to the static part of the model are very efficient PPM algorithms. The static part of the model can be represented by many possibilities. The simplest way of the static part usage is the dictionary of frequently used words in corresponding language. Each word has assigned a codeword with respect to probability of occurrences. The static model is only used if the new word appears in the input text. In fact the dictionary represents Markov model of order 1. Another variant of static part of compression model is to build up the Markov model of higher order. The chosen representation for the model storage is the statistical model for the PPM coder. The sequential research of the model given by the analysis of the learning data of sufficient length gives us the model partially similar to the grammar of analyzed natural language. The use of grammar rules in the static part of compression model is another implicit change of the model.

The novel data compression schema for natural language compression was developed. The efficiency of this compression schema depends on correspondences between the input text and the static part of model (the learning data used for building-up the model). The negative aspects of non-suitable static part of the model can be eliminated by the preprocessing and one-bit flag so the compression ratio is negligible worse which is paid by the longer compression time. The new possibilities for further research (the adaptation of the static model, the amount of data dependency of the compression ratio on the usage of the static part of the compression model etc.) were founded too.

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New Methods for Feature Ranking

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Abstract. Most of Feature Ranking and Feature Selection approaches can be used for categorial data only. Some of them rely on statistical measures of the data, some are tailored to a specific data mining algorithm (wrapper approach). In this paper we present new methods for feature ranking and selection obtained as a combination of the above mentioned approaches. The data mining algorithm (GAME) is designed for numerical data, but it can be applied to categorial data as well. It incorporates feature selection mechanisms and new methods, proposed in this paper, derive feature ranking from final data mining model. The rank of each feature selected by model is computed by processing correlations of outputs between neighboring model's neurons in different ways. We used four different methods based on fuzzy logic, certainty factors and simple calculus. The performance of these four feature ranking methods was tested on artificial data sets, on well known Ionosphere data set and on well known Housing data set with continuous variables. The results indicated that the method based on simple calculus approach was significantly worse than other three methods. These methods produce ranking consistent with recently published studies.

Introduction. The success of data mining heavily depends on quality of input features. For some problems, input features do not contain enough information to be able to perform desired task (e.g., build accurate model or classifier). There often several possible input features that can be collected, however most of them can turn out useless. It is always better to collect more input features than to miss some crucial one. As M. Tesmer and P. Estevez wrote, when many features are available and data records are few, course of dimensionality prevents data mining methods of working well. Statistical methods based on mutual information analysis are able to identify most relevant input features. Algorithms (e.g, AMIFS, introduced by M. Tesmer and P. Estevez. In *Proceedings of the 2004 IEEE International Joint Conference on Neural Networks*) utilizing these methods can select a representative subset of informative non-correlated features helping to overcome the curse of dimensionality. The main drawback of these methods is that they are primary designed for nominal (discrete) variables and classification problems.

In this paper, we propose computational intelligence methods for feature selection and ranking, that are applicable to numerical features and regression problems as well. At first, we would like to clarify the difference among the feature ranking, feature selection and feature extraction. The feature ranking process only ranks all features in correspondence to their relevance while feature selection methods create a subset of the most relevant features. This subset should provide a maximal amount of information from the original subset without any redundant or irrelevant features. Methods of feature extraction, create a subset of new features by extracting the information from the original set of features. While feature ranking simply assign a rank (relevance) to each feature regardless of their interrelations, feature selection

solves a different problem - to choose the best subset of features. Note that in this subset should not contain redundant features.

Generally, it is possible classify feature selection algorithms into filters, wrappers and embedded approaches [2]. Filters evaluate quality of selected features independently from the classification algorithm, while wrapper methods depend on a classifier to evaluate quality of selected features. Finally embedded methods [2] selects relevant features within a learning process of internal parameters (e.g. weights between layers of neural networks). The goal of this paper is to describe new methods for feature ranking where these methods ranks only features preselected by the embedded feature selection algorithm. This embedded approach is based on special type of an artificial neural network, the GAME neural network [1]. Each method, we are proposing, ranks features using different approach, but all of them are based on inter-correlations inside the network. Feature ranking and selection process is always performed independently.

During our experiments, we found out that the best way how to utilize and process intercorrelations among neighbouring units is by using Fuzzy Logic and Combine Certainty Factors approach. These two approaches achieved the best results on artificial data sets and on real-world data sets from the UCI machine learning repository.

A special InfoTool has been also developed for the results (mentioned above) visualisation. This tool contains all the used GAME neuron's description pane, inter-correlation's pane, results pane of new proposed methods and its visualization. Described tool is interconnected with 3D GAME network visualization tool and user's interactions are promptly displayed in both parts (e.g. currently chosen neuron). This tool also contains an implementation of Kendall Rank Correlation Coefitient that is used for ranking results comparison.

Conclusions. In contradistinction to classical feature ranking methods uses these methods only subset of features preselected by embedded feature selection mechanism in the FAKE-GAME. Next advantage of these proposed methods is robustness for different problem as are classification and regression. Experiments showed that significantly robust are methods based on fuzzy logic (FL-FR) and based on combine certainty factors (CCF-FR). These methods also showed the ability to be successfuly compared to other regression methods.

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Auditory Model for Objective Quality Assessment of Coded Audio

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Digitalization of audio signals produces new types of distortions, such as the quantization noise and aliasing. Moreover, it makes it possible to use perceptual coders which serves to data reduction and due to the audio coding the variety of artefacts, for example pre-echo and birdies may appear. All this may lead to degradation of the audio quality from the perceptual point of view. Traditional objective measures, such as the Total Harmonic Distortion (THD) or the Signal to Noise Ratio (SNR), cannot fully describe the perception of audio distortions produced by non-linear and non-stationary audio coding algorithms. Evaluation of the audio quality degradation is done by means of subjective listening tests and also objective computational methods. Subjective tests are demanding and in some cases not applicable, but they are still the best way how to assess the quality of coded audio, and thus design of more accurate objective system is still the issue. Auditory models can be used in objective audio quality assessment systems. Such models must be able to simulate phenomena used in the perceptual coding algorithms, such as masking patterns.

Present paper briefly describes a nonlinear auditory model which was designed in order to simulate the real function of the peripheral parts of the human auditory system, specifically outer- and middle-ear and the response of basilar membrane (BM) and inner hair cells in the cochlea according to physiological and psychophysical observations, and thus it can account for a variety of phenomena affecting the perceived sound signals, for example nonlinear distortions and intermodulation products. Capablitity of the model to simulate psychophysically observed phenomena, such as masking patterns is verified.

Over all model structure is divided into different stages which simulates a sound signal processing by the previously mentioned parts of the human auditory system.

Outer- and middle-ear stage was designed according to measured transfer functions of a human outer-ear canal and middle-ear. Both stages are composed of linear phase, finite impulse response filters [3].

A cochlear frequency selectivity stage is based on a correspondence of mechanical and electrical quantities. It is composed of 251 stages whose outputs correspond to the vibration velocity of 251 points along BM. Characteristic frequencies of the simulated places along BM are distributed between 5 Hz and 21 kHz, ten sections per each critical bandwidth. An active contribution of the outer hair cells to the BM response and the nonlinearity of the BM response is modeled by means of amplifiers and a nonlinear transfer function [1].

Subsequent inner hair cells transduction stage roughly simulates transfer of BM ibrations into changes of membrane potential inside the inner hair cells, as was seen in physiological experiments. The BM vibration velocity signal is in each channel half wave rectified and then filtered by the first order low pass filter with cut-off frequency 500 Hz.

The output of the inner hair cells stage is then transformed into an intensity like representation by squaring expansion and then fed to an adaptation stage. The adaptation stage is composed of three feedback loops simulating adaptive properties of the auditory periphery.

The signal of the adaptation stage is then processed by a first-order low pass modulation filter and following modulation filterbank allowing to take into account a decreasing sensitivity of the model to sinusoidal amplitude modulation detection and other temporal cues of the signal, such as beats, intrinsic fluctuation of the signal envelope etc. And finally, the Gaussian distributed internal noise with constant variance across all peripheral channels of the models limiting the resolution of the auditory model is added to the model output signal.

The model output signal is a three dimensional pattern with axes time, frequency and modulation frequency. It is referred to as the "internal representation" of the sound signal processed by the model. Evaluation of the model was done by means of an optimal detector presented by Dau et. al. [2]. The ability of the model to predict experimental data, such as the intensity discrimination with pure tones and broadband noise and simultaneous masking patterns was evaluated. Obtained data were compared with experimental psychophysical data taken from a literature [4].

Nonlinear processing of the sound and limited frequency and time resolution of the human auditory system affects experimental phenomena like masking patterns. Since the presented model is nonlinear and its output is level dependent, obtained masking patterns were affected in the same way. The measured data showed that the model is able to simulate tested human psychophysical data (simultaneous masking patterns and intensity discrimination). Model capability to simulate other data, for example temporal masking patterns and amplitude modulation detection, will be tested in the future. If the capability of the model will be good for all experimental tasks, it will be integrated in a system for objective quality assessment of perceptually coded audio. The model will be also extended by the binaural hearing stage in order to take account of binaural hearing phenomena affecting masking patterns such as binaural masking level difference.

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Talking Avatar on PDA Device

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Rapid proliferation of mobile devices over the past decade and their enormous improvements in terms of computing power and display quality opens new possibilities in using 3D representations for user interaction. Such rendering power allows creation of new 3D user interfaces such as a 3D talking head on a mobile phone display. However lack of tools for creating these applications slows down research in this area. Inspired by existing solutions for more powerful desktop PCs [3,4], an effective architecture for the interactive fully-automated 3D-talking-head applications on a mobile client and a framework for easy creation of such applications are the challenges we address our work.

We have studied closely distribution between server and client. Using power-consumption and graphics-quality arguments we conclude for performing most graphics functionalities on the client, whereas the speech-interaction functions on the server. We document [1] that the graphics capabilities of contemporary devices are sufficient for rendering of such 3D animations by practical experiments as well as standard benchmarks.

Framework for easy developing PDA applications with talking head

We have proposed and developed a framework for easy creating interactive applications with a 3D talking head on a mobile device. The applications support automated multi-modal interaction using graphics and speech components. We have compared possibilities for distributed network control of the animation and interaction logic and choose the most convenient one for specific criteria. The distributed architecture allows to easily compose varieties of representations and applications, including entertainment, commerce, and education. Further, we document the ability of modern mobile devices to render the required level of detail and show that the power consumption trade-off of rendering on the mobile client versus streaming from the server favors the client.

On the basis of our findings we have designed and implemented an open-source platform-independent framework for creating talking-head applications for mobile devices. We have chosen the Qt library for the user interface development and as a base for the entire application for its flexibility and cross-platform portability. We use an animation module from Xface [3,4] and face meshes from FaceGen. For the voice interaction part we use the Microsoft Speech API, which includes server-based voice recognition and a speech synthesis. Platform-independent rendering is performed by OpenGL ES. Applications created by our framework can run on Windows Mobile, desktop Windows, Linux and Mac OS (separate source code compilation for each of the platforms is required). We are currently working on support for the Android, iPhone and Symbian platforms. Using our framework we have created two cross-platform applications. The first is a virtual customer care center and the

second is a virtual shop. The applications use heads generated by FaceGen and they are capable to render an animated head model with 1466 triangles. The rendering speed of the applications is above 15 FPS.

New algorithm for 3D model reduction for PDA devices

We have published [2] a new supplementary method for reduction of animated 3D polygonal models. The method is applicable mainly in animation of human faces and it is based on intelligent merging of visemes represented by key polygonal meshes. It is useful for devices with limited CPU and memory resources like mobile phones or other embedded devices. Using this approach we can reduce operation memory needs and time to load the model from storage. We describe the algorithm for viseme merging and we prove that our method is optimal for selected metrics. We validate method performance on an example and compare with the case when only traditional methods for 3D models reduction are used.

The presented method primary focuses on the head animation but it is general enough for use in other animation techniques using polygonal mesh interpolation (e.g. body, animals). In our work, we intend to investigate further reduction techniques as part of our ongoing effort of designing an open platform for development of talking-head applications on mobile phones.

Conclusion

We demonstrate that as mobile clients are becoming more powerful, real-time rendering of an interactive talking head is within their reach and we may expect a boom in interactive mobile 3D applications in fields like entertainment, commerce, education or virtual assistance. The client-server architecture, rendering the 3D components locally and controlling the logic and speech processing remotely, allows applications to be less power-hungry and improves the quality of virtual characters interaction. Using our framework for easy creating of virtual character based application on mobile phones; we would like to spark future research and application development in the area.

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Model for Adaptive Environments

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The current Web is an important source of information. However, researchers are looking for new ways to access the information more effectively. Every user is interested in different types of information, has different level of knowledge and various preferences. Adaptive Web systems store user preferences and use this information to present personalized information for each particular user. Unfortunately, processing of the preferences and other information stored in current systems is limited, because systems for processing this data do not recognize the meaning of the data. This problem could be solved by using Semantic Web technologies.

The aim of our work is to develop a formal model for adaptive web systems and a framework based on this model. In our previous work we proposed a General Ontological Model for Adaptive Environments (GOMAWE) [1]. The main advantage on existing user-adaptive systems is the utilization of semantic web technologies. The domains of our adaptive system, as well as the user model, are described by ontology. Additionally, we use rules to infer relations not explicitly stored in the user model. These rules could be specified by the instructional designer.

One of the possibilities for adapting information presented to the user is collaborative filtering. Information is filtered on the base of the preferences of similar users. In one of our experiments, we have implemented selected collaborative filtering algorithms as a program library [2]. There are many approaches and algorithms to compute the similarity of user preferences [3]. We have selected the most simple and most common used algorithms.

Our approach allows dealing with adaptation techniques as black box components. Therefore the collaborative filtering library could be used as an adaptation component. The collaborative library will be used as part of the reasoning layer of the GOMAWE model. By using artificial intelligence algorithms we can derive some user characteristics that were not stored in the user model. Similarly, we could add new rules to the multidimensional matrix in the storage layer based on the rules of similar users.

In the following work we will experiment with other parts of our model. One of the experiments focuses on the integration layer. We will implement a data exchange layer for communication with other systems. A web service will provide the data stored in the local semantic data storage. Another experiment focuses on the semantic data layer. We will study and evaluate various methods to retrieve the semantic data. We will use SPARQL query language to query the data storage. We will implement a social network web portal to achieve an evaluation of our model. The web application will be based on our model and provide various means of adaptation and personalization. Experiments with the data generated by the application should help us to evaluate our theoretical model.

The results of our research are part of the work of a special research group WEBING (http://webing.felk.cvut.cz).

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Theoretical and Practical Courses Innovation in Subject "Data Networks"

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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 Networks" mainly in practical courses but in theoretical level as well.

Innovation of practical courses

Main work has been done in innovation of practical courses. Refreshed practical courses syllabus contains seven practical tasks.

Task 1 Universal cabling measurement
Task 2 Physical level of Ethernet type 10/100 BASE-T
Task 3 Protocol PPP – basic analysis
Task 4 B- and D-channel Data Transmission Analysis
Task 5 FrameRelay – basic analysis
Task 6 Configuration and analysis of VPN networks
Task 7 Analysis of communication in MPLS network

Innovation of theoretical workshops

Three theoretical workshops consist of segment of theory and segment of simulation presentation. Simulation should enrich educational process with demonstration of behavior theoretically known methods and principles.

Simulations are mainly in a manner of

- Primitives exchange in multilayer reference model.
- Signal propagation within Ethernet media.
- Data communication principle in MPLS behavior.
- Call flow in PPP and MPLS protocol.
- FrameRelay operations.

All simulations are done by multimedia presentation.

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 → X32DAS → Materiály pro výuku) and therefore are anytime easily accessible by students.

Innovation of Task 1 – new data terminal endpoint as well as material and tools to successful task realization (cables, connectors …) has been bought, repaired and re-measured.

Innovation of Task 3, 4, 5, 6 – new RAS (Remote Access Server) has been bought. RAS is equipped with an ISDN module to provide a connection to laboratory telephone switch equipment.

Innovation of Task 5, 6, 7 – new three multiprotocol routers has been bought, till now routers had to be commercially loaned out.

As a support for *all Tasks* SW module Observer Expert v12 has been bought, This module enables deep analysis of traffic in data networks namely in Frame-Relay and MPLS networks.

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 → X32DAS → Materiály pro výuku) and therefore is easily accessible by students.

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 parts of course.
- All study material is now in electronic form of presentation.
- Motivation of students to study modern telco technologies.

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New Practical Exercises in Education of Subject Communication in Data Networks

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Subject Communication in Data Networks at Czech Technical University in Prague acquaints undergraduate students with an overview of basic principles and current state of Data Networks. The subject is mainly focused on LAN and WAN technologies such as Ethernet, token Ring, Frame Relay and Asynchronous Transfer Mode (ATM). A significant part of theoretical lectures is focused on explaining of basic principles of TCP/IP protocol family and incoming Internet Protocol Version 6 (IPv6) which is now gradually replacing Internet Protocol Version 4 (IPv4). The main goal of the project: Innovation of laboratory tasks of the course Communication in Data Network was to create new and upgrade present practical exercises.

The practical exercises are focused on practice with specialized networking equipment, such as routers, switches and protocol analyzers. The practical courses have been improved in following points:

- Two new practical exercise and materials focused on dynamic routing in IPv4 and IPv6 data networks have been prepared.
- The laboratory exercise focused on switching and Spanning Tree Protocol (STP) has been equipped with an additional switch. This extension increases modularity of STP topology.
- A new practical exercise focused on queuing algorithm and its impact on Quality of Service (QoS) has been prepared.
- All present and newly created materials have been transformed into the newly used Learning Management System (LMS) – Moodle, which is replacing the previously used system – Classerver.

Key points of new laboratory exercises:

Dynamic routing protocols are used to facilitate the exchange of routing information between routers and automatically react to the topology changes. The basic principles of dynamic routing are explained by the simplest dynamic routing protocol RIP. The following significant points are demonstrated to students:

- Basic principles of subnetting and Classless Inter-Domain Routing (CIDR).
- Types of routing table entries: directly connected networks, static and dynamic learned routes.
- The structure of the routing table and lookup process.
- Main differences between Classful (RIPv1) and Classless (RIPv2) Routing.
- The auto-summary and load-balancing feature.
- Support of split horizon and poison reverse rules.
- Principles of default route redistribution.

IPv6 was developed to overcome the limitations of the current standard, IP version 4 (IPv4). The following topics usually encountered when we discuss about IPv6 in packet networks:

- Main benefits of IPv6 (larger address space, build in security and mobility, simpler header…).
- IPv6 addresses representation and types (link-local unicast, global unicast, anycast, Multicast). IPv6 does not have broadcast addresses.
- The IEEE 64-bit Extended Unique Identifier (EUI-64) format and automatic interface addressing.
- End-to-end communications without the need for Network Address Translation (NAT).
- Transition to and compatibility with IPv4. Implementation of dual stack router with both IPv4 and IPv6 on the interface or protocol translation (NAT-PT) between IPv6 and IPv4.
- Basic configuration of simplest dynamic routing protocol RIPng.
- Principles of default route redistribution.

The last laboratory exercise provides an introduction to congestion management and queuing. The following queuing algorithms available on Cisco routers are compared:

- First-In-First-Out (FIFO) – simplest queuing method, only one queue.
- Weighted Fair Queueing (WFQ) – classifies traffic into different flows. It uses between 16 and 4096 priority queues (256 by default).
- Priority Queuing (PQ) – uses four priority queues (high, medium, normal and low). Ensures fastest handling of important traffic.
- Custom Queueing (CQ) – reserves a percentage of an interface's available bandwidth for each selected traffic type.

The new practical exercises allow students to gain additional skills in dynamic routing, QoS area and IPv6. Students will be able to implement QoS tools such as congestion management or queuing methods. All innovated practical exercises will be introduced into education in the summer semester 2010.

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Section 4

ELECTRICAL ENGINEERING & INSTRUMENTATION

Improvements of Surface Reconstruction Method Based on a Growing Self-Organizing Map

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The goal of surface reconstruction methods is to produce a digital representation of the shape of a real world object defined by an unorganized set of points. Surface reconstruction methods can be classified as static methods, based on geometric techniques, dynamic methods, based on fitting an initial mesh (of specific shape) to an unorganized point cloud, and the learning-based methods which learn the correct shape of the mesh from examples. The limitation of the static methods is that they process all points directly, and thus, can not deal with large amount of input data. The disadvantage of the dynamic methods is need to choose a shape of initial mesh that is topologically equivalent to the target shape. The learning-based methods, on the other hand, can process very large amount of a noisy input data, such as point clouds obtained from 3D scanners, and they usually require minimum a priori knowledge about a reconstructed object.

The growing self-organizing map is type of an artificial neural network that is able to learn a structure of input data from examples while the size of the network grows from an initial state. This approach eliminates the necessity of choosing an initial shape of the mesh – the topology and the object's shape is learned simultaneously. The algorithm Growing Self-reconstruction Maps (GSRM) [2] is a modified version of other growing self-organizing map called Growing Neural Gas (GNG) [1]. GSRM aims to support the representation of triangular meshes, hence it is able to reconstruct the surface of the objects from an unorganized point clouds. This paper sketches the improvements of the GSRM algorithm that significantly speed up the algorithm (in several orders of magnitude).

GSRM works in the following manner: at the beginning three points from input data set are chosen and the map (representing the output mesh) is initialized by this triplet. After the initialization, the map is iteratively updated until the stop criteria is reached: one point from input set is randomly chosen (input signal ξ) then two nodes (s_1, s_2) from the map that are nearest to ξ are found. The edge connecting these nodes is created and the triangular faces between these nodes and all common nodes are created. After that, the nearest node to ξ and its neighbor nodes are moved towards ξ. In every iteration the oldest edges are removed. If the number of input signals presented so far is integer multiple of parameter λ, new node is inserted between nodes which were most changing their position in the previous cycles. Each node has assigned its own error counter growing according to the node's movements. The node with the highest value of the error counter is thus determined as node most changing its position. In addition, on the end of every cycle the error counter of each node is multiplied by the parameter β to decrease it. This avoids situation when the same node is repeatedly found as the most moving node.

The most time-consuming parts of the algorithm are a) finding the nearest node from map to randomly chosen input signal and b) multiplying the error counters by parameter β – both because it requires tracking of all nodes from map.

The former problem can be classified as the nearest neighbor search that can be solved by kd-tree data structure. Using this structure the search has complexity $O(\log n)$ where n is the number of points in the kd-tree. The drawback of kd-tree is that it can hold only the static points – by contrast, nodes in the map are continually moving, and thus, the kd-tree can not

be used. The solution proposed here is following: a bounding rectangle of input point set is determined and this rectangle is divided into several non-overlapping cubes of the same size. Then every point in 3D space belongs to exactly one cube which can be determined in constant time (computation is based on position of bounding rectangle and length of cube's edge). In this layout, a searching for the nearest node can be performed first on all points which belongs to same cube as input signal and then to all cubes around the first one, and so on until the nearest node is found. The asymptotic complexity of this operation is not lower than $O(n)$ but the experiments have shown that this speeds up the whole GSRM algorithm in several orders of magnitude (only small part of space is searched).

The latter problem requires tracking through all nodes in the map. The error counters are multiplied by constant β hence it's possible to create one cumulative error counter. Instead of tracking trough all nodes to decrease theirs error counters only the cumulative error counter is changed. In the step when a new node is added to the map all nodes must be tracked anyway (to find the one with highest value of error counter) – so cumulative error counter can be applied to all nodes as the side effect and then cleaned. This modification has similar influence to speed of GSRM algorithm as improvement described before.

The proposed improvements of the GSRM algorithm have been implemented. The experiments performed on the well known collection of Standford benchmarks have shown that the proposed modifications significantly decrease the run time of the GRSM algorithm from hours to tens of seconds.

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Propagation Models for Planning Mobile Systems Provided via High Altitude Platforms

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With new satellite services (TV/radio broadcast, navigation, phones), there is a demand to investigate the satellite-to-indoor and satellite-thru-vegetation channel propagation in L, S, and C Bands. The penetration loss measurement is based on [1] and [2], where the remote-controlled airship was used as a pseudo-satellite and empirical models for signal propagation within HAP systems for different types of built-up area were developed. In [3] and [4] are described the measurement campaigns focusing on the vegetation attenuation using a helicopter and high building as platform where the source of signal was placed. These effects were measured in the measurement campaign carried out during a spring and summer 2009.

The measurement campaign was carried out using continuous wave (CW) in the L, S and C frequency bands. The 9m-long remote controlled airship was used as a pseudo-satellite to carry the transmitter station. The transmitter station consists of four CW generators, amplifiers and antennas. Planar wideband spiral antennas with left-handed circular polarization (LHCP) were used as the transmitting antennas. A single broadband spiral circularly polarized antenna (LHCP and RHCP) was used as a receiving antenna and was placed inside the building (vegetation) at a constant height of 1.5 m. The received signal strength was measured by a Rohde&Schwarz receiver PR100 remotely controlled via its LAN interface by a notebook running the control software.

At least four flyovers were planned for each measurement position in order to obtain statically relevant data for a sufficient range of elevation angles. One flyover represents about a 1.5 km long flight path. The average height of the airship above the ground during the measurements was approximately 200 meters. This lead to the elevation angle (from the measurement location perspective) range from about 20 to 90 degrees. The airship speed was from 2-6 meters per second, depending on the wind speed. A minimum speed of 2 m/s had to be maintained in order to be able to operate the airship on the desired path.

In addition, the airship was equipped with a number of sensors to track its pitch, roll and compass data, as well as its altitude and the GPS position. These data were collected on the ground using a wireless connection to the airship. The data were subsequently synchronized with other datasets using GPS time stamps. For the precise determination of the airship position a separate lightweight Differential GPS (DGPS) receiver was used as an additional payload. The external GPS antenna was placed on the top of the airship hull.

As was written above, the measurement campaign is separated into two basic areas. There was utilized only one measurement scenario for the penetration loss measurement. The receiving antenna was located inside the building and the flyovers were done as describe above. Building penetration measurements were performed in five different buildings located in the city of Prague area. These building were selected to represent various building types, namely FEE (Faculty of Electrical Engineering) CTU in Prague, CTU Rectors office,

Dwelling house, Office house and EuroPark Šterboholy. Two additional sites were utilized for calibration measurements (large open field and park near the FEE building).

The vegetation attenuation measurements were performed in three different locations in the city of Prague. The locations were selected to represent various vegetation arrangements. As the FEE park and Fleming square are in the close vicinity of our university, transport was not need. For measurements in the Stromovka park a van was utilized for the transportation of the airship and equipment. The campaign was mainly focused on deciduous trees, only one case represents conifer trees. The measurement positions are separated into three basic measurement scenarios, i.e. Inside, Single and Roadside trees. In the first scenario the receiving antenna was located inside the vegetation (antenna was surrounded by vegetation). The next one (Single) means that receiving antenna was placed in a distance from a single tree and the attenuation measurement was only performed for this particular tree. In this scenario the flyovers described above were not used and the airship only flew in one direction to achieve a range from about 20 to 90 degrees. This measurement was carried out once for four different antenna distances from a single tree. The Roadside trees scenario implies that the receiving antenna is placed at some distance from the roadside trees.

The measured data are currently being processed. There are several sources of the raw data: signal strength data from one or two RX stations, GPS data from the GPS receiver, DGPS data for DGPS post-processing, the airship sensors flight data (e.g., GPS position, compass, pressure, temperature, height, wind speed, pitch and roll). These datasets need to be processed and synchronized. Measurement results for an open field scenario are used as a reference. The aim is to determine the penetration loss and vegetation attenuation as a function of the elevation angle for each measurement location and find a suitable propagation model subsequently.

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Satellite Signal Propagation into Buildings at L-, S- and C-Band

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Satellite signal propagation into buildings is one of crucial factors for any of future satellite-to-earth communication links including navigation services, for example Galileo. This problematic has been extensively investigated recently in order to obtain suitable model for this type of propagation channel. The possibility of receiving a sufficient signal level inside a building depends on the attenuation caused by building walls and its other features. This excess loss is usually referred as a building penetration loss [1] and is dependant on many parameters of the satellite-to-indoor propagation channel, especially on the elevation of the satellite with respect to the receiver inside a building.

Several different measurements of the building entry loss have been performed so far and some models for the satellite-to-indoor propagation channel were introduced [2], [3]. However, still a model for a continuous wave signal at L-, S- and C-band is missing. Since many of these measurements were expensive because of the use of an aircraft or a helicopter as a pseudo-satellite, we managed to reduce costs by using a remote control airship to simulate the satellite.

Within the framework of the ESA PECS Project No. 98069 the building penetration loss is measured at different buildings in Prague. The aim of this ESA project is to provide a propagation channel model for representative types of buildings at L-, S- and C-band. The remote controlled airship enables us to achieve a wide range of elevation angles over the investigated building during measurements at different azimuths, which is necessary for further statistical analysis of obtained data.

To be able to perform building penetration loss measurements, both the transmitting and receiving antennas need to be chosen properly. To have the possibility of performing measurements at lower elevation angles, left-handed circularly polarized spiral antennas with wide radiation patterns were chosen. One important parameter of such antennas is their polarization pattern which indicates how close to the circular polarization is the polarization of the transmitted electromagnetic wave in a selected direction. This effect is caused by the design of any antenna and thus cannot be eliminated. If in some direction the polarization is not circular, a polarization mismatch occurs which causes another loss in the whole system.

Before we could use the proposed antennas in our experiment, we needed to obtain their polarization patterns in several directions. The knowledge of these characteristics determines whether the inaccuracy in the measurement caused by the polarization mismatch at lower elevations can be neglected or not.

Two different systems for polarization measurements of antennas were available at the anechoic chamber of the Department of Electromagnetic Field: one using a spectral analyzer and the other using a vector network analyzer [4]. Both of these systems were using different units to control the polarization turntable, which was making them difficult to use. Moreover, these systems were neither standalone nor fully functional because a controlling PC was missing. The system with the spectral analyzer relied on the PC already placed in the

anechoic chamber. The other system with the vector network analyzer was designed to use a notebook which was not available.

The aim of this project was to simplify and enable measurements of antenna polarization characteristics in the anechoic chamber. Both of these goals were achieved by adding a notebook to the previously mentioned systems and by adding another type of the polarization turntable control unit, which is now shared by both of these systems and which enables online programming from a PC, and also by necessary update of measuring software.

Another advantage of the two systems is now that both of them can be placed also outside the anechoic chamber. This is an advantage during laboratory tasks during which polarization measurements are presented because the anechoic chamber can be reserved for other measurements.

Both updated systems were tested by measuring polarization characteristics of transmitting and receiving antennas which were intended to be used during the building penetration loss measurement campaign. On the basis of obtained results, these antennas were found to have sufficient parameters acceptable for the measurement campaign, which was also published in the second report for ESA containing description of the system used for the building penetration loss measurements.

The work supported by CTU grant No. CTU0903413 has been finished successfully. Both systems for antenna polarization measurements are now simpler to use and they also work properly and independently to the hardware equipment of the anechoic chamber. Another advantage is that these systems can now be placed also outside the anechoic chamber, for example to present polarization measurements to students during laboratory tasks. This work also enabled to obtain polarization characteristics of antennas used in the campaign related to building penetration loss measurements and thus supported the ESA PECS Project No. 98069 which is still ongoing. All the planned measurement campaigns within this project have been carried out and the part dealing with data processing will follow. As a result, a new model for elevation dependant building penetration loss will be created.

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Propagation of UWB Signals

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Propagation of electromagnetic waves has been almost entirely carried out in the frequency domain. However, it is more appropriate to use time domain approach in some cases, e.g. by research of ultra-wideband (UWB) systems. One of the main reasons, why the frequency domain is preferred to the time domain, is the requirement of generating very short pulses, which is extremely difficult. Various techniques are used to generate UWB pulses. A conventional short pulse generator consists of an edge sharpener, which sharpens and accelerates a slow rise time driving waveform edge, and a pulse-forming network, which forms the output pulse to the desired shape.

Special solid-state components are commonly utilized as pulse sharpeners. Avalanche transistors, step recovery diodes (SRD), tunnel diodes, bipolar transistors, FETs and nonlinear transmission lines with varactors are used. Avalanche transistors are advantageous as high power sharpeners, but the maximal usable pulse repetition frequency and the transistor lifetime are limited. Tunnel diodes offer the shortest transition times at very small amplitudes. The step recovery diode is a compromise alternative to these components, and is capable of generating pulses with approximately 50–150 ps transition time. This makes them most preferred for current UWB applications.

A pulse-forming network converts the step-like waveform generated by the SRD sharpener to a Gaussian-like or some other pulse form that is required for a specific application. Transmission line pulse-forming networks or simple RC-differentiators are most frequently used. Complex planar structures, such coupled-line couplers, are also reported to exhibit usable pulse-forming properties. However, any circuits connected to the output of the SRD sharpener introduce an insertion loss and inevitable ringing into the output waveform. Therefore, additional circuits have to be employed to suppress ringing. The main constraint of the SRD pulse generator design is the limited minimum pulse width of the generated pulse, which is determined by the parameters of the SRD. Consequently, SRDs are primarily used for lower UWB bands up to about 5 GHz. The output pulse width and amplitude can be improved using MESFET amplification and compression circuits. Unfortunately, the low maximum drain-source voltage of active forming circuits limits the output pulse amplitude.

We have proposed a novel circuit solution of a UWB sub-nanosecond pulse generator [3]. The basis of the generator is an SRD, which works as a standard waveform edge sharpener connected in parallel with a transmission line. However, the sharpener is included in a unique pulse-forming network consisting of a Schottky diode and a delay line. This unconventional circuit solution, where the pulse-forming network precedes the SRD sharpener in the signal chain, has many advantages. It is capable of forming reasonably high amplitude pulses with low ringing levels. In our previous papers [1, 2], we used a similar structure to generate stable high amplitude pulses. A novel pulse-forming network with an improved topology [3] is capable of generating narrow Gaussian pulses in order to increase the bandwidth of the generator. Our second objective was to maintain a low ringing level. The measurement results show that both requirements are fulfilled without the need for additional ringing reduction or active pulse compression circuits.

The RF part of the generator was designed by the AWR Microwave Office Design Suite. The pulse generator was implemented on an ARLON AD450 substrate 0.762 mm in thickness. We used the MA44631A step recovery diode in the ODS-93 package and the MA4E190 Schottky diode in the ODS-276 package, both manufactured by MA-COM. The cylindrical form of the ODS packages enables the diodes to be mounted directly in through-holes 1.3 mm in diameter. The leads of the diodes are then soldered directly to the bottom ground plane without the need for additional vias. This particular form of the pulse-forming network is optimal for generating very short Gaussian pulses.

The delay line between SRD and the Schottky diode was implemented as a section of a microstrip line 4 mm in length and with a characteristic impedance of about 90 Ω. The correct width was obtained by optimization in the AWR simulator.

The output waveform of the complete pulse generator was measured using an Agilent 86100C sampling oscilloscope at a 50 Ω load. A 30 mA constant current from an external source was used to bias the SRD. The maximum amplitude of a measured Gaussian pulse reaches –7.5 V, the pulse has an FWHM (Full-Width at Half-Maximum) of about 110 ps. A lower FWHM is obtainable by shortening the delay line length, however, the pulse output amplitude decreases. The ringing level does not exceed 5 % of the output amplitude.

The power spectrum of the generated pulse was calculated using the Fourier transform. The 20 dB pulse bandwidth is 7 GHz, which is almost twice the bandwidth of the pulses presented in [1, 2].

We have presented a new circuit solution of an ultra-wideband (UWB) sub-nanosecond pulse generator. A Gaussian pulse is generated by a step recovery diode (SRD) sharpener, which is included in a unique pulse-forming network consisting of a Schottky diode and a delay line. The location of the pulse-forming network in the input section of the SRD sharpener provides high output amplitudes and maintains a low ringing level. We also designed a two-stage transistor driver, which does not introduce any unwanted distortion into the output pulse. The measurement results prove that our circuit solution is capable of generating narrow Gaussian pulses without the need for additional pulse compression circuits. The pulse generator concept presented here has been successfully applied in ultra-wideband transmitters and as a part of microwave sampling circuits.

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Electromagnetic Wave Propagation Simulations and Measurements in Indoor Scenarios

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The design of modern wireless systems [1] requires a site-specific prediction of both narrowband and wideband channel parameters. Multiple-input multiple-output (MIMO) broadband wireless communication systems, 3G mobile communication systems, Wi-Fi networks, and other systems providing high speed services need to be designed having regard to their multi-path propagation. Modern digital wireless systems provide users with high speed services using advanced methods of signal processing. For this reason, devices working in these digital systems are not only sensitive to the signal level, but also to wideband channel parameters, including the delay spread, the angle-of-arrival, fading characteristics etc. A prediction of both narrowband and wideband parameters is essential for accurate wireless system design and, subsequently, for high quality system performance.

The classical deterministic Ray-Optical models that are able to compute the above-mentioned channel parameters, require the existence of an obstacle database. This means that the database has to contain the exact positions of any obstacles, including their material properties in the scenario, which are then used in Fresnel equations and also in the UTD/GTD theory. In general it is almost impossible to obtain true and precise values of these material constants. Settings these values is a very difficult task and these models usually only consider a perfectly flat surface and a specular reflection of the ray, because it is also extremely difficult to provide an exact description of this phenomenon. Last but not least, very complicated computations (UTD/GTD) must be performed. This unsatisfactory situation was the main motivation for developing the new model.

Our model belongs to a group of models based on the Ray-Launching technique. The new propagation model is based on the principles used in the Motif Model [2], but now transformed to 3D. The general idea involves the substitution of the electromagnetic wave by a large number of individual plane waves approximated by rays. These rays, analogous to the electromagnetic wave, interact with obstacles in the scenario. However, the main contribution of this model lies in the method of solving interactions between the ray and an obstacle. The subsequent direction of an impinging ray is determined in terms of the probability radiation pattern (PRP). Generally, the PRP is a function of the angle of arrival and is created on the basis of probabilistic parameters (the probability of absorption, the probability of diffuse scattering, etc.). These probability parameters can characterize the obstacle surface (roughness and conductivity).

The tunnel environment is a very special kind of indoor scenario. A typical tunnel environment does not only consist of walls, but also includes a number of other obstacles: rails, cables and even moving trains. There is a reasonable chance that these obstacles will be described in three dimensions (3D). The essential types of scenario were simulated and we found close agreement between the results obtained and our theoretical expectations. The

model can provide both narrow and wideband results (signal coverage prediction, impulse response prediction and angle of arrival prediction).

The model was primarily developed for signal propagation predictions in tunnels but a new version for indoor scenarios is under development. The model, in contrast to classical deterministic models, takes into account the imperfectly flat surface of obstacles, meaning that the diffuse scattering mechanism is also considered. The reflection and absorption of rays is determined on the basis of probabilistic parameters and therefore complicated calculations (Fresnel equations, GTD/UTD relations) can be avoided. The material constants are replaced by few probabilistic parameters which are optimized [3] on the basis of the measured data [4].

The basic principles and an evaluation of our new 3D propagation model were introduced. In contrast to classical deterministic models, the model takes into the account the imperfectly flat surfaces of obstacles, i.e. the diffuse scattering mechanism is considered. The reflection and absorption of rays is determined on the basis of probabilistic parameters which means that complicated calculations (Fresnel equations, GTD/UTD relations) can be avoided. The material parameters are replaced by probabilistic radiation patterns, which are optimized empirically on the basis of the measured data. Despite the fact that this model was primarily developed for signal propagation predictions in tunnels we expect that the model could also be applied to many other indoor scenarios. This provides a direction for our future work on the model.

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New Materials for Antenna Technology - Low Profile Antennas for UHF RFID of People

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Although the RFID technology is known for more than three decades, it started to gain more ground primarily in the last decade. In fact, it has spread in broad fields of applications, such as commercial, industrial, medical, scientific and other areas; basic information can be found e.g. in [1]. UHF RFID represents an irreplaceable tool for applications, which demand the remote identification of objects. As a promising example of such kind of application, we can mention the RFID of people. In spite of the fact that several UHF TAG antenna solutions for wearable purposes have been developed in recent years, there is still a decent room for the design of small low-profile transponder antennas that would be able to meet high requirements of today's market of wearable RFID antennas. Some issues of TAG antennas, suitable for this particular application (such as a very low profile or a badge size) still remain, in principle, unsolved. Several commercial producers offer TAGs for the identification of metallic objects, which can be also placed on dielectric objects, such as a human body. However, a relatively large size together with a high profile represents the main disadvantage of these products in UHF RFID band. In fact, the latter is promising for the purposes of the middle-distance identification; see [3].

A dual-loop antenna, placed over a four-element patch array surface presented in [2] represents one of the possible extremely low-profile solutions. The antenna size equals $70 \times 105 \times 1.82$ mm (relative size is $0.2 \times 0.3 \times 0.005\ \lambda_0$ at European RFID band 869 MHz). The insertion of the patches structure between the metal plate and the dual-loop motive provides a significantly better radiation efficiency than the loop placed over the metallic plate, because the four-element patch array is excited and takes part in the radiation process. However, the drawback of this solution is that the antenna is realized on a high permittivity substrate ($\varepsilon_r = 10$). Consequently, the total weight and the level of production costs make it difficult to use the antenna as a badge TAG.

This paper deals with the advanced antenna structure, derived from [2]. However, unlike the current approach, the low permittivity substrate is used, which is the key way how to minimize both the weight and production costs. The two variants of a very low-weight badge-sized TAG antennas were simulated in Zeland IE3D method of moment software and afterwards also developed and measured. These antennas enable to tune the complex input impedance to the required value. The antennas properties in monopole arrangement were measured and compared in a free space with and without a human body phantom.

Dipole excited antenna:

The above-mentioned disadvantages of the antenna introduced in [2] can be eliminated using a low permittivity substrate ($\varepsilon_r = 3.2$, $\tan\delta = 0.002$). However, this approach leads to a significantly larger four-element patch size, because the wavelength λ_g is equal to approx. 220 mm at frequency 869 MHz. The reduction of the screening four-element patches structure to the two-element structure is the first miniaturization step that does not result in the decrease in the radiation efficiency. The patch array length can be further reduced by the realization of the patches acting as a quarter-wavelength resonators, whose outer edge is conductively connected with the screening metallic plane. A planar meanderly folded dipole etched on the superstrate layer is used as an excitation element, whose length is used in order to tune the input impedance so that it is the complex conjugate to the chip impedance value.

The total size of the dual-layer antenna equals $60 \times 95 \times 1$ mm (relative size is equal to $0.17 \times 0.28 \times 0.003$ λ_0 at 869 MHz). The dipole dimensions follow: $la = 28.5$ mm, $lb = 23.5$ mm and $wa = 8$ mm.

Directly excited antenna

The removal of the upper substrate represents another possibility how to simplify the structure of the antenna. The shorted two-element patch structure can be excited directly by the chip, inserted into the slot situated between the inner patch edges. Unfortunately, this structure does not involve the capability of impedance tuning. By the insertion of two slots (as reactive elements that are, from both sides, symmetrically close to the inner slot), by setting of its distance, length and width the impedance matching can be achieved. The total size of the directly excited two-element shorted patch antenna is $60 \times 100 \times 0.76$ mm (relative size is $0.17 \times 0.29 \times 0.0022$ λ_0 at 869 MHz). The dimensions of the impedance slots follow: $ls = 40$ mm, $ws = 6$ mm and $p = 3$ mm. The antenna is, again, realized on the low-permittivity substrate $\varepsilon_r = 3.2$.

Discussion

The standard patches exhibit a very low radiation efficiency (about 10 % and lower for $h/\lambda \sim 0.005$). The antenna concept presented in this paper shows a significantly better ratio between the antenna size and the performance rate (namely extremely low profile with a good radiation efficiency of better than 50 %).

The TAG antenna size, profile, weight and production costs are the main factors that are taken into account when selecting the badge TAG antennas for RFID of people. The use of the low permittivity substrate is a crucial prerequisite, which is met in case of both of the proposed antennas. The one-layer substrate arrangement represents another key requirement, since it enables an additional weight and cost reduction. Consequently, it is the advantage of the second solution. In comparison to the dual-loop antenna loaded by grounded patch array surface [2], a significant weight reduction was achieved.

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Workplace for Measurement of UWB signals

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Today, access to radio spectrum is difficult as it is restricted by a radio regulatory of every country. Large parts of the radio spectrum are allocated to licensed radio services. Open access to some part of the radio spectrum is permitted with very low transmission power, for example Ultra WideBand [1-2] system works in a huge frequency bandwidth and with very low power spectral density. This system was standardized in the bandwidth 7.5 GHz from 3.1 GHz up to 10.6 GHz [1]. The power spectral density of this type of system was limited to 41.3 dBm/MHz and with fully usage of frequency band it is able to transmit power of 0.5 mW.

Very short time domain pulse is transformed by Fourier transformation to the frequency domain where it is allocated in available UWB bandwidth. This system is called IR UWB (Impulse Radio UWB) On the other hand; OFDM approach is used for wireless communication under UWB spectral mask restriction.

The power spectral density -41.3 dBm/MHz could cause several interference problems. It should or has to be mentioned, that some typical wireless systems could work up to -80 dBm. The solution of this interference problem could be done using intelligent radio principle. This type of radio is called cognitive [3] because of its awareness ability.

As discussed above it is very important that future UWB systems are cognitive if their transmission ranges are to be extended, as this will require the use of increased transmitter powers (above the spectrum mask in unoccupied bands) so occupied areas of the radio spectrum must be avoided through suitable pulse shaping. A suitable dynamic frequency spectral mask for cognitive IR-UWB was studied during project and it is presented in this paper.. The aim is adjustment of the overall power in different parts of the spectrum so as to ensure increased total power at the transmitter delivers range extension. The radiation over the power limitation in UWB systems is not a novelty, but the precise shaping of time pulses is rarely solved directly in the time domain. The main features of pulse shaping will be discussed below with the power (amplitude) improvements of the radiated signal.

Simulations

The pulse shaping algorithms are based on the analytic description of the Gaussian pulse modulated with harmonic function (more in [4]). Several simulations were done to find optimal solution for pulse shaping. Main parameters as width of the pulse, repetition rate or bit rate were discussed during the simulation process. We could not find general solution for several input parameters as maximal bit rate or maximal level of avoidance but it is possible to find an optimal solution or specific solution for concrete case. In the simulation we use frequency background data from real measurement as a typical situation.

Measurements

For commercial usage of the pulse shaping, it is necessary to find low cost option to shape a pulse very generally and dynamically. This pulse shaping could be realized by two ways – using a band-pass filter or a frequency mixer. The filters have several advantages. It is possible to create impulse response of the filter for a compensation of generation, radiation or propagation effects. The frequency mixing of the Gaussian pulse and a discrete harmonic frequency shifts pulse's spectral lines around the discrete frequency. In this project we have focused on wideband mixer. The main goal of the measurement is to shift maximum of frequency spectrum of the Gaussian pulse from DC values to higher frequency bands. The DC component is not suitable for radiation and propagation. There are several measurements for proving simulations with one harmonic frequency and we are going to measure with several harmonic frequencies in the future.

Using the new measurement workplace and setup it is possible to shape the pulse as it was presented. The measurement result proves the background theory and simulations of the pulse shaping using frequency mixer. The results of these measurements could be used for the cognitive radio to avoid the interference with primary users at significant frequencies.

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Advanced Far-end Crosstalk Modelling

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At the present time belong xDSL subscriber lines among the most wide-spread systems used in the access networks mainly for connecting households and small business to core network. These lines use mostly existing metallic symmetrical pairs of the local cables and thanks to that provide very cost-effective connections in a segment of access networks for small companies and households to the core telecommunication and data networks. However, the requirements for the amount of transmitted data and the transmission speed have increased rapidly in the last few years, and this trend is supposed to continue further. These increasing demands on transmission speed and the overall performance of access network infrastructure are caused mainly by the fast development of new technologies and related telecommunication services and their expansion. One of the possibilities is to use optical telecommunication solutions, such as the passive optical networks (PONs), and to offer the necessary transmission capacity through the optical communications. That means to use fully optical connections from the local exchange to a local end user, or hybrid network based partially on the optical fiber as well as on the cheaper metallic connection. Because the global optical infrastructures have not been established yet, it would be necessary for the telecommunication operators to invest heavy costs for preparing and building new optical networks, and this mainly causes the slow propagation of optical connections. That's why it is still important to try finding new solutions for improving parameters of the present digital subscriber lines and existing metallic cables.

The major problem, which appears in large metallic networks, is the crosstalk. It comes from unbalanced capacitive and inductive couplings between single copper pairs, their quads and multi-quads as well as from the ground unbalances. These pairs demonstrate towards themselves small irregularities, which are caused by the manufacturing tolerances, deformations and other specific reasons. Near-end crosstalk (NEXT) can be well limited by separating transmission directions by using different frequency bands, but the elimination of far-end crosstalk (FEXT) is not so easy and therefore FEXT is a dominant source of disturbing in the current xDSL lines. Several solutions for FEXT suppression has already been presented, such as the vectored DMT modulation in [1], but they are usually too much complex and put high demands on the present transmission processors in DSLAMs. One of the possibilities, how to simplify this process, would be performing the vectored DMT modulation only for limited number of pairs or even only for xDSL sub-channels. These pairs could be selected according to their contribution of crosstalk [2], [3]. This method would decrease the number of disturbing systems to be coordinated and simplify the whole process. The new concept of modeling the transmission functions for specific environment in multi-pair metallic cables uses space selection and detailed analysis of disturbing sources. The empirical model is based on theoretical assumptions concerning the allocation of disturbing sources and verified by measurements performed with a specific multi-pair metallic cable. This model could serve for determining the FEXT contributions of each transmission system in a cable and to prepare the necessary parameters for implementing VDMT modulation.

The standard model for transmission channel and crosstalk comes from the derivation of interactions between pairs in a cable, in which the major role plays a crosstalk parameter (a

constant for the given combination of transmission pairs). This parameter presents the rate of interactions between selected pairs and it is different (unique) for all combinations. However, for most applications the value of this parameter is unknown, and only one mean value is usually given for the whole cable. It is obvious that this model with only one parameter cannot be very accurate and that it provides only approximate results. The accuracy of these results can be sufficient for some specific applications (for example, summarization of many contributions), but this simple model is not very useful for the precise modeling of perspective VDSL2 lines with VDMT modulation.

Several changes and improvements of the standard model for transmission channels and crosstalk were proposed. These upgrades are based on previous results obtained by measurements of specific metallic cables, presented in [2] and [3]. The resulting advanced model takes into consideration the relative position of disturbing and disturbed pairs in a cable. The idea of this method for modeling was further extended and a new process for generating it was developed. This model allows the generation of crosstalk transmission functions and simulations of systems using metallic cables. This procedure allows generating pseudorandom characteristics under different and various conditions.

The model is based on detailed analyses of the transmission environment and its parameters, statistical evaluation of measured results, generation of pseudorandom characteristics and the processing of their filtering, detailed description in [4]. The necessary mathematical description was prepared, implemented and verified. The exact description allows the use of the advanced model for various types of environments and situations under different conditions. The calculated results and generated characteristics obtained using this method are very realistic and are very close to real crosstalk characteristics in real transmission channels. The model helped to prepare the necessary results for examining the impact of VDMT modulation on the suppression level of crosstalk without performing time-consuming measurements of real metallic cables. The model could serve for simulations and calculations of FEXT crosstalk and to prepare realistic results for implementing VDMT modulation into VDSL2 digital lines.

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Transmission of Synchronization across Packet Network

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Packet networks are the fastest developing type of networks at present. Convergence of telephone networks to the packet networks clearly set a trend towards further development and usage of the packet networks. Synchronization in the packet networks depending on growth of those networks is more and more discussed issue. It has become a crucial requirement of communication between two or more devices. Clock synchronization is also used for precise time distribution. Currently, the distribution of time information is achieved by using telephone lines or data communication networks [1]. My work focuses on clock synchronization and time distribution across packet networks, such as Internet. To this day several synchronization protocols were developed for time synchronization in the packet network such as Ethernet. Network Time Protocol (NTP), Simple Network Time Protocol (SNTP) and relatively new IEEE-1588 Precision Time Protocol (PTP) belong to the most popular protocols. Network Time Protocol (NTP) is one of the most popular protocols used for computer time synchronization across Internet. The basic emphasis of this work is to concentrate on NTP accuracy and its improvement. Additionally, other protocols used for Internet time synchronization will be discussed.

Network Time Protocol (NTP) is one of the oldest and the most popular protocol used for Internet time synchronization. NTP was invented primarily for computer clock synchronization and it is used to achieve clock synchronization between trusted time server and its clients. NTP is established on time information transfer between individual devices [4]. Time information is transmitted with assistance of NTP packets. Time correction and network delay is computed from four timestamps, which are sent in NTP packets. Many factors have influence on NTP performance. A variable delay can be considered as the most significant and it is caused by other network nodes along transmission path and equipment itself. NTP accuracy is about 10 milliseconds and more across large network, such as Internet, and between 0.5 and 10 milliseconds across local area network (LAN). Packets delay dispersion depends on network configuration and load.

For elimination of network delay dispersion and increase of synchronization accuracy several algorithms were developed and tested. Algorithms are based on filtration using FIR filter and IIR filter. Individual clock offsets are calculated based on NTP packets flowing through a filter, which determines resulting correction of client's clock. This correction is added to client time, which becomes more precise time. The aim was to propose filters with different order and compare the characteristics of these filters.

For verification of my presumption was created the simulation in program Matlab. The simulation researches impact of delay dispersion on synchronization accuracy. Delay was generated with determinate dispersion and range. We can say that the accuracy of synchronization is better when dispersion of the packet transmission delay is lower. When generating the delay by normal distribution, we have better results than generating by uniform distribution. Delay dispersion was chosen in the range from 100 to 500 microseconds. Three types of FIR filter and three types of IIR filter were suggested for testing. We propose a low pass filter with limit frequency of 0.04 Hz. For FIR filter design was used Matlab function *fir1* and for IIR was used function *butter*. Filters with higher order are not very suitable for this

application, because their latency is too high. Therefore, it was assumed that the best choice is IIR filter order of 4. The synchronization accuracy is approximately ± 5 microseconds.

Furthermore was simulated the impact of precision oscillator on synchronization accuracy. The oscillator, which generates time on the client, was slightly changed. This has influence on the size correction, which becomes positive or negative values. Achieved accuracy is very good for time synchronization, but it is not satisfactory if we require generation time with minimal phase jitter. To generate accurate time is necessary to use the principle of local oscillator phase loop. The problem is that the resulting corrections are determined from the packets that are broadcast with a relatively low frequency. The solution was to add clock to the client that is not synchronized by the algorithm described previously. This clock is set at a certain point and then the difference between the synchronized and non-synchronized clocks is measured. Obtained time difference can be used to determine the difference of server and client frequency oscillator.

Network Time Protocol is very extended, and used to synchronize time in computers. Its main advantage is the availability to transfer throughout the Internet. The accuracy of this protocol is not too high, that is why some ideas for improvements were presented here. Today, a new protocol for synchronization of time according to standard IEEE 1588 known as PTP (Precision Time Protocol) [2] is already much extended. The first standard which describes PTP was issued in 2002, but in 2008 a new revision of this document was published. The main difference between NTP and PTP protocol is their implementation. While NTP allows only software implementation, PTP protocol allows also hardware implementation. Hardware implementation enables accurate determination of arrival and departure time of PTP packet, which is a significant improvement of the synchronization accuracy [3]. Current implementation determines final accuracy. The hardware implementation reaches the accuracy of synchronization about 10 ns, where FPGA circuits can be used.

Synchronization of time in many devices is very important issue. To synchronize time of computers NTP protocol is commonly used. The aim of this work was to test a possibility of increasing an accuracy of NTP protocol and to determine what accuracy values can be achieved. Achieved results are now overcome by PTP protocol performance. PTP protocol achieves higher accuracy due to hardware implementation. It was primarily designed to synchronize devices in local networks. The future work should concern using and testing of PTP protocol, along with solution on how to achieve higher accuracy of synchronization.

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Comparison of Ultrasound Non-destructive Inspection Techniques on the Basis of Sensitivity and Detection Reliability

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Ultrasonic nondestructive evaluation is one of the most widely used method for nondestructive testing in Czech Republic [1]. While the main goal of this technique is to find and characterize flaws inside tested structure it is necessary to know sensitivity of this method. Previously published articles [2,3] used Probability of detection curves (PoD) to evaluate new inspection techniques in order to better characterize their characteristics. Laboratory research program is focused on signal processing methods which improve sensitivity and reliability of new ultrasonic systems. It has been also published in [4] how to model PoD curves for TOFD measurements. In this paper we will present signal processing method and it´s verification for Electro Magnetic Acoustic Transducer automatic PoD curve construction.

An EMAT phenomenon uses Lorentz force to produce mechanical vibration of the material grid. According to geometry of the static and dynamic magnetic field it is possible to generate longitudinal shear and Lamb waves. With electronic constrains it is hard to produce magnetic field strong enough to produce elastic waves with the same intensity as with piezoelectric transducers. Two special EMAT probes were developed by STARMANS Ltd. company for university research. The main difference was in the diameter of the coil. One coil has main coil with 30 mm diameter. The second coil has the diameter 20 mm. There are big tradeoffs in those designs. The smaller coil helped to focus the beam in to narrower region to evaluate smaller cracks. Scale down of the coil caused decrease in signal more than 10 dB. For the primary analyses no advanced digital filtration was necessary to use, only 64 samples averaging. Without this processing the noise didn´t allowed to detect even the biggest drilled cracks inside specimen.

To analyze sensitivity within this project were designed specimen and drilled flaws with diameters 0.75, 0.85, 1, 1.5, 2, 3, 4, 5, 6 mm. As the material was used aluminum alloy T2024 T4 and T6060 T5 according to ASTM standard which is for example used for small unmanned aircraft system by U.S. Federal Aviation Administration (FAA). The most important parameter for generation of the ultrasonic wave with Lorentz force is in this case electric conductivity. The difference of this value for studied specimen was smaller than 5.75%. For this reason we neglected impact of this factor on the measurement. This was proved not only by theoretical assumption but also by power measurement of the received signals.

Signals acquired with 64 samples averaging were highly polluted by noise. For the smallest flaws maximum value, envelope or mean value of the signal wasn´t robust for automatic evaluation. For statistical evaluation many samples have to be analyzed to reach confidence level. Human cognition is able to see flaw echo even if the signal is polluted by noise. The main approach was to find robust pattern based method for feature extraction from received signal. In recently published international articles wasn´t found methodology for this type of feature extraction. We used autocorrelation function to analyze sensitivity for crack

detection from flaw echoes. After data acquisition and signal normalization received data were correlated. In was necessary to set the threshold parameter which will in the best way correspond to human perception of flaw echo. We were unable to detect flaws smaller than 2 mm. After long-term tests we found out that the minimum level for information extraction is 3 dB difference in the power of the flaw and the power of the scattering noise. This level also corresponds to the lowest threshold level where probability of a false alarm was lower than 5%. We succeeded in developing measurement system for verification of PoD algorithm and by return the sensitivity of our ultrasonic measurement systems itself.

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Bus Guardian for FlexRay

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The FlexRay [1] is a new communication protocol for the safety-critical real-time applications in automotive. The node-local bus guardian (BG) is used for higher safety and also is responsible for enabling/disabling the media access and error detection. This paper describes hardware implementation of a node-local bus guardian into the field-programmable gate array (FPGA) Cyklone. An improved behavior of BG in the dynamic segment has been introduced and documented. This work is a part of research dealing with the reliability of x-by-wire systems in automotive.

The main object of the bus guardian is supervision of CC which includes channel protection against unauthorized access of CC during diverse protocol operation control states – wakeup, startup, normal active, normal passive and halt. The BG consists of five main blocks described below.

Communication controller core

In order to test the potential behavior of the bus guardian under different conditions, an implementation of the partial CC core was selected. This CC core consists of:

- Decoder – this part ensures a bitstrobing process, decoding of a frame header and symbols (WUS, CAS)
- Macrotik generator – generates protocol time unit
- Clock synchronization – in couple with macrotik generator provides offset and rate correction

Detailed description of each of the mentioned sub-blocks can be found in the protocol specification [1].

Host interface and registry

The data exchange between the host and the bus guardian is established by the serial peripheral interface (SPI). The frame format consists of a frame preamble, a frame type, an address, data (optional) and CRC. The receiver after each frame reception sends ACK or NAK frame in order to frame loss protection..

Bus guardian protocol operation control (BG POC)

The BG accepts two different kinds of command sets. The first set is intended for the BG operation control while the second for the notifications of the host commands to the CC which is used by the CC supervision part. The present implementation does not include the normal passive state. The host has to notify the BG that the CC reached this state.

Strobe and interrupt management

In order to test the hardware, several inner signals can be mapped to outputs. For example the start of the <n>th static slot (user can use number of cycle and cycle mask), header received

and several other. The interrupt management is responsible for resolving of interrupt priorities and for interrupt signal transmission to the host when some of enabled event occurs.

Communication controller supervision (CCS)

The communication controller supervision is a core of the bus guardian. It consists of 4 states, which perform supervising on the CC during different CC modes. In all states except Silent, the BG monitors all communication from the CC and raises error, if the frame format is wrong, time duration of CAS or WUS symbols are not in the limit, asymmetry in the time domain between channel A and channel B is detected (monitoring of transmission enable signal (TxEN) from CC).

Behavior of the Bus Guardian in Dynamic segment

The dynamic segment in the communication cycle is used for non-priority messages. Faulty timing in this segment is not critical for other communication. However, each repetition of the frame slower down transfer rate. In the pre-limitary specification of the BG, the BG holds the BGE signal on active level - it means that media access is allowed. In our solution user can use following improvements:

- User can configure through register which minislot/channel (frameID) will be the first used in data transmission and defines the message length
- During the static segment transmission the host has to inform the BG via SPI command that the frame with frameID shall be transmitted in the following dynamic cycle. If the frame is periodically transmitted in each <n>th cycle the BG does not need to be informed via SPI command, but it can be set in BG registers. After the register setting, the BGE signal is active only in the allowed minislots.
- The BG reports errors to the host if the next statements are fulfilled:
  - TxEN/TxD is activate in not allowed minislots
  - The frame length is longer than expected

These mentioned features are implemented as extension of the normal supervision process.

The system uses 80MHz clock for the full support of the 10Mbit rate on the FlexRay. In comparison with other implementations of the bus guardian [3],[4] this presented solution does not require any other signal except TxEN_A/B, RxD_A/B because the part of CC core is employed. The expansion of the CC to BG brings the possibility to switch between them in case that some unexpected fatal error occurs.

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Realtime control of physical experiments

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For the measurement of the distance between a station on Earth and an orbit satellite are used different laser systems. The distance is calculated from measured delay of back-reflected laser pulse. This method is called Satellite Laser Ranging (SLR). The accuracy and precision of this method is affected by many factors including weather condition, laser beam propagation through atmosphere, and length and stability of laser pulses. The weather condition can be measured and used to improve accuracy by using a proper model of laser beam propagation through atmosphere. The precision of SLR method depends on laser system used and its parameters. The length and reproducibility of laser pulse is crucial for it.

Department of Physical Electronics cooperates with National Research Institute of Astronomy and Geophysics (NRIAG) in Egypt, which have SLR station located on their observatory in Helwan, near Cairo. Diagnostic of laser system is done only by the P-I-N diode connected to the oscilloscope. An interpretation of the diode signal is not straightforward and complex knowledge of laser physics is necessary. There is no technical, experimental, and scientific background to allow operators make other and more precise diagnostics of laser system.

The goal of the project presented is to find a suitable and relatively cheap method, for Egyptian staff, to diagnostics laser system of SLR station in Helwan. The more accurate knowledge of laser pulse shape and length increase reliability of SLR data produced by Helwan station during implementation of new prediction and measured data formats [1, 2].

Existing diagnostic methods can be divided into two groups by their principle. The first group is based on a photon energy transformation to electrons which is called photoelectric effect (outer or inner). The electrical signal generated has time behavior that corresponds to time behavior of the measured laser pulse. In the other words, the electrical signal is short or ultra short like laser pulse, which can cause problems with measuring, especially in the ultra short area. The second group uses sophisticated experimental methods for generating another signal derived from the source signal. The time behavior of the generated signal is much slower than that of the source signal. From the generated signal some parameters (dependent on the method used) of the source signal can be obtained by analytical or numerical methods.

The important aspect of measured method is time resolution of a detector. A direct measurement of short laser pulses (or single pulse) needs such a fast detector, oscilloscope and/or streak cameras as the laser pulse fast is. Fast detectors and instruments are expensive.

Periodical nature of SLR experiment allows using a method which doesn't need fast detector. There are many of these methods. But the basic principle is the same for almost all these methods – time sampling of intensity. A one big area consists of methods based on an optical correlation between signals. Especially useful are autocorrelation methods where correlated signals are directly derived from one source signal.

Autocorrelation methods can be divided into several groups but the most important are intensity and interferometric autocorrelation. Intensity autocorrelation is not technically complex as interferometric autocorrelation and it is also cheaper. But intensity autocorrelation can provide only information about laser pulse length if the laser pulse shape is known.

The laser pulses shape of laser system in SLR station in Helwan is well known from the laser construction and can be checked by oscilloscope and P-I-N diode, the only problem is routine pulse length diagnostic. Therefore the intensity autocorrelation is enough for this purpose.

For better usability with less knowledge the automated autocorrelator was suggested as the best solution. An automated autocorrelator unit based on the author experiences [3] was developed. The prototype unit consists of several subsystems. Analog and digital processing subsystem, digital control core subsystem, and actuator control unit. Digital subsystem includes digital interface to connect the unit to the control computer.

The prototype unit needs testing directly on the SLR station in a running condition. There are several aspects which can negatively affect the unit. Higher temperature, high relative humidity, and electromagnetic interferences (EMI) caused by other systems on the station.

Testing of the prototype unit was unfortunately very complicated because the main control system of the SLR station unexpectedly got broken down. After a few days spent with repairing of the main control unit the station have operable core system but unfortunately not the laser system. Therefore only basic tests of prototype unit were done. Some random problems were observed during testing but not only in the prototype unit. The main control unit and the main computer were also affected. After some research it was discovered that problems were caused by EMI effects produced by mount motor drivers due to their improper filtering and shielding. Due to the time limited visit of the observatory the problem with EMI effects was solved later by local staff according to the instruction elaborated at the Czech side.

As the result of the presented project, the prototype of autocorrelator control unit was redesigned according to the suggestion [4] to work better in the environment, where the common electromagnetic compatibility requirements are not fully met due to higher EMI.

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High Precision Time Interval Measurements

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Time interval measurements are widely used in various fields of science. High resolution time interval measuring systems are used in time-of-flight measurements, e.g. with a laser range finder, an ultrasonic flowmeter, or light detection and ranging (LIDAR) systems. Moreover, they are used for characterization of clock signal frequency, jitter, or skew and also in instrumentation for nuclear physics experiments, digital communication, optoelectronics, and many other areas.

There are generally three methods of time interval measurements: analog, digital, and interpolating. A comprehensive review of various methods is given in [1].

A prototype board of the measuring system based on pure digital (no analog components) TDC-GP2 chip from acam messelectronic gmbh [2] was designed and implemented. A technical details and test results of the board are presented here. The TDC-GP2 chip is based on gate delay times. It uses internal propagation delays of signals through simple logic gates (i.e. inverters) to measure time intervals. A unique circuit structure makes it possible to determine the exact number of gates the signal has passed through. The gate propagation delay time depends strongly on temperature and voltage. However, this dependency is eliminated by doing calibration. During calibration the TDC measures one and two periods of the reference clock.

The chip has typically 65 ps resolution (50 ps rms). It can operate in one of two modes: Measurement Range 1 and Measurement Range 2. In Measurement Range 1 the chip has 2 channels available with measurement range 3.5 ns to 1.8 µs. Four events can be measured arbitrarily against each other. In Measurement Range 2 the chip has 1 channel available with measurement range 500 ns to 4 ms and can store up to 3 events. The chip will be used and tested in Measurement Range 1.

The prototype board contains two TDC-GP2 chips in order to measure long time intervals. The chips are connected to MCU via SPI (Serial Peripheral Interface) bus. The board is capable of measuring time intervals as short as 1.6 ns to approximately 420 ms. The board is driven by 8-bit microcontroller unit (MCU) PIC18F4520 from Microchip Technology Inc. The user interface consists of five buttons and LCD (Liquid Crystal Display). The board can be connected to PC through USB interface via FT232RL USB to UART (Universal Asynchronous Receiver Transmitter) bridge and thus can receive commands remotely. The output data from TDC chips are also sent through USB interface or displayed on LCD.

To interface the board with various signal levels ultra-fast comparators LT1715 from Linear Technology are included in the design. The input voltage ranges from -4.9 V to +3.8 V and the switching threshold can be set between -2.5 V and +2.5 V. The outputs have 2 ns rise/fall time and 15 ps rms timing jitter.

To perform linearity measurements a programmable delay chip MC100EP195 from ON Semiconductor has been included in the design. The internal structure consists of a programmable matrix of gates and multiplexers. The delay increment has a digitally selectable resolution of about 10 ps and range up to 10.2 ns. It has a fixed minimum delay of 2.2 ns. Random clock jitter is ≤1.2 ps rms.

The chip was thoroughly tested by 6 GHz oscilloscope. The tests revealed its high integral non-linearity of 320 ps and glitches as high as 100 ps at regular intervals. The non-linearity and the glitches are caused by different amounts of delay added with the assertion of each individual delay bus pin. In order to use the chip for linearity measurement a special linearized data sequence must be used. The sequence is calculated from the data collected by the oscilloscope. With such a sequence integral non-linearity is about 5 ps.

At the heart of the board is 128 macrocell CPLD (Complex Programmable Logic Device) ispMACH 4128V from Lattice Semiconductor Corporation. This device is simple to program and has sufficient capacity to develop quite complex system. It provides interconnection and control of all devices on the board. Communication with MCU is provided through 8-bit data bus, 3-bit address bus and two control signals.

To measure any performance characteristics of time-to-digital converters a very stable time interval is needed. This can be accomplished by splitting output signal of ordinary pulse generator. For this purpose a modular system was designed and implemented. It uses active components, i.e. special integrated circuits (IC) like clock fan-out buffers or clock dividers to accomplish a very low jitter and low skew outputs.

The main module 1:2 LVPECL (Low Voltage Positive Emitter Coupled Logic) Fanout Buffer is fitted with MC100EP11 from ON Semiconductor. It is an ECL differential 1:2 fanout buffer with a typical propagation delay of 220 ps, random jitter of 0.2 ps rms, and typical within device skew (between outputs) of 15 ps.

TDC-GP2 performance was measured with the help of the splitter and the programmable delay chip. The resolution was measured to be about 53 ps. The linearity was measured within 10 ns range with the linearized data sequence. For each 10 ps delay increment a 1000 samples was taken and the average was calculated. An integral non-linearity of 96 ps was measured. The temperature stability was measured between 23°C (at the power-up) and 37°C (normal operating conditions). Roughly every 2 seconds 100 samples were taken by the TDC chip and the average was calculated. The average shows a change of 32 ps (3.4 ps rms). The change in the output value is caused by the combined effect of fast comparators at the inputs, CPLD through which the inputs are routed, and TDC chip.

To measure arbitrarily long time intervals, beyond the limit of the single TDC chip, two chips are needed. The basic principle is to divide the time interval T between START and STOP events into three parts T_C, T_1, and T_2. The interval T_1 begins with START event and ends with the rising edge of the reference clock that follows the nearest falling edge. This way a minimum interval to be measured is half the reference clock period. The reference clock can be selected between an internal low-jitter 40 MHz oscillator and external clocks. This time interval is measured by one of the TDC chips. The second chip measures interval T_2 which begins with the STOP event and ends with the rising edge of the reference clock that follows the nearest falling edge. The T_C is the number of reference clock periods. The resulting interval T is calculated as follows $T = T_1 + T_C - T_2$. The maximum interval is limited by the size of the counter implemented in the PLD. A 24-bit counter would limit the interval to 420 ms with the internal 40 MHz oscillator. With both chips the standard deviation was measured to be 41 ps rms and 316 ps peak-to-peak.

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Microwave Methods for Evaluation of Biological Effects of EM Fields

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In a modern world various sophisticated devices emitting microwave electromagnetic field are ubiquitous. These devices are used in many fields such as industry, medicine and particularly communication. The rapidly increasing use of devices emitting microwave electromagnetic field, mobile phones in particular, has raised public concern about possible harmful health impacts. The main goal of this work is the design, optimization, realization and verification of the whole-body exposure setup for unrestrained small animals to radiofrequency electromagnetic field.

The setup operating at 900MHz was designed with respect to induced uniform field, external radiation elimination, accurate absorbed power determination, sufficient space for mice and costs. Previously mentioned conditions assure an accurate Specific absorption rate (SAR) determination together with the elimination of stress induced in mice which can affect results of research of non-thermal effects [1],[2],[4].

The exposure chamber consists of circular waveguide terminated by matched loads. In order to prevent the possibility of unwanted resonances between mouse and waveguide bottoms, the electrical resistance of loads grows linearly in a direction of the wave propagation. The loads shape is conical and is made of plastics filled up with salted water.

The dimensions of the chamber components were computed starting from waveguide radius because it is a critical value which can affect electromagnetic field excitation and distribution. It is needed to choose radius so that a suitable electromagnetic field distribution is excited. As the most appropriate mode was chosen the dominant mode $TE_{11.}$ The circular polarized wave is excited in the waveguide. The wave is comprised by two monopole antennas which have the mutually orthogonal orientation. Circular polarized wave provides relatively constant coupling of the field to each mouse regardless of its position, posture or movement. There are two other monopoles serving for scattering parameters measurement. By the analysis of scattering parameters the absorbed power is determined in mice. In the chamber there is a ventilation hole through which electric fan-forced ventilation air is introduced and exhausted through second hole in order to reduce the mice stress and maintain constant temperature inside the waveguide.

Dosimetry is inherent task for the design and use of exposure systems for in vivo or in vitro experiments in investigating possible biological effects of radiofrequency (RF) exposure. Dosimetry is the quantification of the magnitude and distribution of absorbed electromagnetic energy within biological objects that are exposed to electromagnetic fields. At RF, the dosimetric quantity, which is called the specific absorption rate (SAR), is defined as the rate at which energy is absorbed per unit mass. The SAR is determined not only by the incident electromagnetic waves but also by the electrical and geometric characteristics of the irradiated subject and nearby objects. It is related to the internal electric field strength as well as to the electric conductivity and the density of tissues. Therefore, it is a suitable dosimetric parameter, even when a mechanism is determined to be “athermal.” SAR distributions are usually determined from measurements in animal tissues. It generally is difficult to measure

the SAR directly in a living biological body, and therefore dosimetry efforts are forced to rely on computer simulation.

The anatomically based biological model is essential for numerical dosimetry. Such a numerical model is developed commonly from CT scans. The anatomical based model of mouse has been developed by aid of segmentation tool 3D-DOCTOR [3]. Segmentation of medical images is the task of partitioning the data into contiguous regions representing individual anatomical objects. In order to develop a model for numerical dosimetry, original gray-scale data must be interpreted into tissue types. CT provides gray-scale image data as many transverse slices, at a designated spacing, from the head to the feet of the biological body. The resolution in each slice is on the order of several millimeters.

CT scans for model development were obtained from the project Digimouse. The CT raw data were downloaded directly from the web site http://neuroimage.usc.edu/. The mouse model has the resolution 0,1mm, meaning voxel size 0,1 x 0,1 x 0,1 mm. Each voxel was assigned to one of 14 different tissue types, such as bone, muscle, brain, etc. For dosimetry with the numerical voxel models, proper permittivity and conductivity values must be assigned to each tissue. The data from 10 MHz to 6 GHz, which were derived from 4-Cole-Cole extrapolation based on measurements for small animals, constitutes the most widely accepted database for this information. The data are recommended by various international standardization organizations.

The setup basic properties such as electromagnetic field distribution and impedance matching were optimized and verified by 3D simulator of electromagnetic field based on the finite-difference-time-domain method (FDTD). Dosimetry results were obtained in conjunction with simulation and experimental validation with homogenous mouse model The experimental validation was based on analysis of measured scatter parameters. In order to reach more accurate dosimetric results the anatomical mouse model was used in simulation.

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Development of a smart camera and a mobile robot for demonstration and validation of precise positioning methods based on the real time image processing

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Smart sensors based on a real time image information processing are becoming more and more popular at the present time. They are universal solution of complex contactless measurement tasks. The basic goal of this work was to develop a simple smart camera based on a digital signal processor Blackfin (Analog Devices, Inc.) equipped with an Ethernet communication interface. Developed sensor will be utilized for basic image processing methods implementation with a special focus on a precise position and dimension measurement. Used Ethernet interface allows remote measurement which eliminates measurement affection caused by operating personnel and increases total measurement precision. For measurement methods extension a simple module for binocular stereoscopy was also developed. For overall validation of algorithms and methods of feedback regulation based on image information a simple mobile robot was developed.

The basic disadvantage for research tasks of existing smart cameras is their hardware and software encapsulation. This fact means that the final measurement problem must be decomposed to standardized steps. These steps (atomic operation, atomic sensors) are preprogrammed by vendor and user is limited to use only these algorithms and (except of some basic parameters) it is not possible to change the algorithm. Atomic operations cover usually wide range of tasks and theoretically all possible problems should have solution using appropriate combinations of these operations. This approach is totally useless for research of new algorithms or existing algorithms improvement. These facts mentioned above were the basic motivation for a new for-research-purposes-opened simple smart camera development. First model of this camera was introduced in [6]. The only disadvantage of this model is in a small width of image sensor (image information source) interfacing bus – it was only 8 bits. According to a standard CMOS sensor [4] bus width which is 10 to 12 bits this feature was limiting image information brightness resolution and consequently total precision of implemented measurement method. Newly developed – rebuild smart camera is using full 12 bit interface without any limitation. This interface is universal with standardized connector what allows connection of optional image sources (for precise measurement CMOS sensors with high effective resolution are used, concrete APTINA 1,3MPix and 5MPix image sensors). Except for the interface bus, the rest of smart camera hardware is exactly the same as was introduced in [6] – digital signal processor Blackfin ADSP-BF-532SBST400, 32 MB SDRAM, 4 MB of flash memory, everything on a single four layer PCB. This hardware concept is suitable for uCLinux operating system implementation [3].

Introduced smart camera with its high computation performance can be utilized also for measurement methods integrating more than one image information source – especially for stereoscopic measurement [2]. With the use of more than one image source also precision of measurement in one dimension could theoretically increase. A new binocular stereoscopy expansion module for smart camera was also developed. Basic part of this module is a CPLD programmable logic (according to power consumption XILINX COOL RUNNER family was

chosen) which works as an image multiplexer (it is multiplexing two image sources into the single interface bus in the real time). This CPLD is programmed in VHDL and can be also used for image preprocessing [1][5]. Ethernet controller and serial bus expansion are also parts of this module. Expansion module is of the same size as the smart camera module and it is direct interfacing this module without any additional equipment. This allows both modules to be mounted in a single compact chassis which is reasonable for industrial use.

For validation of feedback position regulation methods based on outputs from image processing algorithms a simple mobile robot equipped with described smart camera and extension module was developed. Mechanical construction of this robot is based on a robust metal chassis with 4 wheels. Every wheel has its own DC motor. Robot direction is controlled be difference between rotation speed of left and right side wheel pairs. Image sensor board is mounted on a rotating unit consisting of two servomotors. For robot movement and its basic parts control a "motor control unit" was developed. Heart of this unit is a CORTEX M3 microprocessor (STMicroelectronics STM32F103). The motor control unit allows controlling of 4 DC motors (using 4 H-bridges), 4 servo-motors and 4 reflexive sensors. Communication with the smart camera and other possible parts of robot is realized using USART or RS-485 interface. Mobile robot is powered from 12V NiMH battery.

As a basic method a precise position measurement was implemented into the smart camera. This method with its real results was described in [6] - for the measurement range of 26 cm and camera distance of 2.5m we obtained total position measurement error lower than 0.5 mm and linearity error less than 0.1 % of the full–scale. Utilizing this algorithm an object tracking task was implemented in mobile robot. Object can be tracked using camera rotator to be always in the middle part of field of view or the whole robot can move towards the object.

Above described smart camera module, stereoscopic extension module and simple mobile robot will be used also in the research of simple navigation algorithms and methods for visually impaired people.

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Integration of Low-cost Inertial Navigation Unit with Secondary Navigation Systems

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Introduction

This paper concerns the development of a system that consists of a low-cost inertial navigation unit and the 3-axial magnetometer, which will be used as a secondary navigation system. The development includes measuring and testing of inertial sensors and a magnetometer, and the calibration of navigation sensors used for the following data fusion via Kalman Filter.

As a primary system for integration the Inertial Navigation System (INS) will be used. The INS consists of 3-axial accelerometer and 3-axial angular rate sensor. Tri-axial magnetometer will be used as the secondary system. All of these sensor outputs are disturbed by errors which are a decisive factor for their implementation and verification of their performance [1]. The deterministic sensor error analyses of accelerometers, angular rate sensors, and magnetometers are presented.

Deterministic Sensor Error Analysis

It is well known that the accelerometers, angular rate sensors and magnetometers outputs in general are influenced by random time-correlated errors (either stochastic or temperature dependant) and static errors that can be determined and assumed constant [1]. Estimation of random time-correlated errors is not subject of this paper.

The following static sensor errors were examined: sensor bias, misalignment angles of sensing axes and scale factors. For angular rate sensors, the different sensor error model was used according to [3].

Tri-axial Accelerometer and Magnetometer Error Model

The error models of 3-axial accelerometer and magnetometer can be described by following equation:

$$y_k = C_{a,k}^{p} SF_k (x_k - b_k) = \begin{pmatrix} 1 & -\alpha_{yz} & \alpha_{zy} \\ 0 & 1 & -\alpha_{zx} \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} SF_{kx} & 0 & 0 \\ 0 & SF_{ky} & 0 \\ 0 & 0 & SF_{kz} \end{pmatrix} \left(\begin{pmatrix} a_{kx} \\ a_{ky} \\ a_{kz} \end{pmatrix} - \begin{pmatrix} b_{kx} \\ b_{ky} \\ b_{kz} \end{pmatrix} \right), \quad (1)$$

where k = sensor type (accelerometer, magnetometer); $y_k = [y_x\ y_y\ y_z]^T$ is the compensated vector of a measured quantity in the orthogonal system; $x_k = [x_x\ x_y\ x_z]^T$ is a measured vector; $C_{a,k}^{p}$ is orthogonalization matrix that provides a transformation from the non-orthogonal sensor frame to the orthogonal platform frame with the non-diagonal terms α_{ij} (for i ≠ j) that correspond the axes misalignment coefficients as defined in [2]; $SF_k = [SF_{kx}\ SF_{ky}\ SF_{kz}]^T$ is the diagonal matrix containing the scaling factors, and $b_k = [b_{kx}\ b_{ky}\ b_{kz}]^T$ is the vector of sensor biases.

For finding the sensor biases, scaling factors and misalignment coefficients, the calibration procedure were performed. There are various calibrations algorithms, each based on a little different approach. In this case, the Thin-Shell method was used. This iterative method is based on LMMSE estimation (Linear Minimum Mean Square Error).

Error Model of Angular Rate Sensor

As mentioned earlier, the different sensor error model was used for angular rate sensors described by equation 2 defined in [3].

$$y_g - b_g = SF_k T_g M_g u_g = \begin{pmatrix} SF_{kx} & 0 & 0 \\ 0 & SF_{ky} & 0 \\ 0 & 0 & SF_{kz} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ \alpha_g & 1 & 0 \\ \beta_g & \gamma_g & 1 \end{pmatrix} \begin{pmatrix} r_{g,11} & r_{g,12} & r_{g,13} \\ r_{g,21} & r_{g,22} & r_{g,23} \\ r_{g,31} & r_{g,32} & r_{g,33} \end{pmatrix} \begin{pmatrix} u_{gx} \\ u_{gy} \\ u_{gz} \end{pmatrix}, \quad (2)$$

where $y_g = [y_{gx}\ y_{gy}\ y_{gz}]^T$ is the vector of measured sensor outputs; $b_g = [b_{gx}\ b_{gy}\ b_{gz}]^T$ is the vector of sensor biases; $SF_k = [SF_{gx}\ SF_{gy}\ SF_{gz}]^T$ is the diagonal matrix containing the scaling factors; T_g is orthogonalization matrix which transforms the vector expressed in the orthogonal sensor reference frame into the vector expressed in the non-orthogonal sensor reference frame; alignment matrix M_g is an aerospace sequence Euler angles parametrized rotation matrix, which rotates (aligns) the reference frame to the orthogonal sensor frame [3]; $u_g = [u_{gx}\ u_{gy}\ u_{gz}]^T$ is the vector of referential angular rates. For the calibration of the angular rate sensor, the algorithm which uses the Cholesky decomposition and LU factorization in angle domain, described in [3] were used and evaluated.

Conclusion

In this paper, the calibration procedures of angular rate sensors, accelerometers and magnetometers were described and the sensor error models were estimated. The two different models of sensors and two different approaches were used.

For the evaluation of designed algorithms, the accelerometer and angular rate sensor of AHRS (Attitude and Heading Reference System) unit 3DM-GX2 (MicroStrain) were used. For evaluation of magnetometer calibration, the tri-axial fluxgate magnetometer 534D (Applied Physics Systems) was bought and used.

The root-mean-square-errors (RMSE) were computed for accelerometer and magnetometer data and used as a comparison criterion. For angular rate sensors data, the deviation from reference data was used as a comparison criterion.

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Integration of Ultra Wideband Signals in the Time Domain to Education

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The goal of this project is to enrich the education (not only practice, also lectures) by the new procedures using time domain propagation of the ultra wideband (UWB) pulses. It is a modern approach for physical layer of communication technologies (IEEE 802.15.4a). Within the framework of this project will be the modern time domain approach included into the education. It will be created new measurement workplace for bachelor and engineer education program. This workplace will be used for projects and thesis too. The several scenarios will be examined for differences of propagation between the frequency domain and the time domain. In the international conferences and journal papers it is written, that the time domain measurement is able to be used instead of the time consuming frequency domain measurement.

Ultra Wideband fundamentals

UWB has proved to be an extremely prospective technology. The wide frequency bandwidth allows the utilization of very high channel capacity. The well known Shannon's communication law shows that it is obvious that the channel capacity has linearly dependent on the frequency bandwidth of the signal, but only logarithmically dependent on the signal-to-noise ratio (SNR). It is obvious that the use of a wide bandwidth and a lower SNR enables transmission of the same information capacity through a radio channel as a narrower bandwidth and higher SNR. This is the main advantage of UWB and it is powerful feature.

The basic definition of the UWB frequency spectrum is given by the FCC (Federal Communication Commission) [1-2]. This definition introduces the spectral mask, where the maximum Equivalent Isotropically Radiated Power (EIRP) is restricted to the level of -41.3 dBm/MHz in the 3.1 - 10.6 GHz frequency band The European Commission (EC) published another spectral mask several years after the FCC which is more strict and narrower; however developers and researchers usually prefer the FCCs spectral mask.

To satisfy this frequency-dependent power condition, specific signals (waveforms) are required. The UWB is therefore defined as pulse signals in the baseband without a carrier. According to this definition it is important to carefully select the types of signals which can be usefully implemented into the UWB system.

Ultra Wideband measurement

Wideband and ultra wideband signals can be measured either in the frequency or in the time domain. Both these techniques have their specific advantages and drawbacks. In the frequency domain, measurements of transition (s21 parameter) via a vector network analyzer are mostly utilized for discrete frequencies [3]. A subsequent Fourier transformation provides an easy conversion from the frequency to the time domain. The biggest drawback of this method is that it inevitably requires a stable frequency source. On the other hand, one of its advantages is for example the option of easily calibrating and suppressing of all cable and connector effects.

The time domain measurement is accomplished via a wideband sampling oscilloscope and a pulse generator. The use of these instruments allows us to directly measure the impulse response $h(t)$ of the system. This type of measurement is faster than measurements taken in the frequency domain. TD could be used in particular for antenna testing in an ordinary environment, i.e. without the need for an anechoic chamber. The disadvantage of the time domain measurements lies in data processing, which may require a slightly complicated hardware implementation.

The main goal of this project was successfully accomplished. Two new laboratory exercises with new technology were prepared and applied in winter term 2009/2010. Two lectures about ultra wideband technology were presented during the term. The new pulse generator was successfully implement into new measurement workplace

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Innovation of the subject Digital Signal Processing

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This paper deals with the innovation of the subject Digital Signal Processing in Telecommunication Engineering. The changes were introduced into the education starting the winter period 2009. The improvement of the subject is based on a novel laboratory setup for the digital image and video processing. New laboratory activities were designed, tested and established. The practical experiments are based on the Field Programmable Gate Arrays Xilinx Virtex-5 and Xilinx Spartan.

Using modern FPGA is a current trend in digital signal processing. The Field Programmable Gate Arrays (FPGA) Xilinx Virtex®-5 using the second generation Advanced Silicon Modular Block (ASMBL™) technology and 65 nm copper process to produce the industry's highest performance. FPGAs are the world's first 65nm. FPGA Virtex-5 family is fabricated in 1.0v, triple-oxide process technology, providing up to 330,000 logic cells, 1,200 I/O pins, 48 low power transceivers, and built-in PowerPC® 440. There is also on FPGA Virtex-5 PCIe® endpoint and Ethernet MAC blocks, depending upon the device. [1] They are aimed to the real time processing of audio, voice, image and video signals. This device contains many logic blocks that can be used to realize different kinds of functions. The interconnections between the logic blocks as well as the function each of these blocks realize can be programmed by the user. The FPGA Virtex-5 are based on starter kit, which allow to students use many built-in peripherals. The starter kit ML506 with FPGA Virtex-5 allows use analog audio input with built-in converter to input audio data and analog and digital audio output. There is also built-in analog video input and digital DVI video output, both directly connected to the FPGA. The audio and video signals can be directly processed in the FPGA. The audio and video acquisition, processing and visualization could be processed in parallel. It was also bought starter kits with Xilinx Spartan which are in compare with Xilinx Virtex-5 simplier. The starter kits with Xilinx Spartan are used for first introduction students with FPGA. Students can use built-in character display, buttons and other. We have established five equivalent hardware setups for laboratory activities. For the effective training, we have proposed and tested three projects.

Convolution and FIR Filter

The goal of this lab is to learn how to implement FIR filters on FPGA, and then study the response of FIR filters to various signals, including speech. As a result, students should learn how filters can create interesting effects. In addition, we will use FIR filters to study the convolution operation and properties such as linearity and time-invariance. Students design 1-D FIR filters regarding individual specification. They implement the 1-D filters using linear discrete convolution. Students prepare coefficients of FIR filter in Matlab and then use

coefficients on FPGA on real signal. Adjusted audio signal is submitted to the audio output. The programming FPGA occurs in C language or VHDL.

Fast Fourier Transform

The second one deals with implementation concepts of the fast Fourier Transform (FFT). In this project, students try to implement the FFT on real speech signals. First they apply the FFT on the prerecorded audio signal and after that a spectrum of the given audio signal is sent on the video output of monitor. Students are also invited to attenuate some of the spectral contents of the signal. The modified audio signal is generated applying the inverse FFT. The programming occurs in C language combined with VHDL.

Echo cancellation

The third lab deals with adaptive algorithms used for echo cancellation in telecommunication devices. Adaptive digital signal processing methods are about designing a parametric solution for approximation of the input signal parameters. The model is further used to attenuate and cancel unwanted echo presented in the output signal. In this project, students implement one of the algorithms for echo cancellation. The algorithm is applied on the audio signal in real time. The output audio is submitted by audio output to the stereo loud-speakers. In one channel is presented the original audio signal, in the second channel is presented audio signal without echo. The programming occurs in C language combined with VHDL.

Conclusion

In this paper, we have introduced our latest results in the innovation of the subject Digital Signal Processing in Telecommunication Engineering. The laboratory setup was innovated. New laboratory projects were completely established. In presented labs students will be implementing specific designs on Field Programmable Gate Arrays.

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Sub Picosecond Event Timing System Power Suply and Input Board

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A novel time interval measurement method that makes use of a transversal SAW filter as a time interpolator has been introduced by Petr Panek in 2005 [1]. We do report on a design construction of a power supply and input board for a world unique time interval measurement device based on Surface Acoustic Wave (SAW) filter interpolator providing sub-picoseconds precision and accuracy.

The entire device is a mixture of digital and analog blocks, from this reason there is a high requirement for a low noise power supply on one hand and low power losses to prevent the device from heating of the device on the other hand. The entire device requires 11 different positive and negative voltages with overall current consumption of 1.9 Ampere for positive voltages and 1.5 Ampere for negative voltages.

To digital part of the device fully satisfies AC/DC converters form TracoPower. Their main advantages are broad input voltage and frequency range, low ripple and noise (less then 100 mV), short circuit protection, as well as high efficiency. The AC/DC converters produce also input voltages for next stage, which consists of linear low drop stabilizers. Technique with sequential decreasing power voltages helps to reduce overall power loss. Each of the power voltage has own voltage detector with signalization led diode. It helps to quickly check all power supplies whether they work. The voltage detectors are joint to common logic, which interpret whether all supplies are on. The entire power supply is designed on multilayer printed circuit where a temperature sensor of the power supply is included. It was experimentally demonstrated that the new power supply does not add any additional noise to the system and the measurement performance remained unchanged.

The next requirement to make a real device from an experimental was to develop input board, which enables to lower the requirements for input (trigger) pulse rise time and produce differential signals form single-ended pulses. The input board is based on fast ECL comparator from Maxim Integrated Products. The board contains two identical and independent channels. The timing signal in each channel goes thorough different comparator, which are in one package. It makes the same temperature dependency of the channels. The input trigger threshold voltage can be optionally changed according to the input pulse to positive or negative levels.

The input board also includes fast gate option of the input signal. The minimum of the gate pulse width is 6 nanoseconds. All of the input signals (two gates and two input channels) have own signalization diode which flashes when the signals are connected. There is also temperature sensor on the input board. The entire boar is designed on multilayer printed circuit. The inputs and outs can be connected via SMA connectors and the board is powered by +/- 5 Volts, the total power does not exceed 0.6 Watts. The input board adds the timing

random jitter 0.2 ps rms per channel, which results the single-shot interval measurement precision change fron 1.30 ps to 1.33 ps rms. The other parameters of the device remain unchanged. The temperature drift of the measured time interval on temperature is lower than 0.5 ps/K, the long term stability is better than +/- 0.1 ps per hour [2], [3]. The interpolator non-linearity was measured to be below 0.2 picoseconds over an entire interval range.

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Goniometer Client-Server Control Tools

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With a new recently acquired Huber goniometer device, there have been a need to integrate it into our experiments, to use it with both the original single-point counting detector setup of our KSN-2 diffractometer and the new PSD multi-detector setup using the system of project INDECS as a controlling software.

The experimental configuration and topological placement of the entire experimental setup also gives us additional requirements on the controlling mechanism of the goniometer. Since the goniometer device itself is placed at the reactor hall, where the actual experiment is taking place, and the operator controls and monitors the experiment from the laboratory, which is placed on the other side of the building, and is connected to the diffractometer setup via an Ethernet connection, the goniometer has to be able to be controlled from both of the sites at the same time and both of these sites have to be in sync, so that an operator at the laboratory does has to be immediately visible in the reactor hall and vice versa (the other case is mostly usable during physical adjusting of the sample for instance).

With these requirements in mind a special tool for controlling the goniometer has been designed and created. It is based on a client-server architecture.

The server side is implemented as a *goniod* server daemon (formerly and initially known as the *hubersmc* daemon). It is run just one per experiment, and it can possibly communicate with multiple instances of the physical goniometer device over Ethernet. Currently it can communicate only to the Huber SMC 9000 family of controllers, but others can be possibly added by implementing translation to their set of commands.

Each controller connected to the server daemon can define any number of physical axes that it can handle. At least in case of the SMC 9000 family of controllers, the information about their equipped axes is automatically acquired from the controller. But the actual experiment does not need to use all the available axes and it does not need to use them in the order in which they are implemented on their particular controllers, not speaking about the order of the controllers themselves. So for the actual usage, one set of virtual axes is created and each of the virtual axes is mapped to exactly one pair of controller and physical axis on that controller. Of course there can be physical axes to which no virtual axis is mapped and such axes are present but unused.

Virtual axes have among other things their defined name, optional description, virtual limits (which may of course be superseded by the physical limits preset in the controller, but the virtual limits may optionally be even more restrictive), and defined order, which implies the order of scanning of the individual axes. Since the order of scanning (as well as for instance the virtual limits) of the axes can be different for different experiments, it can be easily changed on-line by special commands implemented by the server.

And as well as other parameters of each axis, if the change of order of the axes is issued by one client of the server, it has to be automatically and immediately reflected by the other clients attached to the server. This requires a special treatment. Usually in a client-server architecture, the server only listens to the requests of clients and either answers them or performs something. But it can not contact any client on its own without it being an answer to previous request by client. To implement the above described synchronizing of client

information (so that each client immediately reflects everything any other client does), it would normally have to be done by the clients periodically and often requesting a status change of some sort or such. But that is both time consuming, Ethernet bandwidth consuming, delayed, and unnecessary.

The other approach, that has been selected in our case, is a bit more complicated and, yet also simple. Each client is also partially acting as a server, that can implement a certain limited amount of commands. When a client connects to a server, the server automatically also connect to the client via a different connection that is in the reverse grade. And so the synchronization is done by sending the relevant changes to the axes states to each connected client only when it is actually done. That saves a lot of unnecessary bandwidth and is reflected immediately when the change occurs. It however places some complications onto the server, since it has to also manage an active connection to each of the clients (and not only one passive connection for all clients, as usual), and also a slight complication in the client, since it has to have a simple command interpreter and maintain a passive connection to the server in addition to the active one.

There are two client implementations for the server. One is intended for use with project INDECS and the new KSN-2 setup with PSDs and it currently consists of a single EEM module that transforms the communication with the server to the commands routed within the INDECS system. The second client is on the other hand an actual GTK+ GUI implementation of the full client to the *goniod* server. It is called *gonioc* and it is intended for the controlling of the *goniod* server and full and user friendly interaction with it. Among displaying the configuration of the controller and physical axes and possibility to change some of its parameters and limits of operation, it can also visually change the order of virtual axes, which are displayed in the given order, it visually and numerically displays the position of each axis, allows to define and configure any number of the intervals and steps of automatic scanning for each axis and it controls the scanning mechanism implemented within the server.

The *gonioc* client is also designed to implement an external measurement synchronization signal via an RS232 serial port (possibly USB implemented) that can be used to automatically synchronize the goniometer movements with the external and otherwise completely independent system of data acquisition from the diffractometer detectors. This is required for the old KSN-2 setup. The new setup has everything implemented via the internal communication of the INDECS system, as both the goniometer and the data acquisition is integrated within.

Currently there is only a Linux port the gonioc client, but since it does not use any Linux-specific features, it may possibly also be ported to Windows with the use of Windows port of GTK+.

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Section 5

MATERIALS ENGINEERING

Linear antenna microwave plasma treatment of diamond

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Diamond is a perspective material for advanced devices in bio- and electronic applications [1]. Considering its extreme electronic, optical, and thermal properties [2] diamond can be specified as an ideal material for fabrication of high performance electronic devices [3-5]. The emergence of thin film nano-crystalline diamond (NCD), grown by plasma enhanced chemical vapor deposition (PECVD) techniques on a non-diamond substrates have led to increased commercial interest. Undoped NCD film is generally considered to be a very good insulator, but it can exhibit p-type surface conductivity when it is hydrogen terminated [6-8]. The typical surface conductivity (SC) values obtained for mono-crystalline diamond (MCD) are in the order of $10^{-4}(\Omega/\square)^{-1}$ [9]. Presently, NCD film shows good enough SC, suitable for fabrication of electronic devices [1, 10]. Moreover, compare with MCD, NCD is more desirable material due to low cost and possibility of deposition on large areas [11].

The usual way for achieving H-terminated diamond surfaces is provided at relatively high substrate temperature (T_{sub}=600÷800°C) [10]. The high temperature treatment is unwanted technological step in production of electronic devices. In most cases, the high substrate temperature causes partial or complete damage of the metal or other electronic parts. In order to avoid any damages in metal layer the low temperature process is required.

The presented work studies the influence of the substrate temperature on the surface conductivity. We show that optimized low temperature hydrogenation process is efficient enough to induce surface conductivity on NCD films deposited onto diverse substrates; moreover, the metal part is completely saved. The role of the substrate material, geometrical arrangement, and NCD films thicknesses during hydrogen termination of NCD films, are also investigated.

Si/SiO_2 substrates were ultrasonically seeded in suspension of detonation nano-crystalline diamond powder and NCD films were further grown by PECVD process from gas mixture of methane and hydrogen [10]. The thickness of the obtained NCD films was around 600nm. The inter-digital contacts (IDCs) were fabricated onto NCD films by standard semiconductor technological steps. The hydrogenation of these films was carried out at temperature range 150÷400°C.

We found that this treatment did not change the size of the diamond crystals, which remain at a constant value of 150nm. Contact angle measurements confirm the variation between hydrophobic (H-terminated) and hydrophilic (O-terminated) surfaces. The quality of electronic grade was characterized by direct current-voltage measurements. We found that SC drops down from 10^{-6} to 10^{-7} $(\Omega/\square)^{-1}$ with temperature decrease from 400 to 200°C. The temperature of 200°C seems to be the breaking point, where its further decreasing results in a steep drop down of SC to $10^{-9}(\Omega/\square)^{-1}$. On the other side, once the geometrical dimensions of IDCs are smaller, the SC shows nearly a linear decrease with temperature decrease from 400 to 200°C. Similar SC dependences were also observed for thinner (160nm) NCD films grown on UV grade substrates.

The presented results indicate that temperature as low as 200°C is reliable to achieve surface conductivity in order of $10^{-7}(\Omega/\square)^{-1}$. Thus, the low temperature hydrogenation of NCD

films opens a new technological window for possible application in semiconductor engineering.

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Distributed Ammonia Detection Based on OTDR Measurements

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Ammonia leaks from cooling systems installed in industrial as well as public areas are very dangerous for people and all living organisms. Low ammonia concentrations cause urgent poisoning of human organisms; several minutes of exposition to higher ammonia concentrations (5000-10000 ppm) can be lethal. Distributed detection of ammonia gas content in air around facilities, such as large scale freezers, ice hockey halls, etc., constitutes an important part of systems of early warning and provides key information for salvage operations. Detection of low ammonia concentration in ppm range by means of optical fibres, location of ammonia leak in range of meters and repeatability of chemical reactions between gaseous ammonia and selected reagents with proper optical absorption properties are the key targets of this issue.

The aim of our research is to understand and to achieve a repeated reversible chemical reaction in which a proper reagent, organometallic dye composed of a bi-valent complex ion and selected anions, substitutes NH_3 for the organic ligands. Generally, ammonia is a stronger electron donor than the organic ligand in this chemical reaction. Our research is based on utilization of transmission fibre optic spectroscopy of selected organometallic compounds within the VIS/NIR range combined with interrogation of the sensing optical fibres by optical time domain reflectometry (OTDR). The spectral shifts are determined before and after the formation of a complex and after the reaction with ammonia.

To be more specific, our research deals with influence of gaseous ammonia on a sensitized multimode optical fibre consisted of silica core and a siloxane polymer clad and on spatial localization of the exposition position and gas concentration. Cuprous and cobalt organometallic complexes possess suitable optical and chemical properties to be used as chemo-optic transducers absorbing the evanescent part of fibre core light intensity and modulating it after ammonia gas exposition [1-3]. This particular contribution is focused on combination of metal central ions with novel amino-quinoline ligands functionalized by hydrophobic chain: (5-(4′-dioctylamino-phenylimino)-quinolin-8-1 [L_3]. The pilot spectroscopic experiments showed us that newly prepared ligand L_3 holds both corresponding spectral properties and ability to form a complex dye with the suitable metal salt. It seems that this ligand is a good alternative to the formerly tested ligands. Comparison of L_1, L_2 [1] and newly prepared ligand gives us the useful information about lipophilic or hydrophilic behaviour of the complexes. Polymer claddings of the fibres to be tested were impregnated by solutions of the complex reagents. In immobilization of the reagent into the fibre cladding, the very important role plays the reagent diffusion process into the polymer matrix. The process is affected both by the matrix structure and by the type of applied solvent. Suitable solvent must provide a good solubility and chemical stability of the selected reagent. Cladding layer of the fibre acts as a membrane or as a filter for the liquid solution of reagent [3]. Possible diffusion

of water into the cladding can vary the actual degree of dissociation and then contribute to the remarkable dependence of the sensor signal to the ambient humidity. The existence of hydroxyl and hydronium ions in the cladding can lead to the creation of ammonium salts, which disturbs the sensor function.

The OTDR method is used to test longer fibres for localization of ammonia exposition. Impregnated fibres are placed in a row of testing chambers and exposed to dry ammonia/nitrogen mixtures of various concentrations. All experimental traces are related to the courses obtained with an unsensitized optical fibre taken as a reference. Optical response of the modified fibres is characterized by collected VIS/NIR absorption spectra and OTDR traces. The experimental equipment used in measurements consisted of Agilent Mini OTDR unit (λ = 850/1300 nm, pulse duration 5 - 10 ns, output power 20 mW) and gas testing setup equipped with Celerity mass flow cells (UFC-1661C), controlling the composition and the flow rate of the testing gas mixture. It is worth to notice that dynamics of the sensor reaction is remarkably influence by the preferential reaction of ammonia molecules with the reagent molecules located in an outer shell of the fibre cladding.

The results obtained so far with the novel reagent L_3 show a good reaction of the sensitized fibre to ammonia accompanied by decay of the original complex absorption peak and corresponding blue shift in the fibre absorption spectrum. Analyses of the OTDR traces allow us to get knowledge about damping variations of the fibre along its length and provide us with a satisfactory leak position location and gas concentration accuracy.
The forthcoming research will be focused at first on further qualitative and quantitative testing of the novel ligand and its complexes followed then by fibre tests focused on recognition of the exposed fibre areas, analysis of concentration sensitivity and determination of dynamic response parameters. The obtained experimental results will be also compared with the theoretical predictions calculated with aid of the simulation software developed recently by our group [4].

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Alternative Stabilization of Loam and Aplication

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A subject of my postgradual study is an alternative stabilization of loam and it's application on outdoor earthen plasters. The developing process is already finished. The special polymer powder binder is used as a stabilizer. The aim of this project, which has been supported by CTU grant No. CTU0900211, was realizing comparison of features of indoor earthen plasters produced on Czech market and the verification of the exterior application of the stabilization variants.

There are three producers of indoor earthen plasters on the Czech market: Rigi, Hliněný dům, Claygar. For testing was bought complete plastering systems from this three producers.

Seven types of testing was made. Some of them were traditional, some was normalized probes by ČSN and another of them were practical. A traditional concept of testing was used in testing of connectivity in wet condition, contraction during becoming dry and water resistance. Probes of the compressive strength and the tensile strength are normalized probes. A testing of practical use was realized by plastering a test wall, which was made from earthen bricks. Samples of plasters was exposed to a rain simulated by a rain simulator as the last probe of testing process.

A probe of a connectivity was accomplished by Havlíček-Souček's methodology described in *Stavby z nepálené hlíny* [1]. The probe of the connectivity is based on the tensile strength probe in wet condition. For testing were used base forms for testing cement, which are number 8 shaped. The area of rupture is 5 cm^2. Results are stated in grams on 5 square centimeters. The minimum recommended value is 250 g/5cm^2. Results are written in sequence priming (weaving under), roughcast, roughcast with chopped straw or hemp, finish plaster: Rigi 316-185-98-150, Hliněný dům 196-185-168-192, Claygar 322-259-346-273. Values of many results were bellow 250, but practical using didn't prove any problems.

The probe of the contraction during becoming dry wasn't accomplished by Havlíček-Souček's methodology, but a modified methodology. The reason for this modification was inclusion of influence of water addition. Firstly I proposed addition of constant quantity of water. But it isn't suitable. Right modification is using constant consistence. Consistence was measure by *ČSN EN 1015 – 3* [2]. As a standard value of spillage was set value 185 mm well tried in practice. Samples had dimensions 40 x 40 x 160 mm. Plasters was used without chopped straw or hemp. Consistence was reached by different addition of water. Optimum of contraction is below 2%. Best results get Rigi – roughcast: around 0,94%, the worst Claygar – finish plaster around 2,97%. Bigger contraction relate to bigger connectivity. The same was testing with stabilizer (0,5% in roughcasts and 1% in finish plasters). Contraction with stabilizer is bigger, because elements of polymer getting closer during becoming dry.

The probe of water resistance was accomplished by Havlíček-Souček's methodology described in *Stavby z nepálené hlíny* [1]. I only changed dimensions of samples to 40 x 40 x 160 mm. The probe is based on one hour exposition samples below the water. The depth of dive is 50 mm. The test was evaluated visually. All non-stabilized samples was destroyed in first 30 minutes, stabilized samples (0,5% in roughcasts and 1% in finish plasters) resisted without any damages. The best of non-stabilized samples was Rigi – finish plaster and Claygar – roughcast. Samples without chopped straw or hemp wasn't tested.

The probe of the compressive strength was accomplished by ČSN EN 1015 – 11 [3]. Values of compressive strength were different. The best non-stabilized is Claygar – roughcast around 3,07 Mpa and worst Claygar – finish plaster around 1,11 Mpa. Stabilization markedly escalate values (frequently over 4 Mpa).

The probe of the tensile strength was accomplished by ČSN EN 1015 – 11 [3], too. Best non-stabilized was Claygar – roughcast around 1,98 Mpa and the worst was Hliněný dům – roughcast around 0,89 Mpa. Positives of stabilization are more regardable in this probe than on the compressive strength probe. Here we can see increases even above 100% (from 0,89 to 1,93 Mpa).

All stabilized and non-stabilized variants was tested on the test wall. Wall was made from CEB – compressed earth blocks. Thickness of roughcasts was 12 mm and thickness of finish plasters was 3 mm. Amount of stabilizer was 0,5% to roughcasts and 1% to finish plasters. Non important problems didn't become. Only in Hliněný dům – roughcast with chopped straw was used some too long stalks, which “painting” to the plasters. It is possible take out that stalks or cover scratches by finish plasters.

The probe in the rain simulator is based on exposition of samples to simulated rain. Samples are square size 300 x 300 mm (12 + 3 mm thickness). Samples are situated to simulator in angle 45°. First exposition to rain with 20 mm/h intensity lasts 60 minutes. After 30 minutes intermission become three intensive rain expositions with 60 mm/h intensity for 15 minutes with 5 minutes pauses. The probe was used in developing of stabilization. I'm going to use it for this comparison. Samples are ready for testing and the test will be realized as soon as the lab will be free.

All tested plasters achieved quite satisfying results. However, the clay used in Claygar – finish plaster I recommend change to clay used in Claygar – roughcast. This clay took good results in probe of water resistance and probe of compressive and tensile strength. Originally used clay is lighter, what is valued, but clay used in roughcast has better parameters. Maybe is possible partial change of clay. My second recommendation is separation stalks longer then 10 cm in Hliněný dům – roughcast with chopped straw. And my third recommendation is changing chopped straw to chopped hemp in Rigi – roughcast and Hliněný dům – roughcast. Surface of hemp is coarse in contrast with straw.

Made all probes I verificated that stabilization method may be applied on all types of earthen plasters produced on Czech market (better with my recommendations see previous). In second part of year 2009 plasters was testing in practice by Claygar and now it is possible buy this outdoor earthen plasters in the store.

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Multiscale investigation of cementitious composites exposed to aggressive environment

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Cementitious composites (incl. Concrete, RC, ECC, HPFRCC etc.) are one of the most widely used building materials. Composites should perform different tasks, depending on the particular structure and technical requirements. Structures have to withstand implied loading during their life-cycle and fulfill many other design criteria. The length of the life-cycle of every building is closely connected with one word: Durability. Durability of every structure depends on many factors and the surrounding environment belongs to the most important aspects.

This work is dedicated to the experimental investigation of mechanical properties of ECC (Engineered Cementitious Composites) under chemical exposure. ECC represents a class of modern building materials with cement – based matrix reinforced by short random fibers [2]. These materials differ from ordinary cementitious composites due to the high ductile behavior under tension. During the loading process formation and opening of a large number matrix cracks bridged by fibers can be observed – this is a process called multiple cracking. Multiple cracking permits the material to accommodate significant deformations in order of percents while retaining very small crack width in the sub-millimeter range. The cracks widths are usually below 100μm. Multiple cracking is closely associated with a significant strain hardening behavior [4].

In the present time the durability and degradation of the cementititous composites and its resistance to aggressive environment becomes important. The influence of various types of aggressive agents has been investigated. ECC are often used to repair the pavements, bridge decks, dams etc. Many of these structures are often exposed to the chemically aggressive environment. A typical representative of chloride (NaCl) environment is the usage of deicing salt for road maintenance. Seashore and marine structures are exposed to the aggressive seawater. Another type of aggressive environment is the long-term contact with pure or deionised water or with a water containing sulphur or ammonium ions which leads to degradation of the durability of composite. This contact induces calcium leaching process and decalcification of hydrated calcium silicate. Calcium leaching belongs to the major factors that alter the mechanical properties of ECC.

The effects of aggressive environment were simulated using the accelerated aging program. Chloride attack was simulated with a cyclic loading. There were 10 cycles of 5 days immersion in fully saturated solution of NaCl and 2 days drying in the electric oven at a temperature of 50°C [3]. Degradation process caused by calcium leaching and its negative effect was simulated by immersing of the ECC specimens into 6mol/l water solution of NH4NO3 for 70 days [1].

The experimental investigation of mechanical properties of ECC can be divided into several scales. The localization of cracks during loading process, material strain-hardening and softening can be observed at the Macroscale level. The multiple cracking and fiber bridging action are investigated at the Mesoscale level. And finally, the fiber - matrix interaction as well as the individual fiber behavior is determined at the Micro-scale level. This multi-scale approach tends to the general description of ECC properties.

The Mesoscale level testing methods used for measurement and evaluations of mechanical properties of ECC are Uniaxial tensile test, Uniaxial compression test, Three-point bending test.

Three types of specimens were tested. The first group of specimens was kept in the room conditions for all the time and was used as a reference sample ('O-series'). The second one denoted as 'S-series' was treated in the fully-saturated solution of NaCl. The last group of specimens denoted as 'N-series' were kept in the 6mol/l solution of NH4NO3.

The subject of the compression test was to evaluate overall Young modulus and compressive strength of the composite. The dimensions of the specimens used for this test are: (width) w= 12 mm, (height) h=12 mm, (length) l=70 mm. This test is displacement - controlled. The compression tests showed that the composite elastic modulus E was almost unaffected by the exposure of chloride and elevated temperature (S-series), while the compressive strength showed a slight reduction. The exposure of nitrate solution (N-series) degrades the matrix of composite by calcium leaching. The Young modulus and compression strength are reduced dramatically.

Tensile test was provided to prove the negative effect of aggressive environment. Dimensions of the specimen are: w=10 mm, h=20 mm, l=150mm. The reference specimens (O-series) exhibited moderate strain hardening with the average strain capacity about 0.6 % during the tensile test. Only a few cracks occurred during the loading process and the main fracture was localized in small area. It should be noted that post-peak strength σ_{pc} was usually lower than first crack stress σ_{fc}. Almost the same behavior was observed for the S-series, though the first crack and post-cracking strength were higher and the overall ductility (ε_{pc}) was lower. Also, very few cracks developed in the specimens. At the other side, the N-series showed multiple cracking and the strain capacity over 2 %. Leaching decreased the matrix cracking strength and increased fiber bridging capacity.

The experimental results show that exposing ECC to cyclic treatment in chloride solution causes embrittlement of the composite, though it still retains some of the hardening ability under uniaxial tension. Immersion in nitrate solution causes reduction in strength but improves the strain-hardening of composite.

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Influence of Technological Properties of Concrete on Quality Concrete Surface Layer

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Simple notion „fair-face concrete“ is relatively difficult to define, simplified told it is concrete, where are not implemented any others surface retreatments after striking. Fair-face concretes are in currently more or less successful final surface finish treatment not only on traffic structures (bridges, scaffold bridges, buttress walls, pillars, etc.), but they begin in larger degree to assert in housing structures too. From mentioned ereas results, that quality of surface layer is not the only one frontier property. Besides an aesthetical experince concrete musts meet static requirements too.

Fair-face concrete is perceived by public quite negative owing to past, despite of is today very popular and passes through huge comeback. In passed years it was in context of fair-face concrete discussed a kind of its evaluation, because realizing companies were met with inadequate visual requirements of investor during statutory approval.

Some opportunity of objective and quantifiable evaluation of concrete surface is offered by a confocal laser scanning microscope LEXT OLM 3000 we use for different types of observations and measurements. Confocal laser scannig microscopy is a representative of new generation of optical systems with the high accuracy, 3D projection and measuring. It offers new possibilities for development and control of various materials and components. It is especially useful for new applications in micro- and nano-technological branches that put heavy demands on nonstandard ways of nondestructive noncontact measurement and control of materials, miniature components, very fine connections and also on control of roughness of surfaces with submicron accuracy.

Effected experimental work was focused on comparison of concrete mixtures with various composition. Influence of granulometry, workability, vibration time and using separation agent were observed and measured. As a formwork was used chipboard with laminated surface. On the whole were designed four trial mixtures, which were unlike especially with dosage of sand and plasticizer.

Merits of experimental work was comparison of concrete surface quality on samples with gradually changed entering paramethers. As a quantitative magnitude for this evaluation was used mentioned arithmetical middle height (a). Each sample was observed on three different places; in following tables are introduced only arithmetical averages of these free measurements.

Already previous research shows, that with using separation agents is concrete surface coarser, but this quality decreasing puts down number of undesirable colour effects, which are on very smooth surface well perceptible, e.g. marbling. Both commercial separation agents got good result, cause quality of boarding and final concrete surface were quite similar.

It is quite logic to suppose, that with longer vibration will concrete have higher surface quality. There exists one huge snag, because by excessive vibration we can evoke undesirable segregation of single components of concrete. In this case concrete structure would embody

different physico-mechanical properties in direction of vibration, apart from colour changing. From this reason was performed test, where samples of concrete mixture three were vibrated in various times. Suppose of surface quality upgrading was come true of course. But roughly after double time of VeBe test is improving of surface quality very inexpressive.

Aggregate serves function of robust skeleton in concrete. Properties of aggregate have large influence on durability of concrete and other physical properties of concrete. Portion of fine aggregate in fair-face concrete is regulary higher then in common structure concrete. With increasing of water-cement ratio can be portion of fine aggregate increassed and from requirement of uniformity arises the necessity of minimum two fractions of small-sized aggregate, eventually D_{max} on value lower then 4mm.

Fine fractions of aggregate are very significant in fair-face concrete, because they are markedly increasing the workability and inhibiting of connectice paste separation, concrete bleeding. So closed structure of concrete is ensured, for fair-face concrete very desirable. But together we must care to not get over the portion of fine component part higher then 0,25mm, this fine parts cause glairiness and decrease the workability. That's why we must seek for optimum granulometry.

At present appears long-expected technical references, which should provide some technological requirements and determine simple classes of fair-face concrete, but concrete is always the most used building material and this trend will probably continue, so it's nessesery to fill up the older knowledge by other ones.

On base of experimental works we can explicitly confirm, that laser confocal microscopy finds using in fair-face concrete too. Its aim is not determination some quantitative criterions for statutory aproval of concrete structure, but it has great potential for preparation and concrete mixture designing. We can exactly provide entering parameters and reciprocally relations of different factores of concrete producing. Just due many factores entered in their producing they are unique. Optimalisation of concrete mixture and manufacture parameters form only fragment of successful structure, the most important one is technological discipline.

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Processing and Evaluation of Ti-based Alloys Used as Perspective Biomaterials

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Titanium and its alloys are now the most attractive metallic materials for biomedical applications because of their high specific strength, high corrosion resistance and good biocompatibility. TiAl6V4 alloy has been a main biomedical titanium alloy for a long period. New types of alloys were developed in order to replace V (β-stabilizing element) which is potentially toxic element. It is well known that the modulus of elasticity of biomedical titanium alloys is a key property for implant applications. This is because of the stress-shielding effect, which can be observed when implants of material with high modulus is used. Than th stress is transfered only by the implant and surrounding bone is without load. This can cause resorption and bone loosenig. Recent attempts at reducing the elastic modulus have led to the development of Ti-15Mo-5Zr-3Al or Ti-13Nb-13Zr alloys having elastic modulus values ranging from 74 to 88 GPa. Nevertheless, these titanium alloys still exhibit modulus much higher than that of bone whose elastic modulus is generally between 17 and 28 GPa. It was also reported that metallic Al and Fe are also cytotoxic elements. Therefore the new titanium alloys for biomaterials use should contain only nontoxic elements such as Zr, Nb, Ta, Mo and Sn.

Beta titanium alloys have lower modulus than α+β alloys and good formability combined with relatively high strength. Because the elements used for producing these alloys are are quite hardly meltable and there could be other problems with microstructure when arc melting is used, new methods of preparation of these alloys are currently used. When compared arc melting (these alloys must be many times remelted in order to obtain homogeneous microstructure and equiaxed grain structure) powder metallurgy allows process with low energy costs.

In our work several beta-Titanium alloys (Ti-35,5Nb-5,7Ta) were prepared by powder metallurgy and arc-melting proces. Arc melted samples were swaged and solution treated (850°C/05h). Subsequently they were cold forged with various reduction section. It was evaluated the mechanical properties in dependence with reduction section. After that samples with strength about 800MPa and modulus about 50 Gpa were obtained. The ductility is still about 15%. After that finally heat treatment-aging was made on these samples. After that the strength of this alloy raised up and the ductility decreased but still is higher than 10%. Modulus increased at about 70GPa.

After swaging the microstructure is composed of beta matrix with a small amount of α". This was measured by the XRD analysis were the α" phase has only weak traces in diffraction spectrum. During hot forging the material is dynamically recrystallized and the grain size slightly increases. After solution treatment the grain size very slightly increases but also the measurements can be influenced by local heterogeneity. After cold forging the microstructure is deformed and on light microscopy can be observed fine precipitates in the structure. Needle like morphology with orientation perpendicular to deformed grains. These needles are probably the α" phase which forms during the deformation. This was confirmed by XRD analysis and TEM (thin foil) observations. After aging treatmentthere were observed very fine precipitates of α and ω phases. These precipitates are very fine plate like morphology. These precipitates have very strong strengthning effect on the alloy.

Other Beta-Titanium alloy with nominal chemical composition of Ti-39Nb (mass%) was prepared by the means of powder metallurgy. Powders were divided into several fractions by their

grain size and than isostatically cold pressed under pressure of 400MPa. These green specimens were sintered in a vacuum furnace at temperatures of 1300°C or 1400°C. It was observed that specimens sintered at 1300°C has relatively huge amount of pores and also it is evident that this temperature is not sufficient for sinterenig this material, because the time of sintering must be very long. In sintered samples still remains certain amount of pores. The porosity increases with increasing grain size of powders. Porosity was measured by image analysis of images obtained from optical microscope. Another method of measuring porosity based on measuring the density of specimens were also used. It was observed that the density remains almost the same after certain time of sintering which depends on grain size of powders. The smaller grain size the shorter time of sintering. After this time the porosity doesn't decrease significantly with sintering time. So it is evident that there are still some pores left in the material and they cannot be vanished by sintring. Because of that forging must be used for decrease the porosity of the samples. The microstructure was observed using ligth microscopy and scanning electron microscopy. Also the nominal chemical composition was measured by EDAX. The microstructure of this alloy is composed of beta-Ti phase and alfa-Ti phase. The amount of beta-Ti phase increased with increasing sintering time because the Nb is soluted in surrounding alfa matrix. Nb act as a beta-stabilizing elements. Also the smaller grain size of powders favours the solution of Nb in the matrix. This is because of shorter diffusion tracks of Nb atoms. So the samples of fine grained powders are composed of fully beta-Ti matrix after 15 hours of sintering at 1400°C.

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Phase Transition Study of $NaNbO_3$ Thin Films by Spectral Ellipsometry

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One of the most interesting cases of implementation of the complex sequence of phase transitions (PT) of all perovskites is antiferroelectric sodium niobate $NaNbO_3$ (NN) [1], which is promising lead-free piezoelectric material for high temperature T applications, and frequency doubling devices [2]. NN changes its phase from a high-temperature paraelectric (PE) to antiferrodistortive and then reaching antiferroelectric (AFE) phase at 643 K [3]. The unit cells of phases R and S are the largest reported for a low-symmetry phase of any perovskite. There are several reports, where additional PT between R and T1 were found on NN single crystals: Lefkiwitz (x-ray, 1966) established unusual PT at 703-713 K (detected also by optical observation), 791 and 799 K; Denoyer (differential thermal analysis (DTA) and x-ray, 1971) - at 796K; and Glazer (DTA, 1973) - at 803 K while heating and at 785 K while cooling. No other revision of these additional phases of the NN single crystals were attempted for many years. There are just few results on the dielectric and piezoelectric properties on the NN thin films and ceramics. According to results of thin films, there is a report on high temperature studies of effective values of the refractive index for NN deposited by PLD on $Si/SrRuO_3$ substrate. There was detected the specific anomalies of the refractive index by the ellipsometry at the temperatures described above, but additional experiments such as band gap energy temperature dependence required to the interpretation of the results.

This work is devoted to the new ellipsometric results, where temperature dependence of refractive index and optical band gap was measured in a wide temperature region of 5-820 K to study the phase transitions of NN thin films made by pulsed laser ablation (PLD). On the other hand significant developments in micro and nano-electronics caused a steep rise in interest in the structure, phase state and properties of the surfaces of solids and films. Such spectacular studies are especially important in nanostructure engineering, where interfaces and surfaces are playing increasingly important roles. There are only a few existing studies of PT in thin and especially in ultra-thin films, and the majority of them are destructive methods which demand very specific precise sample preparation. In this situation, a nondestructive optical method (spectroscopic ellipsometry) of research and diagnostics of PT in thin films is presented here.

NN thin films of thickness ~200 nm with polycrystalline orthorhombic crystal structure were deposited on the $Si/SiO_2/Ti/Pt/SrRuO_3$ substrates by PLD. Room temperature (RT) and temperature dependent optical measurements were performed by means of a J. A. Woollam variable angle spectroscopic ellipsometer (SE) operating in rotating analyzer mode. The main

ellipsometric angles ψ and Δ were measured in a spectral range from 300 to 800 nm at the angles of incidence of 65, 70 and 75 degrees at the RT. During discussion of RT data ψ and Δ all heterostructures and a top layer of superficial roughness were took into account. Specially designed sample holder with PC-controlled heating element allowed the real-time measurements of ψ and Δ during heating. Temperature T dependences were performed in two ways: 1) the T dependence of the main ellipsometric angles ψ and Δ as a function of the wavelength, and 2) the dynamic scan of main ellipsometric angles ψ and Δ at several fixed wavelengths. As the result two kinds of data can be evaluated: 1) T dependence of dispersion of optical properties (refractive index n and extinction coefficient k) and optical band gap, and 2) T dependence of n and k at the fixed wavelengths.

The behavior of the refractive index n and extinction coefficient k at fixed wavelengths 300, 400, 500 and 635 nm, and optical band gap Eg for allowed direct electron transitions under high and low temperatures (5-820 K) conditions for $NaNbO_3$ thin films were investigated by the spectroscopic ellipsometry.

Totally five anomalies in the n(T), k(T) and E_g(T) dependencies were found. The corresponding temperatures of the increase/decrease of the n(T) and k(T) and jumps of the E_g(T) were observed at the 225, 643 (645), 723 (723), 750, and 794 (788) K temperatures. Established anomalies agrees well with the PT temperatures of the N→P, P→R and R→S, S→T1 transitions of the $NaNbO_3$ single crystals and ceramics studied by x-ray, DTA and other techniques. Different PT temperature of N→P and unusual PT at 718 (723) K were found and related to various defects and possible coexistence of different phases in the films, which causes additional structural changes and shift of the PT temperatures.

It was found that more pronounced changes in n(T) and k(T) occurs at the ultraviolet region that in the longer wavelengths, and PT can be seen directly in n(T) and k(T) at the wavelengths near absorption age while temperature deviation of n should be analyzed for longer wavelengths to detection PT.

Negative thermo-optical effect observed in NN thin films can be explained by the 1) inhomogeneity and/or tensile strains in NN films and/or 2) strong influence of higher energy bands and their shift to the shorter wavelengths while temperature rises.

Spectroscopic ellipsometry was demonstrated as an effective method for phase transition investigation in NN thin films and can be considered as a powerful technique for thin, ultrathin films and surface investigation under temperature influence.

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Analysis of Cutting Process Mechanism During Directional Machinig of Metals by Means of X-ray Diffraction Methods

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Surface is, in fact, a two dimensional defect and as such can have properties which differ from the material in the bulk. The most frequently mentioned differences are in surface hardness, yield strength, Poisson ratio and Young's modulus [1] and, hence, the elastic and plastic behaviour of surface layers is often not the same as those observed in the bulk [2]. Even some discrepancies between a prediction model and observed experimental results of stress-strain curves may arise from the usage of bulk input data and, therefore, a model of continuum with variable material properties has to be employed in order to obtain a trustworthy estimate. Despite of all the complications the presence of surface causes, the role it serves is a crucial one since it forms an interface between the bulk and its neighborhood. Knowledge of surface structure and state is paramount for understanding various surface-related processes as well as for surface quality assessment.

The process of surface creation has apparently considerable impact on its final structure and properties. Most often several physical and chemical processes are in progress during the surface creation; the most notable being plastic deformation, presence and evolution of thermal fields and occurrence of phase transitions [3].

There are several attitudes for polycrystalline materials' surface characterization ranging from macroscopic qualities like morphology, roughness, hardness to microscopic parameters like dislocation density, type and structure of inter-grain boundaries or chemical reactivity. An aggregate of structural parameters describing deviations from the perfect structure of ideal crystal is known as real structure. It contains information about the state of macroscopic residual stress, microstrains, grain size distributions, texture etc. An effective and reliable source offering diverse array of real structure parameters can be found in analysis of data from suitably designed diffraction experiments. This contribution deals with milled surfaces and describes them by three qualities, macroscopic residual stress, microstrains and grain size, which were evaluated from X-ray diffraction data measured on either up-cut or down-cut side milled specimens.

Milling is accompanied by plastic deformation and thermal fields which are inherently inhomogeneous due to the anisotropy of directional movements of the used tool. In general, two dominant physical processes are under way. Firstly, energy of plastic deformation and friction between the tool and the machined object generate heat whose presence causes creation of inhomogeneous thermal fields. These fields dynamically evolve as the whole system strives to get into thermal equilibrium and as the tool goes back and forth. Secondly, the surface layers of machined object are being removed and plastic deformation is, thus, inherently inhomogeneous. Moreover, external forces and moments are present and as soon as they cease to be in action, the object proceeds to the state of mechanical equilibrium [4] while the unloading can be elastic or plastic. Milling can be carried out in either up-cut or down-cut modes which differ significantly in the incidence of machining forces and, hence, in the mechanism of material removal.

Considering the surface after milling, there exist two possibilities for milling direction assignment. Being aware of this freedom and having the information about the geometry of milling, the diffraction measurements were performed for both options, i.e. in two coordinate systems mutually rotated by 180°. In order to obtain full stress tensor, the diffraction line {211} of α-Fe phase was measured in both positive and negative tilts in three azimuths 0°, 45°, 90° on an θ/θ Bragg-Brentano ω-goniometer X´Pert PRO with CrKα radiation. The goniometer was adjusted in respect to a strain-free reference specimen of α-Fe powder. For all samples, the azimuth 0° was chosen in the direction of material removal progress, and in the opposite one.

Since the ground surfaces exhibit psi splitting, calculation of tensor for state of triaxial RS was done according to modified $\sin^2\psi$ (Dölle and Hauk) method. X-ray elastic constants for measured α-Fe {211} diffraction planes were computed following the Eshelby-Kröner theory.

Microstrains and mean coherent scattering domain sizes were evaluated by single line profile-fitting method for each obtained {211} diffraction peak of ferrite in order to unveil possible direction-dependent dissimilarities.

X-ray diffraction experiments and subsequent evaluations lead to following conclusions. Values of microstrains and mean coherent scattering domain sizes don't show any dependence on milling modes. Shear stress σ_{31} evaluated from psi splitting in milling direction changes its sign when the reference frame is rotated by 180°. The negative σ_{31} always occurs when the primary X-ray beam impinges the surface in the opposite orientation vis-à-vis the assumed sense of end-mill rotation. The sign of shear stress σ_{31} can be, hence, used for determination of end-mill rotation direction. No systematic difference between up-cut and down-cut mode can be seen in obtained values of normal macroscopic stresses for all measured surfaces. Normal compressive stresses σ_{11} in the milling direction are of lesser value in respect to σ_{22}.

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Heat Treatment of Cr-V Ledeburitic Steel Substrate for Plasma Nitriding

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The heat treatment improves the toughness and hardness of tool steels. Standard heat treatment usually consists of austenitizing, quenching and multiple tempering. After this procedure tool steels gain the hardness suitable for industrial applications. In high alloyed ledeburitic tool steels, retained austenite is an undesired component since it lowers hardness after heat treatment. Moreover, it can transform into martensite and/or bainite at elevated working temperatures or under a high loading. This effect worsens the operational suitability of tools and there is a strong effort to develop a way to minimize its amount.

The goal of this paper is investigation what happens when Cr-V ledeburitic steels are plasma nitrided. For this purpose, it is necessary to prepare a substrate with well defined microstructure and properties. In this paper, the Vanadis 6 steel processed using various heat treatments, including a sub-zero period, is investigated.

The samples were made from Vanadis 6 (2.1% C, 7% Cr, 6% V). . The samples were subjected to specific heat treatment, whose characteristics are shown in Tab. 1.
Hardness testing was carried out using Vickers HV10 and Rockwell HRC methods. Resistance against crack initiation was determined by the three point bending test. The microstructure and fractography were analyzed by scanning electron microscopy. Also quantitative analysis of carbides dissolution during the austenitizing was done.

Tab. 1 - Heat treatment details.

Specimen	Heat treatment marking	Heat treatment process details			
		Austenitizing	Quenching	Sub-zero treatment	Tempering
1 - 5	A	1030°C/30 min	N_2/6 bar	-	2x530°C/ 1 h
6 - 10	B	1030°C/30 min	N_2/6 bar	-196°C/ 4 h	2x530°C/1 h
11 - 15	C	1030°C/30 min	N_2/6 bar	-196°C/ 7 h	2x530°C/1 h

The as-received material has a structure with fine carbides particles uniformly distributed throughout the matrix. The carbides are of eutectic, secondary and eutectoid origin.

After all the heat treatment processes, the matrix consists of tempered martensite, M_7C_3 and MC and M_7C_3,Fig. * The material subjected to heat treatment B, i.e. with sub-zero treatment, shows similar structure at first look. That means existence of the MC and M_7C_3 carbides in the martensitic matrix. . It is obvious that after the heat treatment the number of carbide particles decreases. Also their size decreases in comparison to the carbides in as-received material. The main reason is that the as-received material contains higher number of ultra-fine eutectoid carbides and these undergo dissolution in the austenite completely. In addition, also a part of secondary carbides is dissolved in the austenite during austenitizing.

From these results, it seems that sub-zero period has a slightly positive effect on the three point bending strength. This is in agreement with changes in hardness – the higher is the bending strength, the lower is the hardness.

As-received material hardness was 284 HV 10. Hardness value after heat treatment without sub-zero treatment was 748±6,9 HV 10 (60±0,2 HRC). The process with sub-zero treatment -196°C/4 h leads to the hardness of 734±6,9 HV 10 (58±1,0 HRC). Finally the process including sub-zero treatment -196°C/7 h resulted in hardness of 721±5,6 HV 10 (58±0,4 HRC). It is evident that including the sub-zero treatment the hardness slightly decreased – in order of tens of Vickers units compared to heat treatment without it. This decrease is more important, the longer the duration of the sub-zero period is. This fact contradicts to [2] stating that the hardness increases after this procedure and [4].

Tab. 2 - Average hardness and standard deviation values depending on heat treatment process.

Measurement Method	HV 10			HRC		
Heat Treatment	A	B	C	A	B	C
Average Value of Hardness	748	734	721	60	58	58
Standard Deviation	6,9	6,9	5,6	0,2	1,0	0,4

Results of the bending strength of samples of the same heat treatment are presented in Tab. 3.

The fracture of the specimen processed via “A” treatment was initiated on the tensile strained side of the specimen and propagated throughout the material. It shows that the fracture surface manifests dimple morphology with some symptoms of microcleavages. This indicates that very low energy was spent for the crack propagation.

Fracture surface of the sample processed via the “C” treatment sample shows more significant dimples in the fracture surface than those of the sample processed via the A. It looks that the sample processed via the C treatment consumes greater amount of plastic deformation energy, thus it is possible to say that performed sub-zero treatment slightly improves the plasticity of the steel.

Tab. 3 Results of the three point bending strength test.

Heat treatment	Average value of bending strenght [MPa]	Average value of the maximal load [kN]
A	2436	17,1
B	2961	20,8
C	3217	22,6

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Fractographic Analysis of Spark Plasma Sintered Fe-43at.%Al Intermetallics

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Detailed fractographic analysis of fractured FeAl compacts sintered via Spark Plasma Sintering technique [1, 2] was performed. The feedstock material was an atomised powder with composition of Fe-43at%Al (Fe-27wt%Al) prepared in LERPMS Belfort, France. The powder was sieved into size fractions of <32, 32-50, 50-90, 90-125, 125-160 and >160 μm. An unsieved powder was used as well. The sintering temperatures were in range from 800 to 1250°C. The details about the sintering process parameters or the initial powder can be found elsewhere [3, 4]. The sintered specimens were discs having a diameter of 40 mm and a height between 10 and 16 mm.

The studied fractured surfaces were coming from RCT specimens machined directly from the SPS compacts. The notches were prepared by electrical discharge cutting. Due to the impossibility of the fatigue pre-cracking of this material the crack tip radius was reduced via subsequent sharpening by automatic rectilinear motion of a razor blade continuously wetted by diamond paste.

It was observed that the fracture surface of the specimen sintered at 950°C was composed of initial powder particles deformed during the sintering process. This specimen fractured entirely by interparticle decohesion. The specimens sintered at 1000 and 1100°C fractured also by interparticle decohesion but some areas of transgranular cleavage were found at the crack tip. Whereas in the case of the sample compacted at 1000°C the fracture initiated at the crack tip mostly by interparticle decohesion, a predominance of transgranular cleavage was observed at the crack tip of the sample sintered at 1100°C.

Fractographic analysis of broken compacts sintered from unsieved powder fraction revealed that large particles failed more likely by intergranular decohesion or transgranular cleavage than by interparticle decohesion as it was observed on fine powders.

Three the most important fracture modes were: interparticle decohesion, intergranular decohesion and transgranular cleavage. Increasing of the sintering temperature leads to the reinforcement of the bonds between powder particles and interparticle decohesion mode is accompanied by transgranular cleavage. Intergranular decohesion was observed in case of very coarse particles. These particles are composed of few grains having 10-50 μm in diameter. This phenomenon is more pronounced in case of 125-160 and >160 μm size fractions. On the other hand, even those compacts fractured by mixture of interparticle and intergranular decohesion with predominance of interparticle decohesion.

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Comparison of Mechanical Properties of Modified Plasters with Different Grained Lime Binder

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Pozzolanic admixtures in lime renders can be considered as one of reasonable alternatives in the respect of cultural heritage [1]. Pozzolanic addition appeared to have positive effect on properties of lime binder in the past [2]. According to the composition of the applied pozzolana, hydration, compounds similar to Portland cement products were formed but even compounds of zeolite character were found in lime based plasters, such as phillipsite $3CaO.3Al_2O_3.10SiO_2.12H_2O$ and analcime $Na_2O.Al_2O_3.4SiO_2.2H_2O$, in connection with microcrystalline calcite [3]. A very suitable for adjustment in particular mechanical properties of traditional lime plaster, it appears the use of metakaolin as pozzolana additives. The durability of this plaster is supposed to increase significantly due to the improvement of compression and flexural strength, particularly taking into account the long-term improvements. Pure lime as binder was not yet in the center of interest of many researchers until now although it is often used in historical buildings renovation. In this paper, we are therefore focused on the basic component of lime-pozzolanic plasters, the lime, particularly its chemical composition, grain fineness and their effect on mechanical parameters and on the formation of firm structures together with metakaolin in lime-pozzolana plasters.

As basic tested material was chosen hydraulic lime produced by two different companies, by limekilns Čertovy schody and Morká, Czech Republic. Lime was additional delivered in three different granulometries, 200, 90 and 63 μm. In order to analyze the effect of grain fineness of hydraulic lime on basic and mechanical parameters, ten different mixtures with and without metakaolin were prepared.

Investigation of mechanical parameters was carried out according to the norm ČSN EN 196-1. The compressive and flexural strengths were determined as the most important mechanical parameters for lime-based plasters. For each measurement standard prisms 40 x 40 x 160 mm were prepared. The flexural strength fct [N/mm^2] was measured using standard three-point bending test. The compressive strength was determined using the same test device on the remainders of the specimens after bending test. The measurements were done at 7, 14 and 28 days and also after two years of hardening period. Two years result reflects increasing of strength in consequence of chemical reaction, carbonization and creation of CSH gels, which is typical for cement binder, on one side and decreasing due to natural ageing on the other side. However, according to the literature [4] CSH gel formed by pozzolana reaction is different from CSH gel, arising from hydration of cement, as in the case of testing plasters. Taking into account the results obtained confirm the pozzolana active material initially behaves as an inert phase and only in the final strongholds of exerting influence.

The experimental work presented in this paper revealed that the lime grain size is not to be considered the decisive factor affecting the mechanical properties of lime and lime-metakaolin plasters. The use of lime with finer grains resulted in improvement of flexural strength in the case of pure lime plasters only. The compressive strength of lime plasters was found unaffected by the grain fineness, and for lime-metakaolin plasters even an opposite situation to the expected behavior was observed, when compressive strength increased with

increasing lime grain size. In order to discover the reasons for these seemingly illogical results, the time courses of the $Ca(OH)_2$ dissolution heat production and hydration heat production of metakaolin should be done in the first instance.

On the other hand, the chemical composition of lime was proved as a very important factor. The use of lime of the same grain size produced by two different producers resulted in significant differences in compressive and flexural strengths of lime and lime-metakaolin plasters. For pure lime plasters, application of lime from the kiln Čertovy Schody give the more successful solution; on the other case for lime-metakaolin plasters the lime from Mokrá resulted in plasters with higher compressive and flexural strengths. However, neither here the exact reason for the observed differences could be found out with the data currently available as the composition of lime from the kiln Mokrá. A more precise chemical analysis of this lime is necessary to be done.

Practical usage of this research should serve as an input data for the production of lime as the basic raw material for the preparation of lime-pozzolanic plasters. It should support decision ´if˝ and ´how´ to manage lime´s manufacturing. However for comprehensive decision-making we need to know and take into account other aspects, e.g. economic.

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Study of Transport and Storage of Water and Nitrate in Materials of Historical Masonry

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In the historical masonry and its materials, several types of water soluble inorganic salts can be usually found and recognized. These salts are coming into the inner structure of materials from several sources, e.g. from de-icing agents, underground water, from the chemical reactions of materials with environment, from the biological growth and action, etc.

The main destructive and disruptive effects of salt action are assigned to two main processes – salt crystallization and salt hydration in porous space of materials. Salt crystals can gradually fill the porous space and the crystallization pressures are exerted on the pore walls. In dependence on temperature, supersaturation rate and pore dimension, the destruction of materials can occur. The second degradation process evoked by water-soluble salts is related to the salts that enable to bind defined amount of water molecules in their crystal lattice. The formation of hydration products is characteristic by changes of salt volume that are accompanied by hydration pressures [1].

Because of the evident salt harmful effects on the performance and durability of buildings, the understanding to the mechanisms of coupled moisture and salt transport and storage is quite important issue for building physicists as well as for practitioners. On that account, the water nitrate salt solution transport and storage in the materials used originally in historical masonry is studied in order to support the investigation and characterization of mechanisms of salt transport and binding in different types of building materials. We have focused on the assessment of parameters describing the salt transport in masonry materials originally used in the Central European territory, nominally sandstone and lime mortar.

The sandstone originated from Mšené-lázně quarry. It is siliceous fine-grained material usually used especially for ornamental parts of the architecture, like gothic flowers, romantic shells, and sculptures, having total open porosity 31%. Application of lime-based binders for plasters and mortars can be traced up to ancient world, and their use was significant until the end of 19th century. On this account, the properties of lime-based plaster from the point of view of salt transport and storage are studied as well. The studied lime plaster reaches total open of 36%, and its bulk density is 1650 kg/m^3.

The assessment of material parameters was done using inverse analysis of experimentally determined salt and moisture concentration profiles assuming diffusion-advection mechanism of salt solution transport including the salt ions bonding on the pore walls. In this model, the moisture transport is described by moisture diffusivity, salt transport by salt diffusion coefficient, and salt storage by salt binding isotherm.

For the assessment of parameters describing the coupled moisture and nitrate transport, the experimental measurement of moisture and nitrate concentration profiles were done. The arrangement of the experiment was analogous to standard water suction experiments. The rod-shaped samples with the dimensions of 20 x 40 x 160 mm were first dried at 80°C and 0.1 mbar and water and vapour-proof insulated by epoxy resin on all lateral sides. Then, they were exposed by their 40 x 20 mm face to the penetrating KNO_3 solution (concentration 101.1 kg/m^3 of solution). Duration of the experiment was 30, 60 and 90

minutes for three different groups of samples. After this time, the samples were cut into 8 pieces, and in each piece water content and nitrate concentration were measured. Moisture content was measured by the gravimetric method. In the determination of nitrate concentration, the particular samples were after drying first ground by a vibration mill so that grains smaller than 0.063 mm were obtained. Then the ground samples were overflowed by 80°C warm distilled water and leached. The nitrate contents in particular leaches were measured using the pH/ION 340i device with utilization of ion selective electrode (ISE). For the determination of ion binding isotherm, absorption method was used [2]. On the basis of the measured ion binding isotherm of KNO_3, the profiles of bound and free nitrates were determined.

From experimental data there is evident that the transport of KNO_3-in-water solution in sandstone was slightly faster than in the case of lime plaster. This finding is contrary to the measured total open porosity of studied materials, which was for the lime plaster higher by about 5%. However, we can assign these results to the differences in the pore size distribution of particular materials. This observation was proved also by the measurement of total nitrate concentration profiles. The nitrate binding isotherms give evidence of the very high nitrate binding capacity of both studied materials. For our calculations we have used only first part of nitrate binding isotherm because of short time of the performed suction experiments. On this account, no other points of binding isotherm for specific concentrations were accessed. Calculated nitrate diffusion coefficients were for the both studied materials quite high, typically three to four orders of magnitude higher than the diffusion coefficients of most ions in free water. Therefore, the common diffusion mechanism is probably not the only driving force for nitrate transport within the liquid phase and some other driving forces are taking place here. This acceleration of nitrate transport can be attributed most probably to surface diffusion on pore walls and/or to osmotic effects.

The main practical outcome of the presented work represents determination of moisture diffusivity, nitrate diffusion coefficient and nitrate binding isotherm for the studied materials. These results can find use in computational assessment of the durability of historical masonry exposed to the changes of unfavourable environmental conditions. In this way, the damage assessment can be done and the optimisation of restoration process can be performed.

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Investigation of the Influnce of Salt Presence on the Applicability and Reliability of TDR Method for Moisture Content Measurement

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Since the properties and performance of porous building materials are strictly dependent on the environment conditions, especially on temperature, relative humidity, air pressure, and moisture, there is necessary to monitor the field variables in building materials and structures in respect to changes of these conditions. Among the most negative factors that highly limit the proper action of building materials, the moisture content changes are necessary to be measured.

Several methods of moisture measurement working on different principles and having different accuracy and range of applicability were designed and constructed until now [1], [2]. One must take into account also the fact that not only pure water is present in building materials. The pore water usually contains different types of dispersed substances, such as inorganic salts. Looking at the moisture measurement methods from the point of view of monitoring content of impure water, we should consider that the accuracy and reproducibility of several moisture methods is strictly dependent on the amount of dissolved salts in water and present in porous system of materials. This feature is remarkable especially for electrical relative methods, where the measured physical quantity is highly dependent on salt concentration.

The salt dissolved in water is present in form of dissociated ions. On the conduction of electrical current take part free salt ions in solution. In dependence on ion concentration, the electrical conductivity of material is increasing. For lower concentrations of salt water solutions there is valid direct proportionality between salt concentration and electrical conductivity. On the other hand, electrical conductivity is limited by the free migration of ions. It means that in certain value of ion concentration the migration of ions is reduced, and electrical conductivity of such solutions decreases.

Typical example of electrical moisture content measurement methods represent resistance meters that are often used in building practice even in materials containing salts. However, the resistance moisture meters are in the case of salt presence practically inapplicable, because the errors rapidly increase with the increasing moisture content.

In building practice are very often used also dielectric moisture measurement methods based on the measurement of complex relative permittivity of the studied wet material. These methods are also based on the analysis of electrical properties of material as the response to moisture content changes. Since the presence of dissolved salts affects the conductivity of water in a significant way (see above), the low frequency operating dielectric methods are not applicable for moisture measurement in salt laden materials. On the other hand, with increasing frequency of microwaves, the importance of salt content for the measured values decreases. The imaginary part of water permittivity increases with frequency (it has a maximum at so called critical frequency, f_{cr} = 23.4 GHz), and therefore the relative importance of conductivity decreases. On this account, the application of high frequency

microwave method looks very promising for moisture measurement in materials containing salts.

In the presented work we have focused on the usability testing of high frequency TDR (Time Domain Reflectometry) method working on frequencies close to 2.0 GHz for moisture measurement in materials containing salts. The experiments were proposed in order to evaluate the effect of salinity on the accuracy of TDR method for moisture measurement. For the measurement, sophisticated cable tester TDR/MUX/mts produced by Polish company Easy Test was used. This device is based on TDR technology with $\sin^2$-like needle pulse having rise-time of about 250 ps and allows monitoring of complex relative permittivity, temperature and electrical conductivity of porous media. Using this device, monitoring of moisture, temperature, and salt concentration fields can be done. The measuring range of the used device was for the measurement of relative permittivity (ε) 2 – 90 with absolute error ± 1 for $2 \leq \varepsilon \leq 6$ and ± 2 for $\varepsilon \geq 6$, for the measurement of electrical conductivity 0 – 1 S/m with relative error ± 5%, and for the temperature measurement -30 - +80°C with absolute error ± 2°C. For the measurements, two-rods TDR laboratory sensors were used. The measurement of moisture content was done on calcium silicate samples having dimensions of 40/40/100 mm. Within the experiments, the TDR sensors were placed into the particular samples and sealed by silica gel. Since the material is rather soft, the sensors were placed into the samples by simple impress. The samples were partially saturated by water and insulated to prevent water evaporation from the studied samples. The relative permittivity of wet samples was then continuously monitored until the measured data reached the constant value. Then, the experiment was interrupted, sensors removed from the samples and moisture content in the samples was determined using gravimetric method. In this way, the empirical calibration curve of calcium silicate material was obtained. Simultaneously with calibration for pure distilled water, the experiments were done also for penetration for 0.1 M and 0.01 M NaCl water solution. These experiments were done in order to access the influence of salt concentration on the accuracy and reliability of obtained calibration curve.

The obtained results indicate the high dependence of calcium silicate relative permittivity on moisture content rising. The value of measured relative permittivity of dry material is 1.5, whereas in moisture content close to the maximum water saturation the relative permittivity reached value of 44. From the point of view of the effect of salt concentration on the accuracy and reproducibility of the obtained TDR data, the measured results validated the applicability of high frequency microwave methods for moisture content measurement even in the case of salt ions presence. This finding represents valuable information for building practice and research, where the reliable and precise method for moisture measurement is needed.

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Thermal laser treatment of selected materials

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It is generally accepted that laser surface treatment can be used for improving the materials properties of metallic alloys.This work deals with laser thermal treatment of selected metal materials and focus on changes in hardness after surface hardening of tool steel and structural steel. It also deals with optimal laser set-up parameters to achieve required properties after this type of heat treatment. Different set-up parameters of laser beam (like beam focus, feeding speed, etc.) were used during experimental works and than hardness measurement was made with optimal set-up for verification of reproducibility.

Two different materials, with different properties and purposes were used for experiments. First material was spring Si-Cr steel 54SiCr6 (CSN 14 260). Initial material was hot rolled rod, with hardness HV200. Second material was highly alloyed Cr Steel X210Cr12 (CSN 19 436). Made from hot rolled rod with hardness HV 220. Solid-state Nd:YAG laser, with maximal power output 550 W was used. Samples were wiped and degreased with ethanol before laser treatment. This way prepared sample was exposed to laser beam. Than the most suitable part for metallographic analysis was cut off form the primal sample and flood into Dentrakryl in order to allow grinding and etching of the sample.

The examples, which hardness was too close or to far to tabled data and which was the most suitable for finding optimal laser set-up data was taken after hardening, udder more detailed inspection. Like appropriate table value was considered surface temperature of the hardened sample. Like variables during experiment was taken feeding speed and beam focus. Temperature of the samples was scanned by thermocamera and evaluated by specialized software. Mechanical property, which is evaluated in this thesis is the microhardness, evaluated by Vickers method (CSN EN ISO 6507-7).

From obtained metallographic analysis results and microhardness measurements can be confirmed, that feeding speed and beam focus have big influence on surface temperature, hardness and depth of hardened layer. Too high temperature was achieved in surface layer during experiments with low feeding speed, what leads to surface melting and to influence in hardness of the hardening zone. Microhardness in this samples is not distribute equally in direction from surface layer to inner layers, but in this case the maximal hardness is achieved in depths 0,4 – 0,6 mm.

By using higher feeding speeds is the material insufficiently thermally treated. That leads to poorly hardened material. Hardening zone is too small and it's hardness is low. It was found, beam focusing had big influence to hardened layer and it's hardness. High surface temperature was achieved by lower beam focus even by higher feeding speed. This results

leads to values of optimal set-up of solid-state Nd:YAG laser with output power 550 W. Achieved experimental results, which were verified by repeating, are considered fully satisfactory for surface hardening of structural and tool steels and confirm the possibility of using this type of laser for surface treatment.

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Non-destructive testing high temperature hydrogen attack

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Hydrogen attack

The hydrogen attack (HA) is damaging mechanism, which is making problems in refinery industry, energetic industry and before welding (TOZ). The material after damages have changed structures, defect, and lower mechanical properties. The periodic of changes is relatively low. This change is able because limiting state.
The detection of hydrogen damage prevents economic and ecologic lost. Purpose this article was a recherché and chooses useful diagnostic method.

Mechanism of hydrogen attack

The hydrogen atom is significantly smaller than its molecule. It can diffuse into a carbon steels, readily. Dissociating atom is catched in interstitial positions and cavity. High temperatures and partial pressures accelerate this reaction. At temperatures above about 210 Celsius degree, atomic hydrogen re-dissociates into the molecular. Molecular hydrogen cannot diffuse out, because this atomic diameter is highest, than is crystal lattice of steel. One of the forms of damage attack is surface decarburization and internal decarburization and fissuring.
The hydrogen attack makes problems in refinery industry, when a carbonic medium have pressure about 20 MPa and minimal temperature 810 K. The phenomenon is calling High Temperature Hydrogen Attack (HTHA).

Detection

Most often used method is the non-destructive technology, ultrasonic and eddy current technology. Ultrasonic method based on backscatter and velocity ratio measurement, advanced ultrasonic backscatter techniques (AUBT) and method based on TOFD [2]. The frequencies for measurement are 5-8 MHz [2][3]. More information about this see [1].

The experimental part was presented in my bachelor work [4]. The sample was the part of machinery originally used in the hydrocarbon equipment under highest temperature and pressure. The material of tubes was Ni super alloy with composition:

Ni 35% , Cr 26%, Si 1,5% , Mn 0,5 %, Nb 1,5% and rest Fe

The experimental equipment was based on backscatter and echo. This thesis was assumption from experimental work. Surface roughness is insignificant on account of thickness (20 millimeters). Effect of geometry was minimal small sound with diameter 5 millimeters. Successive, we used metallographic. An echo before degradation was not taken, at all.

Conclusion

The cast austenite structures had high attenuation limiting was detection. The material had stationary size of grain with carbide network. The attenuation wasn't changing this factor. Some of grain content more carbide than other. This factor influenced attention. Only first echo was detected, thus it wasn't be a routine elevation attention. Significant was a curve of echo. The appropriate frequency was determined 5 MHz with small sound. Essential for detection was course of attention. Our course pointed a damaged structure. Kind of damage maybe deduce from machinery on-load.

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CZECH TECHNICAL UNIVERSITY IN PRAGUE

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The aim of the conference 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

PIV Measurement Inside the Elastic Tube during its Collapse

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Flow through elastic tube has been investigated in numerous papers [1-3]. Some papers deal with this subject experimentally [4], others by numerical simulations [2]. The possibility of Particle Image Velocimetry (PIV) measurement within elastic tubes in regimes with small wall deformations has been verified by the author's previous studies.

The aim of this paper was to construct an experimental setup that enables to measure by PIV method also in cases of collapsed tubes. A measuring box in which it is possible to change the pressure was made. The pressure inside the box is being changed by the up and down move of a vessel connected with the box. The pressure inside the box is determined by the height of water level in the moving vessel. The measuring box lives up to the requirements of the optical measuring method. It is made of plexiglass, firstly to make the illumination of the model in the plane by a laser sheet possible and secondly to enable capturing of images of the flow field by hi-speed camera from the perpendicular direction.

The character of flow is determined by conditions at inlet and outlet of a tube and also by transmural pressure at a tube wall. The measuring box was mounted into the experimental setup that enables to feed stationary and non-stationary flow rate at inlet and to determine the pressure inside the tube. This overall experimental setup enables us to change the transmural pressure and allows measuring wide range of flow regimes.

Measuring by PIV method in tubes with moving boundaries differs from measuring in rigid models not only by conditions of image capturing, but also by image processing. The standard masking, where the particle displacement in fixed area of every image is analyzed, cannot be used. The tube walls have to be identified in each double-frame. The easiest way to do this is to compare light intensity in a few picture profiles. The light signal of the wall has different peak width from the peak width of the particle signal. In every picture one can make a few light intensity profiles and identify wide peaks, which are in agreement with the position of the wall. The frequency (temporal as well as spatial) of light signal of the wall is also significantly lower than the frequency of the particle signal. If the tube wall is properly identified in the set of images, the whole wall movement can be evaluated.

The complete experimental setup is designed to simulate Starling resistor [3]. Starling resistor is a device which consists of an elastic fluid-filled collapsible tube mounted inside a chamber also filled with fluid. Starling resistor for specific pressure relations at inlet and outlet of a tube keeps linear dependence of a volume rate on the pressure difference. However, if the pressure at output is reduced further, the flow rate becomes independent on it. The flow is not stationary in regimes when Starling resistor puts limits on a flow rate independently on the pressure difference. If the velocity inside the tube increases, the pressure decreases, which

creates the cross-section decrease as well and hereby the velocity increases further. If the tube closes up completely as a consequence of continual cross-section shrinking, the flow stops and the pressure suddenly increases. This pressure rise opens the entire tube cross-section and the whole process repeats periodically. Starling resistor generates two non-linear characteristics: the flow rate independent on downstream pressure and self-excited tube oscillations.

This phenomenon is described by Bernoulli's equation and others one-dimensional mathematical models. In the past, some papers investigated the flow field behind (downstream) Starling resistor and these measurements have shown the influence of pulsating elastic element on velocity profiles. Only a measurement directly inside the elastic tube during the periodical process reveals the multi-dimensional flow, the creation of eddies and backflow. The Digital Ultrasound Speckle Image Velocimetry (DUSIV) was used by Hickerson [4] to capture wall moving, but velocity profiles weren't evaluated simultaneously. The PIV method with wall movement identification appears to be a functional tool for the study of this phenomenon.

This paper presents the results of flow regime measurement, when stationary flow through the elastic tube is influenced by increase and decrease of outer pressure. This pressure rising has half-sinusoidal character and produces one collapse of the elastic tube. Wall displacement, cross-section change and velocity field inside the tube within this collapse were evaluated. The flow visualization shows eddies and velocity field calculated from particle displacement indicates also the radial velocity.

The results of this sort of measurement are useful for study of non-stationary phenomena and interaction between fluid and elastic boundary. Interaction between fluid and elastic boundary is important for validating transport and accumulation of energy. These insights can be used to design non-conventional pumping mechanism (the impedance pump), hydraulic shock absorbers and pipeline control elements.

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Section 7

MECHANICAL ENGINEERING

The Influence of Conventional Welding Methods to Heat-Treatable Aluminium Alloys Type 6xxx

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The paper deal with results of research of several conventional welding methods influence to aluminium alloy EN AW 6082. It was examined most common and most widely used welding methods, used for aluminium alloys welding. It is about methods of arc welding in shielding gas – MIG and TIG methods.

Firstly it was necessary to explore and map dissimilarities and problems, which rise at welding of heat-treatable aluminium alloys, as is creation of oxidic coat on basic material surface, porosity in weld metal, hot cracks and drop of mechanical properties owing to welding thermal regime.

Furthermore it was solved the choice of suitable filler material, whereby it can be possible to obtain optimal (the best) mechanical properties of weld join and the favourable influence on hot cracks and porosity. There are different sorts of currently (commercially) reasonable filler material which were examined experimentally. The best results were embodying by filler materials with major content Mg and addition Zr – typically AlMg4,5MnZr.

There was made samples of butt "I" welds on sheet metal about 3 mm thickness at position PA. All of experiments was provided by modern welding sources (namely both manually and by robot, or more precisely automatically) in new Laboratory for education of welding technologies on CTU in Prague, which was opened on year-end 2008. Samples were judged by current destructive and no-destructive methods of weld joins test and further both from stand-point of structure (metallographic tests), and from stand-point of mechanical properties.

Because of heat-treatable aluminium alloys series 6xxx (between which belongs frequently used alloy EN AW 6082 also) they are very sensitive to heating-up and during welding cycle they are easy governed by un-strengthening processes, there was examined also thermal loading of parent material and weld joins owing to several welding methods. There were thermo-electrically measured maximum values of temperature in the neighborhood of rising weld join and mapped thermal field. From this stand-point is much preferable welding by MIG method at higher welding speeds (automatically). This is the reason why is manual welding TIG method recommended to the max thickness c. 6 mm.

Further there were experimentally evaluated also repairs possibilities of these weld joins, by mentioned welding methods. There were made samples, which simulated repairs of weld joins and after multiple thermal effect of welding cycle there were re- evaluated strength properties of these samples, hardness behaviour and structural transformation. This eminently contributed to determination of repaired weld joins service life.

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Surface Integrity and Tribological Behaviour of Guide Gibs

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Modern development in materials' strength, improvement of testing methods of material sciences, as well as work experience with operation of machine parts proved that the surface layer often has the predominant impact on their service life and operation reliability. Intensifying of machining process accompanied by higher cutting speeds results in considerable thermal effects and, thus, in higher residual stresses generated in surface layers of machine parts. In consequence, inner volume of components gets mechanical and physical characteristics that are different than those of the treated surface. Knowledge of surface state and structure is principal for understanding various surface-related processes as well as for surface quality assessment. The complex of characteristics describing influence of surface layer on operation properties is recently known as "surface integrity". Since surface roughness (microgeometry) and hardness are the most frequently analysed features of surface layers, residual stresses (RS) are examined rarely. However, macroscopic residual stresses and microstrains are surface characteristics that predetermine such attributes like wear, corrosion and fatigue resistance, susceptibility to crack propagation and service life of the object [1, 2].

The process of wear and friction results in both geometrical and structural changes in the surfaces of the mating bodies. These changes will influence future contact conditions and friction and wear generated in the same contact. At the nanoscale outer surface atoms are released and they react chemically with adjacent atoms, at the microscale cracks are initiated and debris released and at the macroscale wear products are agglomerated and surface layers formed and deformed. The initiation of cracks at the surface or in the material is the starting point of a process that may result in material detachment, debris generation and the formation of transfer layers [3].

Tribological tests are used to analyse friction and wear. The pin-on-disc test is extensively used method for measuring the friction and wear properties of dry or lubricated surfaces of bulk materials and coatings-substrate systems under selected load, speed and temperature. In a typical pin-on-disc experiment, the coefficient of friction is continuously monitored as wear occurs and the material removal is determined by weighing and/or measuring the profile of the resulting wear track. The operating conditions can be set to simulate, as precisely as possible, those in a working process.

Surface layers of three areas of guide gibs were investigated. Each of two parts of guide gibs from steel ČSN 14100.3 (59 – 61 HRC) which were embeded into a cast iron bed (ČSN 422425).

Side milling was carried out by using tool tips from three manufacturers, i.e. *Sandvik* (SA2, SA3), *Seco* (SE2, SE3) and *Walter* (WA2, WA3) [4]. The table 1 includes working and cutting parameters of applied milling where a_p [mm] is depth of cut, n – number of cuts, d [min] – tool´s diameter and f [mm·min^{-1}] – shift, v_c [m·min^{-1}] is cutting speed, and f_z [mm] – feed per tooth.

The measurements of residual stresses were performed on an θ/θ goniometer X´Pert

PRO with *CrKα* radiation. The diffraction line {*211*} of *α-Fe* phase was analysed. The $sin^2\psi$ method [1] with nine different tilt angles ψ was used. The X-ray elastic constants $\frac{1}{2}s_2 = 5.76 \cdot 10^{-6}$ MPa^{-1}, $-s_1 = 1.25 \cdot 10^{-6}$ MPa^{-1} were used in macroscopic stress calculations.

Tab. 1 Working and cutting conditions for investigated surfaces

Sample	a_p	n	d	f	v_c	f_z
SA2	0.5	4	100	570	300	0.10
SA3	0.3	7				
SE2	0.5	3	63	1050	350	0.10
SE3	0.3	7				
WA2	0.5	3	160	500	60	0.17
WA3	0.3	7				

The single line Voigt function method was applied for corrections of instrumental broadening and determination of microstrains and particle size. The microstress σ^{micro} could be calculated from the microstrains e using Hooke's law ($\sigma = e\,E$) with the Young modulus E = 216 GPa in order to be comparable with macroscopic residual stress.

The measurement of friction coefficient was realised by *CSM High Temperature Tribometer*. Specimens' surfaces after pin-on-disc test were observed by light microscopy and scanning electron microscopy. The friction tests were performed with two different layouts using a "polymer"cylinder with diameter 5.5 mm. The tests were carried out using a 2N constant load with 5,000 laps at room temperature.

The achieved results facilitate following main conclusions:

All the analysed characteristics of surface integrity are found to be homogeneous in the frame of performed investigations.

Decrease of the tool's diameter and thus increase of the cutting speed leads to temperature increase during milling and consequently to a qualitative change of the state of macroscopic residual stresses, i.e. high isotropic compressive RS of samples WA convert to anisotropic tensile RS in the case of samples SE3.

Increasing cutting speed leads to rise in temperature on the cutting zone which results in decrease of measured microhardness.

The change of the cut depth from 0.3 to 0.5 mm does not have any impact on the surfaced microgeometry expressed by Ra.

The high roughness (WA) doesn't negatively influence friction coefficient. In this case low roughness (SE) leads to high friction coefficient.

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The Influence of Duplex Coating to Tool Steels Characteristics

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The paper deal with results of research of influence of duplex coating to characteristics of tool steels and theirs service life also.

The requirements for materials used in the machine parts production, especially their functional characteristics and service life are increasing at present. The need of strength, ductility and toughness on the one hand and low weight, corrosion and wear resistance on the other hand, are often contradictory and with standard materials hardly realizable. Suitable solution of this formidable situation appears a surface treatment, which can create the coating with special properties mentioned above. The example is a die, which keeps basic material characteristics and thanks to coating functional properties of its surface get improved. In this case there is a problem of cracking of the coating when overloaded. Very hard and abrasion-resistant coating is applied on softer base material. The substrate is able to deform in an elastic or plastic way on load, but the brittle coating cracks. That leads to intensive wear of coating and as a result of the die, too. The strengthening of substrate surface layers, e.g. by plasma nitriding, appears to be a suitable solution of the low strength of substrate. On the nitrided surface there is applied relevant PVD coating with required properties.

Material used for nitriding is low-alloyed steel 31CrMoV9 (ČSN 15 330). The specimens prepared from this steel were quenched, tempered, pulse plasma nitrided and subsequently lapped. Nitriding was made at the temperature of 540°C for a period of 20 hours in atmosphere N_2:H_2 = 3:1. Heat-treated and plasma nitrided specimens were PVD coated in the HAUSER coating equipment (low-voltage arc). There were used several PVD coatings - TiN, CrN, TiAlN, 3x(CrN-TiN)). Their thicknesses were about 2,5µm. The coating thickness was measured with Calotest and coating adhesion on substrate was classificated by scratch-test.

There was measured both microhardness (load 1kg) and nanohardness (in cooperation with ZCU in Plzeň) on all the samples. The samples were tested on tribometer „pin-on-disk" then. The tests were carried at temperatures of 22°C and 250°C, under the load of 1, 2 and 5N. The samples were tested in dry conditions. The recorded friction coefficient values were processed by programme OriginLab®.

The experimental results showed that during testing of the duplex treated steel with different PVD coatings the friction coefficients increased. The mechanism of deterioration of the duplex treated steel is a combination of adhesive and abrasive wear. The adhesive wear took place on the disk during experiment while ball was worn down abrasively. The evidence of abrasive wear can be seen on grooves created on the ball during experiment.

The conclusion drawn from our experiment is, that duplex treatment is a useful way how to increase the die service life and that the most suitable coating is PVD coating TiN. This coating in combination with nitrided substrate had a low friction coefficient and a small wear.

As far as the coating hardness is concerned the most favourable process shows coating CrN and multilayer coating 3x(TiN-CrN) for microhardness-depth under surface. But in respect to measurement results of the friction coefficient and the wear we can see, that

hardness course on nitride surface is slow enough and it doesn´t reach a coating cracking also when coatings TiN and TiAlN are used. On the contrary, these coatings embody better service life and friction coefficient.

Current thin abrasion-resistant surface layers and coating achieve remarkable service life extension and reliability of machine parts and dies. Most of technologies have not managed to reach the limits of their possibilities so far.

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Problems of Self-Excited Vibrations During Milling Process

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Introduction

Self-excited vibration (chatter) presents one of the limits of machining productivity. It could occur in any machining operation. At certain removal rate, the tool or work piece starts to vibrate violently, the noise increases and there is a significant deterioration of surface roughness. The stable cutting suddenly becomes unstable. Machining under chatter conditions is impossible in relation to surface roughness and life expectancy of tool or machine tool. Dramatic change from stable to unstable cutting is connected with an increase in the axial depth of cut above the limit value.

The fundamentals of the theory of self-excited vibration and application to milling process are described in [1, 2]. The findings were extensively applied in [3]. The theory allows us to draw the stability diagram, which divides stable cutting conditions from unstable ones. It is dependency of axial depth of cut on spindle speed. The diagram shows regions (gaps) where the depth of cut could be higher than elsewhere. Diagram provides essential information utilizable in machine tool design or in setting optimal cutting conditions.

Simplified Assumptions

The original theory was design for turning. Milling application requires a number of simplified assumptions. Milling features are significantly different from turning: interrupted cut, changes in chip thickness during cutting, changes in the direction of cutting force during the cut and also differences between up and down milling. There are other differences like more than one tooth in cut. The aim of the project was to determine the effect of the simplifications on stability limit. Some of the simplified assumptions were removed. Then, the results of simulation and experiment were compared.

First of all, the simulation results sensitivity on input parameter was examined. The dynamic compliance of tool – machine tool system and directional factors proved the most significant. They had an effect on gaps shape and on the position in the stability diagram. A modification of the specific cutting force produced just a vertical shift of the whole stability diagram. A removal of the simplifications, thus considering of the milling features had the following effects. The variable directional factors (depended on both the cutting force and surface normal directions) produced the most significant change in the simulation results. There were both horizontal and vertical shifts of the gaps in the stability diagram. Considering the interrupted cut and changes in chip thickness during cutting produced just a vertical shift of the whole stability diagram. Running direction of tool (up and down milling) and the number of teeth in cut have effect on the directional factors and thus the final stability

diagram. Whether they affect something else remains unclear. Simulation did not help to determine the effect of tool helix; it remains unclear, too.

Experimental Confirmation

The machining test had the following course. First of all, the dynamic compliance of tool – machine tool system was measured by METAL MAX device. Then, the slots were machined in to wedge-shaped a workpiece. Wedge-shaped workpiece produce a gradual increase of axial depth of cut. So chatter arose in a certain moment. The occurrence of chatter is visible on both machined surface and sound record. Each slot was machined with a different spindle speed, so chatter rose at different a moment by a different depth of cut. So the stability diagram was created in an experimental way. During machining, the sound was recorded for chatter identification and for finding a chatter frequency. Workpiece was clamped on dynamometer which measured cutting forces. So we could determine specific cutting force more precisely.

During experimental machining, two-edged tools were used. This eliminated the possibility of more than one tooth in cut. Special tools without helix were used. Feed per tooth was constant during the whole experimental test. This eliminated the possible influence of some milling features on the final stability diagram. The repeatability of measurement of the stability limit was tested too. The repeatability proved to be affected by the duration of spindle running.

Conclusion

The experimental confirmation shows that both the simulation in time domain and the calculation in frequency domain get similarly inaccurate results. In comparison with the experimental results, the gaps in the stability diagram were shifted in a horizontal and a vertical direction. An advantage of a simulation in time domain is a possibility of easy modification of the model. Then, the results' sensitivity to changes can be tested. The tested sensitivity of the results on the input parameters and the milling features did not explain the differences in the results of the simulation and the experiment. Thus, it will be necessary to make another modification of the milling model. The cause of the differences may dwell in the fact that we are not able to measure the operating dynamic compliance.

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Torque Ripple of Permanent Magnet Synchronous Torque Motor

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The main requirements imposed on NC machine tools feed drive axis are high precision positioning and high dynamics. Important prerequisites for achieving these contradictory requirements are stiff and lightweight design of feed drive axis. The resulting dynamics and precision of NC machine tool feed drive axis is naturally significantly influenced by accuracy of feed drive axis mechanism, motor and feedback encoder. The contribution is focused on irregular motion of NC machine tool rotary feed drive axis with permanent magnets synchronous torque motor (PMSM), which is used to direct drives of NC machine tool rotary feed drive axis as rotary tables and carousels.

Irregular motion of PMSM is caused by its torque variation (torque ripple). Subsequently, it causes variations in speed and position of feed drive axis. This effect negatively affects the resulting accuracy of machining and surface roughness of workpiece. Torque ripple of PMSM is caused by effects resulting from the imperfect motor geometry and effects resulting from the inaccuracies of its regulation. Imperfections of the motor geometry (especially the shape and number of motor poles) cause variation of comutation angle and varying distribution of magnetic flux density around the air gap. This can be seen as fluctuations in torque (power), constant of the engine. Inaccuracies associated with the regulation are mainly given by the features of the feedback sensors which bring the information into the inputs of feedback circuits. Due to the high feedback gain of controllers at the inputs of the feedback circuit, are measured inaccuracies highlighted. The resulting inaccuracy is also influenced by assembly precision of feedback encoder and combination of different encoders for different functions in feedback loops (e.g. using one common feedback encoder for commutation, speed feedback and position feedback or using different feedback encoders for different feedbacks). Other inaccuracies are caused by kinematic deviations of the feed drive transmission mechanisms and by vibrations of mechanical structure of machine tool. These influences are presented in [1] and [4].

Further attention is focused on reluctance torque of PMSM which is called cogging. PMSM stator consists of steel poles carrying the windings. The permanent magnets with a constant magnetic flux are fixed on the rotor of PMSM. Surrounding around the air gap is thus a variable magnetic resistance, because there cycled steel poles carrying a winding with air gaps between the poles. Cogging - fluctuations in torque resulting from the transition of the rotor magnet poles through the steel stator poles (rotor permanent magnet is trying to attract a steel stator poles). This negative feature is significant in direct drives with rotary or linear motors. Especially for motors with a high numbers of poles (torque motors) working at low rotational speeds may oscillations excited by cogging lies within bandwidths of control loops

and consequently degrade the precision of machining. For improving the accuracy of machining is therefore important to suppress cogging. Suppression of cogging can be achieved by suitable design of the motor or by appropriate modification of motor control algorithm. The most common construction of motor modifications for the purpose of suppressing torque ripple are poles shape optimization, selection of the appropriate ratio of between the number of stator and rotor poles (misalignment between stator and rotor poles), skewing of stator poles, optimization of the air gap dimension, etc., for more detail see [2]. These ways lead to a constant distribution of the magnetic resistance around the air gap and thus to suppress cogging. These arrangements reduce the torque ripple, but also often reduce the torque (or forces respectively). The resulting motor design is a compromise between its accuracy and torque (or force respectively).

The aim of the research is to find a method to compensate cogging using compensation signal which can be added into the cascade control of PMSM. For easy applicability in machine tool industry the method must respect possibilities of commercial NC machine tool control systems. This research work is carried out on laboratory experimental test-bed with permanent magnet synchronous motor. Key factors of the experimental test-bed approach to the properties of real rotary table. Due to the high moment of inertia of PMSM and negligible damping in the bearing, experimental test-bed could be considered as a one-mass undamped system. For debugging of compensation method was created in Matlab-Simulink simulation model of a PMSM with its usual cascade control structure. This cascade control consists of three loops, the most subordinated current loop, superior speed loop and positional loop. Cogging of PMSM has been added into this model in the form of a fault signal containing harmonic components related to the number of poles of stator and rotor. This signal was constructed using measured current and speed irregularity of PMSM. Individual harmonic components of measured signal were obtained using the fast Fourier transform (FFT) algorithm. These components were also used for the calculation of additional current signals for compensation of cogging. Compensating signals were calculated for different rotational speeds and were stored in compensation table. Using the current compensation signal as additional signal in current control loop was achieved a significant reduction of amplitudes of harmonic components caused by cogging. Now, the laboratorial equipment and software for the experimental verification of the chosen method are prepared.

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Experimental and Computational Analyses Mechanisms and Driving Strings

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There is a research and development of belt conveyor in the project MPO. The company Strojírny Podzimek and Faculty of Mechanical Engineering, CTU in Prague participate.

New theoretical methods and analysis models require experimental verification. There is a detailed research of behavior of belt conveyors in laboratory of CTU. This research runs in parallel in two branches. The first branch is focused on actuating part. It contains a propel motor, gear-box, drums, rollers, tension element, wipers, side guide, resistance of transported material and all components that counteract during transportation. The second branch is dealing with supporting construction. Optimization of construction comes out of wide finite element method computations, and the results are verified by analytic way and mostly experimentally by strain gauge.

There is a laboratory sectional station developed for measurement, which provides mapping of influence and behavior of each individual component in mechanism of belt conveyor, thanks to its structure. Resistance is simulated by a brake motor, which is of the same type as a propel motor. The laboratory station uses pair of identical drives and it is designed as electrically closed loop. So it has propel and brake electromotor, where the brake motor works at generation mode, and it is electrically connected to the propel motor. Energy is taken from the network to compensate losses. The whole circuit is regulated by moment feedback.

First we had to find out real loading of belt conveyors to ensure, that the laboratory results had a sufficient predicative property. The measurement was in the premises of Strojírny Podzimek where measurement station was put together. It contained three belt conveyors and one buffer stocker (hopper with belt feeder). Conveyors with feeder were putted together in closed loop, so there was a “infinite” material flow. During the measurement common operational and extreme conditions were simulated those which can happen during real operation. During these measurements load spectrum was scanned acting on drive of conveyors and hopper with a feeder. All that dependent on the volume of material flow, which was regulated by outlet of hopper.

These load diagrams allow us to simulate real conditions in the laboratory in modular station. Thanks to this simulation we are also able to measure precisely all individual components of mechanism in the way we couldn’t do in real conditions. This partial division is necessary for the quality of description of behavior of the mechanism as a whole. Further on it provides good comparison of new construction solutions, which are also examined.

Permanent increase of requirements on material transport is wholly reflected at design of new transport machines and devices. These requirements stimulate producers to search new

ways for improvement of operating parameters and optimization design solution of such appliances.

Solved project has been based on cooperation of Podzimek Machine-Works with Czech Technical University in Prague, Faculty of Mechanical Engineering. This cooperation has been focused on design improvements of transport device, especially in case of bend conveyor and bridge span parts. This research has been aimed at optimizing of transferred power and structure parameters of transport devices.

Structure robustness of transport devices is very often over-dimensioned from viewpoint of real operating conditions. It is usually caused by existence of any probable extreme work conditions during time of operation. These conditions has not been described and charted yet totally. However, devices must resist to them.

We have described by testing of transport devices some of these conditions and achieved important load characteristics, which are then used for simulation at lab conditions and partial measurements substituting real work of transport devices. In such way impurities of surrounding were eliminated and measuring hardware was able to use.

Optimization of the transport device structure has been solved with use of FEM system. Results of this method must be further checked with help of analytical way and first of all especially verified by means of experimental testing with use of tensometric measurement of real device. We have achieved also positive results in case of bridge span constructions at their weight reduction and not reduced loading capacity.

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Applications of FEM to Optimizing of Machine Parts (Gears)

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It has been demonstrated in numerous papers [1-4] that the optimizing of machine parts (gears) is possible. This part of project describes the calculation method and the results of gears optimization with help of finite element method (FEM). This is the optimization of the shape geometry of gears with the help of finite element method with the using the longitudinal, transversal and angular modifications. Impact of changes in location and shapes of individual part of gearbox are included in this method. Better gear mesh is achieved by modification at more uniform load distribution through a width of tooth.

This part of project describes the problems changes in position and shape of gears in the gear mesh of the loads and methodology, which handle compensation for these negative phenomena. Application of the finite element method for the calculation of gearing with respect to real shapes of individual parts of the transmission system, can process of optimization gears mesh very accelerated. The results of the calculations are used to examination of changes in the gear mesh of the teeth flank under loads, particularly in term of more uniform load distribution through a width of tooth. The aim of methodology is design optimized profile gears with applications longitudinal and transverse modifications of gears on the basis of analysis calculation model with help of FEM [2]. The FEM results for the various options are compared on the basis of contact pressures. The part of project compares several variants.

The methodology of design modified gears is intentionally divided into several stages and component groups. The procedure for modeling and calculations come out from the possibility of partial separation of problems. Output parameters obtained in the previous step are used as input parameters for the next step, but also the results can be transferred back from a higher step to step lower, with the aim of optimizing the structure. In the first stage is made engineering design of complete the gearbox in 3D CAD system. In the second stage FEM calculations are made and the production of parts runs in parallel and their thorough measurements. CAD models are simplified and prepared in the program ABAQUS for FEM calculations. The components of the gear box, shaft and gearing are prepared in separate models. Models should be prepared for the possibility of parametric geometry changes, which could be later modified based on measurement. The model of gear box is loaded in points representing the intersection of the axis of the shaft and bearings radial symmetry axis through the reaction force. The calculation of the shape of gearing deformed by load is most complex part of the calculation. To determine optimized shape with help of constant contact pressures method is necessary to prepare a model for the role of the contact problem by entering torsion moments and the imposition of the gearing position after taking the deviations and deformations. On the basis of results obtained in the previous stage runs FEM calculation of gearing with the change in the model. The goal of the fourth stage is to establish a definitive profile of gearing. Optimizing the shape of gearing is dealt with applications longitudinal and transverse modifications. Their impact is validated calculation of FEM.

Currently is starting the work on second part of the project. This part of project deals with optimization of the gearbox on the basis of dynamic effects by using the FEM.

Methodology itself is not completely resolved yet. This will be applied to transmissions for rail transport. On the basis of specific input parameters could be to optimize the whole gear and not just a performance but also weight.

Mean of achieving the final (modified) shape of the gearing based on the prescribing habits of transverse and longitudinal modifications, while it is necessary to bring as much as possible optimized shape. Another option is comparison with comprehensively addressed role of contact program FEM as whole group in one step. Results from the application of the methodology: The calculations of the modifications with help of the finite element method confirmed the applicability in the design of longitudinal and transverse modifications.

Already the first step where are calculated deformation of the gearbox and shafts, provided important results for the design of angular modification. By summing the calculated deviations of deformations, manufactured deviations from the ideal shape of the bearing and clearances is calculated final position from which can be easily calculated the angle modification. This has a decisive influence on the life of gears.

When creating FEM models for the contact problem, there were no problems, but during debugging and the FEM calculations was a problem with hardware computing power. To improve the output data, the refinement and clarification, the submodel is being optimized. The other problem was revealed in the creation of local maxima in the nodes of mesh during the edge in the session, which occurs on the sides of gear mesh line. For this reason it was not possible to consider the values that were higher than 2000 MPa, but focus on the trend. This lack will be remedied in future by chamfer of the tooth edges.

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Automated Laboratory Workplace for Research of Engineering Equipment Drives

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Bought equipment supported measuring on these three test stands.

1. Test Stand for Pitting Measurement

On test stand for pitting measurement is used Niemann's back-to-back circuit which is less energy demanding than open-loop. Testing circuit consists of measuring and additional gearboxes, driving electromotor, loading equipment, and sensors of torque, rotational speed and temperature.

Testing conditions of gearwheels and its assembly should be similar as actual operational conditions. By reason of test time shortening it is necessary to select larger torque in closed-loop circuit than in industrial operation. In our case, we are limited by torque sensor in circuit up to 800 Nm. Testing is mostly running on one load level because of better possibility of result comparing.

Power losses and virtual power in circuit during running are recorded by one rotational speed sensors and two torque sensors. There is no attendance during the operation and so an overload safety is needed. Torque sensors are mechanically secured against overload. Tooth root break can arise during testing of tooth bending fatigue and the inertia moment can exceed the torque sensor permissible overload during unexpected gear block. Maximal overload is 150 % of nominal torque.

Process of gearwheel load is opportunely characterized by the torque and rotation speed in the time. To control of these actions the automation is needed. For controlling of rotation speed, we used frequency converter which is controlled by software. Measuring of torque, rotational speed, temperatures and oil pressure can be placed in to group of global values.

The torque scanning between electromotor and additional gearbox is used for determining the whole circuit efficiency. This value corresponds to losses in gear assembly, bearings, coupling, etc. Eight thermocouples are attached on testing stand. Three of them are used for measurement of oil temperature in the input and output. The rest of thermocouples are fixed near the bearings.

Measured data are processed by software and shown on a control panel screen and saved into measurement file. Software also assesses adjusted value limits and in case of its overrun stops test processing. A lot of important information of tested gearwheels is possible to obtain from measured data.

In recent it's presumed to apply spectral vibration analysis as one of the main indicator of pitting progress. Generated vibrations in testing gear meshing are transferred through the shaft and bearings to the gearbox and they are measured on outer surfaces. Analyzer can be started by software.

During measurement are taken photographs and then are evaluated via developed software which assesses pixels with big contrast as damaged, carry out the summation of damaged and undamaged pixels. If the whole gearwheel is captured and processed by the software, the database is ready to determinate pitting evaluation. Except image load and crop

window specifying, all software steps are automated. Thereby the processing ensures the permanent quality results which may be graphical supervised by operator.

The main supervised output values are total pitting damaged area on one tooth and on whole gear. Those are demanded for lifetime determination. In DIN 3990 standard, the determined value for one tooth is 4% surface failure of tooth area on one tooth and 1% on whole gear.

The goal of this measurement is to find out which coating is best for tooth flank in term of pitting.

2. Test Stand for Elastic Coupling Measurement

There are measured characteristics of elastic couplings like static and dynamic torsion stiffness. The coupling is fixed in the test stand. Loading torque is brought into the coupling via hydraulic motor over lever of test stand. During static measurement of the coupling, software increase force of hydraulic motor by steps after certain time from minimal force to maximal force and back.

During dynamic measurement of the coupling, software creates pulsating load on the coupling with preset frequency.

In both measurements is force and angular position written in measurement file and then evaluated.

3. Test Stand for Conveyor Belt Measurement

There is a laboratory sectional station developed for measurement, which provides mapping of influence and behavior of each individual component in mechanism of belt conveyor, thanks to its structure. Resistance is simulated by a brake motor, which is of the same type as a propel motor. The laboratory station uses pair of identical drives and it is designed as electrically closed loop. So it has propel and brake electromotor, where the brake motor works at generation mode, and it is electrically connected to the propel motor. Energy is taken from the network to compensate losses. The whole circuit is regulated by moment feedback.

First we measured real load on conveyor belt and then we used these load diagrams allow us to simulate real conditions in the laboratory in modular station. Thanks to this simulation we are also able to measure precisely all individual components of mechanism in the way we couldn't do in real conditions. This partial division is necessary for the quality of description of behavior of the mechanism as a whole. Further on it provides good comparison of new construction solutions, which are also examined.

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Machinability of Titanium Alloys Using New Generation Cutting Tools.

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Machining of difficult-to-cut materials is currently solved in many industrial branches. These materials have usually very low heat conductivity, low elastic modulus and bad chip formation. All these factors cause strong inhomogeneous deformation in area of primary plastic deformation in front of the tool wedge and also strong wear of the cutting tool [1, 2]. Strong wear causes worsened surface integrity characteristics and increases energy consumption for machining. Main members of family difficult-to-cut materials are Ni or Ti based alloys and stainless steels. The most widely used difficult-to-cut material is Ti6Al4V titanium alloy (nearly 70 % titanium workpieces are made of this alloy). This alloy has low density (4430 $kg.m^{-3}$), high tensile strength (900 - 1000 MPa), high yield strength (800 - 900 MPa) and perfect corrosive resistance especially against chlorine. There are also unwanted properties of Ti6Al4V alloy, which have negative influence on machinability, especially low heat conductivity (7,56 $W.m^{-1}.K^{-1}$), low modul of elasticity (113 GPa) and hexagonal close-arranged crystal matrix [3].

The main task of this research was to investigate tool life of the new HSS tool generation during machining of difficult-to-cut Ti6Al4V alloy and determination micro-hardness course in relationship with cutting speed and coolant options. Solid cutting tools were used for the experiment. The tools had diameter 32 mm and four cutting edges with irregular pitch. Geometry of these tools was created especially for difficult-to-cut materials machining. Tools were mainly made of powder-metallurgy HSS in various material modifications (556 D1/N HSS Co Bohler, 557 D1/N ASP 2030 Erasteel, 558 D1/N CPM REX T15 a 559 D1/N CPM REX 76). All these tools were coated with nACRo nanocoating. This coating increases considerably tool life due to high thermal protection of cutting edge and low reactivity with machined material.

The experiments were provided on MCFV 5050 milling machine. Tool life was tested during cutting with cutting speeds 30, 40, 50 and 60 $m.min^{-1}$, 5 mm axial depth of cut, 1 mm radial depth of cut and feed per tooth 0.2 mm. Cutting speed 60 $m.min^{-1}$ was included because of testing nACRo coating as a thermal protection of cutting edge.

Tool life was analysed according to ISO 3665. First measurement was done at the moment allowing detection of transition an initial fast tool wear to the linear area. Next measurements were done in variable time sections so that the dependence of tool wear on time consisted of 7 measured points. Simultaneously with maximum tool flank wear average one was measured. Final tool wear graph was created as an average value of tool wear on all cutting edges. Machining tests of each tool were ended when maximum tool wear of any cutting edge reached value VB_{max} = 0,15 mm. Tool wear was measured on Mitutoyo TM 500 microscope with magnification of 30.

Tool 557 D1/N ASP 2030 Erasteel was tested with all cutting speeds (speeds 30, 40, 50 and 60 $m.min^{-1}$), 5 mm axial depth of cut, 1 mm radial depth of cut and feed per tooth 0.2 mm without coolant. From point of view material removal and ideal machine usage were chosen for other tools tests cutting speeds 40 a 50 $m.min^{-1}$. In the case of machining with the speed 40 $m.min^{-1}$ were reached tool life between 184 and 353 minutes. The longest tool life was determined in the case of 556 D1/N HSS Co Bohler tool. The shortest tool life was determined in the case of 557 D1/N ASP 2030 Erasteel. Tool life of ASP 2030 Erasteel used by cutting speed 40 $m.min^{-1}$ was 3 times shorter in comparison with a speed 30 $m.min^{-1}$ cutting speed.

Tool life during 50 $m.min^{-1}$ cutting tests reached values between 44,7 and 139 minutes. During machining with this cutting speed big influence of cutting temperature on tool life was appeared. The longest tool life was find out with 556 D1/N HSS Co Bohler tool (139 minutes), the shortest one with 557 D1/N ASP 2030 Erasteel (44,7 minutes of machining). Tool life of machining with cutting speed 50 $m.min^{-1}$ and 557 D1/N ASP 2030 Erasteel tool was 14 times shorter in comparison with cutting speed 30 $m.min^{-1}$. Considering tool material, cutting speed 40 $m.min^{-1}$ and 557 D1/N ASP 2030 Erasteel is recommended.

Micro-hardness and surface area hardening was analyzed from testing workpieces which had 0.7 degree chamfer. This chamfer allows the monitoring of micro-hardness from machined surface inward the workpiece. Micro-hardness of the workpiece chamfer was measured on Shimadzu HMV-2 gauge. Measurement was done according to the ČSN EN ISO 6507-1 standard. Optimum measuring force was determined on value F = 0,907 N, time of measurement was 10 seconds. The same cutting conditions as in the case of tool life testing were used. Moreover no coolant and flood cooling with oil emulsion were considered for machining.

There was not determined obvious influence of cutting speed (and coolant type) on micro-hardness of machined surface. Following tendencies were discovered. The highest micro-hardness was measured on machined surface (from 303 to 328 $HV_{0.1}$). With increasing depth of measurement the micro-hardness decreased, until the depth 0.1 mm was reached. Under this depth, the micro-hardness values were constant, without any apparent deviations. With increasing cutting speed the micro-hardness on machined surface increased too, due to higher heat-mechanical deformations. There was no obvious (none) coolant influence on surface micro-hardness.

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Mixing of Suspensions

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The problematic of particle suspension in mixing vessels examined in this work is a continuation of work done by authors in the past and widely published in a lot of their publications [1-3]. Necessity of widely examination of the problematic derives from the fact that industrial usage of mixing systems is very large and these systems are used in a lot of branches like food or chemical industry, ceramics or pharmaceutical industry, and other. Also, reason why this problematic is of great actuality is imperfection of mixing systems used in industry. High energy consumption and low quality of mixed products or of processes associated with mixing, induce the necessity of ample laboratory experiences in the problematic. This is also the reason why companies like Techmix Ltd specialized in mixing system designing appeal to scientists for examining of its products efficiency. In our case there are laboratory examined among other some hydrofoil agitators of above mentioned company. The goal of this project is to determine the suspension efficiency of different agitators in mixing of suspensions with different physical properties and determination of specifically power consumption, with ulterior recommendations for industrial design of mixing devices.

Within this project was examined suspension in mixing vessel by agitators with different physical properties of mixed suspension, composed by water suspension of glass spherical particles. The measurements was done in a range of 2,5 – 10 % volumetric concentration (c_v) of glass spherical particles and four dimensionless size of particles determined by the d_p/D ratio, where d_p is the equivalent diameter of particles and D the diameter of vessel. The measurements were done with standard agitators and hydrofoil agitators made by Techmix with their further determination of suspension characteristics and comparison of the pumping efficiency. Within this project was examined the suspension efficiency of pitched four-blade turbine with pitch angle 45º, pitched four-blade turbine with diagonally folded blades according to Czech standard CVS 69 1043 and three hydrofoil agitators made by Techmix Ltd.

Suspension measurements were done by using of already traditional, electrochemical method to determine of the just suspended impeller speed n_{cr}, which offer objective result of this criterion, combined with visual determination of this state. The electrochemical method is based on determining the value of electrical current between two electrodes, from which one (the probe), is embedded in specified places of the vessel bottom. In this work are used three probes, situated in points of the vessel bottom where is considered that the state of just suspended solid particles occur the latest. The measured current is proportional to the speed of the suspension near the probe, respectively at the bottom of the vessel and from this consideration the state of just suspended impeller speed could be established.

Concluding the above done measurements we obtain important information necessary for successful designing of impellers on industrial scale. The particles suspension in a mixing vessel is described by dependence of modified Froude number Fr' on d_p/D ratio respectively

on volumetric concentration c_v with ulterior establishing of power dependence of these parameters:

$$Fr' = f\left(\frac{d_p}{D}, c_v\right) \text{ and power dependence } Fr' = C_i\left(\frac{d_p}{D}\right)^{\gamma_i}$$

where C_i and γ_i express the suspension characteristics of agitators depending on volumetric concentration of solid phase and could be expressed in the form:

$$C_i = A_i \exp(B_i c_v) \text{ and } \gamma_i = \alpha_i + \beta_i c_v$$

where constants A_i, B_i, α_i, β_i depend on mixing system geometry, respectively on agitator's blades profile. A dependence between blade form, critical impeller speed and power consumption on the other hand was established.

This work is written to help designers to choose between alternative equipment arrangements, their energetic optimization and determination of just-suspended impeller speed and power consumption necessary for off-bottom suspension of solid phase.

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Audiovisual Support of the Experimental Measurement for the Lesson Learning

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Introduction

There was constructed a new roller rig in the Department of Automobiles, Internal Combustion Engines and Railway Vehicles. This device represents two-axle bogies of the railway vehicle installed on the reserve railway track pulley. This device is a technically interesting solution that is intended for research of the dynamics of the railway vehicles' running gears. Apart from the research work of teachers and PhD students, this device is used as a tool for teaching the undergraduate students within the scope of the subject Experimental Methods and Testing in Automotive Technology. The goal of this subject is to make the students acquaint with the different methods of measurement of physical values from the area of transport vehicles and combustion engines. Due to the project "Audiovisual Support of Teaching of Experimental Measurements for Increasing Safety of Students" that was realised under the support of the Higher Education Development Fund the quality of the teaching using the above mentioned device was moved on a new level.

The main project goals

The main goal of this project is the improvement of the quality of the teaching and increasing of the safety of the students during the measurements on the roller rig that is intended for simulation of the running of the railway vehicles. The main goal of the project can be summarized into following parts:

a) **Increase of the safety** – Observing of the bogie movement and the wheel-rail contact from the safe distance using the video camera and imaging technology.

b) **Improvement of the illustration** – The pictures from the video camera are during the measurement confronted real-time with the outputs from the sensors and shown using the data-projector on the large-area screen.

c) **Adding the noise level measurement to the device** – extension of the measurement with the constantly more observed issue of the development and operation of the railway vehicles.

Process and project solving

There is simulated the running of the two-axle bogies of the railway vehicle on the direct line with continuous speed acceleration using the roller rig. The students are acquainted with methods of measurement of physical quantities mainly from the area of running properties and stability of the railway vehicle running. From the values measured, the students have to calculate the length of the undulating movement, find out the critical velocities of the vehicle, and compare them with theoretical calculation. The next part of this exercise that is closely connected with the problem of the railway vehicles running is the noise measurement. Students are informed about the basic notions from acoustic that are directly connected with the measurement. The project started with schedule determination and allocation of the competences among the members of the project team. In May 2009, the sound analyser was

bought, including the software for noise measurement. In June 2009, the data-projector for projection of the fast crosses movements for increase of the teaching safety was bought. The large-area screen was bought. In October 2009, the video camera including the software for computer processing of the record was bought. Then all the works connected with the installation of all of these components to the testing device were realized. From the main components, the most complicated was to find the suitable video camera, objective, and software. After consideration of several possibilities, the solution that fulfilled all our requirements (resolution, frame rate, video camera dimensions, distance from the object recorded and the format of the data saved) was found. In October 2009, the engineering design of the wall dividing the roller rig from the students was prepared, data-projector holder and other small material were bought. Immediately after video camera was delivered, we installed it on the device, and designed and realized the lighting of the wheel-rail contact for the best possible display. The final completing of the device and preparation for the teaching was in harmony with the project schedule and run through without any problem in November 2009.

Conclusion

The project was finished according to the project plan and during the December 2009 the laboratory exercises of the subject Experimental Methods and Testing in Automotive Technology were successfully realized. The measurements happened without any problems with camera or imaging technology and all students were acquainted in detail with evaluation of the cross movements of the bogies, stability of their movements, and also with noise level measurement. They also tried to work with sound analyser. During the experiment, the students can now observe in real time the movements at the wheel-rail contact using the video camera and data-projector as well as the values measured by the displacement sensor. The direct observing of these processes was not possible until now, because of safety reasons, and students concluded them ex-post while processing the readings from sensors. Thanks to this project, the students are informed also about the noise measurement. During the lecture, the microphone and sound analyser is available to all students, and their operation is explained. Also, the notions as sound pressure, sound pressure level, weighted filter are explained to students at short. It is also explained to students, how to measure the noise level of the railway vehicles. Students learn how to work with sound analyser, and during the measurement, they read from the display of the analyser the dependence of the total sound pressure level values on the running velocity. In December 2009, there were 8 laboratory exercises with 58 students run through on this innovated device within the scope of the subject Experimental Methods and Testing in Automotive Technology.

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Temperature Sensors Calibrating Facilities

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Our team at the Department of Physics at the Faculty of Mechanical Engineering has been cooperating with the European Organization for Nuclear Research (CERN) for many years. One of the main activities is connected with designing and consequent test measurements on prototypes of special cooling devices for particle detectors [1, 2]. There is a need of temperature sensors calibration in these applications and a similar demand for precise temperature sensors has arisen during measurements dedicated to characteristics of gas-turbine units for cogeneration [3].

NTC and Pt1000 sensors connected by two wires and Pt100 sensors with four wires connection are mostly used. All the sensors, especially the NTC type, need to be carefully calibrated before their application.

In the presented study, we have prepared three different setups for temperature sensors calibration. The setups are based on three calibrating devices: *Metal Block Calibrator* (AST), *Dry Block Calibrator* (Ametek), and *Liquid Bath Calibrator* (CTB06). The calibrators differ by their cooling principles, sensors placement, and by the number of calibrated sensors at the same time with respect to the temperature precision. The cooling is ensured mostly by the Peltier cell or by a compressor vapor cooling circuit in the CTB06. The Peltier cells have limited temperature range. However, they can be easily controlled and they achieve quite good temperature stability. The vapor cooling circuits have high cooling power and they can, in general, operate at lower temperatures. On the other hand, it is more difficult to stabilize the temperature for calibration. The calibrating devices have following specification: *Metal Block Calibrator* – Peltier couples, RS232 interface, two metal cavities for inserts, declared range from -25°C up to +250°C with a stability better than 0.05°C; *Dry Block Calibrator* – dual block calibrator with RS232 interface, which can communicate only with a special software, one dry cavity for inserts, declared range from -45°C up to +155°C. The l*iquid Bath Calibrator* – calibrator with cooling based on compressor type circuit, integrated liquid bath stirrer, possibility to connect an external liquid circle, control unit with RS232 interface, declared range from -30°C up to 250 °C.

All the calibrators allowed simultaneous testing of a set of temperature sensors varying from 4 sensors in case of *Dry Block Calibrator* up to 10 sensors in case of *Liquid Bath Calibrator*. A correct placement of the sensors plays an important role in the calibration. The location of a sensor in measuring cavity can significantly influence precision of the entire calibration. In order to reduce this effect a liquid bath or a small tight cavity are used.

The calibrated sensors are attached to the end part of the reference 4-wire Pt100 sensor placed in a long metal rod package. The reference thermometer together with calibrated sensors is inserted in calibrator's cavity. The reference thermometer is usually connected to the Keithley 195A Digital Multimeter. The calibrated sensors are connected to the relays extension card in the Keithley 2000 Digital Multimeter. It is possible to measure up to 10 analog channels (mV, V, mA, A, ohm) by the extension card. Both multimeters are connected with GPIB cable to the computer with GPIB extension card. It is possible to control the *Metal*

Block Calibrator and the *Liquid Bath Calibrator* via RS232 with a special protocol for each calibrator. The *Dry Block Calibrator* is equipped with its own controlled system, so a temperature steps of the calibration have to be programmed manually by the calibrator's keyboard, and only the relay output once a temperature is stable is read by the computer.

The automatic control of the calibration is necessary, since each temperature step needs several tens of minutes to stabilize. A universal control program has been created in LabView software. The program either controls the *Metal Block Calibrator* and the *Liquid Bath Calibrator* by RS232 interface or reads relay output of the *Dry Block Calibrator*. All the measured values with actual time together with the reference temperature value are stored as a new line in the *.csv document. Consequently, the temperature set point is increased or decreased, depending on the defined calibration path.

All three calibrating setups were tested in our laboratory. The *Metal Block Calibrator* achieved quite good stability in temperature. However, only one of two cavities should be used due to the temperature difference and this fact limits a number of sensors at one calibration batch. The *Liquid Bath Calibrator* can be used for simultaneous calibration of a large amount of sensors. In case of the *Dry Block Calibrator*, a special aluminum container had to be prepared for the sensors under investigation.

The temperature calibration setups are going to be used for sensors' testing for applications both in Prague laboratory and at CERN research centre. For example, a large number of sensors will have to be calibrated in regard to planned upgrade of the cooling system for the Inner Detector of the ATLAS experiment at CERN.

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Microstructures and Grain Sizes of Magnesium Alloy AZ91HP

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One field of the research interest is the comparison of the grain size, microstructures and mechanical properties of castings made by different casting methods. The reason for this activity is to know and to predict mechanical properties of prototype cast by different method than it is cast the serial part. In the foundry lab it is possible to cast by gravity methods, e.g. investment casting, gravity sand casting and gravity die casting. The difference between those samples is given especially by the cooling rate. This has been demonstrated in numerous papers [1- 4].

For gravity investment casting usually the meanders of grain boundaries could be seen, grains are shapely in size around 5,5 (according ISO 643). Eutectic appears in relatively small amount and mainly around grain boundaries. Phase β + precipitate $Mg_{17}Al_{12}$ build big clumps on the grain boundaries. The EDX analysis showed intermetallic particles of type Mn(Al, Fe) and Al(Si). After the heat treatment, the precipitate and eutectic are dissolved, intermetalic particles appear with the same size within the grains, rarely on the grain boundaries. The average grain size is bigger (around 4 according ISO 643), but the difference is not so explicit compare to other methods.

For gravity sand casting is the microstructure finer. Grain boundaries are mainly built of eutectic, which is here in bigger amount than in the case of ceramic mold. The bigger amount of phase β + precipitate $Mg_{17}Al_{12}$ is here as well. Particles of Mn(Al, Fe) and Al(Si) could be also seen. The grains of phase α are shapely. The average grain size is 8 (according ISO 643). After the heat treatment the precipitate and eutectic are dissolved, locally could be seen in concentrated agglomerations. Intermetalic particles appear with the same size within the grains, rarely on the grain boundaries. The average grain size is bigger than before the treatment (about 5 according ISO 643).

In the structure cast by gravity die-casting method could be seen big clumps of not compact eutectic. Phase β + precipitate $Mg_{17}Al_{12}$ are mainly near to the mold wall than in the middle of the casting. To the middle the porosity is increasing and the content of phase β + precipitate $Mg_{17}Al_{12}$ is smaller. Particles of type Mn(Al, Fe) and Al(Si) are present as well. The grains of phase α are broken, not globular. The average grain size is 8,5 (according ISO 643). The eutectic is after the heat treatment completely dissolved, the precipitate as well. Intermetalic particles appear with the same size within the grains, rarely on the grain boundaries. The average grain size is bigger than before the treatment (5,5 according ISO 643). The structure changes after heat treatment are the most prominent for this method compare to the others.

Comparing to the previous methods, the structure of high-pressure die-casting is very fine and random. The grains of the phase α do not indicate clear boundaries, are not globular, in the middle of the sample exhibit dendritic shape. The structure is composed of phase α and massive eutectic fields containing secondary phase α grains. Fine intermetallic particles of

Mn(Al, Fe) and Al(Si) within the eutectic can be observed. Precipitate $Mg_{17}Al_{12}$ is almost not present because of the rapid solidification. The average grain size is 10 (according ISO 643). The porosity is present in the whole cross-section of the sample. The heat treatment affected mainly the grain shape – the primary phase α grains became regular and shapely with sharp boundaries, the eutectic is dissolved. Locally intermetalic particles appear within the grains and on the grain boundaries too. Microporosity is present and it is more located, rounded among grains. The average grain size is bigger than before the treatment (7 according ISO 643).

As it was supposed, the biggest grain size in the as cast state has the sample of the investment casting, then of the gravity sand casting, then of the gravity die casting and the smallest grain size is the sample of HPDC method. The structures are also different in the content and shape of eutectic. The structure cast into steel molds (gravity die and HPDC) have much less content of precipitate $Mg_{17}Al_{12,}$ have no intermetalic particles containing Si and the HPDC sample has no Mn(Al, Fe) intermetallic particles. It is given by the rapid time of solidification and it could be also given by the process cleanliness.

After the heat treatment the average grain size is bigger for all cases. The heat treatment influenced the most a structure of gravity sand casting and gravity die casting. For the investment casting is supposed the biggest increase of mechanical properties. The structure of HPDC sample has changed mainly in the shape of grains. The dissolution of eutectic and precipitate could be observed in all samples; just the structure of gravity sand casting shows concentrated agglomerations of precipitate, what can negatively influence mechanical properties.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Influence of Thermal Aging and Climatic Shocks on Soldered Joints

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As the electronics industry switched from a traditional Sn-Pb solder to newer, more environmentally-friendly materials, it became apparent new problems and challenges emerged. One of the most important problems was the lack of long-term experience with leadfree alloys and other methods like electrically conductive adhesives.

One of the means to obtain such knowledge is use of accelerated tests, both static and dynamic, simulating operating conditions. These tests can be fine-tuned to simulate a wide set of operating conditions. These tests may include thermal or mechanical stresses, either in the form of various periodic cycles or as permanent loads. In the past, the department concerned itself mostly with mechanical stress, including both static and dynamic bending. [1,2]

During the last year, long-term thermal aging experiments were performed on specimens of Sn-Pb and Leadfree solders (SAC), as well as on electrically conductive adhesives (ECAs).

During the experiment, the specimens were left for a total time of over 2000 hours in 125°C dry heat. Main aim of this thermal agin g was to provoke the growth of intermetallic compounds in solders and to observe influence of such long-time annealing to adhesives. Three types of solder pastes were used (Sn-Pb: COBAR S62–325GM5; SAC: COBAR XM3S, KESTER EM 907), as well as two adhesives (AX-12, AX-20). This combination was selected as it contains typical compositions used in electronic industry. Standard 1206 0R0 resistors used in the automotive industry were mounted. [1]

Electrical resistance measurements, performed throughout the aging, showed a mild increase (3% for Sn-Pb, 2.5% for both SAC solders). Visual inspection revealed a massive oxidation of solder surfaces, confirmed using microscope. Optical microscopy also revealed existence of intermeatllic layers on the solder – copper boundary. Exact composition and thickness of the surface and intermetallic layers will be determined using electron microscopy. The resistance of ECAs showed in first part of the measurement a steep drop caused by high temperature aiding to properly settle the adhesive. However after 500 hours of aging the resistance began to grow to final 10% increase in case of both ECAs. Surface changes were less apparent than with soldered joints. This is of course caused by the structure of adhesive.

Cross-sections of both solder and adhesive joints showed no structural damage as cracks or ruptures, except a number of bubbles – voids – in the body of the joints. More voids were observed in the adhesives, thanks to a different character of processes during their preparation.

In parallel with this experiment, other specimens were subjected to cyclic shocks, simulating varying operating conditions, namely heat-cold, wet-cold and wet-heat cycle, where the "heat" phase was covered by 125°C dry heat, "cold" phase by -40°C temperature and "wet" by 50°C at 100% moisture.

The cycle involving heat and frost was intended to simulate operating conditions of electronics in an automotive industry. Rapid changes of temperature were supposed to lead to

degradation of joints by different thermal expansion coefficients of solder, parts and PCB. The tests were performed by leaving the specimens in each temperature level for 15 minutes - long enough to reach a thermal equilibrium - and then planting them into the opposite environment. Speed of the transfer was measured and close attention was paid to the transfer time.

Cycles involving high moisture aimed both at thermal shocks, but more important was the role of water. It was expected, that water contained in the joints (for example in microscopic cracks) after a high-moisture phase would either freeze (in -40°C) or evaporate in 125°C and that in both cases it will rapidly expand and cause cracks to appear.

Resistance measurements showed a significant influence, especially on the ECAs. In extreme cases, increase ranging up to a whole order of magnitude appeared and subsequent optical analysis discovered large cracks in joints created by adhesives. This was especially prominent in the specimen series which was subjected to cycles between high and low temperatures.

Most notable change on high temperature – moisture cycle was heavy corrosion of soldered joints. Low temperature – moisture cycle showed also creation of surface layers, thought these looked different from corrosion. Exact composition of these layers is yet to be acquired using the electron microscopy. This cycle also showed formation of cracks in some cases, presumably when the body of the joint was porous enough to absorb water.

Currently, the main goal is to start a new series of long-term experiments, combining real conditions (placing experimental circuit boards in real car engine and passenger compartments for a prolonged time of 3, 6, 9 and 12 months) and artificially accelerated tests in climatic laboratory. This experiment will serve to compare both methods. Another example of real conditions will be planting specimens on roof-mounted solar panels and, for comparison, in ordinary office environment.

Another important goal is to get sufficiently high-quality cross-sections for electron microscopy. Unfortunately first batch is plagued with scratches and bubbles in the epoxy. It is questionable whether it will be possible to polish these cross-sections enough to allow electron microscopy without blurring the cut through the joints. If it will prove impossible, new set of cross-sections will have to be prepared.

Third direction for further research is an influence of mechanical vibrations on surface mount devices, including tests performed in accordance with international norms used in the automotive industry. These tests will be performed also on experimental circuits subjected to various climatic stresses before the vibrations and will employ both random and sine vibrations. Also a new continuous method of crack detection will be used, allowing for more precise results than just electrical resistance measurement.

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Comparative LCA Analysis of Compact Fluoreccent Lamp and Classical Light Bulb

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Light sources were one of the first electric equipment in the focus of environmental policy. Therefore this analysis was realized. The main aim of the analysis is to show the environmental comparison of the classical light bulb and its modern alternative a compact fluorescent lamp.

Classical light bulbs are still the most spread light source used in light domestic lighting and many other applications. The advantage of the classical bulb is very low price due to very high level of production technology. These light bulbs are free from hazardous materials and substances therefore they can be land-filled with low environmental impact.

The inefficient utilization of electric energy, poor luminous efficiency and many others reasons lead to new types of light sources being investigated. Some specific requirements are defined for these light sources. The requirements are results of conventional usage of the classical thermal light source, for example: the lighting comfort, color rendering index, proportions, etc. **Compact fluorescent lamps** show up like the most suitable substitute. Nowadays, these lamps meet almost all of the requirements. Furthermore, the compact fluorescent lamps have some indisputable advantages. These are higher luminous efficiency related with lower electric energy consumption, longer life time, etc. It is necessary to mention, there is modern alternative of compact fluorescent lamp to each kind of classical light bulb.

The method of **LCA** (Life Cycle Assessment) was used for the environmental comparison of the light sources. This method is described in and regulated by ISO 14 040 and ISO 14 044. Methodology **Eco-indicator 99** was chosen for the presentation of results. The final output of this methodology is only one number with unit Point [Pt]. Thanks to this number it is very easy to compare the results and allocate which light source represent higher environmental load. Furthermore, there is a set of graphs in Eco-indicator 99 methodology, which help better understanding the whole analysis. In general, the Eco-indicator 99 is integrated from three groups, which are represented by three main constituents of the environment: Human Health [DALY], Ecosystem Quality [PDF.m^2.year] and Resources [MJ Surplus].

Two case studies were realized in this project. First one was focused on production and disposal of one classical light bulb and one compact fluorescent lamp. The second and more important case study was focused on specifics of usage of both light sources, namely electric energy consumption, lifetime etc.

Comparative study of production and disposal of light sources

The functional unit of production and disposal study is one classical thermal bulb and one compact fluorescent lamp. It includes all materials and technologies, which are connected with producing and disposal of the light sources.

The results show, that the environmental load caused by compact fluorescent lamp is proximately six times higher than the environmental load of classical light bulb. The highest difference was observed in group of Resources. The production of compact fluorescent lamp is much more difficult. Different materials are used in process and some of them are hazardous to environment. Moreover, disposal of the compact fluorescent lamp is quite difficult process whereas the classical bulbs could be easily land-filled. At first sight the classical light bulb seems like less environmental harmful. However, the second study shows that in regard of whole life cycle the results are just opposite.

Comparative LCA study of light sources

The determination of functional unit was more difficult because the usage of both light sources has its specifics needed to take in consideration. The most important features are luminous efficiency and the lifetime of the light sources. The lifetime of classical bulb equals proximately 1000 hours and the lifetime of compact fluorescent lamps ranges from 8000 to 20000 hours. Light sources for functional unit were chosen according to these specifics. Those light sources were: classical light bulb (P=60W, 8 pieces) and compact fluorescent lamp (P=11W, 1 piece). It means 8000 hours lighting under the same light conditions.

The results of this LCA analysis clearly show that environmental load caused by usage of compact fluorescent lamp is proximately 6 times lower than environmental load of classical light bulb. The major difference of the light sources environmental load is electric energy consumption and the usage of one (fluorescent lamp) and eight (classical bulb) pieces for the same lighting time.

The analysis proved that the environmental load of compact fluorescent lamp is lower than the environmental load of classical bulb. Nevertheless, the costumers often make their decision only on price basis. The classical bulb is much cheaper than fluorescent lamp. However, final cost of usage of classical bulb is much more expensive. Financial balance is also the part of the study. The balance showed that the costs of usage of compact fluorescent lamp are lower starting after 900 hours of lighting.

The analysis proved that the usage of compact fluorescent tube is more advantageous both from the view of environment and costs. The European Union has reduced the sale of classical bulbs based not only according to these facts. This process started in September 2009 and it will continue next seven years until compact fluorescent lamps will replace all kinds of classical thermal bulbs.

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Processing of reliability data sets containing extreme values

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In the technical world it is usually assumed that measured data are "tidy", originating mostly from the normal distribution, not containing any anomalous values and no reading is missing. In fact, especially when reliability data are processing, it is necessary to process the first "messy" data containing erroneous readings (e.g. transcription errors or extreme and skewed results etc.). This contribution deals with processing of reliability data sets including extreme values.

Extreme value is a name for a result of observation, which is significantly separated from a group of rest observations. Extreme values are then divided into two subgroups: stragglers - values that are detected at a confidence level from 95 % to 99 %, and the outliers – data, which are detected with a confidence level greater than 99 %.

When evaluating the measured data and when the extreme value is found there are two possible cases. Measured extreme value was measured under the same conditions as other observations, belonging to the same population, but the likelihood of obtaining it is small compared to other results. In this case, the value should not be precluded and all statistics should be counted from all the measured data. In the latter case, extreme value was measured by an accidental breach of normal conditions or because of gross errors in observations or during processing. In this case, the reading does not belong to the parent population and should therefore be excluded.

Before starting of data analysis with regard to extreme values is necessary to make sure whether the reliability data satisfy the condition of normality. Data normality can be verify on the basis of past experience with similar data, normality tests (e.g. Kolmogorov-Smirnov test-Lillefors, Shapiro-Wilk test, skew and kurtosis test, etc.) or using diagnostic graphs created from measured data(e.g. . frequency histogram, P-P and Q-Q chart, box chart, etc.).

The easiest way to assess the experimentally measured data is based on their assessment by using of diagnostic charts. The most useful diagnostic chart is box chart. It is an analytical method, allowing the visualization of statistical data and particularly the rapid and comprehensive assessment of their characteristics, including the identification of extreme values. Values that lie at distances greater than 1.5 times the IQR from one of the quartiles are considered as. When they are more than three times away from one of the quartiles they are interpret as outliers. Stragglers and outliers are in the chart displayed shrink as isolated points. Other graphical methods used to identify outliers include P-P and Q-Q chart.

Most of the test for outliers is based on the relative distance of the suspect value from the average. This distance then tells us whether the outlier has resulted from chance or not. Most of the test is looking for one outlier, but sometimes it is necessary to find a more than one outlier. These extreme values can be determined by one of two ways: using iteration

method and standard test for outliers or by using a test to track the pair of extreme values (extreme values that mask each other).

Appropriate tests for extreme values are: the Grubbs' test and the Dixon's test. The main advantage of Dixon's test is its applicability to small datasets. Minimum data set size is 3 values (TN7), 4 values (TN9 and TN11) or 5 values (TN12)

$$TN7 = \frac{x_{(n)} - x_{(n-1)}}{x_{(n)} - x_{(1)}} \quad TN9_u = \frac{x_{(n)} - x_{(n-1)}}{x_{(n)} - x_{(2)}}$$

$$TN11_{up} = \frac{x_{(n)} - x_{(n-2)}}{x_{(n)} - x_{(1)}} \qquad TN12_{up} = \frac{x_{(n)} - x_{(n-2)}}{x_{(n)} - x_{(2)}}$$

For bigger selection (n > 25) from the normal distribution, extreme values can be detected using the Grubbs' test. This test can be used for detection for single outlier (G1), but also for testing multiple outliers (G2 and G3).

$$G_1 = \frac{\left|\bar{x} - x_{(i)}\right|}{s} \qquad G_2 = \frac{x_{(n)} - x_{(1)}}{s} \qquad G_1 = 1 - \frac{(n-3)s_{n-2}^2}{(n-1)s^2} \qquad s = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_{(i)} - \bar{x}\right)}$$

In both tests, if the value of testing characteristics is greater than the critical value, then at the level of confidence is unlikely that the extreme value (values) is created by chance.

This theoretical method for detection of extreme values is currently being applied for processing of reliability data. Our investigation is focused on comparison of electrical properties of electrically conductive adhesives and lead-free solders (especially their reliability). This kind of investigation mostly consists of small datasets which are often random grouping of values and consequently there are extreme values. Especially in reliability extreme value should never be excluded only for statistical reasons. These reasons include statistical charts or diagnostic tests for outliers. Tests for outliers can only say, on the basis of simple assumptions, where you have most likely a technical error (errors). Although the value is strongly separated from a group of rest observations, it could be the correct information. So extreme value should only be excluded on the basis of sufficient expertise.

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Section 9

ENERGETICS
&
POWER ENGINEERING

Construction of Compact Matrix Converter with Nominal Power 20kW

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Introduction

The matrix converter belongs to the category of direct frequency converters. Its beginning goes to the late seventies. The converter is composed from nine bidirectional power switches. Output voltage is constructed from input voltages by means of direct switching of input phases to output phases. This fact means that the converter does not need DC link. The absence of DC link capacitors is one of the main advantages of the matrix converter, on the other side it means that output voltage amplitude is limited to 86,6 % of the input voltage amplitude. Higher voltage could be achieved with overmodulation only, which causes the input current distortion. Other advantages of the matrix converter against conventional indirect frequency converters are its high power factor, ability to work in all four quadrants, high dynamics, sinusoidal currents consumption, almost sinusoidal output voltage waveforms, with low harmonic content. To the main disadvantages belongs: number of semiconductor devices, limited output voltage amplitude, and complicated control algorithms.

The matrix converter system consists of the bidirectional switch matrix, formed from IGBT transistors with anti-parallel diodes; input filter, that is responsible for EMC interference rejection; control system, which drives IGBTs and takes care of the proper matrix converter system function and clamp circuit, which saves semiconductors from destruction in failure conditions.

The aim of this work is to briefly summarize the development of the new prototype of matrix converter at our department. Special attention is paid to dimensions and compactness of the converter. Most papers about matrix converter deals with control algorithms of the converter and with its modulation strategies. Only a few publications deal with design of the hardware of the converter or with input filter.

The converter will be supplied from the ordinary 230/400V AC network and the output current is assumed to be circa 25A. The power of the converter can be estimated to circa 20kW from these values. These three values are used for selection of the semiconductor devices and a radiator. The other components of the converter are designed on the basis of these parameters too.

Power Part

From the parameters of the converter, mentioned above, were chosen the IGBT modules GD401-70-12, manufacturer Polovodiče a.s. Those are IGBT transistors with anti parallel diode in SOT227 package. The transistor endures continuous current 70A, when we consider proposed current 25 A, the power reserve is adequate. The blocking voltage of the transistor U_{CES} = 1200 V is twice bigger then required blocking voltage. Both parameters secure, in case of sudden failure the transistor from destruction.

Input Filter

The filter is designed as a simple LC filter. The filter is supposed to protect the supply network against negative effects of the converter like produced harmonics and distortions caused by switching of the power modules. The important properties of the filter are cutoff frequency and output impedance of the filter. The cutoff frequency of the filter must have

enough distance from the switching frequency, because the filter must already have sufficient attenuation in the range of converter's switching frequency. In order to avoid the oscillations was added damping circuit to the filter.

Protection Circuits

Protection circuits were also included in the design of the converter in order to protect the IGBT modules. The protection circuits are not necessary for the work of the converter. It can work properly without them. Both types of protection were selected for the converter, hardware and software too.

The software protection is realized directly in the modulator of the converter. A testing function, that tries to uncover and block bad switching combinations produced by control algorithm, will be running in addition to the switching pulses generation in modulator.

Clamp circuit, varistors, driver boards, hardware protection board, circuit breakers ranks to the hardware protection circuits used on the matrix converter.

Control System

The control system of the converter consists of driver boards, switching pattern generator board and a pilot controller. Each bidirectional switch requires two control signals and 4 signals indicating its state and current direction puts out. That means that there are 54 signals handled by the controller at any moment. The control system has to work in real time in order to generate the switching pulses and to receive information at maximum frequency. On the other hand, the control system should be as simple as possible because of reliability.

The switching pattern generation board works as a modulator. It contains digital interfaces (PC104, speed sensor, ISP, JTAG, RS232, PS2, switching pulses, error lines) as well as an analogue interface (sigma-delta and voltage-frequency converters). All digital signals are handled by core FPGA device (Cyclone II), which is situated on the board. FPGA has stored inside itself the code for switching pulse generation, basic error detection, diagnostics and also the service routines for all peripheries, including the PC 104 bus.

Summary

The matrix converter is popular topic today. Until now it has attracted mainly academic attention. It has many advantages in comparison with indirect frequency converters. New proposed matrix converter system configuration promises many improvements. However, the real impact of the proposed system will be evaluated when the whole system is completed.

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Buck Converter in AC Circuit

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This project deals with an idea of using a buck-converter in AC circuits. The switching converters are mostly known in some connection with DC circuits. In DC-DC converters they convert the input DC voltage to the output DC voltage having smaller or higher level. There can be also changed the polarity. In AC-DC rectifiers is an AC input voltage rectified to DC output voltage. The switching converters take a role of active filters to make better harmonic spectrum of input current in these solutions. Such approach is called Power Factor Correction (PFC). The switching converters can be also used to generate the AC output. But most of the solutions contain a DC part of the circuit. Even in AC-AC converters is the output signal generated by PWM after rectifying the input voltage. In fact it isn't necessary to use DC part of the circuit in all solutions of converters. For example, if we need to reduce the magnitude of AC voltage, we can use the buck converter for it.

The theoretical design of AC-AC buck converter is the same as it would be in DC circuit. The only change is the input filter and AC power supply. The input filter and the output filter are supposed to be the same. The magnitude of AC signal is controlled by PWM. In case that the cut-off frequency of LC filters are much smaller than the frequency of PWM the output voltage has the same shape as the input voltage. The magnitude is then given by the same equation as it would be in DC circuit. Even though the shape of input current will be the same as the shape of output current if a load is linear. There is only a condition that the highest harmonic frequency in the input signal is much smaller than the cut-off frequencies of both filters in the converter.

The converter has a similar behavior as a step-down transformer. But there is an advantage of fast and simple control of output magnitude. It is also easy to set the duty cycle of PWM from personal computer. So the output magnitude can be controlled by software. Since it is possible to set the duty cycle in every period of PWM the converter can operate also as an active filter. The main disadvantage is that the converter will be always less efficient than the transformer. It is also sure that the converter will be larger than the transformer.

The AC buck converter can easy satisfy the demands of EMC. It would be more difficult if the DC part of the converter was used. The rectifier is supposed to have PFC in common solution. It makes the converter more complex and expensive. For many measurements is required to have the output power signal in phase with voltage in power network because of preventing noise. It is a bit problem for traditional converters but the AC buck converter provides it by nature.

At Department of Electrotechnology was the AC buck converter made for testing. The prototype was designed for operating voltage only 24 V (I_{max}= 1 A). Although there had been made some mistakes in the design of the converter the prototype provided some new information not being noticed before.

The first noticed thing was the distortion of output curve around the zero-crossing. Since the output voltage was low, the voltage drops of switches couldn't be omitted. These drops add to

output additional harmonic frequencies which are difficult to filter because of their low frequency. After increasing the output voltage the distortion is less visible. It is because the drops of switches are exceeded in shorter time.
Output voltage of prototype falls with growing output current. The serial impedance of the converter is relatively high because of the two filters. It is also important to know that the input and output impedances of both filters differ. The input impedance of output filter is higher hence the output signal was better filtered.
Although the prototype proved that this type of converter wasn't suitable for low voltage, some AC-AC applications can be executed in a better way than with using common solutions of converters.

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Section 10

NUCLEAR ENGINEERING

Radiological Characterization of radioactive waste

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Radioactive waste is produced at any workplaces dealing with radioactive materials, for example nuclear power plants, hospitals or any other institutions. The waste can be liquid, solid or gaseous. In this work is dealt only with solid waste. This waste is usually sorted by material and put into containers of various shapes. The most common are 200l drums. Such treated waste is put into the storage. In each package amount of radionuclides and its activity has to be determined. Two methods can be used. One is destructive, when the package has to be opened and radionuclides are measured by laboratory analysis. The second is called nondestructive and the activity is determined from radiation measured outside of the drum. This method is based on gamma spectrometry and the radiation is measured usually by semiconductors detectors. The objective of this work was the efficiency calibration of the detector. The efficiency calibration is the relationship between measured impulses and the number of emited photons from waste. The efficiency is dependant on energy of detected photons. Dependence of the efficiency on energy is called efficiency curve. This calibration can be performed by the use of etalon which has similar parameters (density, shape etc.) or by the use of numerical methods or algorithms. The second method is widely used because the first method is very expensive or sometimes unrealizable. The object of this work was testing of commercial software ISOTOPIC-32 V4.0 used for efficiency calibration of semiconductor detectors.

ISOTOPIC-32 V4.0 is a computer code designed for gamma spectrometry measurement of radioactive waste containers, packages and contaminated pipes, areas and soils. The software can be used with almost any HPGe detector without any special procedure. It is easy to operate and suitable for routine measurement in terrain. The software has two modes: a) The container mode used for measurement waste packages, pipes and finite surfaces; b) soil mode is used for infinite soils and surfaces. Only the container mode in ISOTOPIC has been studied in this work. The detector is characterized by a single point source measurement. This primary calibration, which can be traced to a certified standard, for any detector, is multiplied by correction factors to match the physical situation of the sample: container geometry, material, and matrix composition. The algorithm of calculation of correction factors is based on "point-kernel" methods in which the entire measurement problem is broken down into multiple source/matrix voxels and their contribution to the new spectrum are calculated and summed.

The MCNPX code version 2.4.0 has been used as a validation tool. The algorithm of computation is based on the Monte Carlo method, which takes into account consistent radiation transport effects. Monte Carlo method enables accurate calibration for complex geometries. On the other hand, this method is time consuming and requires accurate inputs like exact information about detector dimensions, structure, dead layers, etc.

ISOTOPIC-32 V4.0 uses a macroscopic approach to simulate the radiation based on semiempirical approximations. The accuracy of such efficiency calibration is the object of the validation performed in this work. The validation process is based on comparison of efficiency curves obtained from MCNPX and those obtained from ISOTOPIC. Several experiments for various container shapes and various matrices have been performed in an energy range from 60 keV to 1836 keV.
All of the 8191 channels of the spectra have been modeled by MCNPX. They have been then processed by GammaVision to obtain efficiency curves. Tally 8 has been used with gaussian energy broadening function.
Efficiency curves in ISOTOPIC for a given geometry are not directly reported but they can be easily obtained from correction factors which are included in the report. A modeled point source MCNPX spectrum was used as an input to ISOTOPIC for characterization of the detector to keep consistency.

The experiment showed that ISOTOPIC calculates efficiency curves in agreement within 20 % with MCNP efficiency curves that is sufficient for the most of practical application. Experiment also showed that one calculation with MCNP takes 48 hours. On the other hand, the calculation in ISOTOPIC takes couple of minutes, what is very important in practical measurements. The best agreement was achieved in matrices of a small density.

This work has been performed at the Department of Dosimetry and Application of Ionizing Radiation at Czech Technical University in Prague collaboration with the Chemical and Nuclear Engineering Department of the Polytechnic University of Valencia.

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Study of Thermal Effects on Low Power Research Reactors

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At the Czech Technical University (CTU) in Prague a new instrumentation for measurement of thermal effects is currently being designed for the use on the training reactor VR-1. The instrumentation is designed to serve both for the purposes of education and training and R&D; in the latter case especially for the examination of possible precision and accuracy measure of calculation of such effects.

VR-1 is a light water zero power pool type reactor which operates at Dept. of Nuclear Reactors (DNR) CTU in Prague. The core is assembled on a grid of 8 x 8 positions (each position possessing 71.5 mm x 71.5 mm) and is composed of three various tubular fuel assembly types: four-, six- and eight-tube fuel assemblies of IRT-4M type. This fuel consists of UO_2 dispersed in Al with the enrichment on U-235 of 19.7 %.

As at the nominal power of ca. 1 kW the reactor operates at an ambient temperature and there is almost no heat generated, the instrumentation has to be designed as a closed loop possessing some external system for water heating. It is assumed it could cover 1 to 4 positions of the reactor grid. Thus, the quantity to be measured with the instrumentation will be the isothermal temperature coefficient of reactivity (ITC) of the used module. It is assumed that the measuring range should start at an ambient temperature going up to some 70°C, the upper boundary being chosen in such way to stay sufficiently safely below design limits of used fuel assemblies. There are two types of nuclear material under consideration to be potentially used in the instrumentation that are in the inventory at DNR: Besides IRT-4M fuel assemblies which are used for standard operation of the reactor also EK-10 pins could be used. These pins use as a fuel meat Mg-UO_2 enriched on 10 % of U-235 and at DNR is their utilisation restricted to experimental purposes only. With both fuel types, an optimization of the instrumentation was carried out. It comprised the calculations of isothermal temperature coefficients of reactivity for various cases of considered fuel assemblies in infinite lattice in the temperature range of 20 to 70° C.

In the analysis all types of IRT-4M fuel assemblies (4-, 6- and 8- tube fuel assemblies) were included; for 4- and 6-tube FA additionally also the case with inner displacer of varying width for modifying fuel to moderator ratio was assumed. As to EK-10 fuel pins, infinite lattices with varying pin to pin distance both for square and triangular geometry were studied. From the results, several modules covering 1 to 4 positions of reactor grid were proposed and the corresponding achievable changes of reactivity for typical core of the reactor containing these module variations were calculated. In the case of modules with EK-10 fuel pins also a layer isolating the instrumentation from the rest of the core was designed (Isolation of modules with IRT-4M fuel is not feasible due to their and grid geometry). Finally, the results were intercompared and the optimal design was found and discussed with respect of design limitation of the particular fuel types, possible reactivity change achievable by given module (and possibility of measuring such reactivity changes at the reactor), possibility of precise modelling of the operational states of the module (for example the impossibility of isolating the module from the rest of the core in the case of IRT-4M fuel assemblies and corresponding uncertainty in reactivity changes prediction connected with heat transfer to the rest of the core

handicap this type to some degree against EK-10 variations) and the possibility of unaffecting of the rest of the core by module operation.

The calculation analysis was carried out in MCNP code with the utilization of detailed MCNP model of the VR-1 reactor. With regard to relatively small absolute values of reactivity changes, great care was paid to nuclear data used and to their processing. The data from ENDFB7 nuclear data library were used; they were processed by NJOY 99.259 code using well described and validated data processing sequence which was used at NEA for processing JEFF 3.1 library for use in MCNP code. The most significant cases were calculated also with JEFF 3.1 and JENDL 3.3 data libraries for comparison purposes using the same data processing sequence. Thermal scattering law data (which are standardly available only for a small set of temperature values) were for desired temperatures obtained by interpolation between the available cross sections data.

Based on the obtained results the following should be stated: From the neutronics point of view the instrumentation is well feasible with both IRT-4M fuel assemblies and EK-10 pins. This holds true only for negative temperature feedback modules. On the other hand, this study showed on difficulty to design positive feedback modules in the conditions of the reactor. Proposed modules containing fuel arrangement having positive temperature feedback in the infinite lattice cases are not able to reach significant positive feedback in a core typical for the reactor.

In case of IRT-4M only two grid positions are sufficient to reach reasonable reactivity change. Otherwise, four grid positions and lower temperature difference could be used. EK-10 modules would have to cover at least four grid positions.

With both EK-10 and IRT-4M modules a sufficient reactivity change could be reached still being far below safety limits of the particular fuel type. However, only EK-10 modules should be isolated from the rest of the core. Thus, their behaviour in a real core configuration is much more predicable than that of IRT-4M as there is no heat transfer to the rest of the core. Thus, EK-10 modules should be preferred to IRT-4M ones for the instrumentation design. No significant difference was observed between square and hexagonal EK-10 lattices; the square ones seem to fit better to the square lattice of the reactor. From the calculation the modules with pin-to-pin distance of 3 mm (containing 100 EK-10 pins in a square lattice) and 4 mm (81 pins) give the best characteristics.

Finally, results obtained by three different nuclear data libraries are in good mutual agreement.

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Dosimetry in heavy ion beams with using of various detectors

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With expanding of therapeutic use of heavy ion beams, it is crucial to describe their energy transfer process. Our goal is to build up library of spectra of linear energy transfer (LET) for various ions and various setups. If we are interested in biological effects of a heavy ion beam, we should not consider only average LET value, but the whole LET spectra of different particles, which are created by passing through the target and surrounding.

Five various materials, employed as the TED, were put in holders, which were specially designed for this occasion. One quarter of inner space might be filled up with TLD detectors, in remaining positions TED were placed in two, three perhaps layers. Holders were upright exposed in beam of carbon ions with energy 290 MeV for nucleon, or neon ions with 400 MeV/n. For every ion, sets of holders were exposed behind increasing thickness of binary filters, for selected ones, the **Liulin** was also applied.

All track etched detectors are polyallyl diglycol carbonates; they are **Page** from Mouldings (Pershore) Ltd, **Tastrak** from Track Analysis Systems Ltd, both from Great Britain, **USF4** from American Technical Plastics from USA and two products of Japan Fukuvi Chemical Industry Co., Ltd µ **TD1** and **Baryotrak**. Exposed materials were etched under our usual conditions µ 5 M NaOH solution, 70 ºC for 18 hours [1]. Employed TLD were two different kinds µ $CaSO_4$:Dy and Al_2O_3:C, which were processed by [2]. Liulin is spectrometer of energy deposition in silicon, which could be transfer to energy deposition in water, eventually in LET spectra [3]. Altogether, detectors cover operational spectrum of LET from very low values to approximately 500 keV.μm^{-1}.

Depth-dose distribution within this beam settlement is well known BraggÑ curve with narrow operational maximum; reference progression of dose curves were estimated with ionization chamber.

For both ions TED described this trend well, even in area behind the BraggÑ maximum. There is greater consistency in data for carbon, since the possible scattering or fragmentation on the material of binary filters lead to shorter list of particles. Before Bragg's maximum there could be applied just the three most sensitive PADC, the other two are blind according to their detection thresholds. We can observe two exceptionally values for Page and TD1 right in the area of BraggÑ maximum. It could suggest some increased sensitivity, which is specific for these materials in this energetic range, or very short range of present particles, which could not be detected even with ionization chamber, or with materials with greater etching velocity (in this case, they would be removed from the surface by etching). For neon exposition, there is systematic underestimation for all materials before BraggÑ maximum, especially for Tastrak and Baryotrak. It is probably due to presence of low LET particles,

which can be detected just partially with the three most sensitive materials. Two greater values for TD1 and Baryotrak in BraggÑ maximum. have connection with exceptional efficiencies.

Accordance to capability of other detectors, Liulin and TLD by them selves fail in description of distribution of general dose. However, combination of TLD and TED together according to [4] gives good results. The uncertainties varied from 5 to 13 percent.

Track etched detectors can provide us information with distribution of particles along LET range. We observed increasing LET behind increasing thickness of select binary filters, as well as spreading peaks due to scattering of beams for carbon exposition.

It should be emphasized that materials were arranged in several layers inside of holders. It means the top of each layer was exposed to the different spectra of particles according to changes during the passing through the previous layers of materials. However, except these shifts, we can observe quit different response in some specific LET field (for example behind 130 mm binary filter for C, or behind 70 mm binary filter for Ne). It could suggest unique changes of sensitivity along LET range, which are related neither to detection threshold, nor to saturation effect, but have connection to specific composition of material.

Liulin can also offer partial LET spectra; compared to TED spectra, peaks are narrower and we can distinguish contribution of fragments and low LET particles.

The efficiencies were estimated as the ratio of particles in main peak and reference value of fluency. It is clear it decreases with increasing thickness of shielding according to scattering or fragmentation. However, low response (about 70 % of detected particles) for even non-shielded detectors, especially for neon beams, is kind of surprising. It suggests either undervaluation of our measuring or overvaluation of reference values. There also occur obvious surprising discrepancies in case of neon beam behind the thickest filter for materials TD1 and Baryotrak, so far their cause is unknown. Results might suggest slight differences among materials in detection sensitivity even for primary ions.

Our specific combination of detectors provides satisfying information about radiation quality during exposition to heavy ions. Besides, results for PADC might indicate differences in detection sensitivity along LET spectrum in according to their unique composition. This suggestion deserves farther attention.

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Section 11

CHEMISTRY

Dissolution of ash materials from municipal solid waste incinerator and brown coal power plants

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The utilization of waste materials as secondary raw materials is found to be generaly beneficial for the enviromental reasons (reduction of amount of dumped wastes, lower consumption of natural raw materials etc.) and might be also favourable from the economical point of view. Hence the growing attention is paid to the wastes recycling in the last decades. The coal ashes from power plants and heat generation plants are one of the most important wastes when considered their mass. The coal ashes are well known as efficient admixtures in cementitious materials, especially in concrete since ash forming oxides (SiO_2, Al_2O_3, Fe_2O_3) are prevailing in their chemical composition and thus can be pozzolanic active. The coal ashes can play role of either filler or pozzolanic active admixture in cementitious composites. The exact chemical composition and physical properties of ash depend on the composition of the burned coal, technology of the burning process, way of desulfurization of flue gases (if applied) etc. The chemical and physical properties of ash can vary in time and must be checked if the ash is intended to be used as secondary material.

Relatively new types of waste materials are ashes which are generated by Municipal Solid Waste Incinerators (MSWI). MSWI facilities are recently built as an efficient and environmental friendly way of reduction of amount of municipal and commercial waste. The MSWI ashes contain all non-combustible components of the incinerated waste. Hence their composition is much more dependent on the quality of the currently incinerated waste and thus varies widely in time. Moreover the used incinerating technology and way of flue gases treatment influence the properties and range of the generated ashes as well. The MSWI ashes contain – beyond the ash forming oxides and CaO – also soluble salts, heavy metals and organics in higher amount than coal ashes [1]. The properties of MSWI ashes are much more fluctuating from plant to plant and in time in comparison with coal ashes. These facts complicate the utilization of MSWI ashes as secondary raw material. Nowadays these ashes are used e.g. as backfill material in civil engineering; the possibility to use the MSWI ashes as concrete admixtures is studied currently. The requirements on ash properties important for its application in concrete as active admixture or filler were summarized e.g. in [2].

The present paper deals with four types of ashes from a modern MSWI plant and three types of brown coal fly ashes from power plants. The MSWI ashes were denoted S (bottom ash), A and B (two types of boiler ashes) and C (fly ash from electrostatic precipitator). The brown coal fly ash L was generated in a fluid boiler in power plant and collected at a fiber filter. The fly ashes Z1 and Z2 (the latter is the coarser fraction) came from a conventional grate boiler in an industrial steam generation facility.

The ashes solubility, content of soluble chlorides, nitrates and sulfates and pH of the leachate were determined. The ash samples (10 g) were mixed with 100 ml of distilled water and let to equilibrate (dissolve) for 1 week. The pH of leachate was determined by help of pH/ION inoLab/740, the concentration of ions in the leachate by ionic liquid chromatography.

The total solubility was determined by help of weighing of the undissolved material. The obtained results were summarized in Tab. 1.

Tab. 1 Chemical properties of studied ashes.

Ash	pH	Cl^-	NO_3^-	SO_4^{2-}	Sol.
	-	wt. %			
A	12.4	0.58	0.02	7.14	12.56
B	11.6	4.87	0.14	6.12	14.28
C	10.9	10.68	0.21	7.47	34.31
S	9.4	0.30	0.00	2.75	5.93
L	8.2	0.01	0.00	7.47	14.82
Z1	6.6	0.00	0.00	0.27	0.52
Z2	6.6	0.00	0.00	1.65	2.14

The solubility of MSWI ashes was generally higher than the coal fly ashes. The MSWI bottom ash S (slag) had the lowest solubility from MSWI materials; obviously the content of soluble salts in this material was rather low. The content of sulfates and chlorides in S is under limits needed for its possible application as concrete admixture [2]. The high solubility of MSWI fly ashes A, B and C was caused by their high content of chlorides and sulfates (above the requirements in [2]). The pH of leachate of these fly ashes was alkaline which was caused mainly by CaO. When one looks at brown coal ashes the only highly soluble is the fly ash L. It was collected on the fiber filters used as the last step in flue gases treatment hence there were accumulated the finest dust particles. The high sulfate content in this ash was due to "in situ" desulfurization technology applied in the fluid boilers. The fly ashes Z1 and Z2 from the grate boiler had low solubility and also the content of anions was found to be under limits.

The dissolution behavior of MSWI ashes and coal ashes was found to be different. Only the MSWI bottom ash S had acceptable composition for its application in concrete production. The fluid coal fly ash contained high amount of sulfates. The grate fly ashes Z1 and Z2 were the most favorable concrete admixtures at least with respect to the anions content and low solubility.

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Impact of Swimming Pool Operation to Stream

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Industrial and domestic waste waters are for a longer time examined. Produces of research in this field are at advanced level and negative effect of these waters to environmental is significant. Gradually are getting ahead such fields, which till now were too insignificant, to somebody deal with. Produces of this research evidently will not too interesting, but though is necessary to solve it.

One of these fields are waste waters from swimming pools. Untill now was not a great reason to examine that water. In contrast to problematical industrial operations, in swimming pools is used relatively clean water, hence is not supposed, that it can lead to some significant damages of environment. Despite of this is important explore this water to foreclose this hazard. While in some countries, as Austria, Germany, New Zealand and Australia, is research in this toppic on advanced level, in Czech Republic are these waters solved hardly even.

The tendency of this research is describe type and quantity of these materials, character and degree damages of ecosystems. The results of this research could be used as groundwork for standards, or public offices, whose process is currently disunited. At deciding about permission for discharging of swimming pool waste waters exists obscurities. Informations on character of these waters and instructions for deciding are just missing. It's a big fault that at deciding about permission for discharging is not consulted environmental value of water body, neither flow rate of stream and flow rate of discharge.

Before specific pollutions we clear up working schemes of pool, on which are final products dependent. Main component of swimming pools is sand filter, in which are the particles of dirt catching. From specific reasons, especially towards sanitary ensure, various chemicals are mostly admixed into pool water. Continuous water cycle, which is necessary especially because of exchange water through the filter, is ensured with the aid of pipeline and water in is moved thanks to pump. Despite of this the water is not possible to treat totally, therefore is necessary taking new water from water supply, and discharging the same quantity to waste. Discharged water leads mostly to sewer or stream, hardly ever on land surface.

It is several types of pool waste waters. Self-pool water, which is permanently discharging, or is one-time discharged at complete emptying, is not supposed to be too dangerous. The main potential danger presents water, which is discharged at filter washing, or at cleaning the pool.

Based on background research, which was for this purpose worked up, were ascertained also materials, or environmental impacts, which can occur in pool waters. The most significant are these:

Chlorine and its compounds, other disinfection agents as bromine and iodine,
Heavy metals, mainly aluminium, copper, manganese, iron, silver,
Acids and pH controllers,
Suspended solids, organic matter and turbidity,
Other chemicals as dissolved solids, AOX, nitrites, nitrates,
Increased flow rate, temperature, loss of free oxygen.

Supposed negative impacts are primarily damage of water and littoral ecosystems, both animal and plant. Also erosion, flooding, bad smell, and damaging of drainage and drinking sources are important.

Self-research, what was financed from this Grant in the year 2009, was realized in two swimming pool water plants - in Slaný and Kladno town. Both of these swimming pool water plants are equipped with sand filters and dosers with sodium hypochlorite. In Kladno's swimming pool water plant is using also aluminium sulphate. Besides above mentioned were dosing other chemicals, for example sulphuric acid. Waste water from these swimming pool water plants is discharging to stream. Flow rate in this streams is quite small, about 10 l/s. Filters are washing once a week.

The measurement and control was in most of cases executed in a way sampling with subsequent analysis in accredited laboratory. Only chlorine was measured in situ. In Slaný were measured 6 actions of washing, in Kladno 2 of these actions. In Slaný was measured in 6 positions in the stream: Closely above discharge, closely below discharge without the washing. Also was measured self-discharged water and too water from several positions below the stream during the washing. The furthermost position was situated at about 600 meters below the discharge. Besides washing, water one sample of discharged water was taken during cleaning the swimming pool walkway. In Kladno was measured more or less only washing water. Within the frame of one sample was measured from 5 to 20 indicators. Free chlorine was measured only in Slaný, and it was realized in a way repeated measuring in the same position all the time of discharging.

In most of monitored indicators was detected significant increase of values. Value of free chlorine in Slaný was measured about 2 mg/l, both in discharge and stream. Free chlorine was detectable at least 400 meters below the discharge. In both swimming pool water plants was detected significant increase of suspended solids and turbidity, whereas these values in unaffected stream were insignificant. Maximal values of turbidity were paradoxically ascertained no closely below discharge, but as far away as hundreds meters farther. It was evoked probably by erosion of fine bottom sediment. Maximal flow rate of discharging water was measured in about 30 l/s in Slaný and 10 l/s in Kladno. When the swimming pool walkway was cleaning, discharging water contains high concentrations of copper, but the amount of discharging water was small.

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Measurement of Dynamic Salt Sorption in Porous Building Materials

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The presence of salts in porous building materials represents potential danger from the point of view of their durability and service life. Negative action of salts consists in their crystallization from the salt solution owing to water evaporation and their recrystallization from the solid phase. Characteristic for crystallization process is the rise of crystallization pressures on the porous space walls that are dependent not only on amount of crystallized salt but also on material's porous structure, in fact on its texture and morphology. High crystallization pressures can then evoke failures of material and in some cases its destruction. On this account the water soluble salts together with moisture are considered to be one of frequent causes of breakdowns of building structures.

Historical masonry often contains significant amount of various salts that originate from several sources. Chlorides ingress into the rubblework comes with filling the streets and roads in the winter. Nitrates are product by process decomposition of organic residues in stalls, in downpipe and so on. Sulfates are result of air pollutants corrosion or bacteria action. Nitrates as well as sulfates input to building construction with capillary rice from subsoil. The problem of salt transport, their crystallization and thereby caused degradation, is very tricky question especially in sea coast areas, where the salt transport is realized in the form of sea water or in the solid phase by wind and secondary by force of water movement.

Water movement is the most significant factor in the process of transporting ions from the surface into the porous matrix. Moreover, the matrix is not inert to the ions and only a part of them penetrating into the porous system can be freely transported in the solution, another part of ions can be bound on the pore walls due to either physical or chemical mechanisms [1]. Therefore, two basic ion phases are generally presented in material, namely free ions that are dissolved in pore water and bound ions that are fixed on the pore walls. Among the mechanisms bonding the ions to the pore walls, the adsorption due to van der Waals forces seems to be a very important effect and possible reaction of ions with active phases of material. However, it is very difficult to distinguish between the physical and chemical bonding mechanisms on the macroscopic level, so, for practical reasons both these effects are usually unified into one phenomenological ion storage parameter. This is the dependence of the amount of bound ions in the material on the free ion concentration in the pore solution in equilibrium conditions that is called the ion binding isotherm.

Basically, just two methods for measuring the ion binding isotherms are used in the current research practice. The first of them is based on the determination of the amount of free ions by the pore solution extraction from a sample using high pressure [2]. The second method is based on the adsorption of ions in a sample due to a contact with external solution and was proposed by Tang and Nilsson [3].

In this paper, a slight modification of the adsorption method was chosen for dynamic chloride, nitrate, and sulphate binding isotherms determination. Several building materials with different

composition and structure, among them cretaceous marly limestone, sandstone, and limestone, exposed to NaCl, $NaNO_3$, and Na_2SO_4 solutions with different concentrations were analyzed using liquid chromatography.

In a practical application of the modified adsorption method, 0.1M, 0.5M a 1M concentrations of NaCl, $NaNO_3$, and Na_2SO_4 salts were prepared. The samples were placed into the cups with 200 ml of each solution. Then they were stored in a thermostatic chamber at 25°C. To observe the dynamic phenomenon 1 ml of each solution was sampled in fourteen days intervals during three months and analyzed. The results in the form of typical chromatograms were recalculated into ion concentrations by the help of calibration and the amount of bound salts additionally to the interior pore surface. From the obtained data the relevant binding isotherms were constructed.

There is no doubt about prediction of unstable dynamic salt sorption during the time effects. Although the experiment confirmed the hypothesis of dynamic salt sorption, but there is no systematic formula of this behavior in the time period. The observed differences in the shape of different ions binding isotherms of tested materials are clearly due to their chemical composition and molar weight; it means the highest bonding capacity shoved sulphates, then nitrates and finally chlorides. Shapes of the ion binding isotherms of measured materials evoked the shape of their sorption isotherms. This could mean that the fast increase of the amount of bound ions for higher concentration than 0.5 M was due to the ions bonding on the pore walls of larger pores which have much higher capacity. The content of binding salt anion in the building material structure rises with concentration of free anion in salt solution.

The measurements dynamic salt storage parameters of different porous building materials determined in this paper can be utilized in the practice in basically two ways. The first is their direct use in computational models of coupled water and salt transport. Secondly, the knowing of the salt storage parameters values enables reliable qualitative estimates of the material behavior in a historical building. The main conclusion following from the experiments performed in the paper is that the ion binding capacity of porous building materials depends besides the material composition also on many other factors such as the volume and surface of pores, the pore distribution, the texture and morphology of the porous space.

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Section 12

BIOMEDICAL ENGINEERING

Web-oriented system for integration of biomedical data

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The current state of research in medicine is characterized by a constant increase and the accumulation of quantitative and qualitative diversity of data that provides a strong information base for scientific analysis and synthesis [3]. All the information potential of data is often unused because storage of accumulated biomedical data arrays, organized in various ways, e.g. from paper-based to database automation of laboratory facilities. The development of Internet and widespread usage of web-resources lead to the need to focus the information systems to web-technology. Mechanisms that allow functioning of overall information and analytical environment, access to scientific resources, and their safety are important problem of information support of scientific research [4].

In our study we focused on the standard documents used in Russia:

- National standards of Russia Federation electronic health records (GOST R 52636-2006);
- "Federal Law of information, informatization and protection of information";
- Industry Standard "Standardization in Health Care. The Basic Provisions" (OST 91500.01.0007-2001);
- recommendations and requirements of proposed within the national project "Health" and the federal program "Electronic Russia".

The developed web-oriented system has the following features:

- creation form of research;
- import / export of data in the most common formats;
- formation of an array of data on a set of criteria for selection;
- remote control mode;
- multi-user access;
- protection of information.

The form of conducted research is the basis for the storage of research results. In the form of research, as fully as possible, the conditions of the research and also the measured indicators are described. Using object-oriented methodology, in which the software system is designed as a set of interacting elements [1], we can generate forms of research of any complexity. In addition, the doctor-researcher decides which indicators and in what sequence should be part of the form [2].

Formation of an array of data from the entire set of data stored in the system is carried out under conditions that meet the interests of the researcher. Then the resulting array can be saved in various formats (txt, xls) for further statistical analysis. Remote mode gives the opportunity to receive information regardless of the location of the workplace researcher. To

eliminate the possibility of unauthorized access to data, there are two user modes: supervisor and user.

The privacy of information implemented by the transfer of information through the secure channels of communication, mandatory authorization of users, etc. Our system automatically creates the list, which reflects all changes occurring in the system. All program logic is located in the Web-server, which ensures the formation of database queries. Basically six static database tables are used (table of elements, table of group of elements, table of partition, table of forms, table of interaction elements and partition, table of interaction partition and forms), and dynamically creates new table with the results of indicators forms of research. Table of Elements contains information on various indicators of research (laboratory, clinical, biochemical, age investigated, the name of the test, etc.). Table of group of elements simplifies the work with the system, contains the names of groups. Table of Partition contains the section name, the date of its creation and its short description. Partition is a semantic unit studies and presented a set of elements. Table of Forms stores information about the forms of research. Each form consists of sections and reflects the essence of that study, also form part of its name and date of creation. Forms are the basis for creating dynamic tables reflect the results of the studies. Table of interaction elements and partition consists of identifiers of elements and identifiers of partition respectively. Table of interaction partition and forms consists of identifiers of partition and identifiers of form respectively.

The developed system uses:

• Web-server - Apache, powerful and flexible web-server that can run on a variety of platforms and in different environments. Apache is a free software application and has a sufficiently high degree of protection;

• Database management system MySQL;

• The programming language PHP.

Web-oriented system allows you to create a single bank of distributed biomedical data. In addition, it enables researchers to work with these data regardless of their location. Implementation of the above functions of the system, allow maximum use the information potential of data.

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Interaction of Recombinant Interleukins IL-4 and IL-4Δ2 with IL-4R I and IL-4R II Receptors In Silico

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Alternative splicing is actively involved in shaping of cytokine regulation polymorphism, and splice isoforms of protein cytokines and their receptors can significantly alter the regulatory functions of various cytokines.

IL-4δ2 is a naturally occurring splice variant of human IL-4. In IL-4δ2, the second exon of IL-4 is omitted by alternative splicing, with exons 1, 3, and 4 joined in an open reading frame. Unlike IL-4, IL-4δ2 do not act as a costimulator for T cell proliferation. However, IL-4δ2 inhibits the ability of complete IL-4 to act as a T cell costimulator. Study of IL-4δ2 interactions with its receptors IL-4R I and IL-4R II can help in creating of new pharmaceuticals for the treatment of bronchial asthma, various leukemias, melanoma, breast cancer [2].

The best method for studying the mechanism of action of IL-4δ2, in terms of saving time and material costs, is a computer simulation (modeling in silico) [1]. A wide range of "in silico methods" can be used to study protein-protein interactions. Among these methods, protein-protein docking has become established technique for studying the interactions between different proteins. AutoDock is a suite of C programs used to predict the bound conformations of a ligand to a macromolecular target of known structure. The technique combines simulated annealing for conformation searching with a rapid grid-based method of energy evaluation [3]. Using AutoDock (methods of molecular mechanics) it is possible to evaluate protein-protein interactions [4], for example, between IL-4 and its receptors: IL-4R I and IL-4R II.

Models of IL-4 and its receptors IL-4R I, IL-4R II were downloaded from the database RCSB PDB [5]. Both complexes were obtained using X-ray crystallography. Computer model of IL-4δ2 was constructed on the basis of physical and chemical laws by A. Denesyuk (University of Turku, Finland).

To calculate the interactions between ligands IL-4, IL-4δ2 and receptors IL-4R I, IL-4R II we used the program AutoDock 4.0. Statistical analysis of data was performed using the program SPSS 11.5.

We found that IL-4δ2 interacts with both types of receptors weaker than complete IL-4. We assume that is because of the IL-4δ2 structural features.

The more negative is the binding energy, the stronger are binds between two molecules. As expected [6], IL-4 was associated with a high affinity receptor - IL-4R I more strongly than with low affinity receptor IL-4R II. IL-4δ2 was associated with both types of receptors weaker ($p < 0{,}001$) than complete IL-4. We think that the lack of a second exon in the coding sequence of IL-4δ2 mRNA significantly alter the surface of binding site, which is responsible for interaction with IL-2Rγc and IL-13Rα - components that are parts of the IL-4R I and IL-4R II types. They increase the affinity for these receptors [6]. Probably for the same reason, IL-4δ2 not able to activate both types of receptors. Other studies have shown [6] that the amino acid Tyr124 is critical for activation of receptors of both types.

Notwithstanding the above, IL-4δ2 can form chemical bonds with the receptors of both types. This can be explained by the fact that the sites responsible for binding with IL-4Rα – a major component of both types of receptors, form the same surface as in the complete IL-4.

Our results correspond to the results of IL-4δ2 biological activity studying in experiments in vitro [2]. Thus, dose-related inhibition of the IL-4 activity by IL-4δ2 is attributable to the low affinity splice variants of the cytokine to its receptors. Indeed, in higher concentrations, the probability of IL-4δ2 binding in the ligand-binding sites of both types of receptors increases.

For inhibition of receptors IL-4R I and IL-4R II types IL-4δ2 is required at concentrations greater than the concentration of complete IL-4, since it binds to these receptors with a more positive free energy than a complete IL-4.

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Comparison of Bactericidal Effects of Corona Discharges for Various Parameters

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Introduction

Nowadays, several methods of sanitation, decontamination and sterilization based on physical, chemical and physical-chemical principles are known. However, it is known that many of bacterial species can acquire the resistance to many of bactericidal agens e.g. antibiotics, cleaner agent compounds etc. So, the search for new reliable and economical methods of decontamination or sterilization is very desired. The low-temperature plasma is looking like a possible good alternative to common used bactericidal agens. Due to it, the decontamination or sterilization using low-temperature plasma is ranked among current trends in research of its possible application. This work compares the bactericidal properties of several corona discharge types at atmospheric pressure in air. Specifically, it is positive and negative stabilized point-to-plane corona discharge applied to an aqueous suspension of bacteria *Escherichia coli* and *Staphylococcus epidermidis*. Description of corona discharge can be find e.g. in the book [4].

We studied the decontamination or sterilization of surfaces and liquids by low temperature plasma generated in corona discharge. The simple apparatus of an open-air type enabling the point-to-plane or point-to-point arrangement was used.

The low temperature plasma was generated using the previously described [1, 2 or 3] simple apparatus of an open-air type generating the corona discharge. Briefly, the negative point-to-plane corona discharge was generated on the point electrode represented by the tip of a syringe needle, connected to the source of direct current high voltage. The plane anode, connected to the positive pole of the source, was realized by the surface of bacterial suspension. The distance of the point electrode from the anode surface was set by a micrometer screw.

Experiment and results

The 0.5 ml of bacterial suspension was injected into a plastic pit and consequently exposed to the corona discharge. After this procedure this suspension was diluted into suitable concentration and inoculated onto the surface of a semi-solid nutrient medium plates. This plates were immediately cultivated at 37 °C overnight. After, the survived colonies of bacteria were counted.

Positive corona discharge experiments were performed on two bacteria - *Staphylococcus epidermis* and *Escherichia coli.* The sterilization of *Staphylococcus epidermis* bacteria appears after 30 s of exposition in the case of voltage 10kV and a current 200 μA. At 8 kV/250 μA it appears after 20 s and at 6 kV/200 μA the samples were sterile after one minute of exposition. Otherwise, the sterilization of *Escherichia coli* bacteria appears after 15

s of exposition in the case of voltage 10kV and current 200 μA. At 8 kV/250 μA it appears after 30 s and at 6 kV/200 μA the samples were sterile after 30 s of exposition.

It is obvious that with a small change of current and with relatively high change of voltage the sterilization is completed within a minute and that *Escherichia coli* is less resistant than *Staphylococcus epidermis*. It is necessary to mention than in both case we have achieved sterilization in one minute so the positive corona can be considered to be very effective.

The efficiency of a negative corona was tested for *Staphylococcus epidermis* only. In can be concluded, that for the voltage 9 kV the sterilization occurred after a minute in both cases of current 180 μA and 370 μA.

Conclusion

The aim of this work was to demonstrate the bactericidal effects of positive and negative corona discharge of point-to-plane type, to compare their effectiveness and to explore an influence of voltage and current on the effective sterilization of the bacterial suspension. We can consider that both discharges are very efficient even in the case of large number of bacteria are used (tens of thousands). The current does not affect effectiveness of discharges; effectiveness is dependent primarily on the voltage and less on the time of exposure. Currently the positive corona appears to be more effective, but there has to be carried out many experiments to confirm the conclusion.

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Empirical Data Analysis in Clinical Stabilometry with White Noise Reflection

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Numerous studies have been focused on static postulography development [4] as useful tool for evaluating balance impairment of patients that could be caused by various facts. Face off fact of traumatic brain injury (TBI), tumor or clinical stability disorders are acceptable taken as good example which provably affected patient stability. Since force foam pad [2][4] has been introduced body upright (sway) analysis becomes to be more meaningful due to vestibular loss identification. In clinical practice is mostly quiet sway used for this identification but there are also other types of checkups as for example we can bring up random walk test. Beside good results in postural control process observation, the role of static postulography in body sway assessment still has limits in clinical expansion. This is mainly caused by its intrinsic high variability which does not permit a reliable diagnosis although sway has been defined by standard

One of serious drawbacks of most done studies can be taken improper method used for data evaluation. As signal taken from postulography should be evaluated as random "stochastic" process is evaluated as statistic and deterministic ones which could cause lot of potential issue and misunderstandings connected with. Some studies intent was to define valuable coefficients for upright sway or random walk evaluation but also with constrain definition in data analysis [4]. They have shown that signal could be defined by several coefficients but these studies have still used methods for evaluating deterministic and stochastic signal.

Our new technique of such data analysis offers way to overcome difficulties with data analysis. Method which we use for clinical data analysis is fully designed since the start for non-stationary, nonlinear and stochastic data analysis. This method is also reflecting noise which is step forward in current data analysis. Noise is not commonly reflected over whole analytical process mostly in conclusion is pointed out that data could be influenced by noise. Our method deals with noise since the beginning of its analysis. Method was introduced by Huang (1996) but still without noise reflection what became to be developed latter [1][3]. Its name is ensemble empirical method decomposition and has abbreviation EEMD [1][3]. Our method is connection of two steps which are needed to be EEMD employ. The first step is "shifting process" which is fully described by EEMD and white Gaussian noise is added in each method step. From this step we gain number of independent function which can be processed. Number of these independent functions is close to $\log_2 N$ [3] although is not necessary to analyze all of them. This number only define maximum of functions which could be extracted from analyzed signal. EEMD Application is also adaptive step in data model analysis because cubic spline function is necessary for. This also allows us to analyze sparse data gained from upright sway. The second step of analysis is to employ Fast Fourier Transform over all data set. FFT is used because of intent to move data from time domain to frequency-energy domain. In Frequency-energy domain can be data better analyzed and better conclusion could be done. This is because common data from any stabilogram does not nicely

visible all perturbation. This perturbation or deviances in body movement could be strong signal of human handicap. Deviances could be signal to various types of movement disorder which are fully connected with human CNS. When patient has any kind of traumatic brain injury (TBI), tumor or clinical stability disorders his movement over upright sway is fully damaged and this issues are projected to his stabilogram over postulography checkups.

EEMD methods works here as dyadic filter bank which helps to divide signal to its parts which are analyzed by Fast Fourier Transform usage then. Fast Fourier Transform moves data into energy-frequency domain where appropriate patients disorders are projected as frequency peak or peaks. This peak is specific to various types of CNS disorders, but discussion around is still under heavy research which is moved to clinical test and result are going to be published soon. Other impact of current results could be appropriate method usage (EEMD) and as advantage or research extension can be help in upright sway characteristic. Our last results have shown that EEMD usage as the first step of analysis is very important. All movement disorders became be better projected (up to 50%) and specific handicap more visible in frequency-energy domain. Results become to be padded by statistical analysis to show its advantages properly. This statement is very important in next clinical research.

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Selected Methods for Automatical Classification of Psychophysiological States in Experimentally Controlled Psychical Load

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This work deals with measuring, analysis and interpretation of the data, obtained from real-life experiments carried-out on the Faculty of natural science, Charles University in Prague, department of parasitology. The data sets contain electrophysiological signals (such Electrocardiogram, galvanic skin response) and further factors, which are the results of certain psychological tests. The number of these pair-experiments was 240 and they contain resting state followed by the psychical stress period. Measuring was realized on wireless free unit developed on the joint department of Biomedical Engineering CTU and Charles University in Prague.

Experiment was designed and realized on the department of parasitology. In the first, resting state of experiment, measured people compose pencils with different colors according to their preferences. There is about 20 pencils. Subsequently, person of opposite sex come to the room and opens case with sadomasochistic equipment (gag, chains, shawl, padlock) and give the measured person an informed consent document. In informed consent there is a checklist of sadomasochistic practices that person does not want to endure. After signing an informed consent experiment ends, follows some questions concerning feelings from experiments.

The first step was preprocessing data. In this step I took sets of data and one by one I checked the right detection of QRS detector and removed or interpolated from record artifacts like (extrasystoles, muscles electric activity, izoline drift). After that step data were ready for computing a cardiotachogram for extracting sets of heart rate variability parameters. During process of preprocessing data were selected a seventy data sets for next step. For extracting HRV parameters I used software Kubios (HRV analysis software from Biosignal analysis and Medical imaging group). This Software extracting standard HRV parameters - frequency domain, statistical and non-linear parameters (RR, SDNN, HF power, Sample entropy, Shannon entropy).

Since that software uses a different structure of data against the structure that is used for a store of data from measuring, I had to create a Matlab script that computing and exporting data in propriety format for Kubios. Records are split in to the two pieces for needs of extracting parameters from both states (rest x stress). Record is split in time where case is opening. Then the HRV parameters computed by Kubios were analyzed in correlation with the Psychological parameters. Correlation was computed in software Statistica 6.0 with statistical test Kendall Tau. Kendall Tau is a non-parametrical correlation test that is used for measuring the degree of correspondence between two rankings and assessing the significance of this correspondence.

Psychological parameters were dedicated for detecting domination, submisivity or sexual preferences of respondents. These parameters were computed on department of parasitology in factors analysis, from a different kind of checklists. Some of these checklists are standard psychological tests and others are new developed psychological tests. Psychological factors of each person were used as filter parameters and their influence on the separation of the rest and stress phase was observed.

In Microsoft Excel software I created a framework for filtering data and creating a box-plot graphs, which shows a separation of phases in according to a used filter. Data to that framework I insert half manually and half with a visual basic script. There is option to use one or more filters and observe a difference on automatically generated graphs. There is another type of graphs that are used for visualizing count of samples coming from is Excel counting data for a box-plot graphs. On bookmark with graphs I too computed a T-Test from graphically displayed data.

From results is evident that some of the HRV parameters include information about psychical load, without using psychological factors. So these parameters are usable for separation stress and resting part of record e.q. Its parameters like a LF/HF ratio, Sample entropy or parameter SD1. Separation can be improved by using filters based on the psychological factors. Best separation for both male and female sex is achieved with filter that quantified non-domination of respondents called “nedominance”.

Using the results of this analysis the basic principle of the classification algorithm was designed and verified. Mentioned algorithm should be usable as the supplement of the psychological tests. As I worked with 70 samples, results of this work are statistically significant.

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The Persistance of Bactericidal Effects in Water After its Exposition to the Corona Discharge

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Introduction

The action of electric discharges and the plasma generated by them is one of the possible methods of decontamination or sterilization, mediated by bactericidal action of UV light and reactive particles. The method is not yet frequently used in practice, but it is potentially important, especially for the decontamination or sterilization of heat labile or otherwise sensitive materials. Its various experimental arrangements, advantages and status of research in this field were reviewed in details in, e.g., [1], [2], [3] and [4].

We studied the decontamination or sterilization of surfaces and liquids by low temperature plasma generated in corona discharge. The simple apparatus of an open-air type enabling the point-to-plane or point-to-point arrangement was used. However we discover some new interesting phenomenon, the bactericidal effects of low-temperature plasma persists in the exposed water for a long time after exposition. This new phenomenon is the aim of this work.

Apparatus

The low temperature plasma was generated using the previously described [4] simple apparatus of an open-air type. Briefly, the positive point-to-plane corona discharge was generated on the point electrode represented by the tip of a syringe needle, connected to the source of direct current high voltage. The plane anode, connected to the negative pole of the source, was realized by the surface of a liquid water suspension of bacteria. The distance of the point electrode from the anode surface was set by a micrometer screw.

Experiment

However, in this experiment, only pure water was exposed to the corona discharge burning between the needle and water surface.

- The 1 ml of distilled water was put into plastic pit connected with the pole of HV supply and exposed to the corona discharge on the tip of the syringe needle situated approximately 5 mm over the surface. The water was exposed for 15 minutes to the positive corona discharge of 9 kV and 0.25 mA.
- A drop of this exposed water was put onto the litmus paper.
- The exposed water was diluted with non-exposed one into the concentration of 1:1, $1:10^4$ and $1:10^6$. In this samples of diluted exposed and non-exposed water both bacteria *Escherichia coli* and *Staphyloccus epidermidis* were put and let the water to affect the bacteria for 10, 40 and 60 minutes.

- After previous step, one-ml of bacterial suspension under study were plated by pouring out onto the whole surface of the semisolid Nutrient Agar (Živný agar No. 2, Imuna Michaľany, Slovakia) culture medium in a Petri dish, all plates were immediately cultivated at 37 °C overnight and the number of grown colonies was counted.

Results

The pH factor was set by the litmus paper to approximately 1 – 2.

The number of survival bacteria (represented by the number of grown colonies) decreases in the case of *Escherichia coli* from the original 70 000 cfu to several hundreds for 10 minutes of affecting and to zero after 40 and 60 minutes of affecting. In the case of *Staphyloccus epidermidis* the number of survival bacteria decreases to zero for all times of affecting.

Conclusion

It appears, that the effects of low-temperature plasma generated by corona discharge in exposed distilled water persists also for some time after the exposition. Important fact is the decrease of pH factor what may evoke some type of explanation. Detailed research of this persistence and the search how to explain it will be the aim of further studies.

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The Evolving of Bacterial Clone Resistive to the Low-Temperature Plasma

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Carl Zimmer wrote in his work [1]: "One of the most important experiments in evolution is going on right now in a laboratory in Michigan State University. A dozen flasks full of *Escherichia coli* are sloshing around on a gently rocking table. The bacteria in those flasks has been evolving since 1988-for over 44,000 generations. And because they've been so carefully observed all that time, they've revealed some important lessons about how evolution works."

Briefly, in the work of MSU biologist Richard Lenski [2], he started off with a single microbe, divides its clones into 12 colonies and kept each of these 12 lines in its own flask. Each clone was everyday provided with a little glucose, gobbled up by the afternoon. The next morning, a small sample from each flask was put in a new one with fresh glucose. Based on knowledge of evolution, the natural selection of the bacteria was expected. Some of the microbes may mutate and most of the mutation would be harmful, but some of them would be beneficial, this bacteria can grow faster and would gradually dominate in the population. Today, the bacteria breed 75% faster than their original ancestor. However, the most important event happened after 33,127 generations, something strange was noticed in one of the colonies. It was *Escherichia coli* chowing down on the citrate, what is against the definition hallmarks of *Escherichia coli* as a species. Thus, Richard Lesnki's team has evolved a new bacterial species.

This work ignited us to look over our study of bactericidal effects of low-temperature plasma. We took inspiration in this work and we would like to test the possibility of the evolving of bacterial clone resistive to the low-temperature plasma. It is known that many of bacterial species can acquire the resistance to many of bactericidal agens e.g. antibiotics, cleaner agent compounds etc. Nowadays, the low-temperature plasma is looking like a possible good alternative to common used bactericidal agens, so the information about the possible creation of resistive clones is actual. In the case of relatively easy chance to find some resistive clones, this fact must be kept in mind for the practical application.

The experiment can be specified in following steps:

- Selection of suitable bacterial species: the species should be easy to cultivate. After discussion we prefer well-tried bacterial species *Escherichia coli* or *Staphylococcus epidermidis*.
- Preparation of stock culture: due to our experiences we prefer frozen suspension of bacteria and 10% solution of water and glycerol. Stored cultures are anytime ready for cultivation.
- Exposition tank: bacteria will be cultivated near appropriate temperature 37 °C in cultivation liquid medium. Surface of this medium will be permanently exposed to the low-temperature plasma. After consummation of most of nutrients, the cultivation

medium will be changed for new one and inoculated by the culture from the original one.

- The low-temperature plasma generation: one of the easiest sources of low-temperature plasma is corona discharge. The point-to-plane corona discharge will be realized by the needle as point-electrode situated several centimeters over the surface of liquid medium. This medium will therewithal serve as the plain electrode. For details se e.g. [3].
- High voltage supply: The low-temperature plasma will be generated in the corona discharge more or less permanently for several weeks (or months, years), so the HV supply must be foolproof and easy to construct. After discussion we prefer the cascade voltage multiplier with constant high voltage output.
- The resistivity test: in appropriate time steps it is necessary to test the presence of resistive clones. Part of the cultivation medium with bacteria will be exposed to intensive low-temperature plasma (see e.g. [4]), the number of survival bacteria will be counted and compared with the characteristic of original frozen culture.

This paper describes our method to possible selection of bacterial clone resistant to the low-temperature plasma. Possible positive discovery will be significant result in this multidisciplinary scientific branch.

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Contribution to Advanced EEG Processing

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Biological signals in general belong to non-stationary stochastic signals. We can measure either electrical or magnetic biosignals, reflecting functional activity of the particular part of human body. The most complex biosignal is electroencephalogram (EEG), reflecting the functional activity of the human brain. Electroencephalography is essential for the diagnosis and evaluation of treatment of epilepsy, sleep disorders and many other brain disorders and for research of higher cognitive functions. To detect the epileptic and seizure activity, long-term recording is necessary in many cases, as well as in sleep research. In the case of sleep analysis, polysomnographic (PSG) recordings are mostly used. These recordings contain not only EEG, but also electrocardiogram (ECG), breathing activity (PNG), electrooculogram (EOG), and electromyogram (EMG). In the case of epilepsy, only the portions of EEG containing spikes and seizures are stored for later reviewing. After identification of such diagnostically significant activity, there is a need for examination of the signal by a detailed analysis to reveal the hidden information that might be contained in the signal. Long-term EEG and PSG recordings are very important, because they give us the possibility to follow disorders that are not permanently present but appear incidentally or under certain conditions. Aims of computer assisted processing are to simplify the work of medical doctors and to make the evaluation more objective. In most cases, the agreement of an automatic method with visual analysis is a basic criterion for its acceptance.

The main objectives of our long-term work have been rather complex. We have focused on the design, development, implementation and verification of appropriate combination of preprocessing, feature extraction, feature selection and classification methods for automatic recognition and differentiation of individual states in different types of EEG and PSG recordings, in particular adult and newborn sleep, epileptic recordings and other disorders. Such methods should speed up the identification of described states, make it more objective, and should be used for classification and as a hint to neurologists. Main steps of used methods are segmentation, identification and removal of artefacts, feature extraction and selection, their normalization and application of various classification methods, in order to compare the results with those determined visually by the expert. The methods are applied to records as a whole, without choosing convenient, typical or representative signal parts.

All described steps in EEG and PSG processing must be visualized not only during development and testing, but also when showing the results to medical doctors. However, pure manual visual analysis is impossible since the recordings are rather long. Speaking in terms of classical "paper" electroencephalography using standard speed of shift of 3 cm/s, 20 minute recording represents length of 36 meters of paper. When studying sleep disorders, length of recording may reach several hundreds meters of paper. During long-term (e.g. 24 hour) monitoring the data load is even much higher. In addition, we do not acquire a single signal but in case of the most frequently used International 10-20 system of electrode placing we acquire 20 parallel signals. In case of PSG recordings we have to add 4 signals more (ECG, EOG, EMG, and PNG). It is necessary to develop such tools for visualization that satisfy several basic requirements: visualization of raw signals, interaction with signal

processing techniques (filtration, segmentation, identification of artefacts, computation of quantitative signal characteristics), visualization of resulting signals and values, possibility to correct the segment borders manually, interaction with data mining techniques, visualization of results in various forms (time domain, frequency domain, time-frequency relation, power spectral density, 3D mapping, temporal sequence of maps, temporal trends, structured temporal profiles), etc.

Now we briefly describe individual steps in EEG processing. Segmentation to segments of equal length and adaptive segmentation have been used and compared. For each segment various parameters have been calculated, for example statistical parameters, autocorrelation, entropy, fractal dimension. Fourier transform and wavelet transform have been performed separately, such that other input data for further analysis and determination of most informative features have been obtained. Various combinations of wavelets and decomposition levels have been tested. Absolute/relative power in delta, theta, alpha and beta frequency bands has been computed with the use of both transforms. In PSG analysis information obtained from other measured biological signals (EOG, EMG, ECG, PNG) has been utilized. Finally, various classification methods have been applied and compared (k-NN, neural networks, SVM, decision trees, naïve Bayes classifier, hidden Markov models). We have also used optimization methods for selection of best feature subsets and setup of parameters in those methods where parameters are variable.

The methods have been tested on real polysomnographic and EEG records. This approach is designed in such way that it can be applied to EEG and PSG records in general. Also, new features or any kind of changes (addition of new methods and visualizations) can easily be incorporated and tested. The described methods are implemented in our developed modular system for analysis and processing of EEG and PSG recordings. The system can be easily extended by new methods since data processed in each step are exported to files in defined format and can be loaded on the input of the next step. In case we perform standard processing we can run the whole sequence of methods at once. The verified setup of parameters is stored for repetitive use.

Based on this experience we designed methodology of feature extraction and selection from heterogeneous multichannel data and methodology of EEG signal processing applicable to diagnostics and monitoring of maturation of newborn brain.

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Wettability and photocatalytic properties of Titanium dioxide layers prepared by pulsed laser deposition at low temperatures

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Titanium dioxide TiO_2 is a semiconductor commonly used in various industrial applications. In the last decades, its photocatalytic and antibacterial properties were studied intensively [1]. In this work, we are interested in photocatalytic and antibacterial properties of thin TiO_2 layers prepared by pulsed laser deposition technique at low temperatures. The objective is to prepare thin photocatalytic active layers at a plastic base, which could be widely used with medical materials mainly as antibacterial layers of urethral catheter. In addition to the photocatalytic properties, wettability of surfaces and free surface energies were determined. Many other properties of the layers were studied such as crystallinity, thickness, morphology of surfaces, roughness, contact angle and transmissivity.

Excimer laser Compex Pro 205 F with KrF gas fill (λ = 248 nm, pulse duration 20 ns, repetition frequency f = 1 ÷ 50 Hz) was employed for deposition of TiO_2 layers. Stainless steel vacuum chamber was used, pumped by turbomolecular pump to the desired pressure (before deposition, the vacuum chamber was pumped to the pressure of $1 \cdot 10^{-3}$ Pa or lower, then filled to the desired pressure and atmosphere composition). The laser beam was focused on target of basic material. We used pure titanium (99.95 %) or pure rutile targets (99.99 %). Silicon wafers (Si111) and fused silica (FS) with dimensions 10 x 10 mm were used for substrates. Some samples were made within radio frequency (RF) discharge.

About one hundred samples (in couples Si(111) and FS) were prepared under various conditions. Deposition pressures varied between 0.1 and 500 Pa, with atmosphere composed of O_2, Ar or their mixture. Different thicknesses were tested by changing the number of pulses in the range from 2000 to 15000. The energy density on the target varied from 2 to 9 J/cm^2. Temperature of the substrate was kept at room temperature (RT) or 200 °C, samples prepared within RF discharge were heated to approximately 80 °C due to RF. Target-substrate distance was 40 mm.

Profilometric measurement on Alpha-Step IQ Surface Profiler (manufactured by KLA Tencor) was used for determination of layers thickness. The morphology of the surface was studied by the AFM microscope Solver NEXT (manufactured by NT-MDT). The crystalline properties were measured by X-Ray diffraction; some samples were tested by Raman spectroscopy too. Transmissivity was determinated by Shimadzu UV-1601spectrometer, but only for FS samples for wavelength λ = (190 ÷ 1100) nm.

The photocatalytic properties were determined by the 4-chlorine phenol (4ClP) solution ($3 \cdot 10^{-3}$ mol) degradation. This method has been adapted from [2]; the measurement was made with cooperation with J. Heyrovsky Istitute of Physical Chemistry AS CR. Each sample was put in an optical class cell (4.5 ml volume) with a magnetic stirring and continuously illuminated by a mercury flash lamp (8.75 mW/cm^2). To prevent decomposition of molecules by UV irradiation alone, filtering wavelengths shorter than 360 nm was

implemented. Additionally, IR filter was used to prevent the cell heating. The cell temperature was lower than 30°C. The illuminated area was roughly 70 mm^2 and the sample plane was set to be perpendicular to the light source. The pH decrease over time expresses the sample photocatalytic properties. The absolute pH value is not needed because there is good linearity in an interval of 3 to 7 pH. For the final pH changes calculation, the value from the 20^{th} minute (after stabilization) was taken and compared with the value from the 100^{th} minute after the irradiation start.

The second way to measure photocatalytic activity we used was based on the decomposition of oleic acid, which can be evaluated by the change of a contact angle of a liquid (in our case water) on the TiO_2 surface. Firstly, a dip-coating method is used to cover the surface of TiO_2 layer by oleic acid. Then the samples are continuously illuminated by the UV lamp (peak at 365 nm, FWHM around 3 nm, 3.3 mW/cm^2) and in defined intervals the contact angle is measured. As the oleic acid decomposes the contact angle is decreasing. There was good correspondence between results acquired from both methods.

For comparison of the results obtained from ours samples we used a reference sample, which was made from 100% anatase powder by sol-gel method with crystallization at 400°C (anatase powder P-25, company Degussa). The reference sample area was about 90 mm^2, which means it was 25% larger than our regular samples. After calculation of different areas we could see that the best samples we made are only little worse than the reference sample. The best performing of our samples were prepared mainly at 200 °C or with RF use. Samples prepared at RT proved photocatalytic properties too, but not as high as others. The best results are obtained for anatase and rutile samples, these results are at grade of (50 ÷ 75) % of anatase reference [3].

Contact angle was measured and free surface energy was calculated for some of the samples, around fifty couples were tested. Device DSA 100 (manufactured by the Krüss company) and software Drop shape analysis v.3 were used. We measured contact angle for three known liquids: distilled water, diiodomethane and ethylene glycol. For determination of the surface free energy we used the Fowkes method. Relation between contact angle and crystalline structure was found, in accordance with. Samples with crystalline structure had smaller value of surface free energy than the amorphous samples. Typically, the differences are in interval from 2° to 12° increasing with growing volume of crystalline phase [4].

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Mechanical Tests of Ultra-High Molecular Weight Polyethylene Used in Surgical Implants

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The ultra-high molecular weight polyethylene (UHMWPE) is a simple semi-crystalline polymer of ethylene consisting of a carbon backbone chain, with pendant hydrogen atoms. However its chemical structure is very simple the UHMWPE is a material with very complex mechanical properties due to its internal structure at molecular level. The long polymeric chains of polyethylene can twist, rotate and fold into ordered crystalline regions but not all of them are arranged in such crystalline regions, some of them are just entangled each other and thus form amorphous regions. The complexity of mechanical properties is even more increased with so called “tie molecules” which pass through amorphous regions and connect several crystalline regions. Its outstanding mechanical and chemical properties like chemical inertness, lubricity, impact resistance and abrasion resistance has given rise to be the material of number one choice for sliding parts of total joint replacements (TJR). Despite its successful use in design of TJR in last 4 decades, wear and damage of uhmwpe-components are limiting lifespan factors of the whole TJR. Reduction of the wear was observed with introduction of highly crosslinked UHMWPE in last 10 years where the highly crosslinked term means that the virgin UHMWPE was modified to increase ratio of crystalline phase to amorphous.

During the service of a UHMWPE component there are recognized several modes of failure e.g. generation of mechanically induced polymer debris, delamination and pitting. Those modes of failure are coupled with cyclic nature of loading, lubrication, intrinsic mechanical properties, degradation and ageing of UHMWPE. When prediction of TJR component lifespan is the point of interest relation between applied load and its time impact on the material must be known. So the prime goal of this project was to carry out a sequence of mechanical tests which would provide enough experimental data that would be used for material parameters determination of UHMWPE constitutive model [3]. A sequence of simple tensile test, simple pressure test, one axial low-cycle full reversal test and three axial Small Punch test (in compliance with [2]) was carried out. Our laboratory coacts with a Czech producer of TJR Medin Orthopaedics s.r.o. thus the probed material was supplied by Medin Orthopaedics and results of this research are going to be applied to products of this producer. The gained material parameters are intended to be used in finite element analyses (FEA). The field of displacement and strain was measured by optical 3D correlation system Q-450 (by Dantec Dynamics). This video-based system uniquely combines the high spatial resolution of full-field optical measurement (two high-speed digital video-cameras) with high temporal resolution. Principle of this optical system is stereoscopical view of a surface with unambiguous grey value pattern. Same object point must be identified in both images of two cameras. After that correlation algorithm is applied and subsequently field of displacement and strain are derived from every taken frame. The use of the 3D correlation system was necessary due to high strain magnitudes overstepping 400% of engineering strain.

Determination of all 13 material parameters of constitutive model for UHMWPE which was developed by Bergstrom [3] is not a straight procedure where each parameter would be determined based on a specific mechanical test but user developed software must be

used. This software was realized as a group of Matlab scripts with use of optimalizing techniques which predicts values of true stress as an answer on given true strain data during one axial mechanical test. The predicted true stress data are then compared with experimental data and the software tries to minimize differences between them. Another User developed software in FORTRAN code was created to enable implementation of the constitutive model [3] in commercial finite element package ABAQUS.

The Small Punch Test (SPT) technique was also used to characterize differences in mechanical response between virgin and modified UHMWPE. There were probed gamma irradiated samples with different thermal treatment like annealing and remelting. The SPT tests were found not only to be useful tool in description of differences between virgin and modified UHMWPE under static conditions but also in low-cycle fatigue mode. The cyclic version of the SPT and mechanical test under temperature of 40°C will be the next steps of this project.

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Diagnostic Chain for Recording Luminescence Space Distribution.

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Fluorescent materials are often used for the detection of extreme ultraviolet (XUV) radiation. These materials emit visible light upon the absorption of XUV radiation. Direct XUV detection is although possible with high efficiency, but it can be problematic due to the inability to transmit or guide of XUV radiation to a detector; use of frequency downconverters alleviates this problem. In addition, frequency downcorversion significantly increases the number of photons available for detection [1].

A typical detection system consists of a photosensitive device coated with a translucent layer of fluorescent material. Other possibility is using scintillation crystal in front of the detector.

From the point of view of information theory, starting point of image processing system, e.g., luminous screen, can be consider as a multi-channeled optical line communication. The number of channels (which have the spatial character) equals the number of discreet location in field of screen elementary fields of local averaging of function of intensity distribution. These areas present the smallest elements of image called “pixels”, but their sizes are limited by physical and technical conditions. The number of pixels as well as number of possible levels of greyness for a pixel, and the number of frames transferred by system pertinent to structural, metric and temporary information represented generally by a signal.

The distortions of a signal of temporal-spatial character with the gradation of intensity transferring the mentioned three kinds of information appear in form of: contrast distortions connected with structural information; noise distortions pertinent to metric information; inertial distortions concerning the temporary information.

Real-valuated function of two spatial variables defining intensity distribution in an output reference plane, which is received as a result of punctual stimulation in an input point, is called the point spread function (PSF). The PSF is the fundamental for the picture generating process, but there are many difficulties with its practical measuring. The response of the system to linear stimulation, so-called line spread function (LSF), strictly connected with PSF, is devoid of this defect. This function describes the changes of intensity across the line in output plane. The third function connected with already introduced spread functions, being the response of the system to the edge stimulations (discrete) so-called edge spread function (ESF). ESF describes an output image being an image projection of an input image in a form of the edge change (jump) of intensity in the input plane. These functions can be used directly to estimate the quality of processing systems or there can be calculated on their basis different profiles such as modulation transfer function (MTF) [4].

In this contribution we present the result of recording of YAG:Ce luminescence making visible the laser beam profile of LTB MNL 100 nitrogen laser with wavelength of 337,1 nm. The lasing is achieved in high-voltage (10-20 kV) high-speed (few-ns) transverse

gas discharges in nitrogen, so the beam profile is not homogeneous. Yttrium aluminum garnet activated by cerium was chosen because it is a fast scintillator with excellent mechanical and chemical resistance applicable in vacuum. Maximum emission wavelength of YAG:Ce is 550 nm and decay time is 70 ns. The thickness of scintillation crystal was 0,8 mm. Front illuminated full frame CCD with resolution 4014 x 2684 and with 9 μm pixel size was used as a detector. Luminescence of YAG:Ce excited with energy and length of pulses of 1,4 μJ and 25 ns was recorded. Vertical and horizontal beam profiles were depicted with 30 Hz repetition frequency and 20 s exposure time. Also luminescence excited with single shot in 2 s exposure time was recorded. Beam profiles estimated from luminescence records excited with single shot and multi shot with 30 Hz repetition frequency were compared. ESF were assigned using an edge knife. Than the PSF were evaluated and fitted with Gaussian curve. Spatial resolution was estimated to 27 μm from FWHM of PSF. .

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The effect of the pulmonary diseases on the mechanical properties of the respiratory system

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Artificial lung ventilation (ALV) is used in many cases during the respiratory failure. The aim of ALV is to ensure the sufficient amount of oxygen for the patient mainly during insufficient spontaneous breathing. ALV is method that does not heal but provides time to lung for regeneration. Inversed pressures are used during the modern types of ALV during ventilation of the patient. It means that the alveolar pressure is positive during inspiration with ALV contrary to spontaneous breathing when the alveolar pressure is negative during inspiration. The inversed pressure causes worsening in the blood flow through the lung during inspiration while the patient undergoes ALV. The common type of ALV is called conventional ventilation and it has similar parameters as a spontaneous breathing. Tidal volume is V_t = 0,5 l approximately and breathing frequency is f = 12–18 breaths/min. High-frequency ventilation (HFV) is a novel type of ALV and it is using higher breathing frequencies (f = 5–20 Hz) and smaller tidal volumes that are similar to anatomical dead space [1]. Recent studies show that the change of the pulmonary mechanical parameters has a substantial effect upon the efficiency of different regimens of ALV. Mechanical properties of the respiratory system are affected by elementary diseases. The change of the respiratory mechanics can be also dependent on the origin of the disease and therefore it is very difficult to choose optimal ventilatory strategy for various pulmonary diseases [2, 3, 4].

The aim of this study was to design an experiment with both types of ALV: conventional and high-frequency ventilator and lung simulators. Conventional ventilator Veolar from the Hamilton Medical company and high-frequency ventilator 3100B from Sensormedics company were used as experimental ventilators. The simulators ASL 5600 from Ingmar Medical company and 5600i from Michigan Instruments company were used to study interaction between the ventilator and simulator mechanics. The simulator allows simulating the changes of the respiratory mechanics as it appears during various diseases. The effect of changes in the respiratory mechanics for different types of ALV has been studied. The same flow profile was set during simulation of the conventional ventilation during whole experiment. The breathing frequency was set to 15 breaths per minute and tidal volume was V_t = 0,5 l. It means that minute ventilation was 7,5 $l.min^{-1}$ and it was maintained constant during the experiment. The constant ventilatory pressure was used during HFV. ASL 5000 simulator is formed by a piston in a tube. The movement of the piston is driven by a computer to simulate appropriate respiratory mechanics. The values of the mechanics are changed through the software. 5600i simulator is two-compartment lung simulator. It consists of 2 bellows with incoming tubes representing left and right lung including airways and central tube representing trachea. The simulator allows adjusting the flow resistance of the central airway and the resistances of the incoming tubes of both compartments. It is also possible change the compliance of both bellows independently. The resistances of the tubes and compliances of the bellows were changed during the experiment. Pressure and flow in the ventilatory circuit were observed for different mechanical parameters that were set on the

lung simulators. Flows and pressures inside the ventilatory circuit are studied during normal and changed respiratory mechanics. Values of resistances of the tubes were 5 cm $H_2O.l^{-1}.s^{-1}$ and the compliance of the bellows was 0,5 l.kPa-1 during simulation of normal condition when using 5600i simulator. The peak proximal pressure reached value of 5,3 cm H_2O. The resistance of the tubes was increased upon the value of 20 cm $H_2O.l^{-1}.s^{-1}$ when simulating the obstruction of the airways. The peak proximal pressure was increased. Its value was approximately 9,7 cm H_2O. The compliance of the bellows was decreased to 0,25 $l.kPa^{-1}$ to simulate decreased alveolar compliance. The resistances of the tubes were 5 cm $H_2O.l^{-1}.s^{-1}$ representing the normal condition of the airways. Similar changes have been made at simulator ASL 5000. This type of simulator has been used mainly for studying HFV.

The measured results show that mechanical parameters of the respiratory system directly affect the intrapulmonary parameters during ALV. The results correspond with the clinical experiences [2-4]. Changes of both mechanical parameters: increased airway resistance and decreased alveolar compliance contribute to an increase of proximal pressure in the ventilatory circuit. The increase of ventilatory pressure increases the risk of injury of patient's respiratory system. Protective ventilatory regimens are used in the clinical practice to minimize the risk of barotrauma even if optimal partial pressure of the oxygen in the blood is not reached during ALV. The experiment has also shown that conventional ventilation seems to be more suitable ventilatory technique for the cases that are represented mainly by increased airway resistance however HFV appears to be gentler to respiratory system in the diseases when alveolar compliance is decreased. The cooperation has been started with 1. Faculty of Medicine of Charles University in Prague during solving of the project. Some measurements that were carried out directly in the hospital confirmed some results of experiment. The experimental measurement confirmed a hypothesis that the pressure swings are significantly dumped in the alveolar space during HFV as it was measured in rabbits and computed in the mathematical model of the respiratory system. The linearity of the compliance of the bellows was checked before the experiment in the range that was used during simulations. The value of resistors is slightly changing with the flow. It can cause some inaccuracies during the experiment. However simulation shows that use of lung simulators can be beneficial for the clinical practice. It can be used to train the medical staff working with ventilators.

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Implementation of Home Care Accessories for Android Operation System Based Devices

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For a number of years the wireless transmission of biological signals is being studied at our department. Lately we have been concentrating on the utilization of 2G and 3G cellular networks in home care surveillance systems. Great efforts have been made to develop our own hardware for telemetry system using GPRS technology. However, this field is currently dominated by commercial companies.

Moreover, great number of third-generation mobile devices with sufficient computing power and with wide connectivity options begins to appear on current market. Hence the development of communication chain for use in home care (also referred to as tele-care) applications starts to move into the software field.

However until the last year most of 2G and 3G devices were based on proprietary operating system such as Symbian (Nokia). This situation complicated development of applications that could ran on great number of different devices. A recent development in this area is the open source operating system Android by Google which was released in October 2008 [1] along with the first device that implemented this OS - HTC Dream (also referred to as T-Mobile G1). Since then the list of Android based devices is growing every month and it includes not just mobile phones but also e-book readers, net books etc. Quick worldwide spread of Android represents enormous potential of this operating system.

Medical surveillance system which could be used in home care environment is being developed at our department since 2006 [3]. Back then it started with the development of our own ECG home monitor device. It implemented sensing of patient's electrocardiogram and GPRS module, which was used for transmission of data over the Internet to the server, which then allows presentation and archiving of scanned data. The system had major problems. It turned out that GPRS technology is not suitable for ECG transmission due to limited bandwidth (scanning frequency of 100Hz and single channel was used in our demo device application) and discontinuous nature of GPRS transmissions.

Furthermore, extension of such system and implementation of additional sensors (blood glucose level, oxygen saturation etc.) was problematic. Instead we begun to focus on use of commercially available sensor peripherals and utilize 2G or 3G cellular device as data gateway. According to the proposed concept [2] the patient should be equipped with adequate medical accessories (such as blood glucose meter in the case of patient with diabetes). The peripherals should relay the scanned data to the gateway device where the basic preprocessing should be done. Finally the gateway should connect to the surveillance server and forward the data for archiving and further processing.

During the development of the hardware for our first GPRS enabled device we realized that instead of lengthy development of our specialized gateway is much more practical to use some sort of gateway that most potential patients already have and that is a

mobile phone. According to the analysis of Czech Statistical Office at least one cellular phone is in use per household (even in the group of citizens of age 70+) [4]. That is an interesting fact especially regarding elderly people as the largest group of potential clients of such home care monitoring system.

As an appropriate communication interface between the peripherals and the gateway was identified Bluetooth. It offers multiple device connection (up to 7), excellent data rates (up to 3 Mbit/s) and great variability of use in desired applications by means of specific Bluetooth profiles.

There are already experiences with Bluetooth medical peripherals for home care at our department. For example Bluetooth blood pressure monitor and scale (both by AD&D) were already tested. During the last year were studied and obtained other potential peripherals for our system. First of them was Spurty Chest Strap (by mobimotion GmbH) allowing heart rate monitoring and GPS localization. Second was Onyx II 9560 fingertip pulse oximeter (by Nonin Medical Inc.). We were also interested in blood glucose meter by Alive Technologies Pty Ltd, but it was not possible to obtain their device.

As a gateway device we tested HTC Dream with Android operating system. It demonstrated ease of software development for the Android platform, but also the biggest problem of our concept and that was the choice of Bluetooth as the only communication interface. Even if it was quite easy to establish communication with a PC and test basic processing routines it was not possible in the case of HTC Dream, because of the fact, that Android rev 1 (or update 1.5 for HTC Dream) had not include a Bluetooth stack even if the device itself has all the hardware necessary. Unfortunately Bluetooth stack was not available until the revision 2.0 which was released on 26 October 2009. Since the update for obtained testing device (HTC Dream) was not released yet, it was not possible to test the connection with real devices as a matter of fact.

The Android platform is subjected to frenetic development. Further testing should be objective for future months. Probably different Android powered device will be needed or wait until the release of applicable HTC Dream update.

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Research on Planar Applicators for Treating Cancer Diseases

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It is well known, that cancer tissue is sensitive to increasing the temperature inside the body up to 42 degrees by electromagnetic power. This power is radiated via the microwave applicator with specific properties and specific absorption rate (SAR) in tissue is obtained, in dependence of the location of the treatment, applied frequency and type of applicator. Numerous calculations of SAR have been done with simple, homogeneous model of tissue. These calculations are instrumental only for the first notion of the distribution of energy. But they haven't been accurate as well as it is required to use this calculations as a part of treatment planning in clinical applications.

The main aim of this work was improving the design of applicator a modeling the SAR inside the tissue. To obtain more accurate results of SAR, it was necessary to use the anatomical based models of tissue instead of homogeneous models. The source of data for creating these models can be found in potentialities of diagnostic methods such as computer tomography (CT) or magnetic resonance imaging (MRI). Several CT image sets was provided by the hospital Bulovka. The task was to create the model of biological tissue from CT images. The way to do it is to class every pixel of the image into the groups with the same parameters. That group can be for example bone, muscle tissue or fat tissue etc. This is called the segmentation of the images. So the principle of the segmentation is dividing every image into the parts, so that every part includes the objects only from one chosen group. To do this, the commercial software 3-D DOCTOR was used. It contains several algorithms for fully automatic segmentation, interactive, which means semiautomatic segmentation, and fully manual segmentation. The final result of the model is strongly dependent on the input data, which means on the set of CT images. Especially it is a resolution of every image, number of gray scale distinguishable in the image and the distance between every slice.

During the work with CT images was found, that it is quite easy to segment the bones, due to the fact, that hard tissues absorb the most of radiation and they're represent with the white or bright gray color on the images. Whereas the soft tissues very often have the same value of gray scale, despite of the fact, that they are different types of tissue. So before the objects were ready to create the model using the rendering command, very often was necessary to edit the objects to keep the quality and originality of the input data. The aim of this work was not to create the detailed model of tissue, but only the improvement of the modeling the SAR. It is not possible to create the perfect and detailed model because of difficulty of human body. The experiences with these models have shown that two or three different types of tissue in one model are difficult enough for another work with these models in simulator of electromagnetic field.

Another reason for creating simplified models of the parts of human body is a fact, that it is a very time consuming problem to make some numerical calculations. When the model is rendered in 3D- DOCTOR, usually the stl format is accepted in simulators of electromagnetic field. Before the model is exported to stl file, it is preferable at first to decimate the overall

number of polygons, creating the surface of the model. The higher is number of polygons, the higher is requirements for computer memory. To study the effects in interaction of electromagnetic filed with body tissue, such as hotspots and distribution of SAR in different parts of the body, it is sufficient to have simplified model respecting the geometry, location of the main types of tissue an dielectric properties.

A few models have been created to calculate the absorption of electromagnetic power inside the tissue. It has been also demonstrated the differences between the profile of SAR in homogeneous model and model created from CT scans. Some planar applicators were developed and tested on this models and comparison with SAR provided by these applicators has been shown. Two basic types of planar structures have been shown. The first is a group of wide band structures. Typically it is a spiral structure with good resistant to dependence of working frequency on dielectric constant. And the second group is resonant structures, typically the slot applicator.

Some models had a localization of tumor, which is the target of focusing the electromagnetic power from applicators. From the numerical calculations with using different types of applicator has been demonstrated, that some applicator had better results of targeting the tumor. All applicators were designed for the frequency 434 MHz. The depth of penetration of electromagnetic field in this situation is about 2-3cm and it is typically used for superficial hyperthermia. The effective field size of used applicators was about 3-4 cm. This is a parameter, with which the treatment area is defined.

This work is for the present only on theoretical level of knowledge. There are some effects, which couldn't been involved to the study. Especially it is a cooling effect of the water bolus, cooling effect of the blood circulation in real tissue and the heat transfer during the clinical applications. Hopefully this study will be for the future the way to connect the theory with the clinical applications. Treatment planning in hyperthermia is a necessary procedure to improve the quality of whole treatment process. It has to be maximum comfortable for the patient with elimination of pain. On the basis of the calculations, it can be chosen the best applicator to obtain the best results of treatment.

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ITAREPS IQ: Module for prediction of schizophrenia

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Recurrent Events Data Analysis, also called Recurrence Data Analysis (RDA), can be used in various applied fields such as reliability, medicine, social sciences, economics, business and criminology.
Whereas in life data analysis (LDA) it is assumed that events (failures) were independent and identically distributed (iid), there are many cases where events are dependent and not identically distributed (such as repairable system data) or where the analyst is interested in modeling the number of occurrences of events over time rather than the length of time prior to the first event, as in LDA. In some applications data may be available for a larger number of processes exhibiting a relatively small number of recurrent events. These types of processes arise frequently in medical studies, where information is often available on many individuals, each of whom may experience transient clinical events repeatedly over a period of observation. Examples include analysis of cardiac ischemia in medical therapy, renal failures in internal medicine studies, pulmonary function in patients with cystic fibrosis or relapses during schizofrenia estimated by ITAREPS system [1]. The main goal of this work is to describe an alternate approach for the calculation of sensitivity and specificity when analyzing the accuracy of event prediction in the ITAREPS system. ITAREPS program is an example of a system for human behavior analysis in psychiatric area. Standard and alternate approaches for calculating sensitivity and specificity has been applied to schizophrenia relapse data. In this application, the outcome of interest is a definition of metric for recurrent events evaluation.

We have found the metrics which evaluate the predictor of psychotic relapses. The metrics takes into account not only correctness of predictor but even the time between the prediction and the event. This time Ts denotes earliness of prediction of the relapse. Ts can be fixed on desired value to evaluate the predictor. Or it can be bounded to interval in order to explore the data, find the best Ts and to examine it against an expert opinion. We have verified the metrics on the data from control group of prospective double-blinded ITAREPS trial. The evaluation metrics will be used for design of the next generation of ITAREPS IQ predictor.

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Algorithm development for correction of image deformations during acquisition of intrinsic optical signals

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Recording and analysis of intrinsic optical signals of the nervous tissue is associated with synchronous recording and analysis of connected action potentials. And on top of that the captured image data are deformed according to type of measurement. However, there are no acquisition systems enabling those measurements using one environment. Therefore we developed software tool for recording and analysis of video data, which is part of software providing unified user interface for synchronous electrophysiological and video acquisition and analysis. The video acquisition component, together with other parts of presented software, was programmed using Microsoft .NET Framework 2.0 library and C# programming language. The component enables to record from several types of camera; standard web and DV cameras and selected high resolution cameras for microscopy use. Captured data can be saved in two types of file, widely used video file format AVI and BVG file format designed for storage of uncompressed high resolution images.

Optical imaging of optical signals is an imaging technique used for functional brain mapping providing information at high temporal and spatial resolution.
Two main forms of brain optical signals have been shown. Extrinsic optical imaging is based on the use of voltage-sensitive dyes that change their optical properties with variations in cellular activity. This approach is used in experimental studies only because of toxicity of the dyes.

In contrast, intrinsic optical imaging is based on signal changes associated with tissue properties themselves. In spite of the fact that imaging of intrinsic optical signals has become a widely applied tool in the neurosciences, the processes influencing and underlying the signal changes are still indefinite. However, it is clear that the signal change is composed of different components in vivo and in vitro.

Two major components of the signal in vivo depend on either changes in blood volume or changes in oxygen consumption. The third component is based on scattered light and depends on cell swelling during cell activation.

In vitro, only the component based on changes of cell volume of the intrinsic optical signal can be recorded. During scattering photons undergo elastic collisions, no energy is lost and the photon changes direction. The more light scatters, the more light is reflected and the less is transmitted. Intrinsic optical signals may be recorded from transmitted or reflected light. These signals give in principle the same results though with different polarity.

Detection of those signals is associated with synchronous detection of electrophysiological signals of the tissue and camera devices must satisfy high technical demands. According to type of measurement the captured data are somehow deformed. During in vitro experiment only data from tissue slice is recorded and the deformation is minimized to deformations caused by flow of artificial cerebrospinal fluid and deformations caused by volume swelling of the cells itself. Such data can be than used for development of

algorithm for correction of deformations caused mainly by rotation of optical fiber and animal movement during in vivo experiments with non-anesthetized animals.

The aim of the present study was to develop software tool specialized for recording and analysis of image data, which is part of a software enabling synchronous image and electrophysiological recording and analysis. Exploitation of the software is expected not only for recording of intrinsic optical signals, but also for other measurements where synchronous imaging and electrophysiology recording is necessary, e.g. long-term EEG-video monitoring.

The video acquisition component, together with other parts of presented software, was programmed using Microsoft .NET Framework 2.0 library and C# programming language and thus it is suitable for any MS Windows based computer. This component is one of the three main components of the software enabling synchronous image and electrophysiological data recording and analysis. The other ones are graphical user interface and signal acquisition component.

The video component in the acquisition mode can cooperate with several different camera devices that can be divided into two groups. Firstly there are standard web cameras and DV cameras. Microsoft application programming interface DirectShow is used to control them. Data captured from those cameras are stored in commonly used AVI file that can be compressed or uncompressed according to user preferences and need. Secondly there are selected high sensitive cameras for microscopy use controlled by manufacturer's camera drivers. The drivers enable to perform basic camera properties, e.g. resolution, frame rate, exposition etc. Those cameras usually perform in high resolution and enable external triggering, whereby provide possibility of synchronization between image and electrophysiological signals. Images captured from those cameras can be stored in two types of file; in previously mentioned AVI file and in our own binary file called BVG (Brain Vision Graphics). Images saved in BVG file can be captured in non-equidistant intervals using external triggering.

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Wavelet Transformation in Brain Evoked Potentials Processing

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In neuroscience it is important to recording electrophysiological signals such as electroencephalography (EEG). EEG is the measurement of spontaneous electrical activity of the brain, which is recorded from electrodes placed on the scalp or directly in the brain tissue. Sources of EEG activity are brain cells, neurons, which oscillates at multiple frequencies having different spatial distribution associated with different states of brain functioning (such as awake, asleep, exploratory behavior etc.). These oscillations represent synchronized activity over a network of neurons. Besides spontaneous electrical activity exist in the brain signals called evoked potentials (EP). Evoked potentials represent changes of EEG activity to an external sensory stimulation. EEG and evoked responses processing is used for clinical diagnostic such as epileptic source localization. Evoked responses amplitudes tend to be low in comparison with EEG. Our aim is to characterize how spontaneous activity of the brain modulates evoked responses. For this purposes we have developed universal software which is able to measure EEG signals and evoked responses using lowcost digitalization cards.

Nowadays in many experiments increase the need of synchronous measuring of electrophysiological signals together with video signals. Current systems are often specialized for either electrophysiology or video without possibility to both in one environment. The aim of present study was to develop free system for broadly used and is able to measure and analyze EEG and evoked responses and synchronous works with video signals.

Acquisition component for electrophysiological signals is part of sophisticated system enabling synchronous electrophysiological and video recording and analysis. Our software is called *Vision Brain* and is developed for Microsoft .NET technology on .NET framework 3.5 in programming language C#. The software architecture of *Vision Brain* consists of 3 main interfaces. The first one is a programmable interface for typical digitalization card settings, such as settings of analog inputs, analog outputs and digital I/O lines. The second one is graphical user interface for displaying signals and the last is interface for events. All mentioned interfaces could be at least supplemented by component for storing data into file. Important part is communication between video and electrophysiological components. If camera supports external triggering, synchronization is managed by using card's digital I/O. However, if camera doesn't support it, we can provide simplified synchronization through flickering of LED diode in predefined sequence.

The software works with multifunction cards of M series produced by National Instruments, which communicate and transfer data through the USB or PCI bus. These cards were chosen because of their low cost. The other advantage is the fact that they together with quality amplifier are comparable with more expensive EEG systems currently used. These multifunction cards have up to 80 analog inputs with 16 or 18 bits resolution of AD convertors, 4 analog outputs and 48 digital I/O. The software enables to set up analog inputs, analog outputs, digital I/O lines and programmable amplifier called NI-PGA. Each of I/O uses their own DMA (Direct Memory Access) channel for faster exporting data. For easy

configuration there is available driver called NI-DAQmx developed also by National Instruments.

Not less important task was to find an acceptable file format for storing measuring electrophysiological data and predefined events including synchronization information. For our purposes we designed our own binary file format called *Brain Vision Data* (BVD) for signals and *Brain Vision Event* (BVE) for events. Both files are divided into several sections, the main header containing information about an experiment and necessary device or events settings as the secondary header and section for data.

The software *Vision Brain* was tested with multifunction NI M Series USB-6221 and PCI-6221 data acquisition cards (16bit, 250 kS/s, 16 AI, 2 AO and 24 digital I/O lines) with homemade EEG four channel amplifiers for signal preconditioning. For video recording we have tested simultaneous image acquisition with high resolution webcam (Philips 900NC), industrial cameras UI-2230C and UI-2230M (Imaging Development Systems, Germany) and high sensitive cooled camera Retiga 2000R (Q-Imaging, Canada).

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Independent Component Analysis Based Single Cell Activity Discrimination Algorithm for Multielectrode Array Sensor Data

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Microelectrode arrays (MEAs) become an important tool for neurophysiology research. They are instrumental in revealing neural network formation processes and inter-cell communication schemes, which helps to understand the functioning of the human brain and to treat it's diseases. The electrode pitch of current CMOS-based MEAs can be as low as 18 μm, which allows for recording the activity of a single cell on several channels [1]. Each electrode in turn records the activity of several adjacent neurons. The presented algorithm employs a modified Independent Component Analysis (ICA) method to recover the spike signals and to assign them to a particular neuron. To overcome the fundamental ICA requirement of linearly mixed independent sources, which is not satisfied in the case of neuronal recordings, the algorithm runs in a loop, successively extracts traces with spiking activity overlays those with previously detected ones and assigns signals to individual neurons.

To better understand inter-neuron communication, the exact firing time of each neuron has to be extracted from the recorded data. The commonly used spike detection, based on adaptive thresholds [2], can only detect the spike occurrence, but cannot assign the spike to a particular neuron. The use of ICA had been reported for spike sorting in different applications [3]. This method is capable to separate statistically independent non-Gaussian signals from their linear combinations. The fundamental requirement of linear combinations is only satisfied to a certain extent in neuronal recordings, as the spikes, measured on different extracellular locations, correspond to currents flowing through different sections of the cell membrane and differ in amplitude and shape. The proposed algorithm overcomes this requirement by executing the independent component separation as a preprocessing step of a traditionally implemented clustering-based spike sorter.

The proposed algorithm was designed and tested together with the Neurolizer system [4], but with minor changes, it can process data from any other high-resolution MEA recording system. The Neurolizer system consists of up to five active CMOS MEAs, the support board providing the chips with the necessary power, voltage references and clocks, and the data processing unit. Besides other functions, this unit compresses the recorded data and sends them to the supervising computer.

The presented spike sorting algorithm is implemented in Matlab, but is planned to be transformed for later implementation on Field-Programmable Logic Array (FPGA). Due to the recurrent nature of the current algorithm implementation and its execution time, the algorithm is executed off-line on recordings saved to file. As the first step, the input parser reads the raw data and creates a set of vectors corresponding to amplitudes on each electrode. It also assigns the real electrode location to each of these vectors Then, the source data are first filtered by a second-order band-pass filter (0.7–5 kHz) to eliminate offset and drift. The deformation of the spike shape, caused by filtering is not of relevance for spike sorting, and in

case the original shape is required, it can be re-extracted from the source data using the timestamps calculated by the algorithm. To shorten the time required for ICA and to reduce the memory costs, the data are preprocessed by a coarse threshold-based activity detector, and only the fraction containing spiking activity is processed by ICA. Such extraction reduces the memory requirements in average down to 20–40 %, depending on the activity.

The FastICA [5], a fixed-point implementation of the ICA algorithm, gives the best performance. After the whitening preprocessing step, it maximizes the characteristic contrast function. There are a number of characteristic functions that suit this application. By default, the kurtosis and skewness are used as measure of non-Gaussianity of the signal. Traces containing spikes shown in Fig. 2 have a kurtosis of 13.37 and a skewness of -0.58, while the traces with no significant spikes have a kurtosis around 0.2 and an absolute value of skewness below 0.005, thus featuring almost normal (Gaussian) distribution.

The separated independent components are then processed by a threshold-based event detection and the Klustakwik [6] clustering algorithm to extract the actual spikes and to identify the neurons, they are originating from. If there is no activity detected, the algorithm stops. Spike triggered averaging results in neuron "footprints", the average spike shape recorded on each individual electrode. If the footprint coincides with a previously detected one, they are merged. The averaged spike signal is then subtracted from the original signal at points of detected activity, which enables the algorithm to detect overlapping spikes.

The described algorithm was applied to recordings from acute rat cerebellar slices and successfully detected neuron (Purkinje cells) positions, even if they were overlapped. The locations of cell body and dendritic tree were extracted from the footprints.

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Processing of EEG Sleep Recordings in Newborns

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Electroencephalography (EEG) is one of the most important diagnostic tools in neurology. Some of its main applications are investigating epilepsy and locating seizure origin, investigating sleep disorders and physiology, and monitoring the brain development. EEG can also be used in the behavioral sciences, ranging from studies of basic cognitive processes to emotional functions. The wide list of EEG applications confirms the potential of EEG analysis and introduces the need for advanced signal processing techniques which can help the clinicians in their interpretation and make the evaluation more objective.

EEG also provides useful information that reflect the function of the neonatal brain. In clinical practice, the ratio of three newborns' behavioral states (wakefulness, active and quiet sleep) is an indicator of the maturity of the newborn brain. A variety of algorithms including various approaches to neonatal polysomnographic (PSG) data preprocessing and processing have been proposed. Most of these approaches target the field of neonatal epileptic seizure detection, but not the detection and classification of neonatal sleep stages.

Experimental data for this study have been provided by the Institute for the Care of Mother and Child in Prague (8 healthy full-term newborns were selected based on the similar postconceptional age from a wider group). These PSG recordings include eight EEG channels (FP1, FP2, T3, T4, C3, C4, O1, O2), electrooculogram (EOG), electromyogram (EMG), electrocardiogram (ECG) and respiration signal (PNG). Each recording was scored by an experienced physician. Only EEG channels from available PSG recordings were used in experiments. The attention was focused on the problem of distinguishing behavioral states of newborns. Steps of the developed algorithm for the automatic recognition and differentiation of these states include segmentation, feature extraction, normalization, feature selection, and classification.

Segmentation, either constant or adaptive, is an usual step in preprocessing of nonstationary and complex signals. Signal from each EEG channel was divided into segments of variable length with the use of adaptive segmentation algorithm. The applied segmentation approach uses two connected windows sliding along the signal [1]. The border of each segment is indicated by local maxima of the difference of the signal parameters in both windows (for the difference measure, the combined amplitude and frequency difference was taken). The threshold was introduced in order to eliminate the influence of small fluctuations of the difference measure.

Further on, each segment derived from the segmentation process was represented with a set of features. The set of commonly used features in the EEG analysis, namely statistical features, and power spectra in typical EEG frequency bands (delta, theta, alpha, and beta), was enlarged with features obtained by analysis in the time domain and wavelet transform [2]. Line length, nonlinear energy, root mean squared amplitude and Hjorth parameters were also computed [3]. When signals were decomposed with the wavelet packet transform, Daubechies 4 mother wavelet was used.

After the feature extraction, a feature matrix was created, with rows corresponding to segments and columns corresponding to features. It should be noted that a feature vector corresponding to one segment comprises of features derived from all eight EEG channels.

Appropriate expert's classification was added as the final column in the feature matrix.

Due to the usage of the adaptive segmentation, segment boundaries for different channels appear in different time instants. Due to the results of experiments performed in our previous work, e.g. [2], for further processing 4s-length segments were chosen. If this segment comprises two or more segments of variable length, its final feature values are obtained by averaging the values of appropriate individual features. And, if this 4s segment contains only one segment, all the features are taken as they are.

After the normalization, the feature selection was performed. Sequential feature selection method was used, namely forward selection, and it was conducted with PRTools4, a Matlab toolbox [4]. From the feature matrix formed after the feature extraction step, 500 segments (vectors), belonging to each of three behavioral states were randomly chosen. Feature selection was performed on this set of vectors. This way three groups of segments with selected features for further distinguishing of two out of three states were formed.

After obtaining sets of selected features, classification based on linear support vector machines was performed. Four different lengths of feature vectors were used: vectors comprised 5, 10, 15 or 20 features for each EEG channel, obtained with the forward selection. The performance of the classifier was evaluated through the 10-fold cross validation was used. The obtained average accuracies for all four different lengths of used feature vectors were: not less than 69.7% for stages wakefulness and quiet sleep, greater than 85.25% for stages wakefulness and active sleep, and over 98.9% for stages quiet and active sleep. The term average accuracy used here implies the ratio of correctly classified segments and the total number of segments in both classes.

Sleep in newborns is significantly different from sleep in adults, but in both cases finding strictly defined borders separating sleep stages or behavioral states is not possible. Consequence is that signal segments from the transition phase between these two stages can be misclassified. It should be stressed out that in this study only EEG channels were used for analysis and classification. The differentiation of stages may be improved by including features derived from other recorded non-EEG channels of PSG recordings.

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A Novel Concept of the Database Systems in Medicine and Healthcare Course

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The data processing rules are nowadays an essential part of strategic project control. Together with the boom of IT much more data are collected and must be processed furthermore. This trend is also present in medical sector (intelligent sensors, long-term data recording systems, etc.). The described project targets the problematic of medical databases in healthcare. It targets the educational part of the problematic.

The goal of the course *Database Systems in Medicine and Healthcare* is to teach students the basic knowledge of database solutions being used in medical environment. The course aims at introducing the students a real database (DBMS) system in a practical way. The students have to design and implement a simple information system backed by a database in a form of semester project. Open and accessible solutions are used (PostgreSQL database system, PHP scripting language together with (X)HTML). The accentuation is put on security and validity of the proposed solution.

The duration of the course is one term (13 weeks) and students have rarely any experience in programming (coding) and have no programming customs (comments, indentation, optimization, etc.). The target group consists of undergraduate students of *Medical technique* domain of the *1st Medical Faculty* of *Charles University in Prague*. The course is mandatory for the students and is assessed by 8 credits and is ended by an exam. In the project we face the fact that these students (in general) are able to learn a huge amount of structured information; however they lack practical experience and skills. Students having barely any experience with computers are also present. Tasks as creating a folder or packing a file often represent a problem for them.

The project sets the following goals: (1) Design and create a methodic for teaching the practical part of the course to cover the area of the proper design, testing and maintenance of database application, (2) Design the theoretical part of the course to support the practical part. The overall goal is to develop and intensify practical skills of the students and tie them to the theoretical basis. The related goal is to create an e-learning module in department e-learning system.

The particular outcomes of the project are: (1) Elaborated structure of theoretical course and presentations that forerun the practical courses, (2) Design and creation of individual practical assignments and their validation (function, validity, demands and time requirements). As the students are not used to work practically and on their own, motivation assignments are scheduled together with a semester project. (3) A dedicated database server available for the practical course for the students. With the *dedicated* feature the students can try to manage the system (web server, backup, replication, maintenance, etc.). (4) Server documentation together with plan for fast recovery from the backup.

One possibility for HW support realization is the use of free hosting agencies, offering SQL database and PHP module of the web server. The drawback is that there is no guarantee on the operation and maintenance of such system. The failure of internet connection and/or web hosting server infers the end of practical work for the students with no possibility to interfere as the response to support notification takes several days. That's why the solution with dedicated server has been proposed and realized. The essential part is simple replicable server that is easy to reconstruct. In the introductory course, an installation of database system and web server is demonstrated. Students have possibility to try these steps using a thin client and virtualized solution. Two virtualization technologies have been considered: KVM [1] and XEN [2]. The XEN technology requires a modified kernel; KVM needs a kernel module only. The hardware support of virtualization is essential. Finally, the KVM solution has been selected. We have used freely available applications, such as Linux OS, PostgreSQL, Apache web server, etc. The (virtual) server is accessible via SSH and VNC connection. The centralized monitoring is also available via the ITALC application.

In the following practical courses the students learn the scripting instruments: XHTML (PHP) and the contribution of validation of the documents. They are taught the rules for the proper design of the information system. Security aspects are emphasized and demonstrated. At the end the students are required to present and defense their design and realization of their information system in the form of semester project. This is a complex project that incorporates all aspects that have been taught individually (design, implementation, validation, security, maintenance).

The described project suggests and implements innovative changes in the *Database Systems in Medicine and Healthcare* course both in theoretical concept and in the practical part. In comparison with other database-related courses of the Dept. of Cybernetics this course much more stresses the practical skills as the students are not used to work practically. The practical courses are designed so as they can be elaborated in given time (incl. an explication). Another difference is the targeting to medical domain where the operation of the database systems has some distinct requirements (high availability, redundancy, security, etc.) that are often regulated by law.

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Design of Tasks for Introduction to Biomedical Engineering Course

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The course *Introduction to Biomedical Engineering* provides a basic review of biomedical engineering and informatics needed for the specialization at the FEE CTU. The course *Introduction to Biomedical Engineering* is taught in the form of an elective course and it is completed with classified credit (not by exam). Students who enter this course are coming from the first to the third year of their study (it means from first to sixth semester) in the bachelor programme and they are (mostly) interested in continuing the study in the master specialization in Biomedical Engineering. The goal of this project is to create a methodology for conducting the practical course that covers in suitable range the tasks from area of biomedical data processing (e.g. tasks from noise filtration, signal segmentation, feature extraction and use of artificial intelligence methods for classification). Now we have prepared five complex individual tasks. The main idea of these tasks is always in relation to practical demonstration of data measurement and the following processing.

In the course for the first task, the student is shown the device used for monitoring body activity and energy expenditure. The device measures transverse and longitudinal acceleration, heat flux, skin temperature, near-body temperature and galvanic skin response (GSR). From these parameters there are acquired trends of physical activity duration (sedentary, moderate and vigorous states), number of steps, lying down state or sleep duration. The goal of this task is to teach the student to perform basic analysis of data which have been measured by the above mentioned device. The students perform preprocessing of the data and try to find relation of simple signals (GSR, acceleration, heat flow). The first part is to determine the values of basic parameters (maximum, minimum, average, median, etc.). The next step is to display relevant histograms. Students have to discuss the probability distribution of values and results which imply this distribution. The results are verified using the graph of normality. The next part is to find missing values and outliers in the data where the students have to choose the way of compensating values. The last step is to compute the correlation among signals for determining of relations among the signals (e.g. acceleration – heat flow). Students have to interpret and discuss obtained results.

In the second course we use the ECG measurements obtained from a Holter device for demonstration in this task. Students use the long term ECG signal with atrial fibrillation from MIT-BIH Atrial Fibrillation Database [3] and they have the information about the sample rate of the signal. The first part of the task is to display the signal with the correct time axis and display the signal frequency spectrum together with correct frequency domain. The reason of this exercise is to be able to understand the relation between the signal and its sample rate and its frequency spectrum, understand the application of the Fourier transform. In the next part it is possible to show the relation of signal and noise in ECG (e.g. respiration and muscle noise, baseline wandering, power-line hum) in the time and frequency domain. Then the students can define the way for removing the noise from ECG signal. The next step is the detection of R peak in each beat. This process is based on methods using an amplitude threshold and on

the detection of peak by means of simple rule. The results of the detection are used for obtaining the heart rate (HR) which is displayed in relation to time position of each related R peak. The last part is to demonstrate the oversampling of HR signal in order to acquire equidistant sampling interval.

The third practical training is focused on the processing of EEG signals. We have prepared the demonstration of EEG signal measurement using the 10/20 electrode setup. The work module for students is divided into three parts. The first part is focused on using four FIR filters for separation of the EEG frequency sub-bands (alfa, beta, theta and delta). Students obtain practical understanding of the use of FIR filters in Matlab. Their task is to design the filters needed. Of course, all displaying, in both time and frequency domains, must be done with the correct time and frequency axes. The next part is to implement the signal segmentation into equidistant intervals. The Fourier transform is used for each of these intervals, so that they obtain simple non-equalized spectrogram. The last step is the application of adaptive segmentation algorithms from the first task to the EEG signal.

The goal of fourth task is to introduce the students the area of artificial intelligence and machine learning methods. Students in vast majority do not know this area hence it is important to explain the task of classification and clustering. We have created example classification task from medical area using the WEKA [2] software for this purpose. We use data from data set from the UCI Machine Learning Repository [4] for the classification task. This data set has been modified for the use in the WEKA [2] software.

In the fifth practical task we illustrate the measurement of dynamic parameters of pulmonary function tests. The device predicts dynamic parameters of pulmonary function tests based on the values about investigated subject (age, gender, weight, height, race, smoker/nonsmoker information). These parameters are compared with measured parameters. Students have to create diagnostic decision tree in the Matlab according to given scheme.

This paper presents the innovative project of the *Introduction to Biomedical Engineering* course. We have designed five individual practical exercises which are in relation to practical demonstration of data measurement in given area. These tasks follow the same concept and they should be taught continually to explain the processing of biomedical data and signals. We have obtained the results from first semester teaching the innovated course and now the evaluation of results of practical tasks and student's inquiry is in progress.

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An e-learning Module of the Visualization Toolkit VTK

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A high-quality visualization of biomedical data is very important. The students of Faculty of Electrical Engineering of the CTU in Prague often face the problem of visualization of measured data and results (in their bachelor and master theses). The students are comfortable with the Java programming language and have no experience with the visualization of high-dimensional data. The OpenGL is a difficult low-level tool, so we had to look for another tool.

Visualization toolkit (http://www.vtk.org) [1] (VTK) is an open source software under the BSD license. It is a visualization toolkit targeted at image processing and scientific data visualization. The graphical engine is based on the OpenGL library, so the toolkit is available for many systems and hardware configurations. The engine supports parallel image processing and speeds up and increases fluency of the 3D visualization.

VTK is composed of libraries written in C++. The wrapper classes for Tcl/Tk, Java and Python are available. Data and program structures of VTK constitute a set of objects that can be easily incorporated (implemented) into other programming languages and can be used in the visualization software development. VTK can be run on many operating systems and platforms: Linux, Windows and Mac OS.

The VTK supports many visualization algorithms including scalar, vector, tensor, space and sampling methods and functions. It also provides advanced techniques for 3D modeling, such as polygonal reduction, triangulation, cuts and 3D objects copying and wire-model display.

The target group of the projects comprises the students of the Faculty of Electrical Engineering of the CTU in Prague. The outcome of the project is available in the form of a tutorial in HTML form at the web page of the BioDat Research Group (bio.felk.cvut.cz). The VTK tutorial is targeted towards biomedical data processing. It should help the students quickly implement a visualization of their data without prior knowledge of 3D visualization.

The goals of the project are the following: Based on the literature retrieval of existing learning modules of VTK create an easy Java tutorial.

(1) Describe installation under Windows and Linux operating systems with screenshots.

(2) Validate function of the installation and run basic examples in Java.

(3) Describe basic components and structures of the VTK pipeline.

(4) Analyze advanced VTK examples and show their relevance to the previous part.

(5) Visualize high-dimensional biomedical data and describe and explain the process.

(6) Design and implement sample application and describe and explain the process.

The overall goal is to introduce the VTK in fast and efficient form to the students and provide well-structured guide to quick-start with the VTK and visualization.

In the creation of the module, the LaTex typesetting software has been used. It allows easy conversion into PDF and HTML format. The module is created in the form of a tutorial, so no knowledge testing is incorporated.

The project has been evaluated and guided by experts on education of biomedical engineering and with experience in Java programming and 3D visualization. Pregraduate students have helped with readability of the tutorial.

The first part describes the installation and compilation of the toolkit that is not easy for unexperienced user. This is a fundamental part of the tutorial, so it is described in detail. The configuration and compilation steps are documented by many screenshots. The download and installation of compiler in both Windows and Linux operating systems is described.

The validation of installation is performed by compiling and running basic testing examples in Java (provided by the Kitware company as a part of the VTK wrapper classes). The process is adequately commented.

Furthermore, the process of running more advanced examples visualizing heterogeneous data is described. A diagram of the VTK pipeline is provided so the user can easily see the structure of the visualization program.

A standalone chapter is dedicated to the visualization and graphical model of the VTK. As described in the VTK User's Guide [2], graphical primitives and their relationship to the VTK concept is described. The visualization of data flow is also provided. The model is illustrated on the advanced examples from the previous chapter.

The last chapter is dedicated to practical use of VTK for easy 2D and 3D data visualization. The electrocardiogram (2D) and vectorcardiogram (3D) data have been used.

The outcome of the project is an easy-understandable tutorial of the use of VTK in Java that can be used by students and scientist to quickly start implementing visualization of heterogeneous high-dimensional data.

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Nature Inspired Clustering in the Electrocardiogram Interpretation Process in Cardiology

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Arrhythmia diagnosis and ECG interpretation is an important non-invasive step in clinical diagnosis process. The presence of significant heart arrhythmias is an important marker of cardiac death. In our work we study the use of nature inspired techniques in the process of ECG interpretation.

During the analysis of Holter recording a huge amount of data is presented to the cardiologist. In commercial systems, mainly the template-matching method is used. The speed of final record evaluation and automated analysis is crucial. In clinical practice, 5 minutes of automated off-line data processing for 24 hour recording is considered as acceptable [1]. Clustering of long-term records should reduce the amount of work which has to be performed by the expert (cardiologist, resp. neurologist). Some methods can produce structures, which can reveal the structure of the data (a white-box approach).

Nowadays many data-mining algorithms with still growing number of modifications exist. In contrary to classical methods, nature-inspired methods offer many techniques, which can increase speed and robustness of classical methods. Clustering techniques inspired by nature also exist (such as self-organizing maps, neural networks, evolutionary algorithms, etc.). The paper focuses on techniques, inspired by ant colonies. Various methods exist, namely methods inspired solely by ant behavior, or hybrid methods (which combine ant-colony approach with traditional methods).

Table 1 shows an average sensitivity and specificity for all methods evaluated. Sensitivity is computed as Se=TP/(TP+FN), specificity as Sp=TN/(FP+TN). These measures are commonly used in clinical statistics. All results have been first clustered into four classes (the data contained four natural classes); final classification used the majority vote rule. Only the best results are presented in the table.

The methods have been (after preliminary parameter-tuning tests on smaller datasets) applied to the MIT-BIH [2] database with more than 80.000 records. The best results have been achieved by the hierarchical agglomerative method, which is the only method not using centroid approach. It is however very demanding. The nature inspired methods, however, outperformed the basic k-means algorithm both in specificity and sensitivity and achieved more stable results (in term of standard deviation).

Using the DTW [3] measure improved Se about 0.7 % and Sp about 0.9 % when compared to classical feature extraction for a #106 signal. This leads to the overall Se=92.8 and Sp=90.1 which is satisfactory as no other feature extraction has been used. The disadvantage is the computational complexity of the measure.

Table 1 presents a comparison of nature inspired methods.
It shows the averaged accuracy in %.

Method/Result	Measure	SE	SP
K-Means	L2	77	65
Agglomerative	L2	94	74
Ant Colony Clustering	L2	79	68
Kohonen SOM	L2	79	66
Ant Colony Clustering	DTW	79	69
RBF (ACO_R)	L2	87	71
RBF (PSO)	L2	89	68
ACO_DTree	L2	93	72

The best-performing has been the agglomerative hierarchical clustering (Se=94.3, Sp=74.1), however it is practically unusable as it is memory and computational demanding. Acceptable results (complexity vs. error) have been obtained by the Ant-Colony inspired method for Decision tree generation (Se=93.1, Sp=72.8).

The main advantage of the ACO_DTree [4] method is that it produces a white-box structure, which can be understood also by physicians. It can be also used in long-term processing, as the application is straightforward and simple. It also reduces the memory needed (in the application phase), as it can process the data in a serial manner.

The ant colony inspired methods can be applied in many stages of the ECG processing process. However, only some process stages are really suitable for such methods. The evaluation of the ECG clusters must be validated by cardiologists in the final stage.

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Study of Gait Angles and Posture in Physiotherapy by Cyclograms and Methods of AI

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Key words: simulation, human body model, walking, artificial intelligence, gait angles, bilateral cyclograms

In nowadays science sphere there is a really extensive use of the simulation. For us the most important is the simulation of human walking. Simulation of human walking is useable for prosthetics and therapy e.g. rehabilitation, optimization of sportsman's moves, evaluation of advances in rehabilitation etc. Also we can use methods of AI for prediction of gait movement and identification of disorders.

Our project is about measure of human walk, simulation of musculo-skeletal system for study walking and its prediction and quantification by NN and all of this is for study and research purpose in biomechanics' laboratory at FBE CTU and could be useable in a clinical practice at 2nd Faculty of Medicine, Charles University.

We decided to use for study of gait angles methods that are based on the measurement of geometric properties of bilateral cyclograms (also called angle-angle diagrams). The symmetry measures are simple, physically meaningful, objective, reliable and well suited for statistical study [1]. Furthermore the technique is strongly rooted in geometry and the symmetry measures are intuitively understandable [3]. Depending on the cyclicity of the gait, cyclograms are closed trajectories generated by simultaneously plotting two (or more) joint variables. In gait study the easily identifiable planar hip-knee cyclograms have traditionally received the most attention. In order to quantify symmetry of human walking, we obtained and study cyclogram from the same joint from two sides of the body as well [2].

For measure of gait/movement we used two methods: infrared (IR) camera with active markers and web camera. The first of all we had to measure a human walk for gain a quantum of data. For this we used two methods of movement in the space measure. First was by the IR camera with active markers (system Lukotronic AS 200), which we have in the external workplace Joint Department of Biomedical Engineering CTU and Charles University. We placed LED diodes markers on the measured person to the following points: malleolus lateralis, epicondylus lateralis, trochanter major and spina iliaca anterior superior. By this method we could register the movement in a three dimensional space. The second method was recording video of human walking by web camera, which was consecutively analyzed in the program Coach6, version 6.1. In this case we made own circular markers which were contrast with the wear of the measured person who was in black. Program Coach6 is an adequate tool for detection of the markers. We chosen frames of video which for our analysis were usability and in them we marked positions of markers one by one. Because it's about a video method we gained only two dimensional co-ordinates of captured markers.

Model of human body was created in the environment of program Matlab (Mathematic Laboratory), version R2008b of which component is SimMechanics for simulation and modeling of mechanics elements and theirs direction. For creating a model of human body we

used tools - blocks, which the SimMechanics offers. The condition for practically useable model was built a base of the model which was representing by grand block. We had compilation a skeletal via body block and custom joints. By the help of joint actuator block we could import data to the body model and by the joint sensor block we could export data of the body model. Our body model can counts angles in joints and takes it into the simulation of the human walking.

From lot of options we took out an artificial neural networks to analyze the cyclograms, because for us the NN are most interesting, and we thing, that there is a huge use of them in future [4]. The component of M-S body model is an option of movement prediction, closer an inferior limb motion prediction which is represent by the NN. We made-up an NN in sw Matlab too, there is a toolbox for AI which we used. We created our NN for a prediction of angles in a knee and hip of a right leg and we used a backpropagation network training function traingdx, has 10 input layers (we defined this number according to count of breaks in the angles function behavior) and one output layer. We used a log-sigmoid function as a transfer function of input layers and a linear transfer function in an output layer. Our neural network learns for 500 epochs, because the mean squared error (MSE) of the predicting function of angles in the knee and hip was the smallest there. We designed functional user interface in the Matlab component GUIDE in which the user can easily handle all parts of our program.

Output of our project is user interface for work with our application whose parts are an analyze (graphs of measured data and of a change of angles in the knee and hip, bilateral cyclograms), the body model (animation of motion) and a prediction (setting of the NN, graphs of an input vector, a target vector and output vector).

The program which we made is now ready to use in biomechanics laboratory for study of walking. Body model is modifiable by changing of weight of body or single segments, from which we can count moments of inertia of these segments and forces in joints. It could be also update by more realistic human model, e.g. in CAD. In next step of our research we would like to produce a hydraulic mechanism which will be controlled by NN and which could help patient in rehabilitation.

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European Marrow Donor Information System - Concept and Praxis

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Haematopoietic stem cell transplantation (HSCT) is an increasingly used treatment option for patients with severe disorders of haematopoiesis, especially acute leukemia. In about a third of the patients, an HLA-identical family member is available for donation. However, in roughly two thirds of the cases, an unrelated donor must be sought. More than 13 million unrelated donors [1] are readily available worldwide and their data are stored in different computer systems around the world. The search coordinator in charge must not only be able to work with large databases and have thorough knowledge of the HLA system.

Donor searches would nowadays be unimaginable without the support of information technologies. Search strategies and algorithms are being continuously developed and the user interface of software systems presenting search results is progressing.

Reliable communication and data transfer of donor and patient records between all partners in this huge network is one of the most important success factors in stem cell transplantation.

The internet gives us great opportunities in registry to registry connections, including the software support of the whole process - from the preliminary search request to transplantation.

EMDIS (European Marrow Donor Information System) is an open computer network for data exchange among different unrelated hematopoietic stem cells donor registries. The first work on the system started in 1992 [2,3], but it has become a trend in this branch not until recent times. Nowadays it covers 85% of all potential unrelated stem cell donors and cord blood units worldwide.

A stem cell donor registry is a communication HUB in every country. It is the medium between national institutions such as transplant centers, donor centers, harvest centers and HLA laboratories. It is also the information gateway to foreign institutions and international networks.

EMDIS is conceived in such a way that singular registers have servers permanently connected to the internet or are connected regularly. EMDIS is a P2P (peer-to-peer) computer network, so in contrast to Bone Marrow Donors Worldwide (BMDW) [1] where data exchange and search procedures are not only between national registers and the central database but directly among each other.

EMDIS could be perceived as an electronic replacement of the fax machine. But the original idea of EMDIS is more ambitious. EMDIS is considered as a single virtual donor registry database, i.e. distributed database that consists of national registry databases.

We will present EMDIS progress on the example of the Czech Stem Cells Registry in Prague [4]. The registry became a member of the EMDIS community at the end of 2003, when

it was connected to the German registry, ZKRD. At that time, the EMDIS community included only West European registries. Nowadays (at the end of 2009) the registry is connected to 21 foreign registries, including registries in the North America, Australia, Asia and Africa.

In 2003 the registry (manually) processed about 300 preliminary donor search requests. After connecting to EMDIS, there was a large increase of the number of requests, but with less effort, because these requests have been processed automatically. In 2004 it was more than 1000 requests and in 2008 more than 14 000 preliminary requests. There are about 4 000 active patients in every-night repeat search process. In 2003 the registry exported 32 stem cell products and in 2008 the number was 63.

The whole process from preliminary search, through additional requests to the transplantation is now managed by a computer system, which simplifies and speeds up the workflow. The time interval between preliminary request and workup request was shortened.

The main advantages of EMDIS are: quickness, reliability, security and computer support of the communication between stem cell registries. Data integration and electronic communication can bring many benefits, such as simplification of work, prevention of clerical errors, automatic processing (preliminary requests) and better control over the whole process.

On the other hand, EMDIS is not a ready to use software that could be downloaded and used. It means a lot of effort in own development or the purchase of a commercial software product. Data quality of local database becomes very important, because the registry exposes its data to foreign systems. The search algorithm is critical, it must be robust and scalable in order to handle a large number of patients. EMDIS also brings increased importance to software stability and reliability than a standalone application.

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The Emotional States Classification based on the EEG

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In this paper we describe a method for the classification of EEG signal based on machine learning methods. We analyzed the data from an EEG experiment consisting of affective picture stimuli presentation, and tested automatic recognition of the individual emotional states from the EEG signal using Bayes classifier. We also identified correlation between the classification error and the extroversion-introversion personality trait measured by EPQ-R test.

Keywords: feature selection, SOM, Bayes classifier, emotional states, EEG

Introduction

There are several methods to measure brain activity (fMRI, EEG, PET) in the area of cognitive neuroscience, but we will focus on the EEG signal and its frequency analysis in the presented research. The research line of R. J. Davidson [1]-[2] uncovers regularities between the affective stimulation and the subject's inter hemispheric asymmetric responses in the alpha band wave, especially in the frontal and prefrontal brain areas. Although the results of these studies attribute the processing of the emotional stimuli to the specific brain regions and frequency bands, we analyzed every aspect of the EEG signal in all areas.

Methods

Prior to the experimental procedure we administrated the EPQ-R personality test to all participants to examine a correlation of its results with the EEG signal analysis. The experimental part of the research was based on the presentation of pictures eliciting different emotions. The experimental sample consisted of 23 subjects with the average age 25,6 years. There were four categories of the pictures, chosen from the IAPS database [3] and each category consisted of 25 stimuli. We selected pictures with the highest and lowest value of valence (pleasant or ugly) and arousal (boring or arousing). The signal was recorded from 19 electrodes placed according to 10-20 international system. The signal was adaptively segmented and the signal features were calculated. The signal from each electrode was described by 93 features. These were information about power spectrum, wavelet transformation and statistical descriptors. We also calculated intra hemispheric and inter hemispheric correlation and coherence between electrodes. All features were then resampled to the 1 second resolution and these data serves as the input to the algorithms for feature selection and classification.

For each subject, we obtained 600x1902 matrix with 600 instances and 1902 features, where each instance (features extracted from 6 seconds of EEG signal) was classified into one of four classes (emotional states). 25 instances corresponded to one stimulus (picture that should evoke a particular emotion). Before testing a classifier, we preprocessed the training data using the following procedures:

- Removing outlayers--class by class a distance matrix is constructed and objects are removed
- Normalization--transform that shifted the data into origin and scaled the variances of features to 1.
- Feature pre-selection—the features were individually evaluated using a distance-based class separability criterion and the best 100 features were further used.

- Feature selection—subset of 7 features was selected using forward search algorithm and the distance-based class separability criterion.

Results

After many preliminary experiments, we decided to use the Bayes classifier and assuming normal densities of data from particular classes. To provide the fair testing, we had to avoid the presence of two instances corresponding to same stimulus in training and testing set simultaneously. Each cross-validation fold was created using 5 randomly selected stimuli (5x6=30 instances) from each class that gave 4x30=120 instances at all. Thus, we have used a special case of 5-fold cross-validation. The preprocessing, normalization and feature selection procedures were created entirely on training data which imply the fairness of classifier testing.

Discussion

We should imply the relation between the emotional category and classification error. As we were interested in the finding regularities between emotional responses and the personality traits, we compared the results of the classification with the results for the EPQ-R. The analysis uncovers the correlation between the classification error and the extroversion scale in the questionnaire. The subjects with the highest extroversion obtain the biggest classification error (approx. 30 percent). The lowest score in the extroversion scale resulted in the best classification ratio (approx. 10 percents). We should interpret these results in consistence with the psychological theories of emotion [4]. The introverts have the low threshold of excitation and tend to react to very small affective stimuli. It should result in biggest variance in the EEG activity and the better classification. But this is just the preliminary hypothesis and has to be tested in the future research.

Conclusion

We should conclude that the individual classification algorithms are able to detect emotional states with the 75 percent accuracy. But there are problems with the ability to generalize results. It is necessary to calibrate this system separately for each participant with the known type of stimuli to identify most salient features for the classification. It is also necessary to test the reliability of the calibration and its stability over longer time periods. These should be confirmed by the testing the same subjects with the same methodology in the future.

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Study of Bio-compatible Materials using FTIR Spectroscopy

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Infrared (IR) spectroscopy is used for the measurement of absorption spectra of analyzed material in IR wavelength region. IR radiation is electromagnetic radiation on the range of the wave length 0.78–1000 mm (wave number 12800–10 cm^{-1}). Whole IR area can be separated into the near area (13000-4000 cm^{-1}), mid area (4000-200 cm^{-1}) and far IR area (200-10 cm^{-1}). We studied infrared spectra of TiO_2 layers using FTIR spectroscopy (Fourier Transform Infrared Spectroscopy). Apparatuses works by the process of interference spectra that measures interferogram by the modulated bunch of radiation after pass the sample. The apparatuses require mathematical method of Fourier transform to gain classical spectral imaging. Analytical output is IR spectrum - that is the graphic imaging on functional dependence of energy by wavelength incident radiation that is generally expressed of transmittance (T) and absorbance (A). FTIR spectrometer works with tree modes, absorbance mode, transmission mode and reflection mode. Mostly used is transmission measurement. Reflection has different methods as specular reflection which classify into near-normal reflection-absorption and graying angle reflection-absorption. Next method is DRIFTS (Diffuse Reflectance Infrared Fourier Transform Spectroscopy) and last method is ATR (Attenuated Total reflectance). FTIR spectrometers have a lot of advantages. During the measuring that always whole bunch of radiation incident to the detector. It makes possible to measuring with accessory to analysis for solid and liquid samples.

FTIR spectrometer is frequently used in a biomedical application. In a medicine is used to the investigate titanium materials for the orthopeadic and dental implants [1] [2]. In medicine is also used to study the calcification of layers containing TiO_2 and to study mechanical strenght for orthopeadic apparatuses [3]. FTIR is also used to study the heat treatment temperature of sol-gel prepared TiO_2 layers [4]. Bioceramic Hydroxyapatite/TiO_2 was coated on Titanium and studied anatase crystalline structure. They evaluated band about 1000 cm^{-1}, and TiO_2 peak at 1092 cm^{-1} and 961 cm^{-1} [1]. For study of coating of bioactive materials, like titanium and silica the FTIR (Shimadzu FTIR spectrometer, Model IR Prestige-21) was used. The band of TiO_2 near 1109 cm^{-1} was measured [2]. Calcification capacity may determine porous and cytotoxicity [3]. It is observed calcification structure after incubation time. It is over 53 days and than do study it on FTIR - BRUKER IFS 66. They measure absorbance in band 564-603 cm^{-1} and 1000–1200 cm^{-1} [3]. The influence of temperature on bioactive materials was simulated on body fluid in 20° C, 400° C, 700° C. They measure area 400-4000 cm^{-1} on FTIR spectroscopy ELMER 2000 FTIR. Band of TiO is in 3000-3600 cm^{-1} and 1300-1700 cm^{-1}. Band of Ti is in 800-400 cm^{-1} [4].

Our samples were measured in graying angle reflection mode. We applied FTIR spectrometer NICOLET 6700 for mid area and far infrared area. Our FTIR spectrometer disposes tree detectors with different accessories. Detectors are DTGS Polyethylene (Deuterated Triglycine Sulfate), DTGD KBr and MCT/A that must be frozen by the N_2.

MCT/A detector is for the mid area and near area (11700-6000 cm^{-1}), is more sensitive, there is less noise, higher absorption. DTGS detectors are insufficient to the thin layers. DTGS Polyethylene is for the far area (500-700 cm^{-1}). DTGS KBr is for the mid area (12500-350 cm^{-1}), it is not transmit lower wave number than 350 cm^{-1}. For the each one detector we can use different accessories. We have accessory called ORBIT, it measures at all areas. Accessory includes plate with Diamond that is for the far area to the 150 cm^{-1} and plate with Germanium that is to the 700 cm^{-1}. It has high index of refraction than the Diamond plate and it also has lower depth of diffusion (1 μm) than the Diamond (2 μm). Accessory SMART SAGA is without limits, it is on the 80% reflection with fixed tabulator and it is on the thin layers (unimolecular layers). Accessory SEAGULL is on all areas. It has flexible angle. It has been measuring under the reflex angle from vertical reflection to reflex. By the 30° angle we can penetrate to the substrate. It is necessary to optimize angle.

We studied TiO_2 layers prepared by PLD (Pulsed Laser Deposition) method. Layers were created on Si a FS (Fused Silica) substrates. Conditions of deposition take in energy density, pressure and temperature at deposition, types of targets and layers and crystalline structure. Density of energy moves between 3 and 6 J/cm^2. Pressure during the deposition was ~ $3 \cdot 10^{-3}$ Pa. Substrate temperature was set up in region from 200° C to 500° C. Types of targets were usually used from Ti or TiO_2 NEYCO Company. Layers were created on Si (111) or FS substrates. Fabricated layers were amorphous or crystalline [rutile (110, 111), anatase (111, 103) and brookite (120)].

We measured IR spectra in region 600-100 cm^{-1} and 4000-600 cm^{-1}. To eliminate the water and steam moisture we used a generator of dry blow air. On the Si samples we often observed the interference in the spectra that obstructs in the classification. On the measured spectra we can see the hydrocarbon zone (2960, 2930, 2850, 1460, 1380, 720 cm^{-1}). In zone 1100 cm^{-1} we find Si and O_2 spectra. In 1640 cm^{-1} (middle of 3400 cm^{-1} region) we can find water vapors. During the measurement of samples with different accessories we found strong IR spectra in region 600-100 cm^{-1} on the samples exhibited brookite phase.

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Section 13

CIVIL ENGINEERING

Technological instruction for control measurements of the highways

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The technological instruction provides control measurements of geometric parameters of the highway for the input, production and acceptance inspection. The instruction is designed for control measurement of the surface and cover the ground during construction of the highways, after the completion and acceptance. Results of control measurements can be used for documentation of actual implementation. The instruction is not designed for setting of the highways neither for measuring shifts and deformations.

Implementation, evaluation and documentation of controls
Requirements for precision size, shape, position and orientation of the geometrical parameters of structures are placed on the technical drawings for the implementation of rules and in technological rules for production and assembly. The nominal values of geometrical parameters are given in the documentation for implementation.

The technological rules for production and assembly of the documented requirements:
a) the accuracy of critical parameters derived from functional requirements,
b) the accuracy of geometrical parameters of a detailed definition,
c) check the accuracy of selected geometrical parameters and the method of evaluation accuracy,
d) ensure the accuracy of measurement.

Check the accuracy of geometrical parameters and the method of evaluation accuracy:
Results of control measurements of geometrical parameters of line construction are used for documentation of the actual implementation and consist of three parts:
a) technical report which contains a description of the controlled section, justification of the methods used, details of staking the network, including precision data and the accuracy of HVB. Than contains the way of addition definition site and method of positioning and height control points of focus, a list of calculations, data on computer technology, programs and results and parameters of the devices.
b) the results of control measurements which contain the actual deviation calculated control points in the table. The results are assessed and documented as specified in the project respectively in the control plan. Way to document expresses the relevance of the results of examinations and corresponding ISO 7737 and general rules for the control measurements.
c) surveying and computing elaborate [1].

The documentation on the control measurements includes:
a) the measured object and its parts,
b) the controlled parameter, including the required deviations,
c) using the controls method,
d) plan and process of control,
e) the date, climatic conditions, used equipment, gauges and their parameters,

f) methods of measurement and accuracy,
g) evaluation methods,
h) measured values,
i) the name and signature of the processor, the date of preparation,
j) the name and signature ÚOZI, date verification [2].

Methods of measurement:
Control measurements be made using the cross cuts. There are two methods:
- methods of project cross cuts,
- method of general transverse cuts.

The cross sections are measured will set out the places where we will check the position and height of each layer construction or cover the road.
The line construction check:
a) spatial location,
b) location in the horizontal plane at the points that characterize the conduct of road axis, at least in the beginning, the middle and end of the directional arc,
c) altitude in areas designated project documentation,
d) banked road and hard shoulders,
e) the thickness of the layers of the road,
f) equality between the road surface,
g) distance from other objects in the crossing or overlapping.

Evaluation methods:
The quality of the file can be examined ether 100% inspection or sampling inspection.
Sampling inspection, according to the standards allowed to carry out a statistical quality control. Types of statistical quality control are ether statistical regulation or statistical inspection (comparison).

This instruction is based on existing ČSN and ISO standards:
ČSN 73 0202: 1995 Geometrie accuracy in building. General requirement.
ČSN 73 0205: 1995 Geometric accuracy in building. Design geometrical accuracy.
ČSN 73 0212-1: 1996 Geometrical accuracy in building industry. Accuracy checking. Part 1: General principles.
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The role of the Czech national long distances measuring standard Koštice for metrology and geodesy

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Surveying engineer duties in the course of surveying activities in the Czech Republic (CR) to comply with regulations, in particular Law about surveying, and its execute public notice, the Law about metrology, and its execute public notices and other generally binding regulations. For selected surveying activities officially authorized engineer further confirms that the results of surveying activities are in conformity with state regulations. A natural person with official permission is required to verify the results of surveying activities to act professionally and follow the statutory requirements and conditions agreed in writing with the client, they do not conflict with the law. One of the requirements of generally binding regulations, the use of established metrology gauges, normally calibrated meters (Law about Surveying and the Law about metrology). Follow meters is defined as the inclusion of the gauges in an uninterrupted sequence of transmission of values quantity starting etalon highest metrological quality. Law on Metrology defines meter as:

- Standards,
- Working gauges provided,
- Working gauges not provided,
- Reference materials

This law regulates the rights and obligations of natural persons who are entrepreneurs and legal persons (hereinafter referred to as subjects) add institutions of government, to the extent necessary to ensure consistency and accuracy of measuring instruments and measurements. In art. 11, par. 5, of Law about metrology provides that the consistency and accuracy of working gauges is provided by the user with calibration, unless the meter is more appropriate for other means or method. In the CR is calibration of gauges solved independently in two ways:

- in terms of national legislation by the Law about metrology n. 505/1990 Coll., as amended by law n. 119/2000 Coll., law n. 137/2002 Coll. and law n. 13/2002 Coll. and execute public notice n. 262/2000 Coll. which ensures uniformity and accuracy of measuring instruments and measurements, as amended by execute public notice n. 344/2002 Coll., execute public notice n. 345/2002 Coll., which provides for mandatory verification of measuring instruments and meters subject to approval and a execute public notice about the basic measuring units and their labeling,
- in terms of quality standards EN ISO 9000 and 9001 and related regulations.

Both of these ways are intended to ensure consistency and accuracy of measuring instruments and measurements. This condition usually provides calibration, respectively meters for the establishment of higher standards of measurement quality. The issue of ensuring the continuity of meters is not very easy, particularly in terms of technological and economic. Organization has to, prior to the implementation of continuity of gauges, consider its technical possibilities and on the basis of economic analysis decide whether will pay for

their own solution, or whether will use accredited subject, where the cost of implementation and where stratification is guaranteed under the authorization and accreditation of professional work. In the eighties of the twentieth century began in the CR to apply on a wider scale measuring electronic distance meter (EDM), later integrated into total station. A necessary condition for quality measurement is to verify its accuracy. This can be done in two ways:

- laboratory determination of parameters of meters (in the case of EDM is the determination of electromagnetic characteristics such as carrier frequency EDM, which is measured by a precise counter),
- comparison with appropriate standard instrument of quantity.

Long experience shows that users of geodetic survey techniques prefer comparing with measurement standard instrument, which by its nature correspond to the normal use of the meter. Therefore, in the past decided to build a Czechoslovak calibration base. It is important to highlight the fact that the resolution EDM, previously characterized by the value of several millimetres, has changed to one tenth of a millimetre. These circumstances and the requirement of the Government, stated in the resolution of the Government to develop the concept of metrology system of the CR in ensuring equivalence with the system in the European Union and ensure consistency and accuracy of measurements specified types of meters, especially in the construction of the motorway network and rail corridors in the CR, led to the declaration of the Czech national long distances measuring standard Koštice, as an ensemble:

- 12 physically stabilized points,
- Set of 12 pins,
- TS Leica TCA 2003 with an integrated distance meter,
- Meters of influencing quantities.

Using a standard that is broadly described in the Manual of Quality of Accredited calibration laboratory (ACL) VÚGTK, v.v.i. - guarantor of standard, which is part of document management of ACL. The main use is to receive standard metrological characteristics of measuring instruments of long distances, in particular EDM. These characteristics are additive constant for the whole ensemble of the meter, typically is used by a constant ensemble EDM and prism reflecting a multiplicative constant, reflecting the size dependence of repair on the size of measured distance - ppm.

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Strengthening of constructions

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Fiber-reinforced polymer (FRP) composite materials have developed into economically and structurally viable construction materials for buildings and bridges over the last 20 years. Nowadays, there are commonly used for strengthening of constructions (strips, bars, fabrics) and also for making structure elements. Strengthening of the members or structures are made by sticking FRP materials to the structure or by its prestressing. One of the progressive methods to strengthening RC structures (buildings, bridges) is to use external FRP reinforcement. Main problem of strengthening by external FRP reinforcement is bond presstresing force to usually cracked concrete. In the past, it has been done experimental tests of bond area of FRP strips, but without strengthening this area by FRP fabrics.

The goal of the experiment is exactly to define transfer of internal force thorough anchor zone FRP strips where the anchor zone is strengthened with the help of FRP wraps.

Efficiency of strengthening structures by external FRP reinforcement (prestressed or not prestressed) depends largely to possibility to transfer internal force of external reinforcement to cracked RC structure, in case of prestressed external reinforcement to efficiency of anchor and not prestressed external reinforcement of adhesive joint. This project is designed to show, if is possible to replace mechanical anchor by reinforcing FRP fabrics, or how much it improve effectivity of bonding area. It has been made reinforced concrete testing beams 190mm long, 55mm width and 95mm height from concrete C 20/25. FRP strips S50x1,4 have been stick to those testing beams in three different bonding lengths, which are 50mm, 100mm and 150mm. Finally have been bonding areas wrapped by FRP fabrics all around its perimeter.
Prestressing test beams and observe behaviour of the bonding area will take place in laboratories of Klokner Ústav ČVUT in Prague during January 2010 and test results will be published in technical literature in 2010.

Nonlinear finite element method has been used for mathematical model. This is well supported by commercial software ATENA. It is a well-established finite element program for realistic computer simulation of behaviour of elements under the test load. The program allows monitoring of the element in all stages of examination from transfer of forces through crack development to the failure.

Results of mathematic models from Atena have been indicated that they are equivalent to other laboratory tests. Therefore, it is used to simulate experiment in mathematical way and laboratory test will be used to calibrate it. All the beams have been made in ATENA to show behavior of bond area to simulate of bonding behavior in different types concrete quality and to show transfer internal force from external reinforcement to concrete through bond area reinforced by wrapped FRP fabric.

The results of this experiment will be used to modify analytical formulas for determination of anchorage length as well as for determination of c_1 and c_2 coefficients which usually determine characteristics of the anchor zones of FRP strips.

Increase in transmission efficiency of anchor force to the strengthened element allows a better use of mechanical characteristics of FRP reinforcement.

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Water Reservoir - Water Quality Influence

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Water is a basis of life, so supplying people by drinking water is one of the topic of our interest. Usually water must take a long way from source to taps, so in some parts is getting older and it´s quality is decreasing. The quantity and quality of drinking water is ensured by a water supply system operator. He takes and tests samples from a distribution system and consumer´s taps. We must realize, that water after a preparation in a drinking water treatment plant is secured in a distribution system usually only by the chemicals for a secondary disinfection. The Water reservoir is probably the first and last place where the secondary disinfection could be done.

The Water reservoir has tree basic functions. First function is a water accumulation for compensation inequality between inlet to a water reservoir and outlet to a water supply system. Second function is given by the reservoir´s elevation location and set the pressure in a water supply system. And third function is a good recirculation for the secondary disinfection. With problems of a quality drinking water deal for example the legislation act 258/2000 Sb., 274/2001 Sb.,. 252/2004 Sb., 409/2005 Sb. and the standards ČSN 73 6650 or ČSN EN 1508 (75 5356). In the European standard EN 1508 (Water supply - Requirements for systems and components for the storage of water) is written, that is necessary reduce to minimum dead zones of flowing water. This could be done by suitable design of a reservoir, water inlet and outlet placing in dependence on a useful storage capacity. An imperfect water reservoir design could have adverse reaction. Water in some parts has tendency stagnate and create dead zones. Another problem is in a free water surface, if a ventilation system isn´t secured by an appropriate air filters.

The research is focused on water reservoirs problems, which have connection with a water quality and suggests solving. In thesis are described desired utilities of water storage tanks and valve chambers, follow description of locations, in which were obtained data. Below are shown data about water reservoirs construction failures, pipelines deficiencies, unsatisfactory construction part and fittings sanitations possibilities. The research discovered, that is good to know the hydraulics of water reservoirs to prevent water quality degradation.

For the hydraulics evaluation was selected a water reservoir with capacity 2x 8000 m^3. Because of an axial symmetry only one chamber was solved. Solutions were made for three steady flows (30 l/s, 75 l/s, 150 l/s). These flows represent small, middle and high outlet. At first was the hydraulics of a accumulation chamber solved by a CFD (Computational Fluid Dynamics) modeling software and then by a laboratory model. Results were compared to each other.

The CFD model was designed by the software GAMBIT in scale 1:1 and then solved by the software ANSYS FLUENT. This software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial

applications. Special models that give the software the ability to model in-cylinder combustion, aeroacoustics, turbomachinery, and multiphase systems have served to broaden its reach. Results represent pathlines, velocity vector field or age ratio field. The flow has two main streams. One is a direct flow from inlet to outlet and second is a spiral flow around the accumulation chamber. For the highest flow we can say, that the recirculation is quite good without dead zones. For smaller flows aren´t conditions so positive.

Mathematical model results were compared with laboratory model results. The laboratory model was built in scale 1:50 and steady flows were modified by the Froude similarity law. Laboratory simulations were recorded on a video. For demonstration of main streams was used tracer (Water blue). Laboratory model results were a little bit different. The flow has only one main stream, spiral flow around the accumulation chamber. If we compare designing and running of both models, we must say that the laboratory model is much cheaper, but measurement and getting reliable data is more difficult.

The biomonitoring showed us, that is possible use a water reservoir for a water quality risk prediction, but complex hydrobiology and microbiology analysis of water are needed. Crucial problems of water reservoirs are inlet and outlet placing in same place, using unsuitable construction materials, unsuitable floor covering, unfiltered ventilation, unsuitable windows or missing door between water storage tank and valve chamber.

The further research is focused on an improvement of a water chamber and inlet design. Different inlet placing and different inlet shape will be designed first on a laboratory and then on a CFD model. On models will be installed some flow conditioners to find an influence to the hydraulics.

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Deconstruction of Structures under Sustainable Building Conditions

Draining Concrete of Recycled Resources

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V projektu se autorka zabývá řešením drenážní vrstvy s využitím recyklovaných materiálů ze stavební činnosti. Pro různé konstrukce je možné využití mezerovitého drenážního betonu z recyklovaných cihelných drtí či betonového recyklátu. Vzhledem k zaměření autorky na pozemní stavby bylo nejvhodnější možností aplikace drenážního betonu na příkladě pro jeho využití v drenážní vrstvě střech s vegetační úpravou.

Jako u všech střešních plášťů, také u střech s vegetační úpravou musí být zřízeno dostatečné odvodnění plochy střechy kvůli přebytečné přirozené srážkové vodě. Drenážní vrstva je společně s hydroizolační vrstvou nejdůležitější část celého systému střech s vegetační úpravou. Jejím úkolem je zadržet co největší množství srážkové vody v drenáži a zároveň přebytečnou vodu odvést do akumulační vrstvy a přes filtrační vrstvu na vrstvu hydroizolace a dále do kanalizačního systému. Musí zajistit rozvedení vody po celé ploše ochranné a akumulační vrstvy a zároveň možnost výparu vlhkosti z ochranné a akumulační vrstvy do substrátu.

Drenážní vrstva byla dříve prováděna pouze z nasypaného drenážního kameniva, které mělo pouze funkci drenážní. Akumulace srážkové vody buď zcela chyběla, což vedlo k nutnosti projektovat náročné zavlažovací systémy a bylo třeba počítat se zvýšenou spotřebou vody na umělé zalévání, nebo byla zajištěna dalšími samostatnými vrstvami, například nasákavými deskami z minerálních vláken nebo vrstvou rašeliny. Pro drenážní vrstvu se nejčastěji používal drobný štěrk nebo keramzit. Rozdělení velikosti zrn a rozložení póru v drenážní vrstvě je v tomto případě řízené. Objem materiálů drenážní vrstvy musí umožňovat akumulaci vody ve středně velkých pórech a odvedení vody přes větší póry. Rozmístění zrn v drenážní vrstvě musí spolehlivě odvést vodu z vegetační vrstvy bez lokálních a plošných přebytků. Tloušťka drenážní vrstvy závisí na druhu vegetace, druhu použitého materiálu, způsobu zhotovení a spádových poměrech. Úprava horního povrchu drenážní vrstvy má být vodorovná po celé ploše.

Další systémy umožňují částečné zadržení vody v drenážní vrstvě, odkud pak vzlíná a je k dispozici vegetaci v období bez srážek. Jde tedy o spojení drenážní vrstvy a akumulace srážkové vody. Používají se drenážní desky z polystyrénu, drenážní prefabrikáty z plastů a další typy. Systém nopových folií kontroluje a podle potřeby usměrňuje pohyb vlhkosti v konstrukci a zároveň chrání před vlhkostí všechny nasákavé materiály. Systém nopové fólie vytváří vzduchovou mezeru, která absorbuje vlhkost a zároveň ji vhodným způsobem odvádí. K tomu napomáhají vzduchové kanálky vytvořené nopy, které slouží jako drenážní vrstva a nárazník při mechanickém zatížení. V nabídce některých systémů jsou drenážní a akumulační profilované desky z recyklovaného polyethylenu vhodné pro extenzivní zeleň, z pěnového polystyrenu a z extrudovaného polystyrenu, desky z recyklovaného polyesteru a tvrdé pěny vhodné pro extenzivní i intenzivní zeleň a desky z recyklovaného kaučuku. Různost rozměrů

je z důvodu potřeby zadržet různé množství vody a materiálová různost je z důvodu odlišného použití jednotlivých materiálových variant.

Projekt se zabýval možností využití prefabrikovaných dlaždic z drenážního betonu, na jehož výrobu byl použit recyklát, pro vytvoření vrstvy, která bude materiálovou variantou pro využití v drenážní vrstvě střechy s vegetační úpravou. Při zkouškách byly hodnoceny vlastnosti tohoto betonu, pro jehož plnivo bylo zvoleno cihelného recyklátu a ve druhém případě betonového recyklátu. Částečně byly porovnávány vlastností při použití přírodního kameniva tak, jak je užito pro vrstvy ze směsí stmelených hydraulickými pojivy ve vrstvách vozovek pro celoplošnou drenáž.

Mezerovitý beton vytváří vrstvu ze stejnozrnného betonu stmeleného cementem s vysokým objemem mezer. Byla zvolena receptura betonové směsi, která by měla zajistit vznik vhodných mezer v betonu pro potřebný odvod přebytečné vody, dále možnost akumulace vody v materiálu a zajistila potřebnou pevnost výsledného materiálu. Kromě stanovení základních vlastností byly na příslušných vzorcích provedeny zkoušky pevnosti v tlaku, výpočet mezerovitosti, zkoušky propustnosti a nasákavosti. Počítáno bylo s použitím dlaždic o tloušťce 100mm a 150mm, které jsou opatřeny v ploše určené k položení na hydroizolační vrstvu drážkováním, které umožňuje rychlejší odvodnění plochy. Tyto vrstvy by bylo nutné používat stejně jako vrstvy z polyetylénu do sklonu střechy 8^{o}, na rozdíl od desek z pěnového polystyrenu, které jsou určeny pro střechy až do sklonu 45^{o}. Zvlášť může být součástí systému akumulační a ochranná rohož, která musí splňovat dva důležité požadavky, a to chránit spodní vrstvy proti mechanickému poškození a zadržovat určité množství vody, která se zpětně dostává difúzí do substrátu a ke kořenům rostlin.

Kromě provedených zkoušek by bylo dále vhodné provést ještě další zkoušky, např. odolnost proti chemickým látkám, které dešťová voda těsně před dopadem na povrch obsahuje, dále zkoušky mrazuvzdornosti, apod. V projektu byly hodnoceny především vlastnosti zásadní pro využití v souvrství střechy s vegetační úpravou a funkčnost materiálu jako spolehlivé nejen drenážní, ale také hydroakumulační vrstvy. Veškeré podstatné výsledky zkoušek se závěry budou zveřejněny na posteru během Workshopu ČVUT v Praze.

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Effect of Admixtures and Addition Agents on Physical-Mechanical and Chemical Characteristics of POPbeton® (Fly-Ash concrete)

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Since 2003 research work of fly-ash alkali activation has been proceeding. This work is provided by the Department of Construction Technology, Faculty of Civil Engineering, CTU in Prague and the Department of Glass and Ceramics ICT Prague. A very important part in activation process of fly ash grains is the quantity of alkali activator and water. Water is used for preparation of activator solutions, its volume and its quantity is deciding for workability of the mixture. To achieve optimum results it was necessary to search quantity of activators and their concentration in activator solutions that allows required workability. Of course it is necessary to keep mechanical and physical properties of fly ash binder. Quantity of water in activator solutions may be various, but quantity of alkali activators is the same. This paper describes problems with different water ratio in fly ash concrete mixtures especially with reference to concentration of alkali activator solutions.

POPbeton (fly-ash concrete) is new type of cement free concrete, where only fly-ash is used as binder. Whereas the term ash concrete signifies cement concrete with ash admixture as fine inert component supplementing the binder, the new type of concrete was named just POPbeton. POPbeton has ambitions to become new building material using some of further waste materials such as slag, metakaoline or fine glass waste. The area of POPbeton application can be extended for solidification of some dangerous waste materials, e.g. heavy metals.

The whole program is primarily focused on using brown coal fly-ash whose production is much higher than the production of black coal fly-ash in the Czech Republic. As the tests demonstrate brown coal fly-ash is less reactive and the final mixture has worse characteristics than the mixture with pure black coal fly-ash.

Fly-ash is activated by the help of silica sodium water glass solution (event. silica-potassium) – water glass and strong alkali – sodium hydroxide or potassium hydroxide. In this case Sodium water glass and sodium hydroxide were used to verify the effect of water quantity in the activation solution. The process of POPbeton production is more sophisticated from the point of view of the technological preparation. It has been demonstrated in numerous papers [1-4]. For fly-ash activation it seems to be suitable to temper the prepared samples in the drying oven at the temperature of 80°C for 24 hours. The second way is activation under laboratory conditions (temperature at 20°C). The tempered samples have in practice immediately after the tempering completion final physical characteristics. In the process without tempering it is necessary to use activators and so called “intensificators” which will equally start the activation reaction. The process of physical and mechanical characteristics rising is slower and proceeds till the 90th day of sample age. As test specimen cubes 100/100/100 mm were prepared, on which compressive strength and specific gravity were examined.

As one of possibility of speeding whole activation reaction, addition of some admixtures is. As suitable admixtures shows especially admixtures with higher content of CaO, as are e.g. blast-furnace slag, variety of clay and earths, fly-ash from fluid combustion, lime or cement. Experimental cubes size 100/100/100 mm where prepared. Blast-furnace slag and lime hydrate in different quantity as admixtures were used. They were prepared to alternate technological process.

Using of ground blast-furnace slag and lime hydrate showed like acceptable combination for achievement of optimum compress strength characteristics. On the basis of achieved results it is possible state, that the characteristics of POPbeton like real mixture, where alkali activated fly-ash as binder is used, it is possible easily modulate how suitable technological processes at mixtures preparation, so adjustment feature of fly-ash, like milling of fly-ash. To achieve required features it is possible also with advantage usage of some admixtures. During this research should be proved how the water quantity in the mixture and the concentration of the activator solution change the final characteristics of POPbeton substance. In the relatively small range of water ration happens to drastically changes in the final values. Thus it can be expected that for keeping the declared POPbeton characteristics it is necessary to retain high standards for mixture processing, as it is by the cement mixtures as well.

Above stated estimations for final values of strength are partial base for corrections and comparison of POPbeton mixtures prepared from variously concentrated activator solutions.

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Analysis of Selected Deterioration Factors and its Effect on Physiomechanical Properties of Building Materials

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Following the experimental and laboratory research on reliability, durability and residual properties of historical brick structures conducted within the research project MSM 6840770001 [1] and grant GACR 103/06/1801 [2], the internal grant is focused on experimental and theoretical research of physical and mechanical changes of building stone properties (sandstone) and binders properties (lime, lime-cement mortar) in historical buildings. The basis and starting point for this research project are the partial results that have been published in the research project [1] and the grant [2].

From both theoretical and experimental findings published in the research project [1] and grant [2] it can be said that reliability and durability of building structures and hence of whole buildings is a question of a time-dependent behavior of materials. The main focus of this grant is to verify the durability of chosen materials exposed to degradation processes, properties of which affect transport processes in materials. Humidity both in liquid and gaseous state is one of the main means of transport as it is the main carrier of aggressive substances affecting the internal structure and the outer surface of building materials. Humidity supports chemical degradation within materials, characterized by changes in pore system due to chemical reactions of components of building materials (mostly bounding compounds) with water or dissolved salts, as described in [3].

Static modulus of elasticity and compressive strength are the physical and mechanical properties of materials, chosen to verify the durability of materials in historic buildings. Both have already been researched and published by already mentioned projects [1] and [2]. The research is extended to include frost resistance and dynamic modulus of elasticity and dilatometric properties (impact of moisture and temperature). Measurements are carried out under the influence of both humidity and corrosive salt solutions. Moisture is considered a staged percentual content of relative humidity in the material. Chemical processes are then simulated using several solutions with different concentrations of salts and the number of recrystalization cycles is established as the maximum number of cycles needed for the destruction of samples.

Experiments in compressive strength and static modulus of elasticity will proceed in accordance with relevant standards for natural stone: ČSN EN 1926 - Test methods for natural stone. Determination of strength in a simple pressure., ČSN EN 14580 - Test methods for natural stone. Determination of static modulus of elasticity, and mortar: ČSN EN 1015-11 - Test methods for mortar for masonry. Part 11: Determination of strength of hardened mortar tensile bending and pressure. The experiments are conducted on uniform test specimens 35x35x70mm (sandstone) and 40x40x160mm (mortar), which are exposed to excessive moisture and concentrated solutions salt. For comparison and verification of measurement results it will be required to test a set of standard samples, dimensions of which are 50x50x50mm (sandstone). Measurement of these properties is carried out on the testing facility with the possibility of simultaneous measurement of both properties during the whole process of continual loading of samples.

To determine the frost resistance of materials, testing bodies were prepared according to relevant standards and requirements - 50x50x300mm (sandstone) and tested by the test procedure consisting of cycles of freezing and thawing in air, in water or saline (ČSN EN 12371 - Test methods for natural stone. Determination of frost) .

By determining the resonant frequency of the basic material using normative procedure (ČSN EN 14146 - Test methods for natural stone. The determination of dynamic elastic modulus (using the basic resonant frequency)), it is possible to calculate dynamic deformational module. Fundamental resonant frequency is determined using the method of continuous vibration of the test piece, oscilating the body using the lengthwise, bending and torsional oscillations. Size of samples for examination in this case is 50x50x150mm with a tolerance + / - 1mm.

Before the measurement of dilatometric properties (under both temperature - BS EN 14581 - Test methods for natural stone. The determination coefficient of linear thermal expansion.), it was necessary to dry the test bodies to a constant weight and measure in the direction "i" at at least two different temperatures. The coefficient of linear thermal expansion is then calculated as a length change in the of temperature change of 1 °C. The same principle is used to measure specific volume expansion when exposed to moisture in the test sample.

Based on data obtained from experiments (in-situ sampling, laboratory measurements) published within the research project [1] and Grant [2] (dependence of compressive strength and modulus of elasticity on the humidity), it is possible to compare the results obtained during experiments of internal grant. Experimental measurements of an internal grant confirms the diversity of physical and mechanical properties of materials similar in appearance (sandstones). The grant also provides a scheme for deterioration of the mechanical properties in binders (lime mortar, lime-cement mortar) depending on the degree of relative humidity. Measured properties can be correlated with the size of pores and their participation of the total porosity, where there is apparent effect of the size and proportion of macropores and coarse pores.

The relation between physical and mechanical properties and the ratio and effect of salts in the material is tested in a long-time process depending on the material resistance to these aggressive agents. Therefore at the moment the experimental measurement is in the stage of exploring the degradation effects of concentrated solutions of selected salts on the examined material. The expected effect of salinity, especially in sandstones, is degradation of binding agent, due to chemical processes and time and thus salinity directly affects physical and mechanical properties observed in the experiment.

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Determining the Sound Reduction Index of Structures in Special Cases

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The aim of my PhD thesis is to develop a calculation methodology that would help to determine prediction sound reduction index in less usual cases (wooden structures, construction with mounds). In practice, there are only commonly used methods that serve for discovery of values of transmission loss for silicate-based structures (homogeneous single-layer structures, layered structures, double structure). These procedures are listed eg [1, 2]. Using these methods, however, fails to calculate transmission loss of wooden buildings and structures with mounds. Any possibility of precise prediction for this type of design can help designers to design the reconstruction, especially for loft conversions, that can improve the value of embankments the sound reduction index. Wooden buildings are now increasingly designed.

The specific formulation processing methods can be broken down into two basic parts: theoretical and practical. In the theoretical part was a study of literature addressing the issues of determining the sound reduction index construction and development of computational model for predicting transmission loss the previously mentioned structures. Structures are also included well-known computational procedures and also by developed calculation procedures. New procedures have been derived from the laboratory measured transmission loss structure. In the practical part, I deal the assembly of a sufficient number of measurement results (laboratory and building) companies made soundproof air CSI a.s. Prague (branch in Zlín), A.W.A.L. s.r.o. and college STU Bratislava. The results of measurements are necessary to verify those obtained from the calculation model and to determine the correction between the laboratory and building sound reduction index.

The overall output of this work is computational model for determining the transmission loss predictions and the measured inter-comparison and predicted sound reduction index of the structures.

Determining the sound reduction index of wooden ceiling cellular-type structures

In order to obtain sufficient quantities of the results of laboratory measurements of the transmission loss ceiling structures cellulose-type I first engaged in problems of these ceilings. Such ceiling structures are produced by the company Agrop, that has provided consent to make the measurements for the purpose of this work [3]. Laboratory measurements were accomplished in the laboratory CSI a.s., specifically branch in Zlín.

Ten different compositions of these structures were available Depending up the materials used in these structures are divided into several ceilings subchapters:

1. cellulose base beam,
2. cellulose beam panel with the floor,
3. cellulose beam panel with the floor with the embankments,
4. cellulose beam with a loose material on the lower deck,
5. cellulose beam with a loose material on the lower deck and with the floor,
6. cellulose beam with a loose material on the lower deck and with the floor with the embankments.

The cellulose base beam was calculated in the following variants:

Option I: replacement of one material on the same surface weight
→ calculation of the simple structure with the thickness of the lower chord (27 mm)
Option II: replacement of one material on the same surface weight
→ calculation of the simple structure with total thickness of two chord (54 mm)
Option III: replacement of one material with a thickness of bottom (27 mm)
→ calculation of the simple structure with the indicated parameters CSI a.s.
Option IV: replacement of one material, the total thickness of two chord (54 mm)
→ calculation of the simple structure with the indicated parameters CSI a.s.
Option V: calculation as in the double structure
Option VI: calculation as in layered structures
Option VII: calculation according to formulas derived from measured values

The calculation of option VII is done through relationships, which have been identified based on the measured values. The principle is the distribution of frequency bands at intervals more (instead of 4 intervals typical for silicate-based materials there are 6 new). For various intervals, the followings relations, where $f_{XY} = \frac{f_X + f_Y}{2}$:

$$\langle f \le f_A \rangle \rightarrow R = 20 \log \frac{m' f}{531}; \quad \langle f_A \le f \le f_{AB} \rangle \rightarrow R = 20 \log \frac{m' f_A}{237} + \log \frac{f_{AB}}{f^2};$$

$$\langle f_{AB} \le f \le f_B \rangle \rightarrow R = 20 \log \frac{m' f}{1{,}27 \cdot f_B}; \quad \langle f_B \le f \le f_{BC} \rangle \rightarrow R = 20 \log \frac{m' f}{0{,}89 \cdot f_{BC}};$$

$$\langle f_{BC} \le f \le f_C \rangle \rightarrow R = 20 \log \frac{m' f}{0{,}77 \cdot f_C}; \quad \langle f_C \le f \rangle \rightarrow R = 20 \log \frac{m' f}{0{,}7 \cdot f_C}.$$

Calculation of the sound reduction index cellular beam with layers of flooring, with a loose material on the lower deck and with the floor with the embankments is based on the above procedure. To this calculated values added to the impact floors using method for double construction (transmission loss of floor down the principle of layered structures) and the added value of additional attenuation, the values differ by type of construction.

In terms of the grant the measurements of the building sound reduction index were also realized, however another type of timber structures, because the cellular-type ceiling structure is not yet widely utilized.

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Analysis of climatic effects for the efficiency of photovoltaic systems

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The main part of project is measurement of meteorological dates on weather station Davis VP2+ aspiration radiation shield, wireless with entrance console and data logger with notation of all measurement dimensions in set up 1 minute or 1 hour. It include Integrated Sensor Suite – ISS, which consist of a rainfall measurement, a anemometer with 12 m long cable for attachment on ISS, a sensor of temperature and relative moisture of air, which is located in radiation shield, a console, AC adapter, a back-up battery and detailed manual in Czech language. Data are transferring using radio signal (wireless) and it shows on display entrance console VantagePro. The weather station is situated on Building in Pilsen and on the Building is also photovoltaic system, which owns private investor and its installed capacity is 5,275 KWp with data logger, 11 x PV Kyocera KC200GH2P + alternator SMA 2000 a 15 x PV Kyocera KD205GH2P + alternator SMA 3300. The location of weather station is 0,5 m above the roof, about 6 m above the ground and with sensors solar radiation, which is oriented on south.

The weather station is able to measure these magnitudes: out temperature [°C], humidity [%], air speed [m/s] and its course, solar radiation [W/m2]. From measured values are evident different weather conditions between different days, which are we able to predict.

For example we can show a day, exactly 28.12.2009, whereon we will show data output from data logger of photovoltaic system SMA Sunny beam (chart no. 1). For this day is on chart no. 2 visualization output from sensors solar radiation on weather station.

Time	8:10	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00
FVE [W]	3	19	113	107	209	875	642	2333	1852
FVE [W/m2]	0,1	0,5	3,1	3,0	5,8	24,1	17,7	64,4	51,1
Solar RAD [W/m2]	5	9	23	21	56	102	112	175	191

Time	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:20
FVE [W]	1478	647	216	119	133	97	18	12	11
FVE [W/m2]	40,8	17,8	6,0	3,3	3,7	2,7	0,5	0,3	0,3
Solar RAD [W/m2]	191	122	57	44	43	36	8	5	0

Chart no. 1 represents a lot of energy from photovoltaic systems in 30-minute intervals and Solar radiation for day: 28.12.2009.

All date and chart are available at email jakub.ulc@fsv.cvut.cz

From actual measurement results, that efficiency of photovoltaic systems is influenced by solar radiation, which is basic indicator, but also associated climatic effects: outdoor temperature, which connections with overheating of photovoltaic cells.
For example is for summer's month's degradation peak performance minus 15% influence on too high temperature of cells. Again air speed, which is the other measured data, can overheating of photovoltaic cell curtail, and sometimes also anneal during extreme climatic situation and so advance efficiency of photovoltaic systems.

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Measurement and Interpretation of Thermal Fields in Concrete Bridge

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Resolving straining of cross-section from uneven temperature loading is very difficult problem, especially due to shape of cross-section and varying thermal fields. Lay-out of thermal field is product of many influences, e.g. material properties, cross-section shape and climatic effects (edge conditions of the problem such as sun radiation, temperature of surrounding air, speed of wind, and so on). In general we aren't able to solve this problem without specialized computer programme.

I would like to present the computer programme which is able to process information about lay-out of thermal field (*T(A) - origin temperature*) into individual components. As the components are considered average temperature, thermal gradient in direction of axe "x" and "y" and lay-out of residual temperature. This is shown in following formula:

$$T(A) \Rightarrow \phi T + \Delta T_x \cdot x_{hl}(A) + \Delta T_y \cdot y_{hl}(A) + T_{rez}(A) \ .$$

These individual components of thermal field we can use to transfer into loadings which are implemented by specified strains. Statical software in general makes possible to enter into model uniform length strain affected by average temperature and rotating strain affected by thermal gradient. In case of freely supported beam we can suppose only deformations without creation of stresses.

Rezidual thermal field causes "only" warping of cross-section which means uneven lay-out of normal stresses. The problem of uneven normal stresses can be solved separately and results can be combined with results from the statical software. In most of cases, these stresses can be neglected. In case of freely supported beam we can suppose no deformations and no stresses.

The solving of thermal field with my computer programme is based only on elementary physical formulas, e.g. $\varepsilon = \alpha \cdot \Delta T$ (*length strain, coefficient of thermal strain, thermal variation*) and $\sigma = \varepsilon \cdot E$ (*normal stresses, length strain, modulus of elasticity*) .

- firstly, we can obtain easy way average temperature of the cross-section and location of "thermal gravity centre" in accordance with these formulas:

$$\phi T = \frac{\int \alpha E(A) \cdot T_0(A) dA}{\int \alpha E(A) dA},$$

$$x_T = \frac{\int \alpha E(A) \cdot x(A) dA}{\int \alpha E(A) dA}, \quad \text{formula for } y_t \text{ is analogical}$$

- secondly, after making substitutions of temperatures and coordinates, we can obtain thermal gradient in direction of axe "x" and "y" in accordance with these formulas:

$$T_l(A) = T_0(A) - \phi T,$$

$$x_{hl}(A) = x(A) - x_T,$$

$$\Delta T_x = \frac{\int \alpha E(A) \cdot T_l(A) \cdot x_{hl}(A) dA}{\int \alpha E(A) \cdot x_{hl}^2(A) dA}, \quad \text{formula for delta } T_y \text{ is analogical}$$

- thirdly, if we'd like to solve warping loading we can calculate field of residual temperatures in accordance with these formulas:

$$T_{rez}(A) = T_l(A) - \Delta T_x \cdot x_{hl}(A) - \Delta T_y \cdot y_{hl}(A) .$$

The solving of the formulas, which are written above, is based on finite element method. Elementary linear triangle elements were chosen due to simplicity, their accuracy is sufficient for solving of this problem. Material properties are prescribed in elements, thermal loading is prescribed in nodes of FEM mesh.

Final computer programme is used for processing data which are measured continuously in-situ, in cross-section of prestressed concrete bridge. The inputs and the outputs are ordered in formatted text files. User can define any plane shape of cross-section, material properties and thermal loading. User obtain average temperature, thermal gradients and field of residual temperatures. Here is example of input and output file:

```
INPUT:
#MATERIALY                          (definition of materials)
1 0.01 100000                       (nr., coefficient of thermal strain, , modulus of elasticity)
…
#SOURADNICE                         (definition of nodes, cross-section shape)
1       -7.15   2.30                (nr., coordinate X, coordinate Y)
2       4.40    0.00
…
#ELEMENTY                           (definition of triangle elements)
1       4       2       1       1   (nr., node 1, node 2, node 3, nr. material)
2       4       10      2       1
…
#TEPLOTY                            (definition of loading)
1       14.8                        (nr. node, temperature)
2       14.8
…
#KONEC                              (end of file)

OUTPUT:
Teplotni teziste:  [ 0.00 ; 1.55 ] m   (coordinates of thermal gravity centre)
Prumerna teplota:      2.38'C          (average temperature)
Vodorovny gradient:    0.00'C/m        (thermal gradient in direction of axe "x")
Svisly gradient:       2.96'C/m        (thermal gradient in direction of axe "y")
Rezidualni teplota:                    (list of residual temperatures in nodes)
nr.     teplota
1       10.2
2      -15.2
…
```

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Hybrid Steel-Glass Beams

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In the last few years, due to the intensive progress and research on the field of glass structures, mechanical properties of glass have been distinctively improved and possibilities for using glass as a load carrying elements are now advanced. Different types of hybrid constructions, consisting of glass and another material, are analyzed or even newly developed focusing on an optimal structural interaction between both materials and in respect to architectural, static-structural and fabrication criteria. Hybrid beams with glass web are currently the subject of the interest in a lot of research centres around the Europe [1-3].

In glass structure engineering and design, in general, tension strength of the glass determines the load carrying capacity of whole element. Glass is a material, which shows brittle behaviour. Pure glass beams always fail suddenly and without extensive previous warning. Therefore, one of the main advantages of hybrid beams (except the higher stiffness, load carrying capacity and robustness) is the possibility to achieve more ductile behaviour of whole system in comparison with a pure glass beams or fins. Stiff member (flange) works as a consumer of the break energy even after the first cracks in the glass pane are visible. This phenomenon is called residual carrying capacity and it is required because of the safety. From previous investigations came out, that this residual carrying capacity depends mainly on the used connection type (adhesive) and also on the type of used glass. It means, there were different achieved residual capacities of the hybrid beams with float, heat tempered and heat strengthened glass [2-3].

The new hybrid steel-glass beam consists of steel flanges, glass web and bonded connection between them. Explicitly, for this type of joint, glued connection is more effective than bolted connection mainly because of better (more uniform) distribution of the stress along the long joint. Adhesive layer itself also provides a protection from direct contact between steel and glass, which always has to be avoided in glass structure engineering. Different variations of the connection detail between the glass web and steel flanges were designed by using helping angle profiles or U profile. But there is also a possibility to connect the web with the flange directly without any helpful profile or to a small channel cutted to the flange. In general, whole glued joint has to be stiff enough to provide an optimal interaction between both materials, but the adhesive layer has to flexibly compensate the different temperature elongation of glass and steel. There is a possibility to use simple linear theories for approximate calculations of average shear stress in adhesive layer or average deformations of overall joint. The shear stress-strain relation of adhesive layer can be simplified by bi- or tri-linear diagram for compliant adhesives like silicon or polyurethan, sometimes by linear diagram for stiff epoxy resins. According to this theory, bonded joint can be modelled as bedding with three linear stiffnesses – one normal stiffness and two shear stiffnesses in two perpendicular directions, [4].

A key aspect of this development was the detailing of the steel glass interface and choice of suitable bonding material. Wide range of adhesives with different mechanical and deformation properties was involved to the experimental program after long consulting with

SIKA CZ (worldwide adhesive producer). Set of chosen adhesives starts with a very stiff epoxy resin and goes down via acrylates and polyurethans to very flexible silicone.

Material tests of all chosen adhesives were arranged in accordance with ISO 527-1, 2 (european standard for testing of plastic materials) and performed in certified research center Swell (company works for automotive industry, Hořice, Czech Republic). Important data like a real tension strength, stress-strain diagram, elongation at break, Young's modulus and for some of the adhesives also a Poisson's ratio were obtained from these material tests and serve as an input data for nonlinear FE material models of the adhesives.

Next experimental set, instant small-scale tension and shear tests of the steel-glass connection were performed at Klokner's research center by CTU Prague. Ultimate tension and shear carrying capacity of the steel-glass connection and the ratio (diagram) between stress and deformation of the joint were obtained from these connection tests. Results of these experiments served as a device for calibration of the simple FE models of the glued connections including adhesive layer with nonlinear properties obtained from previous material tests. Clear idea about the behaviour of the adhesive layer and knowledge of the shear and tension strength of whole connection, are the first steps, needed to be done on the way to successful modeling and investigation of the whole hybrid steel-glass beam behaviour under increasing load. Only verified and properly working nonlinear finite element model of the adhesive layer could have been involved to the complex FE model of the hybrid beam.

Full-scale tests of the hybrid beams with 4m span will be performed at the laboratory of the faculty of civil engineering. These tests will make a final verification of the nonlinear adhesive material models and complex FE model of whole hybrid beam. Mentioned full scale tests will also prove the accuracy of the modified simple hand calculation methods like a well known solution by Möhler or Pischl's analytic method, which were applied to this problem and used for determination of the normal stress distribution along the cross section of the beam with semi-rigid horizontal shear connection. Very good agreement was obtained for mentioned modified simple methods in comparison with the results of preliminary FE calculations for stiff epoxy resins. General parametric study will be carried out on verified model in accordance with the results of mentioned full-scale tests of the beams under 4 point bending.

Described experimental and numerical analysis should better the knowledge about the exact behaviour of such a hybrid structures including the semi-rigid glued connection realized by polymer adhesive. Generalized results of the experiments and numerical studies will help to create the guidance, how to safely and economically design such a structural element like a hybrid steel-glass beam.

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Influence of Weathering Processes on Geotechnical Properties of Building Rocks

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Historically, sandstones were often used as a main building material in the Czech Republic. As any other building material they undergo weathering processes and so are damaged. Study of these processes is very important to understand the rate of decay and also to estimate the redevelopment arrangements during reconstruction of heritage buildings. The range of the deterioration of rocks depends on the petrography (internal structure, mineral composition, type of cementation etc.) and on the changes initiated.

Sandstones are consolidated sedimentary rocks mostly formed from quartz grains with addition of feldspars and stone chips. The grains are connected by cement of different character (e.g. calcareous, argillaceous, quartzy, iron oxides or hydroxides). The cement binder is changed during weathering processes and that influences hardness of the damaged rocks. These failures are present both near the surface and also deep in the structure.

The presence of water in the pore structure leads to the changes of rocks volume, especially if there are argillaceous minerals in the cement. The content of water can also influence the cohesion of rocks because of the increasing volume of freezing water. The frost activity can cause flaking and exfoliation of the surface and also other damages. The highest rate of the deterioration due to the frost action is in humid atmospheric conditions [1].

The weathering process is generally long-term and, therefore, it is almost impossible to determine dynamics of changes in the rock samlples from natural bassets. On these grounds the accelerated weathering tests in laboratories are used. These tests are based on cyclic action of chosen events (e.g. freeze/thaw) on rock samples with duration of few days or weeks. It is useful to create weathering simulation tests that conform to the climatic conditions in a concrete location.

For the simulation of weathering processes typical for Prague climatic conditions, the data from winter season during the last ten years were used. Data measured in months December, January and February 1999 – 2008 by the station of Czech Hydrometeorological Institute in Prague Libuš were statistically analysed. It was ascertained that during the winter period there are 56 days with the sub-zero temperatures. The lowest temperature – 18,7°C was measured 29.12.2000 and the highest temperature 19,5°C was measured 26.1.2009. The average values of measured absolute temperatures are for the minimum temperature – 10,8°C and for the maximum temperature 10,7°C. In both cases the standard deviation (SMODCH) was calculated, which is very similar for both sets of data ($SMODCH_{max}$ = 3,06 and $SMODCH_{min}$ = 3,26). The simulation programme was developed upon this ascertainment. This programme consists of 56 cycles and theoretically corresponds to one extreme winter with the temperature range from – 14°C to 14°C. Samples stay at these temperatures for two hours. These 56 freeze/thaw cycles were divided into four stages. Each stage consisted of 14 freeze/thaw cycles. The samples were soaked in destilled water for 24 hours before every stage to ensure their high moisture. The destilled water was used due to its properties – it has a similar composition to rain water. The samples were placed in the climatic chamber Heraeus Vötsch HC 4020.

Three types of sandstones often used in the Czech Republic were chosen for this experiment – Hořice, Božanov and Kocbeře sandstone. Two of them (Božanov and Kocbeře sandstone) are often used as a material for the repair works of herritage buildings. Hořický sandstone was often used as a sculptural material and also as a building material in the past. The basic properties of these sandstones are presented in the following table [2,3,4].

parameter	**Hořice sandstone**	**Božanov sandstone**	**Kocbeře sandstone**
Real density (kg/m^3)	2546 (min) 2580 (mean) 2599 (max)	Not assessed	2660 (min) 2661 (mean) 2670 (max)
Apparent density (kg/m^3)	1915 (min) 2005 (mean) 2078 (max)	2140 (min) 2183 (mean) 2214 (max)	2120 (min) 2243 (mean) 2490 (max)
Total porosity (%)	18,1 (min) 21,7 (mean) 26,3 (max)	10,6 (min) 12,1 (mean) 14,0 (max)	5,4 (min) 9,6 (mean) 13,0 (max)
Open porosity (% vol.)	Not assessed	Not assessed	Not assessed
Water absorption at tmospheric pressure (% hm.)	8,0 (min) 8,2 (mean) 10,3 (max)	4,8 (min) 5,5 (mean) 5,5 (max)	2,2 (min) 4,4 (mean) 6,2 (max)
Uniaxial compressive strength by dried samples (MPa)	20,0 (min) 29,6 (mean) 41,0 (max)	33,6 (min) 47,0 (mean) 72,4 (max)	56,0 (min) 67,8 (mean) 86,0 (max)
Uniaxial compressive strength after saturation (MPa)	17,0 (min) 25,1 (mean) 34,0 (max)	25,5 (min) 34,2 (mean) 62,2 (max)	38,0 (min) 53,9 (mean) 68,0 (max)
Uniaxial compressive strength after freezing (MPa)	15,0 (min) 22,9 (mean) 32,0 (max)	23,4 (min) 29,8 (mean) 56,1 (max)	42,0 (min) 51,0 (mean) 60,0 (max)

At the time being, the developed changes of geotechnical properties like water absorption at atmospheric pressure, uniaxial compressive strength, real density, apparent density, total and open porosity are being studied. DTA analysis and RTG diffraction are used to study the changes in the cement composition and to study the changes in the internal structure optical microscopy methodes are used.

The data were not available at the time of the submission deadline. Most of them will be available in the second half of January 2010. Their evaluation will be included in the planned workshop poster.

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Hydraulic Capacity of Damaged Gravity Sewer Systems

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Sewer and storm water systems in cities often suffer from insufficient capacity, construction failures and pipe deterioration. This affects the hydraulic function of sewer system, the function of combined sewer overflow and with others sewer network defects cause underground and surface water pollution, often leading to significant environmental accidents. The rainfall-runoff models are very useful tools for the assessment of a behavior of gravity sewer systems. However, the level of schematization in space domain of these models is significant. Therefore, the effects of local hydraulic losses caused by their structural failures are difficult to be considered. The tools based on the CCTV (closed-circuit television) inspection, which are able to include the local hydraulic losses due to deterioration, were already developed. Nevertheless, it considers the failures effect in isolation, likewise for the short distance between failures.

Therefore, the author try to bring the upgraded approach taking into account the dimensionality (the distance effect between failures). The methods of numerical and hydraulic modeling we used to evaluate the effect of dimensionality.

The pressure losses were investigated for both numerical and hydraulic models under same conditions. The pipe cross section of the model pipeline was 200mm (DN 194mm) and the magnitude of the velocity had the range 0.5 – 1.0m/s.

On the hydraulic model, the head losses were measured by differential pressure gauge in front and behind of the obstacles section. The position of these sensors, connected with an electronic measuring system of pressure, was set with regard to the upstream and downstream effect of failures and to the local losses due to bends. The magnitude of the velocity was set according to flow rate meter. The length of the experimental section, from transparent material, was 12m. A number of runs under different conditions (discharge, number, size and position of obstacles) were examined with respect to the head loss, i.e. the slope of energy grade line. Firstly, the experiments for clean pipe (without obstacles) were made. The measured losses for this condition are caused by friction. Further, the obstacles (model bricks) were fixed in several different positions. Increased losses involve the effect of the friction (known from experiments for a clean pipe) and the local head loss – effect of the obstacles in specific position.

The mathematical modeling of a pressurized flow, which was calibrated with data from the physical model, was done with CFD (computational fluid dynamics) program Fluent. It was used the Standard k-ε turbulent model. A velocity inlet and an outlet pressure were the basic boundary condition. It is possible to find the value of pressure in any pipe cross section after the simulation.

The resulting pressure loss for each condition was evaluated and compared. The critical distance of obstacles (the beginning of an influence) and the effect due to their

position changing was found for every ration between cross-sectional area, size of the obstacle and distance between them with regards to the cross-sectional velocity.

Since the pressurized flow is not the standard regime for gravity sewer systems, the results are also compared with the measured data for free surface flow conditions.

The results shown, that the simple approach, which accounts the impact of local failures in isolation, in the case of a short distance between the failures overestimates the real losses. The upgraded tool which includes the dimensional analysis can decrease the uncertainties of the calibration of hydrodynamic models and will improve the reliability of rainfall-runoff modeling.

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System Development for the Location of Moving Object Based on GPS

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New application using Global Positioning System is main ambition of this project. Essential tendency is location of moving object on a predefined track. The predefined track is a trajectory that is geometric and spatially defined. It stands to reason that resulting position of the object would comport with some position on the track, it is the basic requirement. This requirement is not realize during the common processing of GPS measurement without any additional condition. Most of solutions in commercial software project the result on the track additionally, i.e. after processing of GPS measurements. But it is more inartificial to process GPS measurement with condition to locate object on the track simultaneously. It produces complication during mathematical solution but it also benefits. New condition in computation declines amount of necessary satellites to only two satellites.

First practical example of moving object on a predefined track is moving of rail vehicles. Moving of this vehicles is strictly organizes, it is impossible to the vehicle deflects its rail. Moving of trams in Prague was used for demonstration of system and for next improvement. The utilization of the developed system in mass transportation bargains for active preference of mass transportation, mainly tram transport, where older system "infra-beacon radio-signal' should be replaced.

The work on the system development including also testing could be divided into four groups: technical support, software solution, predefined track, evaluation of precision.

Technical support

First step is represented by the choice of GPS receiver. Receivers Leica (GX 1230 GG), Topcon (Hyper+) and U-blox were used for this research. All GPS receivers have to be able to be mounted on the roof of tram vehicle and must be ensured against motion, they should be able to run and register data minimal for eight hours by internal battery or by connection to external power supply. The measuring interval should be variable to the value lower then 1s.

Software solution

All software solution is supported by C++ and Linux platform. Open source project GPSTk is used for ephemeris calculation, atmospheric delay models and Rinex data streaming. Software solution enables different processing of GPS measurements (single point positioning, relative positioning, smoothing and processing with condition to locate object on the track). Reference stations are selected according availability from CZEPOS network. All measurements are process by post-processing methods. Real time solution is not available yet. Commercial software has to be used for downloading data from receivers and consequently exporting to Rinex format.

Predefined track

The predefined track has to be accessible in WGS-84 coordinate system or transformation key to this system must be known. The most reliable method is to locate the track by some geodetic methods, choose some identical points for transformation to WGS-84 coordinate system. This method is acceptable only for small project. For bigger project such as Prague tram, it is necessary to receive already existing data, for example digital map of Prague from former organization IMIP. The tracks of trams are available with centimeters precision in JTSK coordinate system. The digital map has unfortunately some major errors. Some connections between points are missing, some short trails are missing completely and mainly information about heights is missing. Missing date makes unpleasant work. Problem with missing heights is possible to solve by different methods (using zero heights, using average heights etc) but everything will influence precision. Precision is also influenced by transformation from JTSK coordinate system to WGS-84. One way how to transform digital map of Prague to WGS-84 coordinate system is e.g. web service of Research Institute of Geodesy, Topography and Cartography. The service reaches the standard deviation 4 cm in each component and 7 cm in height on the territory of the Czech Republic.

Evaluation of precision

Evaluation of precision is mostly graphics matter. It is possible to choose the best way for solving of missing heights, the best way for transformation method of digital map from JTSK to WGS-84 coordinate system, the best method of processing of measurement, the most proper receiver. We can also observe development of precision represented by DOP during the object is moving. The value of DOP depends not only on amount and configuration of satellites but also on an orientation of track.

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Application and Usability of Geospatial Data

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Terrestrial Photogrammetry finds application primarily in care of historical monuments, where the outputs are the spatial models of small construction objects or models of sculptures, statues. Aim of this paper is to present the possibilities of presentation of the external shapes of these objects. This area offers the ideal medium to use – Internet. The goal is to create a web system that will bring these models over Internet and provide basic options of viewing in a web browser. This research was divided into two parts. The first part examined the technological conditions for the inclusion of 3D scenes into the body of a web page. On this basis, two different web applications were created. The second part focused on the issue of user-centered design. To this end, we created different design concepts for the control of a 3D scene. The appropriateness of these concepts was verified by using usability testing and performing an experiment.

There are two methods of presentation 3D scenes depending on the involvement of users in the process of presentation. It is possible to distinguish between passive and interactive presentation. In this research we have chosen an interactive control that allows a direct impact on the scene with a virtual model. This approach requires an intuitive control, for user to obtain in a reasonable time an objective idea about the displayed object. When we examine the object in the real world, we perform the following processes: change object position (shift), object orientation (rotation), approximation to the object (move/zoom). Therefore in designing a control we have created all of these procedures (functions).

Internet environment is primarily oriented to the 2D graphics. Bringing 3D graphics is limited by browsers, which do not natively display the 3D scene. But there are some exceptions, e.g. WebGL - in development. This disadvantage can be solved by using plug-ins. User's web browser must contain this plug-in or user is forced to install appropriate plug-in. This fact is in contradiction with the requirement of maximum availability and usability. It's useful to take such of a plug-in that is the most widespread. The balance sheet of the used technology was created for this reason. Java plays a large role in the web environment. Using the so-called applets can be viewed in a browser environment, almost any content. This language has the advantage that it is extended to 77% of personal computers connected to the Internet. But Java applets can be also a security threat because they may perform harmful activities. Therefore, many users do not trust them. Due to the requirements of the wide availability was necessary to take into account the enlargement of Adobe Flash which is the most widespread - currently it has more than 99% of computers connected to the Internet. Flash is a very advanced technology with strong position in the presentation of multimedia content over the Internet. Low performance has been still disadvantage, since there is no 3D graphics hardware acceleration, and all calculations perform CPU.

The above advantages of Java caused a creation of the first application 3Dmuseum, whose development was based on cooperation with open-air museum Vysoký Chlumec. In view of authors inexperience in Java language was used with advantage Wirefusion software environment which allows easy creation of Java applets. Wirefusion uses for a description of virtual 3D models the VRML language. Application 3Dmuseum contains the above-mentioned functionalist for the model's study (rotation, shift, zoom), and advanced

functionality such as measurement of distance or animations. The disadvantage of this software solution is the inability to influence the method of control 3D scene. For this reason was created application 3Dviewer, that uses the Flash environment with support library Papervison3D. This application allows the use it for the presentation of the virtual models, but mainly is used in the research control 3D scenes.

The second part of the research focused on understanding of user‘s access to control 3D scenes. User interface decides about the value of created product largely. Inappropriate control design leads to a state that the user is not able to work with the virtual scene or he’s disorientation in the spatial scene. Therefore, two ways of control were developed (Concept A, Concept B). These concepts assume that the user uses the mouse as a standard pointing device (with two buttons and scroll wheel). Both approaches have been defined as the primary action rotation using the left mouse button. The suitability of this option was verified by usability testing with six participants. This usability testing is also focused on the perception of three-dimensional model by user. It was obtained knowledge that the choice of high quality texture allows that the user gets good quality sensation with less detailed model (less vertex). The disappointing results in the field of zoom and shift, were created an experiment to compare Concept A and B. Zoom-in is mapped in concept A by turning the scroll wheel into the user and vice versa for concept B. The shift is implemented by pressing the right mouse button (Concept A) or by pressing scroll wheel (Concept B). Second experiment was participated by more than 100 of participants - unfortunately, unequal representation of men (65%) and women (35%). Users received three tasks aimed either zoom and shift. The activity of users (pressing the mouse buttons and time duration) was recorded in the experiment. Analyzing the data and feedback from users it has been found that in the case of research on the zoom users preferred Concept B (zoom-in by turning the scroll wheel away from the user), which showed a double success rate than the Concept A. In the event that the user encountered of unsatisfactory control concept of zoom, quickly adapted with this concept. For shift task it has been more accepted concept B (shift by pressing the scroll wheel). However, only 25% of participants found that it is possible to make a shift task in the 3D scene.

This paper offers two different techniques for interactive presentation of small (simple) 3D models in a Web browser. Research is also focused on usability testing and measuring user experiences in the control of the spatial scene. Conducted experiment demonstrated the appropriateness of controlling rotation and established method for controlling zoom. Further bottlenecks revealed - shift with 3D object in the scene. It is therefore an area with potential for future research.

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Low-energy School in Indian Himalayas

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Abstract

We have built a low-energy solar school in the village of Kargyak in northern part of Indian Himalayas. It was designed to use local materials and traditional building techniques. The project is a response to the difficult socio-demographic situation in this remote region. Literacy is far below average in India; only few local people out of hundreds can read and write.

The village of Kargyak is located at altitude of 4200 meters in the Zanskar area of the Himalayas and is the highest located village in the region. Kargyak is located 80 kilometers (3 days walk) from Padum, the administrative centre of the region, where the regular road ends. The village is located in a rain shadow of the nearby mountains; with more than 300 sunny days, this makes the local climate extremely dry. The climate has the character of a mountain desert. Sporadic green vegetation occurs only alongside watercourses or on artificially irrigated fields. No systematic monitoring of the local climate has been carried out yet, although limited measurements are part of this project.

The building of the school is in tune with the local architectural principles and emphasizes the use of local natural materials and traditional building technologies. The design was based on detailed research of local procedures, material properties and traditional architecture. In the region, the tradition of making and using clay bricks and other natural materials like stone, poplar and willow wood, low bushes, straw and yak, sheep and goat dunk, is still alive.
Usually, the local schools cannot remain open during winter due to the climatic conditions. However, due to the use of solar energy, it is possible to teach in our school almost all year round, which makes it a unique and very valuable asset to the local community. The project started in summer 2006, when the realization team made an agreement with Kargyak village. In autumn 2006, a greenhouse was built in order to test cooperation with the villagers, verify the possibility of the use of solar energy, investigate the quality of local building materials and building technologies, and to obtain fresh vegetables during winter. Data logger was placed in the greenhouse to record indoor and outdoor temperature and air humidity.

In February 2007, the realization team travelled to the construction site to ensure delivery of timber over the frozen river from the village of Ichar to Kargyak. During spring 2007, the transport of building tools, timber and provisions for workers living in the village continued. As no machinery was available, all the work was done manually or by simple hand tools. In spring and during summer 2007, trenches of 1600 cubic meters of stony soil were dug, three abutment walls of total length 120 meters built and other groundwork was done. During the summer 2007, the production of clay bricks (size 20x20x40 centimeters) was optimized.
Samples of clay bricks were tested in the laboratories of the Faculty of Civil Engineering in Prague during years 2007 and 2008.

The school building consists of three classrooms, a corridor, a lobby and two toilets. Strip foundations of the building are made of shaped stone. Vertical framework consists of a stonewall and timber poles. Cladding is filled with adobe bricks. Thermal insulation is ensured by a layer of straw between the stone and adobe walls, which runs around the building periphery.

The roof structure entirely followed local traditions and its construction is based on low occurrence of rainfall in the area. The horizontal supporting structure is made of poplar wood. Heat insulation layer is made of straw mixed with yak dirt and branches tabulated with soil and covered with clay (hydro insulation layer) with mound of sandy soil.

Since the characteristics of the indoor climate are determined by the local customs, the expected use of the building is non-standard (by European norms). It is difficult to carry out classification of energy intensity of the building according to established European conventions. It is assumed that major part of the heat loss will be covered from solar energy and heat generated from indoor sources.
The main aim is to maximise the use of solar energy: air heated by the sun is distributed around the building by specially designed system of air circulation.

Project Surya will continue in long-term observations of indoor environment characteristics in the school building and observations of the efficiency of the solar system, and will use this monitoring to further improve the school.

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The Energy Savings Possibilities in Cooling Systems

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The cooling systems are already the integral part of commercial building sector. At present the cooling units become part of the residential building sector. Cooling requirements result in high energy demands. In response to this problem the effort is to use technologies with the potential to reduce energy consumption in the field of alternative and passive cooling strategies and systems, passive and hybrid cooling technologies. Passive cooling strategies are often used in the countries with hot climate. These technologies are the base for passive cooling systems in mild climate.

Traditional cooling systems such as compressors, absorption and thermoelectric cooling systems are very energy demanding systems. Devices require a large amount of energy for its operation. Energy is entering the process in the form of electric energy or in the form of heat. Use of passive and alternative systems aims to reduce energy demand. Alternative cooling systems are based on traditional cooling systems. As a source of energy is used in renewable energy. Solar and wind energy is used as the energy input into the process of cooling. Solar cooling is based on absorption cooling cycle. The source of heat is solar energy. The advantage of solar cooling is the near coincidence of peak cooling load with the available solar power.

Passive cooling systems are based on fundamental physical principles and natural laws. One of the fundamental phenomena used in the passive cooling strategy is the stack effect. Buoyancy occurs due to a difference in indoor-to-outdoor air density resulting from temperature and moisture differences. The result is a natural flow, movement of cold air up. It drives natural ventilation and infiltration. The principle of natural ventilation can be used in the design of cooling. Thermal comfort is a set of several factors. One of the preconditions for thermal comfort of the human body is uniform heat dissipation. Airflow around the body causing the cooling and helps set the feeling of thermal comfort. Natural ventilation is also used for night cooling. It combines the cooling effect of the „chimney“ effect and storage capacity structure. Night cooling uses an outdoor air with low temperatures at night. Necessary condition for the functioning of the system is sufficient storage capacity to design buildings. The cold is accumulated in massive reinforced concrete or brick structures. It is also necessary to ensure adequate air exchange. Cool night air is feed to the interior, the cold is accumulated in the structures. This leads to pre-cooling of the building.

The optimal solution to the problem with the cooling of buildings is to use the building to eliminate heat loads. A properly designed building can significantly affect the internal microclimate. The basis for the optimal economic and environmentally-designed system is therefore the correct design of the building itself. The quantity of heat loads should be minimized. Elimination of heat loads from internal sources is very difficult. Computer equipment and electronics are necessary for an operation and a work and can not be removed. We should focus on reducing the thermal stress from the exterior. Restrictions on the external heat loads should be solved already during the architectural design. Conditions for the correct design can be divided into several groups. The first group consists of properties of the construction of envelope. Heat loads through the constructions of the envelope is lower than throw the glassing. Their importance is still not negligible, as in the case of heat loss,

especially in buildings with inadequate parameters of heat transfer coefficient. Glassing parts pretend the weakest parts of the envelope. The solar heat load through the windows present the major part of the heat load in the interior especially in modern office buildings with a high percentage of glazing. This thermal load can be eliminated by decreasing of the percentage of the glassing or by using appropriate shielding devices. Use of shading devices may be complicated. Elements must be designed to prevent entry of sunlight into the interior on summer and allow an entry of sunlight into the interior in winter. When the proposal is necessary to take into account radiation and convection component of solar heat load. It is necessary to monitor not only sunlight but also external air temperature. Dimensions of the shading devices are proposed depending on the altitude of the sun above the horizon. The use of moving elements shading (blinds) allows shielding the interior while maintaining sufficient natural lighting of interior. Condition for functional use of the shielding is their application the outer side of the window. Elements reflected a part of the solar radiation. These prevent their entry to the interior.

In terms of limiting heat gains is the best orientation of the long axis of the building in the direction east - west. The sum of the solar gains from the south and the north is lower than the sum of gains from the east and west

Passive cooling strategies are used mainly in very warm climates. There are large differences between temperatures during the day and at night. High outdoor temperatures help to increase air buoyancy. In these areas, is much greater demand for cooling performance. The annual need of cooling is triple against the need in middle climate areas.

The efficiency of passive cooling change depending on weather conditions. The annual need of cold is quarter in the orientation of windows to the north than in orientation to the south. In orientation to the east or west is about the same, approximately 85% compared to the orientation to the south. Efficiency of shielding elements depends on the orientation of windows. The largest decrease is for the south, term load can be reduced up to 60% by using external shading, it is 8% for orientation to the north and 75% for orientation to the west or east. Big differencies are in the efficiency of shielding by their use on the outside and the inside of the glazing. The effectiveness of external louvers is 60% larger than the internal blinds. The room used for model represents an office space. Heat transfer coefficients of the constructions and windows were chosen according to the standard recommended value.

The computational model shows that the buildings should be designed with respect to the orientation to the compass also in moderate climates. The design of the constructions of the building envelope, the percentage of glazing, shading of windows significantly affects the value of term loads.

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Technical-Economic Benefits and their Potential

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The question of energy intensity changes the world nowadays. Products with higher energy intensity lose their competitive strength and consumers are willing to pay more for better energetic standard and lower negative impact on the environment. However in lower impact, this trend starts to be significant also for the civil construction segment. Buildings from the energetic point of view demand high energy intensity and thus both in the realization phase including material energy intensity and the operation phase. And the result of both phases is decided already in the phase of design.

Guarantee of building operation corresponding to the up to date standards is in term of energy consumption highly exacting. There are numerous of electric appliances such as boilers, refrigerators, televisions and so on in each house we can not imagine our lives without. In order to meet the EU objectives in the field of energy efficiency of the buildings and the decreasing of green house gas emissions part of the energy consumed during the building operation could or even should be replaced by the energy produced by the technologies based on the renewable sources.

Not to forget is that the basic assumption of the application of these technologies is the reduction of the operating energy intensity of the every one building, which is usually achieved by the following arrangements:

a) Envelope thermal insulation,
b) Roof thermal insulation,
c) Thermal insulation interior wall separating non-heated rooms,
d) Replacement of windows and door facing,
e) Equipment of heating system by thermostatic valves.

Fulfilling these basic conditions it is further reasonable to apply the technologies of renewable energy sources. A renewable energy source is the energy source gained primarily from the nuclear conversion of the Sun's core. Other renewable sources are heat of the Earth's core and the persistence of the set Earth-Moon. The mankind extracts these energies mostly in the form of solar radiation, wind energy, water energy, tidal energy, geothermal energy.

The energy demand during the phase of operation can be divided into two parts – the need of the heat energy and the need of the electrical energy. The renewable energy technologies usable for covering one of the two parts are namely:

- Heat pumps,
- Solar collectors,
- Photovoltaic,
- Micro wind power plants,
- Micro water power plants.

The question now is which technologies eventually which combination of all applicable technologies are the best to apply. This question can be answered by the analysis of technical economic benefits of these technologies.

Generally utility of any product means rate of satisfaction of the consumer needs. To be able to analyze the utility of the renewable energy technologies we have to know the consumer need. The consumer need is the operating energy intensity of the building which can be

covered by heating systems based on either fossil fuel sources or combination of the renewable energy technologies. All this heating systems are from the technical point of view indifferent, this mean that they all can cover the required energy demand. The difference between these heating systems results from the different operating costs on energy based on using the renewable energy sources. Therefore we can understand the utility of the renewable energy technologies as difference between the operating costs of heating system based on the fossil fuels and the heating system with combination of renewable energy technologies.
Within the utility analysis it is further important to include investment costs of the alternative variant and the development of fuel and energy prices to be able to verify if the generated utility is large enough to cover the initial investment costs. The best evaluation of variants is then using economic criteria such as NPV (net present value), IRR (internal rate of return), PP (payback period) and DPP (discounted payback period).
It is further important to extend the analysis of the technical economic benefits with socio-environmental analysis which sorts the alternative variants regarding the reduction of green house gas emissions.
The renewable energy technologies bring the consumers the independence from the exhaustible fossil fuels and lower the individual contribution to the negative environmental impacts. But analyzing the utility renewable energy technologies bring to the consumer it is important to define all technically possible combinations of the renewable technologies and compare their difference in the operating costs and green house gas emissions.

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Numerical Modeling of Fluid-Structure Interaction

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In the last decades we can observe increasing interest in numerical methods solving fluid-structure interaction (FSI) problems. The most common art of computer modeling of this type of problems consists in the use of Eulerian or arbitrary Lagrangian-Eulerian (ALE) formulation. The movement of a domain occurs separately from moving a finite element mesh and it is related via the convective terms in momentum equations. Treatment of a convective term is not the only numerical difficulty coming with ALE approach in FSI problems. Also the incompressibility condition, tracking of a free surface, correct interaction on a phases' contact or description of large movements need to be secured, similar to Eulerian approach. In Lagrangian description of a fluid and solid domain the mesh follows the movement of the material points. As a consequence the convective terms disappear from characteristic equations and must not be handled.

Particle finite element method (PFEM) [1] represents a modern way of modeling fluid problems. This method is based on Lagrangian formulation and, compared to traditional approaches, is advantageous in several ways. The problem domain is represented by a set of nodes – particles that may or may not be structured. By integrating the momentum and mass conservation equations in time, the updated positions of the particles are obtained in each time step. Integration of the governing equations over the entire fluid body requires suitable tessellation of the nodal set, interpolation of the nodal values, and a boundary recognition algorithm.

Delaunay triangulation, which is able to generate high quality meshes, was chosen as a suitable meshing method. It triangulates a given point set on the basis of satisfying empty circumscribed circle property. This leads to a quite numerically stable mesh. One of most used algorithms to produce Delaunay triangulation was simultaneously developed and described by Bowyer and Watson. It belongs to a group of incremental insertion algorithms, which are quite simple and can be generalized to higher dimension. The points are inserted one by one into the current triangulation in each step and the satisfaction of Delaunay criterion is enforced. Each triangle is checked, if its circumscribed circle encloses the new added point. If the Delaunay property is violated, the affected triangle is removed from the triangulation. Its edges define an inserting polygon surrounding the new point and vacant space is filled with new triangles by simple connection vertices on polygon edges with the new point.

Delaunay triangulation algorithm is typically used to obtain suitable tessellation. However, it is not unique in degenerated cases, when multiple nodes lie on the same sphere and it could produce elements of very low quality in near-degenerated cases. Such elements are detrimental for the precision of the numerical integration. To exploit the speed and simplicity of the Delaunay tessellation while avoiding degenerated cases, an extended version of the Delaunay tessellation was proposed by Idelsohn. In the Extended Delaunay Tessellation (EDT), the simplex (i.e. tetrahedral in 3D or triangles in 2D) elements produced

by the standard algorithm are merged in degenerate and near-degenerate cases, producing a mesh consisting of various polyhedrons (or polygons in 2D).

To recognize the boundary of the domain defined by a set of nodes, the alpha shape definition can be used. The alpha shape is closely related to the Voronoi diagram – a node is considered lying on the boundary if the radius of the empty sphere / circle defined by this node is larger than certain ration of the minimum or typical distance between nodes in the analyzed partition. Thus, isolated particles may be identified if they are sufficiently far from the rest of the nodes.

The particle finite element method presented above is being implemented into a finite element package OOFEM [4] developed at the Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, in order to enable FSI-analysis. OOFEM is an object-oriented FEM code, released under the GNU General Public License.

Delaunay triangulation using Bowyer/Watson incremental algorithm was chosen as a suitable meshing method, which will be used during solution of a fluid-structure interaction problem for mesh regeneration in each solution step. In this case, a classical mesh generator is not considered. The mesh is built by connecting particles together, not by meshing a given region.

Delaunay triangulation and its future extensions represent the first step of solving coupled fluid-structure interaction problems by using OOFEM. The results have been published in [3-4].

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Risk Management of Tunnel Projects

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The application of risk management in the construction industry and related branches is a relatively new phenomenon. During the last twenty years, the number of countries where risk management has been applied has been progressively expanding. The risk-based approach enables informed decisions based on analysis of risks and opportunities to be made, including consideration of life-cycle evaluation. Risk management is especially useful within large, complex infrastructure projects which require consideration of many different factors, besides performance and technical requirements also for example environmental impacts and involvement of the public. The risk-based approach supports transparency, improves communication and brings innovations into the construction industry.

Tunnels are one of the most costly and complicated part of transport infrastructure. Their construction is connected with high uncertainty in the field of costs, schedule, safety and impact on surroundings. Risk management became therefore a common part of tunnel projects, especially after a set of fatal collapses occurred in 1990's.

In the Czech Republic, a boom in transport infrastructure development during last 15 years has led to frequent construction of tunnels (see [1]). The risk analysis has been carried out for some of tunnel projects. However, the results of the risk analyses have not been sufficiently reflected during later phases of the projects. Risks have not been considered during the choice of general contractor, operative decisions have not been carried out based on risk analysis. In addition, the insurers of large tunnel projects have not had appropriate data for setting the insurance premium.

This project therefore suggests a framework for a systematic process for risk management, it provides tools for analysis of risk connected with excavation in uncertain geotechnical conditions (including collection of historical data) and last but not least it intends to increase awareness of the principles and benefits of risk management amongst stakeholders (investment bodies, designers etc.).

Risk classification and risk management system

To maximalize the efficiency of investments, the risk management must become an integral part of project management. Basic principles and tools for risk management have been summarized in new norms:

ISO 31000: Risk Management - Principles and Guidelines on Implementation

IEC 31010: Risk Management - Risk Assessment Techniques

ISO/IEC 73: Risk Management – Vocabulary

Fundamental guidelines for risk management of tunnel projects can be found in [2, 3]. Geotechnical risk management is a subject of [4], where GeoQ risk management system is introduced.

Within this project, a framework system for risk management of tunnel projects in specific conditions of Czech Republic has been suggested as cyclic repetition of four steps (risk

identification, risk assessment, suggestion of risk mitigation measures, risk control) in every phase of the project.
Further, a classification of risks related to tunnel project has been elaborated to serve as a baseline for risk identification and analysis.

Tools for risk analysis

A particular group of risks has been chosen for more detailed examination. It is group of risks connected with the construction phase of the project, particularly the risk of unsuccessful excavation in rock tunnelling.
Models such as DAT (Decision Aids for Tunneling) developed on Massachusetts Institute of Technology or simulation models based on Simphony environment are powerful tools for prediction of costs and schedule that enable consideration of uncertainties in geotechnical predictions and assessment of unit costs and advance rates. But they do not deal with risk of rare accidents that may essentially influence the success of the project.
Therefore, the attention is paid to the risks of extraordinary events having a small probability of occurrence but a potentially large impact. They are as follows:

- Cave-in collapse
- Significant exceeding of acceptable deformation of the tunnel tube
- Exceeding of acceptable progress of subsidance trough
- Disturbance of water regime in the surroundings

A methodology for risk quantification of the extraordinary events has been developed, it combines Event Tree Analysis (ETA) and Failure Tree Analysis (FTA). This kind of risk is often analyzed by means of different classification and rating systems. However, real quantification is feasible and reasonable as well and it is the aim of the process described bellow.
Within suggested methodology, FTA (Failure Tree Analysis) is first used for determination of intensity of occurrence of particular types of failures and for identification of most serious causes. Such collapses are usually caused by combination of factors that can be divided into three main groups, i.e. unfavourable geological conditions, failures in the design and planning or failures in the execution.
Second, ETA (Event Tree Analysis) is applied for calculation of related risks. The suggested approach supposes sharing of information between particular projects, in order to obtain as exact inputs for analysis as possible. The Failure and Event trees were prepared to cover broad spectrum of tunnel projects, the inputs will be modified in the given range according to specific conditions.

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Experimental Investigation of Early Age Concrete

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Abstract

Speed of buiding-up is today the basic parameter of structure succses. In contrast to precast concrete structure, where constructions are completed from structural members of designed properties, concrete is usually used as a liquid material with gradual hardening up to robust material of designed properties. This difference in technological process is not very propitious for monolitic structures, because construction of concrete structures using in-situ placement of concrete inherently suffers from necessity to provide a technological pause for concrete to gain prescribed strength, which eventually slows down the entire construction process. In case of falling behind schedule, construction companies often seek possibilities how to accelerate the construction, which may result overloading of concrete at extremely early ages.

The fact that the strength of concrete increases with the progress of cement hydratation, coupled with the fact that the rate of hydratation of cement increases with an increase in temperature. Temperature is not the only one factor infleunces the process of cement hydratation, there is kind of curing and complete composition of concrete. That's why for modeling of early age concrete is nessesery to gain basic experimental data for realistic numerical simulations verification. A variety of numerical tools has been developed for analysis of early age defects caused by premature loading, e.g. [1][2][3].

The material models necessary for such analyses need to take into account the rapidly progressing evolution of concrete microstructure. In most models, this is done by including another parameter which expresses the age of concrete, such as the degree of hydration or equivalent age. In multi-level models, e.g. [4], the evolution of microstructure is not expressed by a single formula, but by another analysis of a representative volume, where the kinetics of hydration reaction is evaluated. Nevertheless, either type of the modeling requires experimental data for calibration or verification.

The main difference between the hardening concrete and the already hardened one, especially noticeable at sustained loading, is the significant change in the material parameters due to the hydration process which no longer allows the simplifying assumption that material parameters are constant during the whole length of loading. It also should be pointed out that in the case of hardened concrete which is loaded at higher ages the duration of sustained loading can be, and usually is, measured as the time elapsed from the instant of loading until the moment of interest, which is in accordance with the assumption of the constant material parameters. In the case of hardening concrete, duration of sustained loading is actually prescribed in terms of time, however, for modeling it is more convenient to express the duration of sustained loading in terms of the degree of hydration, proposed above, allowing more general considerations which cannot be expressed as a mere time duration. This is, for instance, the effect of elevated temperature due to hydration which further accelerates hydration process and which results in relative contraction of the loading period.

The instantaneous deformation of hardening concrete comprises the strain of solid particles of sand and aggregate, the strain of water and the strain of the already hardened cement paste and the not yet hydrated cement grains. These particles can be considered to be nonaging constituents of concrete, which is consistent from the physico-chemical point of view once the effect of aging is dealt with separately.
The reversible viscous strain represents the strain component which later for the hardened concrete becomes the strain usually described as the viscoelastic. For the sake of consistency of the description of the deformation for both the hardening and hardened concrete the reversible viscous strain component is used for description of the deformation of the hardening concrete, especially the time-dependent, which in its nature resembles that of the already hardened concrete. Even though the term reversible is used as the name of this strain component, in the case of the solidifying and hardening concrete the reversible part of the deformation is negligible when compared with the irreversible part. This reasoning is justified by the experimental data obtained by the author and also by the method of the description of creep of concrete at the very early ages (2 to 7 hours) adopted by Okamoto. In his work, Okamoto used the viscoelastic three- and four-element rheological models without any clear explanation about the possible reversibility of the creep strain. This may have been for the reason that there were no experimental data on cyclic loading available at that time.

Based on the experimental data on short-time and time-dependent response of cube specimens obtained with the standard compressive strength test setup, a simple pre-scription for evolution of modulus of elasticity and com-pressive strength were derived along with a formula for the creep function, which also takes into account the effect of progressing hydration. These formulas were taken and implemented in the finite element code SIFEL and used for numerical simulation of the test with pressing a cut tire into a concrete slab. The results obtained for instantaneous strain were acceptable with the computed results, when considering the accuracy of the measuring equipment and configuration. However, the computed creep strain was rather higher than the measured strain.
The simplicity of the presented formulas allows an easy calibration with the experimental data commonly provided by concrete producers. Therefore, it can be ex-pected that the formulas would be used by the practicing engineers, especially when the estimations of strain are on the safe side.

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Load-Carrying Capacity and Rehabilitation of Existing Bridges

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Objective of the project is a determination of the possible usage of existing bridge structures made from precast prestress beams I 73 in accordance with typified data by Dopravoprojekt Bratislava [1] and amendments by D.S Olomouc and SSŽ Praha [2]. Common application of these structures in road and highways net in the Czech Republic together with their serviceable life argue for the next possible usage. For the project purposes the typical simple span bridge 30m long has been chosen. The work is focused on calculations of the load-carrying capacity of typified cross-sections in accordance with ČSN EN 73 6222 [4] and on possible future usage in new structure with or without structural adaptations.

The first step in calculation of load-carrying capacity of I 73 beams was determination of the inner forces in accordance with ČSN EN. Forces were calculated on 3D model in software ESA Engineer 2009 including time depended analysis. Basis for time depended analysis were typified data [1] and [2]. Dead load data were defined in accordance with ČSN EN 1990, including amendment A1 and ČSN EN 1991-1-1. Location of the critical sections and the load positions were defined in this step. Quantification of prestress loses in tendons including consideration of shrinkage and creep in accordance with ČSN EN have been taken in account as a précising of valuation of the base data [1] and [2].

The first project output is determination of load-carrying capacity – maximal approved weight of each vehicle witch under the conditions given in [4] (calculated for superstructure only). Load-carrying capacity was calculated for SLS, ULS and fatigue. Consequently the assessment of the live expectance of the structure has been evaluated. The set of possible measures for conservation of serviceability and/or prolongation of live expectancy of these structures is included in the project.

In the second part of the project the future usage of precast beams in new structures in considered. Good condition of beams is assumed together with designed set of measures and adjustments of beams. New composite solution involves concrete deck continuously cast over I 73 beams. This is in variance with the original solution witch includes concrete deck between the bottom flanges of beams. Assessment of the structure defined above has been done in accordance with ČSN EN 1990, including amendment A.

The result of the project is the assessment of the proposed conceptual solution for structures made from this type of precast beams used in the Czech Republic, their possible preservation in original structures or new usage in new construction.

Question about rehabilitation or re-adjustment of existing bridges will be topical due to frequent of occurrence of these structures in road and highways net. Objective consideration of load-carrying capacity and rehabilitation of existing bridges or possible usage

original precast beams I 73 in new structures will be helpful in reconstruction of road and highways net in the Czech Republic.

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Sediment assesment in small water reservoirs

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The paper deals with problems from erosion and transport processes in the watershed. Assessment methodology derived in the workplace of doctoral student which is Czech Technical University in Prague; Department of Irrigation, Drainage and Landscape Engineering. Ph.D. student is testing this method on an experimental watershed Hostačovka and her right hand Vohánčický tributary stream. Experimental watershed with an area of 62 km2 is intensively cultivated agricultural area, part of the watershed are forests. The two streams flow is a series of small water reservoirs to capture soil particles, transported by water flows from those processes of erosion on agricultural land.

To estimate the amount of sediment can be used many methods, including simulation of mathematical models. Below, the method is based on the initial determination of the intensity of erosion in the watershed in terms of the universal soil loss equation (USLE) and estimated number of transported sediments using facto of sediment run off (SDR). As for processing documents is used geographic information system software (GIS). GIS works with USLE factors.

Results of loss soil particles from the experimental watershed are determined using the universal soil loss equation (USLE) by Wischmeier and Smith.

This method is based on statistical analyses of data from 47 locations in 24 states in the central and eastern United States.[1]

Transported amount of soil particles is determined on the basis of the ratio of loss soil, depending on the size of catchment's area, topography ratio and the average number of drainage curve (CN curve).

The volume of sediment deposited in a reservoir depends on the trap efficiency and the density of deposited sediment. The trap efficiency of a reservoir is the ratio of the quantity of deposited sediment to the total sediment inflow. Trap efficiency depend mainly on the fall velocity of sediments particles, the size and shape of the reservoir, and the rate of flow thought the reservoir. Empirical methods for estimating reservoir trap efficiency are based on measured sediment deposits in a large number of reservoirs.[1]

When the anticipated sediment accumulation is larger than one-fourth of the reservoir capacity, the trap efficiency should be analyzed for incremental periods of the reservoir life. The trap efficiency generally decreases continuously after storage. A resurvey of a reservoir's effective storage volume once every 10 years may be needed.[1]

This method was in the Ph.D. student workplace successfully tested on several large water tanks (Brno reservoir, Vrchlice reservoir).

In paper work "Sediment assesment in small water reservoirs", we work by methodology determined by the annual amount of transported soil particles from erosion processes in different sub-watersheds (like closure profile are a dams of small water reservoirs and the specified amount of sediment compared with the volumes of sediment stored in water reservoirs).

To assess the annual transportation solutions will be included the period during which the sediment was mined from the reservoirs and will be taken into account while also farming on agricultural land used over time (changes in land-use).

Comparing the results of calculations of the quantity of sediment transported with relevant data from the measured values established in the sediment of the reservoirs will first evaluate the applicability of methods for solving similar problems; both these results provide information about risk watershed in terms of river erosion vulnerability and in terms of silting of small water reservoirs by sediments with negative consequences of eutrophication, reducing water quality and reducing the retention volume in small water reservoirs.

Using the results of the verification methodology for the evaluation of erosion processes and sediment transport on the experimental watershed can be used to estimate the amount of sediment in small water reservoirs and the need for mining in the frequency of type localities, where the draft anti-erosion measures to reduce the rate of washing the surface horizons of agricultural land, thereby clogging of small water reservoirs.

Water erosion is to scratch the surface of the earth surface by the drops of rainwater and surface run-off. According to the form is divided into erosion area, rill erosion, gully erosion and flush erosion. [2]

The consequences of water erosion leading to degradation and reduce production capacity of soils. Reduces the power of the natural soil surface horizon, the worse the soil structure, is to reduce the permeability pore and change physical properties. Pollute the surface water resources, there is clogging streams and reservoir sediment and material damage urban areas.

A key factor is the way of management of agricultural land in the watersheds and its influence on the transport of soil particles from erosion processes.

In a pond reservoirs also reflected riparian erosion phenomenon, which come up when the reservoir has been discharged, filled or during waves. By mining sediment from pond reservoir is part of the sediment used to create islands which are compress and riparian edges reinforced with wooden stakes with slab bunding.

All these islands are about 10 years after damaged and the ponds banks recede. It is therefore necessary to take into account also the material washed away from the islands, which is included in the measured values of sediment powers.

Final aim solution of project is verify method erosion process and transport of soil particles on the experimental watershed and what quantity in time period is caught up in reservoirs and how much is flowed away from watersheds. Whether has mate cultivated land in watersheds influence on a fouling storage reservoir and in what measurement?

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The Causes of Construction Failures - Structural Analysis

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The aim of the project is innovation of a course named Structural Analysis lectured at the Department of Mechanics by incorporating a brand new lecture about the causes of failures of constructions. The governing idea of the introduced lecture is focused on practical investigation of the causes of failure. For this purpose a large amount of data were gathered, containing the photo documentation, construction description, failure description and remedial measures proposals. Majority of the examples of damaged constructions comes from the doctoral stage of co-author from Brazilian state Tocantins. After the data acquisition several examples were selected for the theoretical lecture and others were left for the practical part of the course. The theoretical lecture is prepared for two lecturers presenting at one time, who interact with each other during the presentation and also drug the students into general discussion on specific parts of the lecture.

As the length of both, lecture and practical lecture, is limited, the theoretical part was prepared in such manner that the students are at first introduced the possible causes of the damage. This part of the lecture contains explanation of stresses involved in the processes that cause the damage as well as recapitulation of principal loading experiments.

The second part of the lecture is devoted to the analysis of fractures. Possible ways of fracture measurement and fracture development measurement are introduced and the desired outcome from the analysis of fractures explained.

Third part of the theoretical lecture contains detailed description of the common causes of failure for different materials with typical examples and also remedial measures that proved to be appropriate in practice.

Fourth part of the presentation is devoted to the numerical modeling and its use in back analysis of the cause of damage. First example shows the back analysis of laboratory bending experiment while the second example shows the complete back analysis of real structure with modeling of remedial measures.

Last part of the theoretical part of the lecture contains practical examples of historical sacral structures and base structures. The aim is to discuss the effect of the biological agents to the roof structure and then to stability of the entire structure as well as the effect of groundwater flow and the untraditional measures used where groundwater is involved.

The practical part of the lecture contains numerous examples of real structures equipped with the explanation of the most probable cause of the failure. The aim is to allow the students to improve the knowledge gained during the theoretical lecture. For every example structure the approach for estimation of the cause of the failure should be designed and assuming the hypothesis made is correct the remedial measures are to be designed. Some more difficult examples are included to explain the necessity of multiple hypothesis of the cause of the failure at the beginning of damage investigation.

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Calculation of close range photogrammetry for 3D scanning

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The text is focused on calculation processes which are used in close range photogrammetry. Terrestrial scanning systems for small objects are often based on equations of collinearity transformation. These calculations were developed for 3D scanning system with virtual binary targets.

The newest way of obtaining large number of detailed points is the 3D scanner technology that obtains space information about body surface in contactless way - automatically and in short time. The obtained data enable creation of space object model and also virtual browsing and manipulation when using the relevant programme equipment.

BiMatrik is a photogrammetric scanning system which is being developed for documentation of smaller objects, especially in the area of care of historical monuments. The whole system is based on a data projector, which projects the virtual targets on the scanned object, and a digital camera, that serves as a data-collecting unit. The virtual targets on the object are interconnected with the coordinate system by the 4 photogrammetric points. The text [1] deals with the realization and the evaluation principle.

The scheme of calculation is based on the projective transformation. Virtual targets projected onto the object are also used for the purposes of adjustment so as to determine the elements of the outer orientation. So as to determine the proportion and to calculate the approximate values we need only four photogrammetric points in a plane (according to [2]), which can be placed to the object in the form of a simple tool measured with a high accuracy. We also suppose an exact determination of the elements of the inner orientation for the used digital camera and the lens, so that it was not necessary to determine them always when measuring from a small number of the photogrammetric points.

Distortion of the lens will be characterized by invariables k_1, k_2, k_3, p_1, p_2 in the following formulas, where x' and y' are the photograph coordinates (reduced by the coordinates of the main photograph point x_0, y_0), x'' and y'' are the photograph coordinates corrected by influence of the distortion.

$$x'' = x' \cdot \left(k_1 \cdot r^2 + k_2 \cdot r^4 + k_3 \cdot r^6\right) + p_1 \cdot \left(r^2 + 2 \cdot x'^2\right) + 2 \cdot p_1 \cdot x' \cdot y', \quad (1)$$

$$y'' = y' \cdot \left(k_1 \cdot r^2 + k_2 \cdot r^4 + k_3 \cdot r^6\right) + p_2 \cdot \left(r^2 + 2 \cdot x'^2\right) + 2 \cdot p_2 \cdot x' \cdot y', \quad (2)$$

where $r^2 = x'^2 + y'^2$. So a deccentric component was added to the originally used radial component of the distortion.

The projective transformation according to the known relations will be used for calculation of the elements of the outer orientation and also for the calculation of the coordinates:

$$x_0 = x_{00} - f \cdot \frac{r_{11} \cdot (X - X_0) + r_{21} \cdot (Y - Y_0) + r_{31} \cdot (Z - Z_0)}{r_{13} \cdot (X - X_0) + r_{23} \cdot (Y - Y_0) + r_{33} \cdot (Z - Z_0)}, \tag{3}$$

$$y_0 = y_{00} - f \cdot \frac{r_{12} \cdot (X - X_0) + r_{22} \cdot (Y - Y_0) + r_{32} \cdot (Z - Z_0)}{r_{13} \cdot (X - X_0) + r_{23} \cdot (Y - Y_0) + r_{33} \cdot (Z - Z_0)}, \tag{4}$$

where x00 and y00 are the photograph coordinates of the main photograph point, X0, Y0, Z0 are the space coordinates of the input pupil of the lens, X,Y,Z are the space coordinates of the point, the coefficients r_{11} to r_{33} express rotations around the individual coordinate axes and invariable f is the focal distance of the relevant camera with the lens.

The advantage of this calculation model is not only a geometrically correct formulation, but also a possibility of a separated determination of the elements of the inner orientation during a single-use accurate calibration.

This is the basis for the program BiMatrik 2.0 (Bimatrik_2.0_software.sci), which is created using Scilab 5.0.3 and used to calculate the spatial coordinates.

The program works with any number of standpoints and provides users the option to select virtual targets to be used in the calculation of the external orientation. Furthermore you can set a tolerance for the iterative calculations of bundle adjustments (percentages) and switch off or turn on the detection of remote measurements using a robust estimate. Last thing the user can choose the calculation of the external orientation with constant of chamber or without constant of chamber.

The proposed calculation procedure based on projective transformation and its processing into a coherent program is fully functional and can be applied not only to the system with virtual binary targets. Another possible development of the system could be the calibration of cameras, where the field of calibration will serve a virtual targets and all parameters of the internal orientation will then be determined from a large number of points, which greatly simplify and improve the calibration procedure.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

The Influence of Social Model on the Form of Cities

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Walter Siebel in 1987 stated, freely translated, that the city today is no longer a separate entity. Today city became a unit, which has been integrated into the system of international law, social tactics, federal and state political processes, and the global market. It is certainly a fundamental idea, and it is necessary to supply: Even though the city is significantly influenced by external processes, its basic principles (processes) still have to be present (along with humans). What are these basic principles? At the most elemental form it is REPRODUCTION, PRODUCTION, COMMUNICATION (generally INFRASTRUCTURE), without which further development wasn´t possible, and naturaly PROTECTION. These processes are later followed with OVERPRODUCTION, allowing the development of the TRADE, SERVICES and CULTURE, and later on RELAXATION. If we understand how these prosesses works in these days and what affect them, we can see how our cities really works. We can´t do this without historical comparisons that allow us to correctly understand the manifestations of the present town. The elements influenting the city and its form, of course, overlap each other, and probably could be formulated in many ways. I understand as significant elements: religion / philosophy, political and social structure, the potential of the city, communication - generally the infrastructure, the impact of nature / geography, urban theory and concepts, and economics.

Religion and philosophy have the primary influence on the shaping of society and its behavior. Which in turn avokes specific needs in cities. An important position of Agora, as a central element of the Greek cities, is clearly a reflection of need to comunicate and participate on the public life. For instance Christian doctrine supported feudal system, so it could run on without much resistance. But Christianism also directly influences the form of city by inserting the most important city landmark. And also, without question, Christianity laid the moral foundations still influencing (not only) European society. In contemporary society the impact of faith (whether it is fragmented in any way), or personal philosophy, subside. More important are economic factors and social position.

It is clear that social and political model of organization have essential influence on the urban development. City in feudal society and the city in a democratic society must necessarily have a different characters. It is interesting how a diagram showing the ratio of "the powerful and the poor" in every period corresponds to a specific form of the city. Also today's broad middle class and need of individualism are clearly reflected in the form of the city. Flatness of suburbia and new housing estates clearly confirmed it. It is logical that people with the same income and similar cultural background prefer similar form of housing which meets their ideals. However, this "flatness" is also defined economically. Goes from the selection of cheap sites by developers, or bribes for change of zoning, through the simple shapes of houses, to cheap materials and lack of public space.

It's pretty well-known, that the so-called competitiveness of cities depends on its potential. That one is different for each period. At random: infrastructure, ports, raw materials, technologies etc. Today cities are truly searching and supporting its potentials, anyway the problem is that the current potentials are always converted into the money. Small town may lose the potential to produce excellent bread just because hypermarket from England or France sells it cheaper. This is a potential in a global world, where it is advantageous to produce textiles in China and distribute it in Europe. In fact, all manufactural and production potential is global and economically converted, the only stable potential is cultural heritage, including landscape and mineral wealth.

But nature and landscape became the subject for the Ground plan only if brings money into the budget. Influential elements can be usually described as determinative, necessary or ever-present.

Landscape is currently not in either of these categories. The threat of the built landscape or loss of water doesn´t frighten us enough to build more compact cities. Despite that we does not respect the nature, it doesn´t prevent us to adore it. Previously also played a role, due to the construction material, geographic location of the town - city was built from what was available. In today's world, where we can deliver anything anywhere such a restriction doesn´t exists.

Infrastructure, including everything from communication, through the network, internet, to cars and other traffic, can not be understood otherwise than as an integral part of the structure. Formerly the infrastructure was a priority, but its options were limited, therefore, it has become determinative for the structure (definig the location of the city and olso its main axis and center). With the functionalism the transportation became demonized, while the reflection of the structure was disappearing (mass application of solitaire, suppose to solve everything). Even today the infrastructure is just a function, which need to be figure out. Its aesthetics or design is undesirable. But what is more interesting is the scope of infrastructure. It is essentially the most common urban element, and its influence is now much essential, even in a different way. It is because of that the movement and communication between people is no longer necessarily take place on the street - specific locations. Now we communicate everywhere, ergo through the mass. In addition, movement between locations is made by "jumps" - we are unaware of continuity. So it appears that the mobility, communications, global trade and other factors caused a major separation from the "place". The internal structure of the city is breached - the relationships which were giving a sense to places, have been lost. This of course impact on the public space which is emptied and becomes uncertain. Structure is degraded, topography chaos take place.

Does our urban theoretic or practic arsenal responds it? It seems that we are still amazed with the lesson of industrial era and reaction of the modernism, which is still rooted in our law. Postmodern times and other critics of urbanism pointed to important aspects of the city and the errors of modern style indeed: problems of mono-functional areas, barriers in the city, the importance of the orientation of man in space, low population density, urban sprawl in countryside, the lack of communication with users of the city etc. But even so, the criticism is usually not heard, except a few cases, abroad. Our planning standards are so far redefined by meaningless heights of cornices, roof shapes, maximum built-up areas and functional zones. In contrary nobody doesn´t define public space and its overall aesthetic concept in relation to the infrastructure. How is it possible that the city is not able to enforce the essential public interests and at the same time requires everyone to adjust its private needs?

The economy was certainly always a powerful force. The difference is made by democracy, and more important the economy itself doesn´t respect democratic principles. Also earlier there was a different understanding of "myself" in the company - there was a dependency and thus responsibility. With extended specializations of people, with mass machine production, with infrastructure that works alone, it seem as we lost contact with the real world. Everything we do, we do for ourself, and moreover everything is recalculated into money. It is the only true measure of the world of the 21st century, which makes us independent and therefore irresponsible.

So why don´t we take the lessons from history? Why don´t we reduce the impact of the global market on our cities, by making them more independent (leaving them their own taxes)? Why don´t we support the use of local materials? Why don´t we move the regulation on the right side of playground, and introduce ecological motivations? Why don´t we highlight the hierarchy of cities by supporting the places where it makes sense in terms of infrastructure? Why do not we stop sprawling the city, which is neither environmental nor economic? To conclude the circle, let's go back to the first chapter: God knows why.

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Building of Visual Artists Association Mánes. Digitalization of Plans and Archival Documents

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The Visual Artists Association Mánes [1] is the most important artistic group in Czech lands during the second half of the nineteenth and the first half of the twentieth century, nevertheless we have no general publication about the association Mánes where we could learn about all details of its very plentiful private developer activity. I would like to collect all accessible informations not only describing the Building of Visual Artists Association Mánes in Prague but also and primarily about operation of the association before the opening the possibility to build its own building at Masaryk´s embankment. The CTU grant supported financially acquiring high quality copies of a lot archival documents, photos, architectural sketches and large-screen architectural plans from several resources: Archiv hlavního města Prahy, Archiv architektury Národního technického muzea in Prague and Stavební archiv stavebního dboru ÚMČ Praha 1. I acquired digital copies of resolved archival documents, construction plans or period photos. Every piece of documents is very important to understand the behaviour development of association during the time of its decision making why, where and what to build. The digital copies help to observe the architectural transformations of architectural project, too. The majority of material acquisition will be used like a picture supplement in my academic dissertation and like a companion of thoughtful papers.

I had possibility to document a lot interesting documents and plans which can describe to us very deeply the history of The Building of Visual Artists Association Mánes and association´s operation in the first half of the twentieth century. I found out several very interesting architectural designs of the Building of Visual Artists Association Mánes at number of building sites in Prague by a few of very known Czech architects. It is very interesting because the association wanted to build its own exhibition hall at any rate. The association made a lot of negotiations with a plenty of state and municipal authorities and of course with the other artistic associations, e.g. Umělecká beseda and Jednota umělců výtvarných. The straight Association Mánes collaborated with e.g. Viennese artistic group Hagenbund and helped to other one e.g. Association for Building and Upkeeping of Exhibition Hall in Moravská Třebová. Many archival documents confirm it.

Otakar Novotný [2] is very famous Czech architect. He was born on January 11th 1880 in Benešov near from Prague and he died on April 4th 1959 in Prague. He is author of many famous buildings in Prague and all over the Czech Republic. One of his the most awarded realizations is the Building of Visual Artists Association Mánes at the Masaryk´s embankment in Prague. We can learn about his work from a lot of journal articles but his work has been not yet explored enough. The first and the last deep research, too was made by Prof. Šlapeta. He prepared a large exhibition about architect Novotný in 1980. The exhibition had two stays: in Prague and in Olomouc. It took place on March 13th 1980 - April 7th 1980 in The Exhibition Hall of Mánes here in Prague and in March 13th 1980 - April 7th 1980 in The Gallery of Visual Arts in Olomouc. The exhibition was named Otakar Novotný 1880/1959 Architectural Work. The catalogue is the mentioned universal issue about work and life of architect Otakar

Novotný. It is very slender book. I think it could be place for researching for other architecture historians.

My academic dissertation and my poster during Workshop CTU 2010 will take acknowledge of the last findings about Novotný building and of course the ideas of thoughtful building renovation and results of the Building history investigation, too.

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South Bohemia Exhibition In Tábor, 1929 – Professor Theodor Petřík And Tábor

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The aim of this project was to present in a publication and web presentation an exhibition areal of the South Bohemia Exhibition in Tábor, 1929. Architectural design of exhibition pavilions was very new and important for the future development of architecture style in this region but today is nearly forgotten. Eighty years after the end of exhibition all that is left is a gym building (formerly the Pavilion of Trade), and a series of more than 300 photographs. These photos, from the Šechtl & Voseček Studio (the exclusive photographer of this event) document its construction, its realisation, its destruction by a storm, its restoration, and a series of accompanying events.

The phenomenon of Industrial Exhibitions in the 1920's contributed to the introduction of modern architecture to smaller towns. Most famous is the North Bohemia Exhibition in Mladá Boleslav in 1927 by architect Jiří Kroha. The South Bohemia Exhibition in Tábor in 1929, and the associated Czechoslovak Military Display, was the architectural and urban work of two important Tábor citizens: architect Jan Chomutovský and Professor Theodor Petřík. The grand composition of Exhibition pavilions built on the banks of Lake Jordan amazed and inspired its visitors.

Several Exhibitions had already been held in Tábor in the 19th and early 20th centuries (in 1864, 1886 and 1902). However, the South Bohemia Exhibition in 1929, designed by architects Jan Chomutovský and Theodor Petřík, was noted for its modern architectural and urban concept. After it others modern buildings were build in Tábor. The South Bohemia Exhibition, opened on June 23, 1929, consisted of several themes. The main ones were the Czechoslovak Military Display, and the pavilions of Trade, Industry, Agriculture and Education (located in the secondary school building). In addition to the exhibition itself on the banks of Lake Jordan (now the site of the Tábor swimming baths), it was complemented by a series of displays spread throughout the city. The exhibition was accompanied by congresses, festivals, cultural events and various crafts and political parties and visits by many eminent guests, including President T. G. Masaryk, who visited on 30 June 1929.

Renowned Tábor-born architect Jan Chomutovský graduated from the School of Architecture at the Academy of Fine Arts in Prague, and did most of his work there. Through the 1920's and early 1930's, he was also active in Tábor. In 1926, with František Novoveský, he won a competition to design the new Electrical Workers Union Hall. In 1929 he became famous as co-designer of the South Bohemia Exhibition in Tábor, this time in conjunction with Theodor Petřík. In 1930–31 he designed the main building of Bechyně spa (today's Jana House), and in 1931, he built his own villa in Tábor. The life and work of Jan Chomutovský after his emigration to the USA in 1948 is unknown.

In 1929, architect Chomutovský published an article about the South Bohemia Exhibition in the magazine Stavitel (Builder). He describes the concept of the exhibition in this way: "In the South Bohemia Exhibition project, we achieved unity of composition in the architecture, which was essential for its success. The layout of the exhibition was expansive,

ideally complemented by the unique natural beauty of Lake Jordan. The foundation of the design was the entry avenue, with its entrance gate, leading to the main ceremonial area bounded by the rectangular wings of the entry pavilions. Administration, ticket office, fire, police, etc were in two longitudinal wings in front of the entry gate. The bulk of the entrance gate harmonised with the bilateral longitudinal pavilions beyond. The entrance avenue was visually closed by the Pavilion of Trade, Business and Industries, with the illumination tower in the middle of the ceremonial area. The Pavilion of the Ministry of National Defence was situated on the left side of the ceremonial area. The Czechoslovak Military Display was located in the adjacent open space. The right side of this area was closed by pylons, forming the entry to the Exhibition of Horticulture. A requirement for the Pavilion of Trade was that it later would be adapted into a gym for the sport union Sokol, so it had to be designed with this in mind, while the large Pavilion of South Bohemian Agriculture was designed to demonstrate the technological achievement of the region. Among other pavilions deserving mention were those of Písek town, and of three large restaurants (including that of the local brewery, with its dance floor). The capital city of Prague provided the landscaping, where the garden setting made an appropriate background for the architecture of the pavilions. The South Bohemia Exhibition and its architecture will be a notable milestone in the development of contemporary architecture in South Bohemia, and will give publicity to, and win acceptance of, the modern architecture seen here. This exhibition has contributed significantly to transforming the view of modern architecture, which is still very conservative in this small town. It will help in the realising of other modern projects in the future."

Theodor Petřík was born in Tábor on 8 October 1882, son of Dr František Petřík and Tonička (born Koldová). After graduating from secondary school in Tábor, he studied Architecture and Building Construction at the Czech Technical University in Prague. Later, agricultural architecture became his life's work. In 1910 he gained his Ph.D. at the Czech Technical University, and in 1923, he became a full professor, and chairman of the new Institute of Agricultural Engineering. In 1927–28, he was dean of the University of Agriculture in Prague. While Professor Petřík became most famous for his contribution to agricultural engineering, regrettably, his work in other fields of architecture is almost forgotten. In Tábor you will find a number of buildings by Professor Theodor Petřík, which greatly influenced the character of the town. These include the circular extension of the Civil Bank (now the Post Office) on the main square, the refurbishment of the old Savings Bank, the Hýlačka lookout tower, the new Savings Bank on T. G. Masaryk Square, and many others. On many projects, he collaborated with his wife, Milada Petříková-Pavlíková, (daughter of Tábor doctor Josef Pavlík), the first Czech woman to study architecture at the Czech Technical University. After the death of Professor Dr. Theodor Petřík in 1941, Milada Petříková-Pavlíková wrote a detailed biography of his work.

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The impact of inner and urban environment on human mental status

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All scientists agree upon a fact that inner and outer environment, either natural or artificially created, has an influence on a man and this is agreed upon by all scientists, who dealt with this question. Findings of experts on an interconnection of physical and mental reactions are interesting. These reactions are linked together; mental reactions depend on physical feelings and vice versa. Human being reacts to inputs with all senses, which are subsequently processed in limbic system. Both real impulses and imaginations are processed together. Subsequent reactions to both are than similar. Therefore it is possible to deduce for example the importance of positive pictures within an environment, where a stress is present as such, like in health care institutions. There are many components of environment, which are perceived by a man. Some are of great importance and others are negligible.

It is obvious that an architect can create spaces able to influence a human being both positively and negatively. Surely, it is architects' main goal to generate harmonic spaces, mainly for living. However the same architecture is used to move one's mind, like cathedrals in middle ages. Architecture can serve as a manifestation or a tool of power. It is noticeable from Vitruvius and Palladius tractates, that it is not grandioseness or ostentatiousness as primary requirements on a structure, but it is mainly a harmony. Harmony in individual parts, mutually in spaces and also a harmony with structure's surroundings, if not with the whole universe.

The rules who affected a civil engineering are primarily based on observations in nature. They came directly from physical and mental needs of a human being. Man was substantially more dependent on nature in past times. Man's life was affected by natural conditions, weather; life rhythms were driven by changing seasons of the year and the man was directly dependent on weather's grace. He was able to modify his habitations by own experience and receptiveness in such way they provided the most comfortable use and protection from surrounding disgraces. Both Vitruvius and Palladius works present recommendations regarding an orientation of habitats and individual rooms to cardinal points. These authors recommend noticing anomalies of plants and viscera of animals living in given location.

Of the recommendations which are based purely on sense impressions, there is an interesting Alberti's opinion advising the use of odd number of windows and doors. We can find also a notice on odd number of steps in stairways. This is based on the fact that a climb will be with right foot, if we start with it at the beginning of the arm. At Alberti, we also can find comments that could be set at symbolic or mystical level. Middle ages were governed by faith, which is abundantly reflected in buildings. I will also bring forward an example of staircase, where builders placed seven of nine steps to one arm. Is it a link to a number of planets of star circles? More similar references can be found in texts. Symbols are treated with humbleness and the experiences of "elderly", i.e. predecessors, likewise. Otherwise, all recommendations are explained by connections to seasons of the year, lunar motion or climate. All this required very sensitive field observation of natural principles and cycles. Alberti encourages mimicking the perfections of nature, "*the greatest form artist*", because

according to him the building is like a living creature and it is necessary to follow laws of symmetry. He says that harmony is a provider of all beauty and grace. Again, we should seek for a model in nature, which uses odd and even numbers according to its rules. There is an even number of limbs in nature and likewise buildings should have even number of walls or other supports. And there should be even number of openings, because the nature provided living creatures and opening – mouth in even number. Alberti deals with general interrelationships, derived mostly from music, far more than Vitruvius.

We can find many recommendations for harmonic living in feng-shui teaching, coming from China. They are also derived from observations of natural principles. Feng-shui mainly utilizes cardinal points orientation, like Palladius and Vitruvius do. The school of shape is very interesting. It deals with an influence of various environmental forms, which can have beneficial or adverse impact on life in buildings. The environment is made of five elements – water, wood, fire, earth and metal. Colours are very important in Eastern teaching and their influence is interpreted in the similar way in Europe. Compensation and consonance of colours, which can be found in European literature (Rodeck, 1998), is interesting and parallels with Chinese philosophy could be observed.

The character of various elements is in Chinese philosophy designated by ying and yang. These elements can have either positive or negative charge. Water can serve as an example. It can have negative charge if too ying (dead water, potential source of harmful bacteria) or too yang (too strong river current, which could have destructive impacts).

The comparison of effects of various shapes on a human is very interesting. In 1933, a psychologist Köhler introduced term for two individual shapes – Takete and Maluma. Various adjective are given to these shapes and this assessment if irrespective of age, race, sex and religion. Architecture can evaluate objects according to takete and maluma character as well. In a symbolic way takete can be perceived as male – yang element and maluma as female – ying element. It is possible to use these features in architecture for evaluation of potential impact on human perception. It is interesting to observe human assessment of curves. Round shapes are mostly accepted positively contrary to pointed shapes and curves. The explanation is that there is less strain to ocular muscles when following round curves compared to pointed ones. Therefore in architecture are round shapes perceived positively. Parallels with Eastern teaching can be found here, as it recommends round shapes as being more enjoyable for human.

Because buildings for living were developed mainly according to empiric results, were improved by generations and were dependent on natural circumstances, we can find some parallels in feng-shui teaching and European civilization, despite it was never systemized in Europe.

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Participatory Process in Urban Design and Planning – Goals and Evaluation

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The discussion about the usefulness of public participation in design and planning in Czech Republic usually is very emotional – even in the community of professionals. It is more about beliefs than clear ideas, what should public participation be good for and how can we be sure it really is so. This work tries to overcome the hidden assumptions that prevent the discussion from being focused on the real effectiveness and efficiency of the process. As a main outcome it offers the possible list of goals, which can be (not all at once) reached by participatory process and indicators which can be used to evaluate that the goals were actually achieved.

Dangerous assumptions

The following dangerous assumptions, implicitly shared both by the proponents and opponents of participatory process, usually prevent the discussion from being focused on the real efficiency and effectiveness of the process:

1. *Participation is conceptualized as power* – the understanding of participation is still mostly based on the "Ladder of Citizen Participation" [1] published 40 years ago, which describes the increase in participation as an increase in power that was passed by the local government / public administration to the citizens. The shape of the ladder leads to the impression that the higher the type of involvement is (that means the more power is passed), the better. It gives the understanding of participation as a power struggle between citizens trying to move up and government limiting citizen's movement to top [2].
2. *There is only one method of participation* - there is usually no thinking about the scale of the project, thematic classification of the project, the number of people involved, and other characteristics of the particular situation - as if these key features had no influence on the need for participation and the desirable form of involvement.
3. *The goals of participation are clear to everyone and it is not necessary to define them*. Usually they are not and it leads to a senseless discussion. Where there are no defined goals, which could be measured by its results.

For a reflection on the usefulness and necessity of any procedure, the evaluation must be based on clear understanding, what the goals of introducing the procedure are, how to find out, that goals were really reached (effectiveness) and what is the ratio of inputs and outputs (efficiency).

Goals of public participation

Different communities and different projects have different backgrounds and goals to achieve. Therefore, it is natural that public participation in different projects should have community and project specific goals. The participatory process is then designed individually to fit the project and the community. This means also, that there are no universal indicators of successful participatory process – they need to be set at the same time as the goals and must fit the community.

Although each project is unique in its own way, it is possible to identify general topics that appear in more projects. Goals can be placed in the following three areas (In the individual projects, the importance of these topics – of course – varies):

1 *The contribution to output* – using the local knowledge and accurate definition of the priorities for improving quality of the resulting proposal – to better meet the needs of users. Dissatisfaction with the quality of the top-down planning process was one of the main starting points promoting participation in planning. The benefits of participation for the quality of the final output are to obtain information about the user requirements which would not otherwise be available. The prioritizing of the requirements is also very important. Quite often the substantive nature of the problem / requirement is known, but the surprising findings are the priorities of users. A type of information that can be obtained only in group work with future users is a preliminary assessment of proposal alternatives and various phasing options.

2 *Benefits to the community* – improving the social environment: an improvement of relations, cohesion and communication between residents, generating leadership.

There are two main topics – the first is to empower the community – its ability to act through the improvement of relationships, trust and communication. The second emphasis is dedicated to enhancing the sustainability of the community in terms of the social, economic and environmental dimensions. Changes in people's behavior is very difficult to motivate only with the top-down process.

3 *Benefits for individuals* – is the personal growth of individuals, which may or may not be associated with the project. It is usually understood as additional value (with some exception of place-based education and complex projects, where change of behavior of the participants based on shared knowledge is part of the implementation phase).

Evaluation of the participatory process

After being sure about the goals of the project, it is necessary to find some specific indicators. If indicators are determined early in the process, it is easier to determine if they were fulfilled; versus doing them in the end when many things are forgotten with no record left. Both, quantitative and qualitative indicators are needed. As an outcome, the research offers examples of possible indicators. Although evaluation of projects where the goals were not defined is never as accurate, it is possible to do it in a "rear view mirror" way – we can search for the implicit goals by asking the people involved (also the designer and investor) to identify some positive outcomes according to the list created by the research.

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Urban space - transformations and searching for identity

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Urban space is under incessant transformation process, its form, appearance and usage are changing. Contemporary architectural design, reflecting actual needs, brings new forms of urban space and living patterns. These new forms meet original identity of space, which is (especially in Central European cities) a result of long lasting evolution within the bounds of traditional architectural concept. Varied, but legible original forms are often replaced by disintegrated uniformity of mainstream building development, without ambition to continue or develop the traditional concept of urban space. Former varied city activities are frequently reduced to commercial interactions and transportation. The urban space is losing its individual uniqueness and new buildings admit it by turning into their inner space, where the new substitutes of lost quality and "public" space are being made. An abstract and meaningless architectural language of these buildings is creating less legible and impersonal environment. Such new created urban spaces may suffice actual needs, but question is, if they will stand the future changes of needs and values, as the traditional space forms did.

To understand and interpret these processes and phenomenons is one of the most important urbanistic issues. The aim of this project was to explore urban space identity, its attributes and forms as a base for further thesis work. Project was based on following tasks. To find characteristics and create a method, which can be used to choose a representative samples of urban spaces (from Prague, other European cities and compare them) and make case studies on them. After that analyze results and find attributes and processes, which are essential in forming identity of urban space.

The method was based on analyses of related works and studies. Urban spaces were chosen because of their position in the city, their typology, importance and historical context. In Prague was it both historical and non-historical streets. Historical ones where chosen also because of their position in the historical core of the city, their different typology and primarily because of their similarities (time and reason of origin, place, accessibility and so on). It was Národní (representative), Na Příkopě (commercial and banking) and Revoluční (commercial and traffic) street. Non-historical streets were chosen because of their time of origin (last 30 years), residential typology and morphology, which is based on traditional street concept of urban space. It was Bryksova street (part of Černý most district, built on 2005), Trmická street (part of Prosek district, built on 2008) and Přecechtělova street (part of Velká Ohrada district, built between 1988 – 1993). Other five urban spaces were chosen from European cities – Bath, Bristol, London and Rome. It was because of their special identity and character. Gay street in Bath was chosen because of its representative human scale and proportion in contrast with grandiose urbanistic concept of district layout. Broadmead in Bristol is a new commercial street built on historical trace as a part of huge shopping center district. Regent street in London is a kind of great commercial and banking street with a lot of traffic. St. Mary Axe is a small street in London, where is a lot of modern grandiose buildings situated and are mixed with old buildings and urban space fragments. Via del Corso in Rome is a long and narrow commercial and banking street, one of the most famous in the city.

Selected urban spaces where visited and examined. Photographic and sketch documentation was made with a focus on morphology and architectural boundary of a space.

Related information was gathered, as historical and local context, actual maps and layouts of spaces, connections to other spaces, position in urban structure and so on. This set of information was analyzed.

The results of the analyses are sets of attributes, which are essential (from architectural and urbanistic point of view) in forming the identity of the urban space. One set is following the "physical" aspects of the urban space and the other spiritual ones. The physical attributes are very tightly connected to space and architecture (physical environment) itself. The most important of them are the morphology of urban space (such as dimensions and forms of space and its changes and irregularities, beginnings, endings and accessibility), boundary of urban space (which mostly means the building facade and its proportions, shapes, materials, details, scale, perforations, openings, complementarity and diversity), elements and features of urban space (trees, objects, surfaces) and the position of urban space in the city organism (affinity and connection to other spaces, role and approachability of urban space). All these attributes are mainly connected to the present form of urban space, but all of these also include the previous transformations, proceeded in past. We can call it the past forms of urban space.

The second set of attributes is based on spiritual aspects of urban space. These are less connected to the architecture itself, but even more influence the identity and usage of urban space. First, it's a position in city hierarchy, importance and representation potential of urban space. These aspects are mostly connected with context and surroundings of the urban space. Inner spiritual attributes are the past and present activities in urban space. Present activities include current usage of space, its functions and behavior of its occupants. The past activities (important activities, which proceeded in the past) form a symbolic and ideological meaning of the space (also from a political point of view), but also the contemporary habits of usage of the space. The last spiritual attribute is a behavior of urban space occupants (visitors or inhabitants) and its ethic dimension. It means the people manners, but also the quality (level) of offered services and advertisements.

It is clear, that all of these attributes influence the identity and legibility of urban space. The way, how people think about it and how they understand it. Results of this project will be used in my thesis and will contribute to complex knowledge of transformations and identity of urban space, especially in context of urban environment and its quality. I conceive the understanding and interpretation of urban space forms (as the most stable and durable kind of human settlement) as one of a most important urbanistic issue. The results of this project can be also used in urban space design and revitalization process or teaching on Department of Architectural Design III, Faculty of Architecture, Czech Technical University.

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Development of Residential Building Typology under the Conditions of a Market Economy in the Czech Republic and the Netherlands.

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The objective of the project is to obtain a more profound insight into the scope, characteristic and typological changes of residential buildings in the Czech Republic and the Netherlands. To examine the various aspects of collective housing, the case study methodology was used. The research is based on the selection of influential and innovative housing projects and on the analysis of their significant aspects. The presented paper briefly outlines the conceptual framework used for the research project and discusses the main findings emerging from the case studies.

The research project consists of two parts, the first part deals with the historical development of collective housing from 1900 to 1989; the second part focuses on the development in the last 20 years. The systematization of the information in the research project facilitates comparisons and assessments in order to apply the past design knowledge in generation and development of new form concepts.

The historical development of collective housing in the Netherlands is presented as a selection of residential houses representing different forms of urban multi-story housing. Based on the study of architectural periodicals and literature, a case study database of 125 Dutch residential houses was created. The collected data were organized and subsequently searched in the online Collection Information System (CIS) of the Netherlands Architectural Institute (NAI), which houses a unique collection of architectural drawings, sketches collages and photographs since the beginning of the nineteenth century till 1970. Based on the search according to the CIS archival codes, 18 projects with further undetermined form of architectural drawings were found in the NAI collections. Pre-selection of nine residential buildings representing diverse typological solutions was made before the six-day research stay in NAI. During the research in archives three pre-selected projects had to be excluded and replaced by similar projects from the same period because of incomplete project documentation. The same methodology was chosen for the presentation of the historic development in the Czech Republic. For the purpose of comparison, nine analyses of the selected residential buildings were made, based on the project documentation published in the Czech architectural periodicals.

The historical development of building typology in the Czech Republic and the Netherlands is demonstrated on an illustrated timeline, which presents case study projects of both countries in historical context. Each project is also described separately by the plans and the sections, a site plan, a small photo as a visual supplement and by systematized additional information permitting easy comparison. A list of information in the margin contains the building type description, method of financing, building size, circulation scheme, number and type of units. In the short text part, the cultural and historic background of each project is described.

The second part of the research project concentrates on the development of collective housing after 1989. The objective is to define contemporary architectural visions and present the overview of innovative housing projects. Research is based on the analysis and comparison of the residential housing projects published in the architectural yearbooks of both countries in the last 20 years. Although there is no unifying theme or obvious structure in history to describe a common keynote for this period yet and the individuality of every collective housing project is the only evident matter, the development of residential housing is characterized by transforming typologies in order to answer to the needs of societal changes in the world, for example the increasing dissolution of the traditional family structures, emphasized individualization or the ageing of the societies.

According to urban-planning categories, all studied projects were arranged in the illustrated timeline clarifying the chronological context, and further classified by building type. For the analysis, 10 case study projects of both countries were selected. The collective housing projects were chosen under the aspects of innovative and influential concepts responding to the new requirements of societal changes and sustainable development; also important were the originality and variety of examples.

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The Liquid City

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The Liquid City project examines the role of infrastructure in forming a city. Project focuses on interactions between infrastructure and structure in a contrast to traditional city planning practice that describes space by its function neglecting structural characteristics. The key question is whether and to which extend infrastructure determines the city structure.

City structure is being perceived as the mass and space of a city itself and infrastructure as a set of transport, security and defense systems within the structure. Phenomena at the fuzzy border of infrastructure and structure are common – the fire station is in its function infrastructural but the building itself is very structural – it is not difficult to recognize a fire station on a map by its structure.

Project observes historical shift in city structure as a result of introduction of new infrastructural technology. Railway in 19th century made significant change in transport relations. Cities that accepted railway had experienced enormous industrial development on the detriment of those that refused it. Railway station caused unprecedented concentration of traffic flows and evoked demand for public transport for way from/to railway station. The rails itself took large areas of city space, still significant despite the decline of railways in the second half of 20th century.

Invention of elevator and escalator allowed building high rise. Once undesired top floors have become the most valued. Escalator connects seamlessly different levels and creates impression of continuous space, perfect for retailing, thus the shopping centers could emerge.

Mass production and the falling price of automobiles meant more could afford the freedom of 'holding the steering wheel'. The car propelled the era of suburbanization. The whole drive-in culture completely changed city and surrounding landscape. Focus has moved from the city center do its outskirts that offered enough cheap space for all the highway junctions, drive-in restaurants and shopping mall.

Information technologies and fast information exchange are relatively new phenomena to observe the long-lasting effects on the city form. Still some conclusions might be already made – IT networks were supposed to suppress the need for physical movement, but rather than replacing physical flows, they started evoking new ones.

Other influences on city might be found with emergence of other technologies as air conditioning, containerization (usage of standardized cargo containers), civilian passenger airliners etc... Observing the development of infrastructure technologies we could conclude that however the technology becomes smaller, smarter and more efficient the overall city space demand does not fall. It sometimes even grows thanks to increasing appetite for more comfort and safety.

As history of introductions of new infrastructural technologies illustrates, the infrastructure fundamentally changes the form of city and its structure. The contemporary city is more than ever controlled by its infrastructure. These principles should be reflected in city planning practice.

Strict dominance of the infrastructure over the structure has been practiced by central planning offices in communist Czechoslovakia. This approach was ideologically motivated and employed infrastructural project as a means of fight against pre-communist ideas and city structures. It has become widely unpopular and alienated general public against development of infrastructure. Events concerning these projects has undoubtedly bitter idealogical aftertaste, but the overall conception was rational and is in fact followed in contemporary projects.

Project concludes increasing influence of infrastructural technologies and even the control of infrastructure over structure. The integrated, well organized and effective infrastructure should determine the structure in spacial planning thus the whole city from. Though city planning is not an exact scientific discipline and it always demands subjective approaches. Art has to be part of the method therefor all the rules might need to be sometimes broken in order to design right space for life.

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Public Spaces in New Blocks of Houses

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The aim of this research into public spaces is to raise public awareness of the importance of such spaces. It is mostly focused on the suburban areas of large cities. The lack of public spaces in housing estates built at the end of the 20th century will lead to future problems, and will cause difficulties in maintaining the quality of urban environment for future generations. How to preserve our country against urban sprawl? Communities themselves, through their municipal plans, need to specify their requirements for provision of facilities in newly-built neighbourhoods, and encourage or force developers to create high-quality residential environments.

Public spaces have always been a social platform for forming bonds between people. They create the heart of the city, linking the activities of the community, and developing the comprehensive systems which provide the identity and attractiveness of the place, and the motivation for people to live there. Historically, public spaces are not limited to access streets for housing areas. They are also connected to activity “magnets”. Public spaces such as purpose-designed squares, streets and parks are linked to civil amenities, and are complementary to housing estates.

As at the beginning of the 20th century, we today face problems of suburbanisation. In the Czech Republic, the reasons for increasing suburbanisation can be found in the history of the 20th century. In the period after World War II, panel pre-fabricated housing estates were the first form of suburbia. After 1989, these began to be abandoned due to their lack of conventional public spaces, and because they didn't provide the civil amenities demanded by their inhabitants. Even in recently-developed suburbs, public spaces are missing: the areas have been created with the emphasis on a fast return on investment. Around major cities, we see today dormitory suburbs of family houses only, sometimes wrongly called “satellites”. Satellite towns were in their historical beginnings multifunctional units, but in recently-created colonies of family houses, we often see only private spaces bounded by high, non-transparent fences. Public space survives only as a web of streets.

Several examples in the vicinity of Prague were investigated, but revealed mostly negative results, with not a single fully positive example of a new suburban locality, capable of providing a wide variety of both physical and social environments, in order to reduce, among other things, the most negative consequences of suburbanisation, such as dependence on private cars. A result of the investigation was also the recognition of opportunities to improve the present situation. Of particular concern should be the coherence and the cohesion of the new-built towns, and the creation of new multi-purpose centres, accessible by public transport. Furthermore, the use of different types of housing within estates, such as combinations of freestanding and terrace houses of different sizes, should be encouraged. This would involve using principles already introduced by town planners 100 years ago, with the concept of “garden towns" which are functional to the present day.

Several "garden towns" in the vicinity of Prague, featuring such public spaces, were investigated. Towns such as Ořechovka and Spořilov are examples of living centres with a high-quality residential environment, providing evidence of urban planning leading to sustainable development. Characteristics of those towns are the following:

- a complex territorial entity, meaning a multifunctional satellite with civic amenities within walking distance
- connection to public transport
- a mixture of various activities
- a linked system of footpaths
- parks and green spaces
- street-greening
- integration of public and private spaces

Among the results of the research was the determination and comparison of measures quantifying the required area of public space per hectare of building area. In fact, Czech Republic decree 501/2006 Sb specifies 1000 square metres of public space (excluding communication areas and spaces of width less than 10 m), for every 2 hectares of building area. In comparison to the area of public space in new development areas abroad, which build on the tradition of "garden cities", this parameter is still too small. "Satellite" housing districts around the French city of Nantes, for example, are designed as self-sufficient units: each has its own small centre, a good public transport system, and the streets have enough green. In comparison to recent development around Prague (such as Hostivice, Jesenice and Jeneč), the area of public spaces is twice or three times as large. Thanks to the approach and liberality of the municipality, the city of Nantes is today one of the world's ten best cities for living conditions.

Contemporary city planning needs to emphasize the creation of space according to permanent values, as being the minimum requirement for sustainable development. Determining a parameter regulating a minimum area of public space would help to create those values. A community has to be built as a complex self-sufficient area, not just as a dormitory settlement of family houses.

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Analysis of the Original Copperplate Engravings of the Müller's Map of Bohemia

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The Müller's map of Bohemia is outstanding masterpiece of our cartography. It is the largest map of Bohemia created in "one-man cartography era". Johann Cristoph Müller created his hand made map in 1720 in the scale 1:132,000. The map was engraved on 25 copper plates by Michael Kauffer and finished in 1722. The map was analyzed by professor Kuchař [1] and recently by Krejčí and Cajthaml [3].

The main topic of this research of the Müller's map of Bohemia is to determine the original dimensions of the map sheets. For a long time, the Müller's map of Bohemia was not analyzed in this way. Dimensions of the map are frequently cited from the famous work of professor Kuchař [1]. After 50 years we would like to confirm or refine these values. In [1] we can find following numbers: each of 25 map sheets has 557 mm by 473 mm, the whole map has 2822 mm by 2403 mm.

The first step of our research was to find original copperplate engravings of the map. They are stored in the National Technical Museum in Prague within the geodetic collection founded by František Fiala in 1910. Original copper plates are accessible only in the study room for research purposes. As every map sheet has clear rectangular frame we decided to measure all 4 sides of this rectangle. Width and height of every rectangle were measured in the middle also. Original copper plates are notably flexed and so 2 people were necessary for measurement; one for flatten the plate, the other one for measurement. We decided to use drafting triangular tools, commonly used within construction of analogue cadastral maps. The accuracy of this instrument in length measurement is about 0.1 mm.

Complete tables with measured values are included in the diploma thesis of J. Malimánková [2]. There are no significant differences between the length of the upper and lower or left and right side of the map sheets. We expect that map sheets should have been perfectly rectangular and small differences are caused by the imprecision of engraver. Values measured in the middle of every map sheet didn't show any distortion of the frame. Final values were computed as averages of measurement in one direction (e.g. upper and lower) for every map sheet. As the final values differ from each other maximally by 2.5 mm we also computed final averages for the whole map. These averages are important for later merging of map sheets images together.

Width of map sheets varies between 558.2 mm (sheet no. 23) and 560.1 mm (sheet no. 10). Average width of one map sheet is 559.2 mm. Height of map sheets varies between 471.2 mm (sheet no. 16) and 473.7 mm (sheet no. 2). Average height of one map sheet is 473.1 mm. If we compare final average values 559.2 mm by 473.1 mm with early published 557 mm by 473 mm [1], there is significant difference of 2 mm in the width of the map.

Beside measurement of the original copper plates, original prints of the map were measured. Apparently there existed many original prints of the Müller's map of Bohemia. Unfortunately maps were occasionally damaged or are in private property. Two original sets of the map are stored in the National Technical Museum. Other interesting original prints can be found in The Institute of History of Academy of Sciences of the Czech Republic or in the Central Archives of Surveying, Mapping and Cadastre in Prague. Some of these original prints were measured as well. Tables with results can be found in [2]. When we compared determined dimensions of the copper plates with determined dimensions of the prints, there were evident differences. The original prints from 18th century were shrinked dramatically. The prints made from the original copper plates at the beginning of 20th century are shrinked as well, but not too much. In the dimensions determined on the prints we found values occasionally incorrectly cited in literature.

Determined average dimensions of the original copperplate engravings of the Müller's map of Bohemia were used after creation of the full vector data model of the map [4]. Vectorized data were transformed into these dimensions and now we have the vector data model reflecting the original image without any distortion. This precise vector data model will be analyzed in GIS software. It is mentionable that the data model contains over 15 000 point features, that can be used for georeferencing the map into some well-defined coordinate system. Then the model might be distributed via internet and could be used as a GIS layer using web map services. Beside this research we would like to make similar measurements on the Müller's map of Moravia.

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Testing of Leica HDS 3000 Distance Meter

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Introduction

During the study of systematic errors incurred during the measuring on spherical surfaces [1] grows up a question whether the accuracy of laser 3D scanner´s nonprism distance measuring depends on angle of incidence. There was set up some experiments that should clear up this question. The experiment testing the dependency of standard deviation of the distance measurement on the angle of incidence was based on the hypothesis declaring the fact that the accuracy will be the same when the reflection is sufficient. It means that with increasing angle of incidence rises up the number of unmeasured points. In parallel with "angle of incidence experiment" was made an experiment testing the dependency of standard deviation of distance on scanning distance. This experiment expected the fact that the accuracy will be constant if we ensure sufficient reflection alongside whole measuring distance. These two experiments were made with terrestrial laser 3D scanner Leica HDS 3000.

Experiments description

For purposes of the experiment testing the dependency of standard deviation of distance measurement on the angle of incidence was invented and made special tool that was surveyed during the test. The tool consisted of wooden board located on geodetic tripod in vertical position. The tripod was equipped with angle scale and provided the opportunity of horizontal rotating.

The wooden board with tripod was located on geodetic stand and then it was surveyed with Leica HDS 3000 scanner in two distances – 5 m a 15 m. At each distance was made several measurements differing in angle of incidence. The difference between positions of the board was 10 grade.

During the second experiment (testing the dependency of standard deviation of distance measurement on the scanning distance) was also used the wooden board located on the tripod. The board located on geodetic stand has been gradually placing on the standpoints away from the scanner from 1 meter to 40 meters. Spacing of standpoints was 1 meter.

Data processing

In the first step of data processing had to be clouds of different stages purified from points, that were not appropriate for our needs. In practice this means that from every cloud were selected points corresponding with the surveying of wooden board. But not all were used. Points, located on the edge of the board or in its vicinity, have been removed due to inaccurate in measurement of the positioning of these points. It was also striving to ensure that every cloud contained about the same amount of points. The purifying of the clouds was done in the software Cyclone. In the second part of data processing was cleaned clouds fitted with plane on the basis of least-squares method. This act was made with using of Spatfig library [2]. Checking the accuracy of the results was performed with second fitting of clouds with plane in the software Cyclone. After fitting the point clouds with the plane was made calculating the standard deviation of distances of points from the fitted plane s_{PR}. Also for this calculation was used Cyclone software and Spatfig library.

The standard deviation in fitting s_{PR} includes effect of the standard deviation of length measurement s_d and also the standard deviation of angle measurement σ_φ. The subject of our study was only the standard deviation of length measurement. It was therefore necessary from the value of s_{PR} quadratically subtracted the size of projection of standard deviation of angle measurement on the perpendicular to a fitted plane $\sigma_{P\varphi}$.

$$s_{Pd} = \sqrt{s_{PR}^2 - \sigma_{P\varphi}^2},$$

where

$$\sigma_{P\varphi} = d \cdot \sigma_\varphi \cdot \sin\alpha.$$

The resulting standard deviation s_{Pd} (the projection of the standard deviation of length measurement on the perpendicular to a fitted plane) is then be converted into the direction of scanning. The final equation for the standard deviation of length measurement is:

$$s_d = \frac{s_{Pd}}{\cos(\alpha)}$$

where α is the angle of incidence

Results

The results show that there is a clear dependency of standard deviation of length measurement on the angle of incidence. With increase of the angle of incidence increases the value of the standard deviation. By the angle of incidence of 50 grade is the increase very gradual but when the angle of incidence is greater than 50 grade the values rising quite vigorously. This refuted the hypothesis that was set before the experiment. In it was assumed that if the reflection is sufficient to measure the length the accuracy is same and increasing the angle of incidence will only increase the number of "unmeasured" points. The results show that the accuracy with increasing impact angle decreases. The results also show that the measurement accuracy at 5 m is greater than the measurement at 15 m.

Results of the second experiment show that after the measurements on the first 14 standpoints where the value of standard deviation of length measurement was quite constant, started the value of standard deviation fluctuate. This fact is most likely associated with the process of automatic control of precision (the process of "checking accuracy"), the scanner itself starts and carried. Fluctuation is quite regular with variance approximately 1 mm. Be also noted that the limits of fluctuation are smaller than the standard deviation of length measurement stated by the manufacturer.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

Differences between Configurations of OLAP-based MIS for Branches of Fast Moving Consumer Goods and Job-order Manufacture

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Today's enterprise management utilizes OLAP (On-line Analytical Processing) technology based managerial information systems (MIS) in quite a large extent. One of these MIS is also Business Navigation System (BNS), developed and implemented by company Inekon Systems. Applied technology enables storing data in the form of multidimensional database (so called "data cube"). The key advantage of such data representation is the possibility of displaying the data in any "view". By simple settings of elements of individual dimensions, it's possible to focus the view (e.g. display of revenues) on particular group of customers, product group and particular year and month.

Aside from sophisticated analytical methods and instruments, another integral part of such system is a set of corresponding tools (so called "panels") for planning. These "panels" are organized in logical sequence, creating so called "planning process model", which follows the logics of planning process in a particular company. However, each company is, to a certain extent, unique. The same applies to each branch of business. The uniqueness of companies and business branches means that it's not possible to apply a single process model in all customer applications of the system. It's worth trying to trace fundamental differences in configurations on the branch level. In this case, we focus on the branches of Fast Moving Consumer Goods (FMCG) and Job-Order Machinery Manufacturing (JOMM). In the branch of FMCG, we concentrate mainly on companies producing food and beverages. There are several fundamental differences between these two branches. These differences affect the composition of planning process support tools.

Concerning the sales plan, the main difference is that in the FMCG branch, we can use planning of products, product groups, product lines, in other words, a portfolio, which remains, at least for a certain period of time, steady. Thanks to the steadiness of portfolio, we can use repetitiveness or extrapolation techniques based on data from past periods. On the other hand, planning in the branch of JOMM is different because every order is unique (to a great extent). Therefore, we can't use the same methods and techniques as in FMCG and a large part of the tools has to be different. Instead of methods using repetitiveness and extrapolation, we must offer tools respecting both non-repetitiveness (to a great extent) of each order and the fact that production time of the final product (order, in this case) is in overwhelming majority of cases much longer than the production time of FMCG product.

Another fundamental difference, partially resulting from the aforementioned sales planning differences, is in the area of variable costs planning. In the FMCG branch, we can determine the standards of consumption for variable costs items. These standards can then be repeatedly used for calculation of variable costs of products. Situation in the branch of JOMM is, again, different. Due to the heterogeneity of orders, the utilization of consumption

standards is very limited. However, in the case of similar orders, using a method of *order representative* can be at least a partial solution. This "representative" can be conceived as an imaginary standard of consumption, which can at least simplify the process of variable costs calculation in the case of similar orders. Besides the *amount* of variable costs, it's also required to use a different (form FMCG branch) approach to their *allocation over time*. In contrast to FMCG, where the production time of a particular product is usually substantially shorter (and takes place in only one period), portions of total variable costs of production in the JOMM branch can be allocated to multiple time periods, for example several months, or even years, in some cases. The planning process of MIS has to offer adequate tools for such situation.

Last area with a significant difference of planning process between the branches of FMCG and JOMM is the planning of production capacities. While the planning in FMCG branch can utilize standards and data of past periods, the utilization of such methods is at least limited in the branch of JOMM. In the case of job-order manufacturing, it's necessary to do a detailed planning of production capacities utilization in order to fulfill the orders on schedule and, in doing so, there shouldn't be a situation of excessive lack of production capacity or, on the contrary, too much of unused production capacity. It's necessary to provide corresponding tools for this situation and it's clear that such tools can't be the same as those used in the branch of FMCG.

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The Best Practise in the Process Mapping Methodologies as a Tool for the Process Re-Engineering in the World

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This paper provides analysis the methodologies how to mapping business processes in the company. This should be the first step in the re-engineering and keeping the company healthy. The approached will be taken from foreigner experience from the United Kingdom, Finland, Germany, Unites State of America and the Czech Republic.

The methodologies can be divided to several classifications. **Pojasek and Hamid (2005, 2008) authors of this methodology divided processes to strategic, tactical and operational.** The focused is to the hierarchical processes mapping (not to content of processes) and on the understanding of organizational processes according fulfillment of eight steps concentrated to business model only. This model can be used as a process mapping in the organization for better understanding of hierarchical order of processes in organization and their relationship among each other.

Fleming, Lee, Aouad and Cooper (2000) describe divided processes depending on the hierarchical position. They divided processes to three levels, I, II and III. These levels are connected together and they create hierarchy between them. In contrast with previous approach the processes in the level I can be divided to the level II as a two sub-processes. The processes bore information about owner, name of process, and category as a development management, project management, est.

AS-IS process model referred by Okrent and Vokurka (2004) is very simple approach of mapping. This is base of needing a very quick research of processes just from small area. But for the future perspective is considered as unsystematic, not deep enough, missing selected processes and missing administrated notation to keep for future consistency. The advantage of this processes analysis is in the expedition and involvement of only the needful (responsible) employees. This approach can be used for small processes analysis where detail is not needed.

TO-BE process model referred by Okrent and Vokurka (2004) is focused to the evaluation of the processes according critical risk for the business or according to the impact on organization. The good step is involving ERP to gain sureness about the capability of the organization to change. This approach can be used as a selection of the processes according the critical process for the organization.

Third classification is based on typologies of processes is from Wiesinger (2008) is based on the as-is state with involving ERP-system. The processes are differentiated into the primary and the secondary process and are further cut according to their contribution to their added value to the company into useful, supporting, blind and error processes. The application of the process chain paradigm leads to an integrated visualization and analysis of workflows

and creates the necessary transparency in the company's goals, process flows, the internal and external customer-supplier relationships, as well as the allocation of resources.

ISO 9001:2000 described by Carmignani (2008) is not exactly focused to the process analysis, but t is good start for building the system defined in order to guarantee the customer's satisfaction and fix organizational structure. This definition misses just a few points: problems with "sequences and interactions"; "objective deployment" and "difficult to find the past data for monitoring and control". Although this approach is not suitable for process analysis it is the most complete framework.

Processes analysis **according EN 15 221 (CET/TC 348) described by Strup (2005)** is totally focused to the process analysis. The sheet demands name of process, area according EN 15 221, process topic, owner, client. Farther covers input, output, relevant activities and how should look final state of process. This approach is very wide and can be taken as a appropriate tools for process mapping.

Value added assessment for eliminating business process waste by Trischeler (1996) is possible the oldest source for this topic but it is the based for it. The process definition form covered general information about process name, type, project leader and process purpose. This sheed is very similar with the Strup sheet and can be used as a very good tool for the basic analysis.

These paper exanimate several options of processes mapping. For the best practise can be consider three methodologies from **ISO 9001:2000 described by Carmignani (2008), EN 15 221 (CET/TC 348) described by Strup (2005)** and **Value added assessment for eliminating business process waste by Trischeler (1996).** Their approach covered all information which should be find about process. This mapping can lead to the successful business process re-engineering in the company.

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E-learning as a Tool for More Efficient Higher Education

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E-learning is mostly understood as effective use of information technologies in the process of education. This alternative is also being explored as part of research plans at the Faculty of Mechanical Engineering of the CTU. As regards the mode of teaching, E-learning shares certain features with teleworking. Although the teacher-student contact is somewhat limited (depending on available technology), E-learning has a wide scope of application. It can be of benefit to physically disabled students who are thus able to participate in certain workshops and lectures taking place in buildings which are not barrier-free. (As regards the CTU, not all buildings are designed as handicapped-accessible.) Also, E-learning can be of use to students leaving for a period of study abroad, who need to stay in touch with their faculty at home. In traditional education, all students in the classroom are assumed to have the same level of understanding, to be comfortable with the oral mode of presentation and willing to study the subject matter at the given time. However, the reality is somewhat different. E-learning eliminates these drawbacks to a significant extent and makes it possible to greatly enhance the effectiveness of the entire process of education.

The entire cohort of students taking part in our research was selected at random. Debates were transferred to the NYX discussion server. In this way the students could obtain 60 % out of a maximum of 100 points. (To earn a course credit, students must have at least 50 points.) Half of the students thus got their credit through E-learning. The other half had to sit for a credit test.

For the purpose of our research the students were divided into 5 clubs: 1) *Social psychology – discussion club,2) social psychology – papers, 3) social psychology – teachers' club, 4) social psychology – service club and 5) teamwork clubs.*

The first club was accessible to all participants – students as well as teachers. Here, tasks were set and discussions were held, focusing on a given topic. To a certain extent the topics were selected by the students themselves, who were greatly encouraged by their teachers to do so. Throughout the semester the students were repeatedly called upon to propose subjects which they found interesting.

In the second club the students' papers were uploaded and discussed. If for some reason a paper was deemed deficient in quality, the student in question was discreetly informed of this via e-mail.

The third club served as a site for E-learning participant assessment and a virtual teachers' conference. Here, the teachers discussed the work in progress and exchanged information on specific questions. The fourth club provided services and the teamwork clubs comprised groups of 4-6 participants working on a common task. The students' individual work was also continuously monitored and assessed by their teachers. The tasks were mostly of a practical nature, relating to the field of social psychology and sociology.

Having been selected at random, some of the participants tried to limit their contribution to discussion groups as much as possible. Several students did not meet the credit requirements and had to earn their credit in a different way, e.g. by sitting for a test. This was mainly due to the way in which the E-learning participants had been selected. Indeed, like in the employer-employee relation in case of teleworking, mutual trust is necessary in E-learning. Thus, the optimum mode is not a random selection, but a selection based on the work and results previously achieved by the student.

As a follow-up, a survey was conducted in which the students were asked whether they liked the method of E-learning. Altogether 76 % of the students answered in the affirmative. A majority of the students answered "mostly yes" (28.7 %) and "yes" (33.3 %), with 14 % stating that they "definitely liked" the E-learning method. Some of the students also expressed their wish to take

at least part of a course in the form of E-learning. Here, however, compared with the previous question, their answers showed more caution, with 68.7 % stating that they would like to take at least one course in the form of E-learning. Responses to this question were less decided, with only 4.7 % answering "definitely yes".

Furthermore, the students were asked what they liked about E-learning. Above all they appreciated its flexibility (36.2 %), i.e. the fact that they could carry out their study duties in a self-paced manner. Some of the students liked the fact that they did not need to travel to school (17.4 %) and could work from home. Other reasons in favour of E-learning were financial savings (7.4 %) and the possibility to juggle work and studies (8.1 %). The students also cited the possibility to overcome health problems, their fear of public speaking, the need to study on their own and their eagerness to try new things.

A minority of the students expressed their awareness of some drawbacks, the greatest being the absence of personal contact with the teacher (32.9 %). Next (18.1 %) they mentioned the inability to draw a line between their studies and their free time or to get down to studying at home, when surrounded by many distractions. Also, they were worried about losing touch with other students (14.8 %), the reason being not only the possibility to work together, but also to spend their leisure time in company.

Most students find E-learning attractive because they do not need to attend seminars and workshops regularly, but not all of them realize that E-learning can be much more demanding than the usual practice of "sitting through a course".

A comparison between the students' approach to teleworking and their willingness to take up a distance learning course suggests that they adopt a much more cautious stance towards teleworking (only 41 % would be willing to work in this way while 68.7 % would like to try E-learning.). This difference is mainly due to the fact that E-learning concerns only one part of the education process (a certain number of courses) whereas teleworking is an activity carried out over a longer period of time. Another reason may be the fact that E-learning can be perceived as a more "liberal" form of education.

E-learning as a mode of distance learning using a virtual online study space is gaining more and more prominence. This pedagogic educational technique makes maximum use of technology and didactics, but pedagogic factors must be at the forefront. The main advantage of E-learning lies in its accessibility, which is not limited to a particular place. It can also function as a type of teleworking, e.g. in the education of teachers and students.

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Identification and Analysis of Problems in the Application of Product Life Cycle Costing Method in the Construction Sector in the Czech Republic.

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The building industry in Czech Republic is facing many substantial and demanding challenges in the future. One challenge is to meet society's requirements for sustainable development, based on greening buildings and processes. Another is to reduce the costs of buildings and their operation and maintenance. Building costs, in Czech Republic today, are too high and the main causes for this are several as for instance taxes and fees along with poor productivity development. Initial costs can be lessened by reduction of built areas, adoption of appropriate construction methods, simple structural systems and standardization of designs and components. However, not only the initial costs require reduction. Operation and maintenance costs currently account for approximately 55% of the total cost, over a span of 40 years. One way to create a more comprehensive view of costs in the different phases of a building project is to perform life cycle cost (LCC) analysis. A LCC perspective consists of estimations related to initial costs for acquisition together with operation and maintenance costs. The main motivation to use LCC is to increase the possibility of cost reductions during operation even if that means spending somewhat more during planning and development. Another important use is in updating older buildings. Despite the advantages LCC models bring in order to optimize costs, there are some indications that the building sector in Czech Republic has not fully adopted the methodology. This paper contains results from a performed survey examining to what extent Czech developers and clients use life cycle cost estimations, in which phases they use it, what their perception of the limitations and benefits are.

Although the theoretical concepts of LCC techniques are well developed it was suspected that LCC use in the Czech building sector was limited. To examine this a survey was conducted. To gather information about the practical use of LCC estimations by Czech clients a questionnaire was sent to 15 public and private clients in order to examine: Which clients use life-cycle cost analysis and to what extent do they use it? Those clients who had not answered the questionnaire in due time were sent a reminder (with the same questions) within a three weeks period. A total of 10 (67%) clients answered the questionnaire. From these 8 clients use a LCC perspective when making decisions about investments. The motivation to use a questionnaire, in order to gather information, is the ability to reach a large target group in a practical and efficient way. Clients have several reasons for embracing long term economic models into the different phases of a building project. Most use is in the early stages of design where the possibility to effect costs are the greatest. However, the initial investment cost is of great importance to the overall cost so the potentially increased cost in the design stage can be viewed by clients as barriers. Even if the initial investment can be somewhat higher when performing LCC calculations, it must be placed within the context of cost savings during operation and maintenance. As low operation costs increase the profit, this can be a way for the developer/ client to attract tenants. By expanding the cost perspective to include LCC in tender evaluation, new and improved construction methods can

be encouraged. Clients must be prepared to abstain from forms of construction organization that determines technical solutions since stated technical requirements can prevent development of new and better methods. If the client decides on which technical solutions to be used at the briefing stage, this will both limit the design team's creativity and also the contractor's ability to develop new and better construction methods to carry the work out. Instead, requirements should be stated on functions, quality and costs. The contractor must have the possibility to find the best available methods for carrying out the construction work. Today, the design team is usually represented by several groups as architects, structural, mechanical and electrical consultants, etc. the building is considered as different parts rather than as a whole, resulting in each group's decision casting costs onto the others. Increased co-operation between clients, design team and contractors could lead to lower costs and higher quality. However, legislation may limit these forms of co-operation and also the competitiveness among practitioners may be hindered which can increase costs. Clients must also, in procurement documentation, clearly specify how the evaluation is going to be performed (which parameters are included and how they are evaluated). If this is not done in an accurate way, there is a possibility to come in conflict with laws associated to the procurement process. For the public client, an extended use of LCC can cause some constraints related to the funding policies used by them, especially if capital costs and operation costs are handled separately. Administrators are usually limited by annual budgets, which limits the time perspective.

Operation of a building is cost demanding and the environmental impact caused, due to energy use amongst other factors, is large. If economics and ecology are considered together from a lifecycle perspective, another implication for expanded use of LCC models is found. By looking at life cycle costs, an environmentally progressive building design, which might have a higher initial cost, can be motivated since these types of buildings often have low operation costs. These lower costs are due to utilization of natural ventilation, effective use of day lighting and passive solar energy use. If the initial and operation costs are not seen through a long term perspective, the true economic benefits of green building design will not be displayed. Life-cycle assessment models have generally been accepted as the only legitimate basis to make environmental comparison of alternative materials, components and services (Cole, 1999). To perform such analysis is time demanding and there is a need to develop simpler, more operational models which can be used by clients and consultants for design and procurement of buildings (Sterner, 1999). One way to simplify the assessment could be by quantitative measuring environmental impact through costs in a life cycle perspective.

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External Costs of Air Transport

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As other activities, transport give rise to environmental impacts, delays bind to congestions and accidents. These additional costs are often not borne by the users of transport. These not born costs are called external costs. External costs are not taken in account when decisions about transport are made. Transport with important external costs is decreasing the global welfare of society. The internalisation of external costs policy represents efforts to implement external costs in transport user decision making. Internalisation of external costs may lead to reduce negative effects of transport by prefer such transport with less external costs [1].

Policy of internalisation of external costs is mentioned in both Czech and European elementary legal enactment (EC White Book of the overall transport Strategy, Dopravní politika ČR). Despite this, the implementation of internalisation policy is still incipience. Problematics of external costs is complex and consist of economic, environmental and transport sciences. Research in this area is still unable to give satysfying answers to all questions.

Air transport was chosen as pioneer in new internalisation strategy implemented by EC. There were three main reasons why to choose air transport. First reason is technical maturity of air transport as complex, second when decision was taken air transport was growing much faster than other transport modes, third reason is connected to problematics of air pollution, because there is strong suspicion that air pollution emitted from aircrafts in higher atmosphere have multiple impact on environment. In EU directive 2008/101 [2] was held that aviation will be added in system of greenhouse gasses trading. This directive has fundamental meaning. Air transport will be from 2012 the first and only transport mode which will internalise part of its external costs. On success of this program depends advancement of all other internalisation programs. How important is this issue may clarify the fact that presumption for external costs of transport in EU countries in year 2010 is about 980 milliards of €. These external costs are now not born by transport users but are born by whole society – it means us.

EU directive 2008/101 involve aviation activities in Greenhouse Gas Emission Trading System (ETS). Involvement of aviation in ETS bears many difficulties and problems, which are to be solved to allow the ETS bring benefit to the whole aviation and whole society as well. The European Union Greenhouse Gas Emission Trading System (EU ETS) is executive part of EU climate policy. The ETS is anchored in Directive 2003/87/EC. Main goal of the ETS is to force producers of greenhouse gas to decrease volume of greenhouse gas produced, by charging part of emissions. The EU ETS mechanism is targeted on large emitters of carbon dioxide within the EU, about 11 000 operators which covers about 45% of EU carbon dioxide production. The EU ETS works on a “cap and trade” basis – each member country of EU has it´s own limit of emissions which is covered by allowances which redistributes between involved subjects. Allowances (EUA - one allowance represents right to produce one ton of carbon dioxide) are distributed by national governments according national allocation plan on the basis of their Kyoto protocole commitments. The whole cap of allowances is year by year smaller and thus operator receives a less allowances on emissions

each years. That forces them either to reduce their emissions or to buy allowances from the other operators who produced less emission and save their allowances for trade. The EU ETS is planed in 3 phases till year 2020 and main goal is reduction of emission by 21% compared to year 2005. Since January 2008, the 2nd Trading Period is under way which will last until December 2012. [3]

The implementation brings many problems which should been solve quickly. The uncertainity about future development is the greatest problem. EU still didn´t designated the most important information for years after 2012. Air transport operators still don´t know how large will be the whole cap of EUA and even don´t know ho large part of them will be allocated freely. According to Lufthansa [4] estimation this extent of variation is between 10% and 100% of fuel costs. This extent is unacceptable. Air transport operators are unable to prepare meaningful programs to decrease external cost, when they don´t know if costs from EU ETS will be 100 or 1000 millions of €. This mentioned difference in costs are relevant for Lufthansa in 2013. From my point of view this the essential problem connected with implementation of EU ETS on Air transport and must the relevant data have to been established as soon as possible. But there more problems especially connected with involvement. Involvement European air transport operators in EU ETS will give them strong market disadvantage against operators from other countries. As well as will give disadvantage to whole air transport against other transport modes, but this disadvantage should be balanced by fact that air transport will not be the only one implemented in such scheme and other transport modes will be added later and air transport should have lead against them. Another problem is connected with price sensitivity. Especially Low cost airlines are highly price sensitive and involvement in EU ETS will hit them harder than noral air operators. This is the main reason why low cost airlines are lobbying against this legislative.

Of course there should be side positive effects too. Mostly mentioned is synergic side effect of investments in “green” jet fuel. Because air transport used technologies don´t allow use of alternate fuel there are many initiatives to produce environment less impacting jet fuel based on today fuel, air transport operators should support these activities to cut own ETS costs. It is expected that similar fuel will be later used in other areas, for which is complete change to alternate fuels as difficult as for air transport.

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Contribution to the Recycling of Asphalt Mixtures in Plant

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Recycling of construction materials for the construction and maintenance of roads is becoming increasingly important. Not only production costs reductions, but also savings on often scarce resources and waste problems solutions can be achieved. Moreover, scarce bitumen, the most expensive component, is fully used from the old asphalt mixtures. That is why a worldwide attention has been paid to the use of the old asphalt adjustments. The most common technological possibility is a hot recycling in plant. This is not a completely new technology; its principles were already known in the USA in 1915. However, its significant expansion occurred in the 70's of the last century. Nowadays, the technology of hot recycling in plant is widespread; the current trend is the addition of modified old asphalt mixtures (R-material) in increasing quantities. Nevertheless, even for high-quality treatment probably an optimum exists, moving mostly in the range of 30 to 70%.

Quality of mixtures with R-material

In the last forty years much attention has been paid to the quality of recycled asphalt mixtures. Comparisons with mixtures produced only from new materials were carried out. The wide range of research and development projects, including tests of resistance to permanent deformations, resistance to cracking at low temperatures and fatigue tests, showed that most important results for the conditions of use in the Czech Republic the are the ones found in Germany [1] [3]. Essential outcome is particularly the one, confirmed by the findings from the Czech Republic; mixtures with R-material can achieve as good results as the mixtures produced only from new materials.

Manufacturing process with using R-material

Especially when using a high amount of R-material (in the world today up to 50% for the cover layer, up to 80% for the base layer) the manufacturing process is fairly difficult and generally includes the following workflows [2] [4]:

- Basic survey of the place, from where R-material should be acquired.
- Extraction of old asphalt layer (cutting, milling), preferably separate from individual layers
- Transport of the excavated material to the plant and its storage.
- Adaptation of old material by crushing, sorting and homogenization followed by storage.
- Laboratory preparation of production.
- Production of asphalt mixtures with R-material; in case of a high amount of R-material batch sets with parallel heating drum, continuous plant with drum heating mixer or special equipment must be used.
- Laboratory control of produced mixtures.
- Mixtures transport and laying.

Laboratory preparation of production

This part of the production process belongs to the most important ones - especially when using high amount of R-material; includes not only the verification of properties of the modified R-material, but also the possible control or modification of the production code.

Testing must include:
- Determination of piece grading (1 test for 1000 tons of R-material).
- Determination of mixture gradation and content of bitumen for extraction (1000 tons).
- Determination of bitumen properties after extraction, i.e. penetration, softening point, penetration index (2000 tons).
- Determination of pollutants volume, i.e. wood, plastic, concrete etc. (2000 tons).
- The presence of tar substances (2000 tons).
- Determination of homogeneity.
- Determination of mixture aggregate resistance against crushing - for example minicrushability test (2000 tons).

Deviations of the observed values must correspond to the quantity of added R-material; the higher amount added, the smaller deviations from the values "set" in the production code must be. For their determination can be used nomograms [1] or corporate codes.

Note: The production code is processed according to the composition listed in the type test. During the preparation it is necessary to determine the right type of asphalt to be added and its quantity. In case of a high amount of R-material may be advantageous to use modified low temperature binders; the need for low-temperature properties test also can not be excluded.

Conclusion

From the presented data it is clear that the use of a high amount of R-material for the production of asphalt mixtures can be very convenient, but also very demanding. The performance results not only from the process of acquisition, transport, storage and mixture production, but also from the preparation and quality control. However, use of R-material can significantly contribute to life cycle costs reduction. Furthermore, it is advantageous for the environment protection, and so for the sustainable growth of the construction's life cycle as well.

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