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MATHEMATICAL MODELING OF THE MOVEMENT OF THREE-LINKED ROAD TRAINS

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Three-linked road trains move along a track with a thick coating, the surface of which may be wet, covered with rain, frozen, snow-covered or in other conditions. In accordance with the specific operating conditions in a real trunk (road) mode, the factors, which affect the efficiency of transport processes, must be taken into account in the method of accounting for the parameters of motion of road trains. Since the modular formation of a three-linked road trains may increase the total mass, length, the coefficient for placing the mass above the drive wheel decreases from the drive mass to the drive wheel. During the relative movement of the auto-drive, there should be considered the following:

A condition of sufficient driving force of the drive wheel indicates that it is necessary to respect the correlation between the driving forces and the resistance forces of a road train;

A condition of a sufficient placement with the surface of the road means that in order to overcome the resistance to movement of the drive wheels without detecting the slipping (as a result of which the truck will stop), the necessary traction force should be created.

The equation of a road train is the following:

$$\frac{dv}{dt} = \frac{g}{\delta m_a} [P_k(v) - P_c(v, v^2)], \quad (1)$$
$$\frac{dv}{dt} = J_a = \frac{\delta}{g} [D - (f \pm i)].$$

Where g is an acceleration of free fall, m/sec^2 ; m_a is a full weight of a road train, t, δ is a coefficient of equilibrium of the rotational masses of a road train; $P_k(v)$ is a power of the traction generated by the driving wheels; $P_c(v, v^2)$ is a total resistance forces of motor traffic; J_a is an acceleration of the carrier drive; D is a dynamic factor; f is a leading gear drag coefficient; i is a road bias, grad ($i \leq 4^\circ$).

A dynamic factor

$$D = \frac{P_k - P_w}{m_a} = \frac{M_e i_0 i_k \eta'_{tr} - \frac{kF}{3,6^2} v^2}{r_k m_a}$$

M_e is a moment of turbulence of the engine, n, m, i_0, i_k is the number of gears of a main gear and a gearbox, accordingly; η'_{tr} is a number of gears of the transmission; kF is a factor of ambient flow, v is a speed of movement, m/sec, r_k is a radius of the drive wheel, m .

A drive force of the driving wheel is

$$P_k = \frac{M_e i_0 i_k}{r_k} \eta'_{tr} = \frac{10^4 N_e}{n_e} \frac{i_0 i_k}{r_k} \eta'_{tr},$$

N_e is an effective power of the engine, kW; n_e is a number of revolutions of the crane roll, sec⁻¹;

The total resistance of the vehicle movement:

$$P_c(v, v^2) = P_f + P_i + P_w = m_a \left[(f \pm i) + \frac{kF}{3,6^2} v^2 \right],$$

where - P_f is a rolling resistance power, n; P_i is an inert power, n; P_w is an air resistance power, n. Substituting the values in equation (1), we obtain the equation of motion for a three-linked road train

$$\frac{dv}{dt} = \frac{\delta}{g} \left[\frac{M_e i_0 i_k}{m_a r_k} \eta'_{tr} - (f \pm i) - \frac{kF}{3,6^2} v^2 \right].$$

The model confirms the fact of a current theoretical support of the force of motion and resistance and the total mass of the road train.

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DIFFERENT REJIMS OF MOTION OF MOVING PARTICLES

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In this study the mathematical models of moving particles, describing a behavior of various systems (traffic, communication and others) constructed and investigated. Different rejim of motions, appearing in these systems are founded. The diagram, allowing to find various rejims of motion is given. For comparison of various rejims of motion an efficiency index is introduced. Relatively to this index it was compared different rejims of motion and an optimal is derived.

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CONVERGENCE OF SEQUENCE OF BELLMAN-HARRIS BRANCHING PROCESSES TO JIRINA PROCESS

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Let $\xi_n, n=0,1,2,\dots$ be the number of particles in the n -th generation. If

$$\xi_{n+1} = \theta_1 + \theta_2 + \dots + \theta_{\xi_n}, \quad n > 0,$$

where θ_i are independent random variables denoting the number of direct off springs of i -th particle, then we say that ξ_n is branching

process with discrete time (Galton-Watson process). In this work a limit theorem on convergence of sequence of normalized Bellman-Harris branching processes with one type of particles to Jirina process (continuous state space branching process) is obtained.

Bellman-Harris processes differ from Galton-Watson processes only by that from the moment of appearance of particle to its conversion moment passes some random time called lifetime.

Let $\eta(t), t \geq 0$, be the number of particles of Bellman-Harris process at the moment t ($\eta(0)=1$). Distribution function of the lifetime of one particle l we denote $G(t)=P\{l \leq t\}$. We suppose that $G(0-)=0$, L , $0 < \alpha = \int_0^\infty tdG(t) < \infty$ and $F(s)$ -generating function of Galton-Watson process.

Let $\eta^{(m)}(t), m=0,1,2,..., t \geq 0$ be a sequence of Bellman-Harris branching processes with generating function

$$F^{(m)}(t;s) = M \left[s^{\eta^{(m)}(t)} \mid \eta^{(m)}(0)=1 \right], \quad |s| \leq 1$$

and with lifetime distribution function of one particle l_m , $G_m(t)=P\{l_m \leq t\}$.

$$\text{Denote } \alpha_m = \int_0^\infty tdG_m(t) < \infty, \quad A_m = \left. \frac{dF^{(m)}(s)}{ds} \right|_{s=1}.$$

Under some condition on generating function $F^{(m)}(t;s)$, α_m, A_m the limit theorem on convergence of Bellman-Harris processes is obtained.

THE RESULTS OF DECISION-MAKING BOLOGNA PROCESS FOR PHILOSOPHY OF EDUCATION IN GEORGIA

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The present report discusses, that Georgian scientists and researchers in philosophy see the opportunity to solve its economic, political and social problems through education. This is important and correct policy. However, how the Bologna Process can develop educational system and thus economic and political influence of the country is the main concern. We argue that Georgian geopolitical situation, Soviet educational heritage and development in “Hard Sciences”, educational

history and attainment and value of education, cultural value of welcoming foreigners together with main trends of the Bologna Process can have positive effect for Georgia's educational development.

The section of the report "The important factors for internationalization of higher education of Georgia" focuses on important factors, which can promote success of Georgia in the Bologna Process. There are four important characteristics of Georgia for effective internationalization of higher education: Geographical situation of Georgia; The Soviet educational heritage and development in "hard sciences"; Educational history and attainment and value of education; and Cultural value of welcoming foreigners [3]. We will briefly analyze each factor and its possible effect on higher education development of Georgia.

The section of the report "The impact of the Bologna Process on higher education of Georgia and its possible consequences" analyses, that the factors mentioned in previous section are only precondition and one part of successful internationalization of higher education of Georgia. The second and most important part is based on quality assurance and development appropriate infrastructure for teaching, learning and research, establishment credit transfer system and recognition of qualification with other states and their HEI and "branding" Georgian higher education worldview system. We think that the Bologna Process can promote the achievement of such worldview objectives, as the main principles of the Bologna Declaration are following: Facilitation the readability and compatibility of qualifications; Implementing a system based on two main cycles; Arrangements to support the mobility of students, teachers and researchers; Establishing European system of quality assurance; Promoting the European dimension in higher education in terms of curricular development and inter-institutional cooperation. All above-mentioned principles are reflected in the policy of internationalization of higher education of Georgia.

The section of the report "Quality Assurance" emphasises, that the quality assurance of HE has two directions in Georgia: quality assurance regulated by state; and quality assurance regulated within the structures of HEI. The quality assurance policy of higher education of Georgia changed greatly due to participation in the Bologna Process. The quality assurance is implemented by the state as part of the accreditation process. The special administrative body, State Accreditation Service of Education Institutions of Georgia, is created within the Ministry of

Education and Sciences of Georgia. The quality assurance is very crucial for Georgian higher education. Georgian government should monitor the process of quality assurance of higher educational institutions through established accreditation body [1]. This structure, as independent body, can develop cooperation with similar agencies in foreign countries to assist HEI in receiving accreditation of foreign countries.

The section of the report “Credit transfer and degree recognition” underlines that according to the new law on Higher Education of Georgia, the three circles degree system is introduced-bachelor, master and doctoral. This change is also part of the Bologna Process as well. Georgia signed the Lisbon Recognition Convention and ratified it in 1999. The official body of Academic Recognition and Mobility was established in the Ministry of Education and Sciences of Georgia. These steps will enable HEIs of Georgia, on one hand, to raise the reputation in international market and on the other hand, to establish flexible credit transfer system. Both approaches are important tools for recruiting international students. HEI of Georgia now can develop the strategies for international cooperation and sign bilateral agreement with foreign universities; Establishment of double-degree programs in cooperation with universities of developed states is important to raise Georgian universities reputation in world market. The policy and strategy of Caucasus business school is very good example in this respect.

The section of the report “Research Development” analyses, that the main problem is that initiatives came from the international organizations and not from HEIs of Georgia. The shift of initiative from international organizations to HEIs is necessary to achieve the process of internationalization of research [2]. The internationalization of research, especially in hard sciences, is a cornerstone of internationalization of HEI. The Georgian HEI should understand this importance and elaborate adequate strategy and policy regarding the internationalization of research. The Bologna Process can play crucial role in this respect. Cooperation with European research institutions, using their infrastructure can promote development of research in Georgia. The Bologna Process requires from the government of Georgia to invest money in knowledge production and dissemination, which is conceded as a key of sustainable development. Under the Bologna Process the government of Georgia will facilitate an improvement and modernization of infrastructure and facilities of research institutions.

The author concludes that the Bologna Process is the respond of the process of globalization in the regional level. This process has very clear political and economic rationales. Establishing the European research and development community, increasing the capacity of the European industry and strengthening the international competitiveness of the European economy are rationale for the Bologna Process. Georgia became part of the Bologna Process and debates about its positive and negative impact emerged immediately. The impacts is mainly depends on policies and strategies implemented by the Ministry of Education and Science of Georgia and by the higher education institutions themselves. The only solution is to be part of European integration to respond successfully to the process of globalization. Failure of the Bologna Process will be important challenge for higher education of Georgia. However, failed Bologna Process will still be more useful for Georgia, than isolation from this process.

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SOME APPROXIMATE PROPERTIES OF CESARO MEANS FOURIER SERIES AND THEIR CONJUGATES

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Some approximate properties of Cesaro means of negative order of Fourier trigonometric series are established.

Suppose, that $T = [-\pi, \pi]$ and $f : R \rightarrow R$ 2π - are periodic functions. If $f \in L(T)$ as a rule, $\sigma(f)$ and $\bar{\sigma}(f)$ represent respectively trigonometric Fourier series and their conjugates

Further assume that

$$g(n, f) = \frac{1}{n} \int_{\frac{\pi}{n}}^{\pi} \frac{\omega(t, f)_c}{t^2} dt.$$

Here we note that $\omega\left(\frac{1}{n}, f\right) \leq g(n, f)$.

Theorem 1. a) Let $a \in (0, 1)$, $p \in (1, +\infty)$ and $ap > 1$. Then for the function $f \in C(T)$ the following inequality is true

$$\|\sigma_n^{-a}(f) - f\|_c \leq A(p, a) n^a \omega\left(\frac{1}{n}, f\right)_p + A(a) g(n, f).$$

The following is also true

Theorem 2. a) Let $a \in]0, 1[$ - is a number. If function $f \in C(T)$, $a, ap > 1$ then

$$\|t_n^{-a}(f) - \bar{f}_n\|_c \leq A(p, a) n^a \omega\left(\frac{1}{n}, f\right)_p + A(a) g(n, f).$$

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THE NONLOCAL BOUNDARY PROBLEM FOR ELIPTIC EQUATION WITH CONSTANT COEFFICIENTS WITH PERTURBATIONS OF DIRICHLET CONDITIONS

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A fundamental role in development of nonlocal problems and a shift operator theory has works of T. Carleman. A general theory of nonlocal elliptic boundary problems was formed on base of researches of Y. G. Beid and R. S. Friman, R. Bills, F. Brauder, L. Ehrenpreis, L. Hermander, G. Grub, J. W. Kalkin, Ya. B. Lopatynskiy, M. Malgrange, M. Shekhter, M. I. Vishyk.

This work is a continuation of the studies that begun in [1-3].

Let us denote by $G := \{x = (x_1, x_2, \dots, x_m) \in \mathbf{R}^m, 0 < x_j < 1, j = 1, 2, \dots, m\}$;
 $\beta := (\beta_1, \beta_2, \dots, \beta_m) \in Z_0^m$; $|\beta| := \beta_1 + \beta_2 + \dots + \beta_m$; D_j is the operator of
differentiation by variable x_j ; $D^{2\beta} := D_1^{\beta_1} D_2^{\beta_2} \dots D_m^{\beta_m}$ and
 $W_2^{2n}(G) := \{y \in L_2(G) : D^\beta y \in L_2(G), |\beta| \leq 2n\}$.

Let us consider nonlocal problem

$$\sum_{|\beta| \leq n} (-1)^{|\beta|} a_\beta D^{2\beta} y = f, x \in G \quad (1)$$

$$D_j^{2s-2} y|_{x_j=0} + D_j^{2s-2} y|_{x_j=1} = 0, j = 1, 2, \dots, m, s = 1, 2, \dots, n, \quad (2)$$

$$D_j^{2s-2} y|_{x_j=0} - D_j^{2s-2} y|_{x_j=1} + \sum_{r=0}^{r_j} \sum_{q=0}^{q_{s,j}} b_{q,r,s,j} D_j^q y|_{x_j=x_{j,r}} = 0, = 0, \quad (3)$$

$$j = 1, 2, \dots, m, s = 1, 2, \dots, n.$$

Let us denote by L operator of problem (1)-(3), by L_0 operator of the problem with Dirichlet conditions, where $(b_{q,r,s,j} = 0)$.

We describe properties of transformation operator $R: L_2(G) \rightarrow L_2(G)$, which sets connection between self-adjoint operator L_0 of the problem with Dirichlet conditions and operator L of the nonlocal problem $RL_0 = LR$.

Also we construct commutative group $\Gamma(L_0)$ of transformation operators. We show that to any operator $R \in \Gamma(L_0)$ some abstract nonlocal problem corresponds and vice versa. We construct system $V(L)$ of eigenfunctions of the operator L . Also we define conditions under which system is $V(L)$ total and minimal in the space $L_2(G)$, and conditions under which it is Riesz basis in the space $L_2(G)$.

In case if system $V(L)$ is a Riesz basis in the space $L_2(G)$, we obtain sufficient conditions under which nonlocal problem has unique solution in form of Fourier series by system $V(L)$.

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GENERAL SCHEME FOR CONSTRUCTION OF THREE-STEP METHODS FOR MINIMIZATION FUNCTIONS

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Consider the problem

$$f(x) \rightarrow \min \text{ для } x \in R^n. \quad (1)$$

To solve a task (1) there are a number of methods. We are offered a new class of methods that are expedient to use with a sufficiently large dimension of the problem.

Let a solution to a problem (1) know some recursive algorithm of the form

$$x_{k+1} = W(x_k). \quad (2)$$

Moreover, it is known that when the relevant conditions imposed on the function takes place assessment

$$f(x_{k+1}) - f(x_*) \leq C(f(x_k) - f(x_*))^\tau \text{ where } \tau > 1. \quad 0 < C < \infty$$

Along with algorithm (2), let's use another kind of algorithm

$$x_{k+1} = \psi(x_k), \quad k = 0, 1, \dots \quad (3)$$

There is an assessment

$$f(x_{k+1}) - f(x_*) \leq C_1 (f(x_k) - f(x_*))^{\tau_1}, \quad 1 \leq \tau_1 < \tau.$$

On the basis of two algorithms, we will construct a new algorithm of the form

$$\begin{aligned}
u_k &= W(x_k), \\
v_k &= \psi(x_k), \\
x_{k+1} &= \arg \min_{\gamma} f(u_k - \gamma(u_k - v_k)), \quad k = 0, 1, \dots
\end{aligned} \tag{4}$$

The sequence $\{x_k\}$, obtained in (4) coincides with the solution of the problem (1) and there is an estimate

$$f(x_k) - f(x_*) \leq \prod_{i=1}^k \mu_i^{\tau^{k-i}} q^{(\tau^{k3}-1)/(\tau-1)} (f(x_0) - f(x_*)), \text{ where } \mu_i \leq 1.$$

Consequently, theoretical studies and practical implementation have shown the effectiveness, in the sense of the number of calculations, of three step methods in relation to the basic at relatively large n .

DECISION MAKING IN EDUCATION MANAGEMENT IN UKRAINE

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Modern education management should be based on an analysis of current trends in the development of the country's economic, political and cultural life.

Thus, the modern management of the education system should perform the following main functions:

1) Identification of the most promising specialties in demand at the labour market.

The government in Ukraine constantly reduces the number of budget places in the higher education institutions, justifying such decision by the low level of demand for specialists at the labour market.

However, providing an opportunity to study at the expense of public funds will increase the number of people willing to learn promising professions.

2) Ensuring the formation of the core competence of staff.

This is one of the main tasks of the management of the education system, which can be solved by creating a system of motivation of teaching staff for obtaining academic degrees and titles, learning foreign languages in order to provide educational services to foreigners.

3) Ensuring the attraction of the necessary contingent of applicants based on the calculated predicted values of the number of potential students by specialties.

4) Providing the possibility of combining the education system and enterprises operating in various sectors of the national economy, by the way of increasing the number of industrial practices in production sphere.

This act will allow prepare specialists necessary for the economy, starting from the initial courses, which will subsequently enable enterprises to obtain already trained specialists of necessary qualification who have practical work skills.

The fulfilment of these functions will allow the state to optimize expenses on education, and to the higher education institutions to determine promising areas of student learning and be motivated to improve the skills of teaching staff.

ON THE RENEWAL-REWARD PROCESS WITH DEPENDENT COMPONENTS AND INTERCLAIM TIMES HAVING A DISTRIBUTION WHICH BELONGS TO THE CLASS $\mathcal{L} \cap \mathcal{D}$

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In this study we consider a renewal-reward process ([1, 2])

$C(t) = \sum_{i=1}^{N(t)} X_i$, $t \geq 0$, where $N(t) = \max \{n: S_n \leq t\}$ is a renewal process,

$S_n = \sum_{i=1}^n T_i$ and $\{(T_i, X_i)\}$, $i \geq 1$ is a sequence of independent and

identically distributed random vectors with possibly dependent coordinates. T_1 is non-negative random variable and we will denote its distribution by F and the integrated tail function by F_I :

$F_I(t) = \frac{1}{\mu_1} \int_0^t \bar{F}(x) dx$, $t > 0$, where $\mu_1 \equiv E(T_1) > 0$, $\bar{F}(t) = 1 - F(t)$.

We denote the classes of long-tailed distributions and dominated varying distributions by $\mathcal{L}$ and $\mathcal{D}$, respectively.

Theorem. Let the following conditions hold:

- 1) $F \in \mathcal{L} \cap \mathcal{D}$, F has a finite second moment $\mu_2 \equiv E(T_1^2)$ and F is non-singular (or for some n , $F^{*(n)}$ has an absolutely continuous component);
- 2) $\lambda \equiv E(X_1) \neq 0$ and $m \equiv E(T_1 X_1) \neq 0$ exist;
- 3) $|g(t)| \leq M$ as $t \rightarrow \infty$ for some $0 < M < \infty$,

where $F^{*(n)}$ is a n -fold convolution of F and $g(t) = E(X_1 | T_1 = t)$. Then the following asymptotic relation as $t \rightarrow \infty$ for the mathematical expectation of the renewal-reward process holds:

$$D(t) = \frac{\lambda}{\mu_1} t - \frac{m}{\mu_1} + \frac{\lambda}{\mu_1} \int_0^t \bar{F}_1(x) dx + o(t \bar{F}_1(t)).$$

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WIRELESS NETWORK SECURITY SYSTEMS

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Like usual networks, based on the use of wires, the wireless networks provide information between computer devices as well. This information can be presented in a variety of ways: by e-mail, WEB-page, database records, video stream or voice message. In most cases wireless networks transmit data through e-mail and files. In connection with the improvement of wireless networks' quality, it is possible to transfer video signals as well as to provide a telephone connection.

Wireless networks like transmitters, that ensure interaction between users, servers, and databases, use radio waves of infrared range. This area of information transfer is invisible to humans. Today, most

manufacturers integrate the Network Interface Cards (NIC), known as network adapters, and antennas into computer devices so that they are invisible to consumers. All this makes the wireless device more convenient to use.

The safety and service quality of wireless networks has become a subject of considerable and active research over the past few years, what is caused by a growing requirement for supporting the transfer of data packages [1]. Without the corresponding security, organizations will avoid using wireless networks. Security issues in wireless networks represent an important obstacle for broadly adaptation of such networks. Consequently, the security of such wireless networks is an important area, which requires an appropriate response if such networks are widely used. Security is a very important issue for wireless networks, as communication signals are available for use in the environment. Therefore, companies and individual consumers should know about the potential problems and take appropriate measures [1].

All the above issues are discussed in the present work.

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MAIN STAGES OF DESIGNING AUTOMATED SYSTEM SUPPORTING WIRELESS NETWORKS

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The present work aims at the development of a number of measures that would contribute to increasing the safety of wireless networks and through which it would be possible to manage remote workstations.

On the basis of the main tasks of the automated security system, it is necessary to define and develop system algorithms, information security and dialog procedures and create an automated system software complex.

There should be determined the input and output data for each algorithm, created such databases that would help carry out the security processes provided by algorithms (Figure 1.).

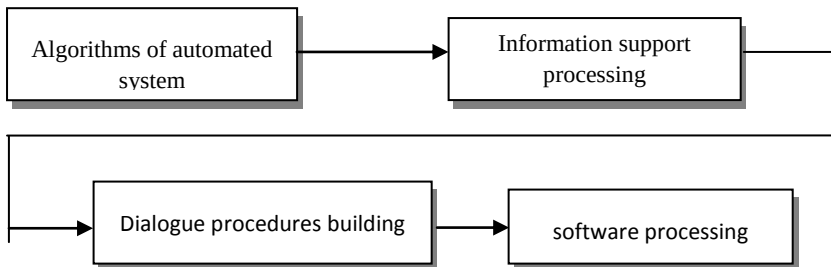


Fig. 1. Main stages of designing an automated system.

After conducting the above procedures, the automated system software complex and its structure are processed. Classes, constructors, procedures, functions and methods of software complex are created as well.

The efficiency of the solution of security supporting automated system depends on the system algorithmic support. For the optimal solution of this issue, a security task is allocated by separate algorithms for each method.

All the above issues are discussed in the present work.

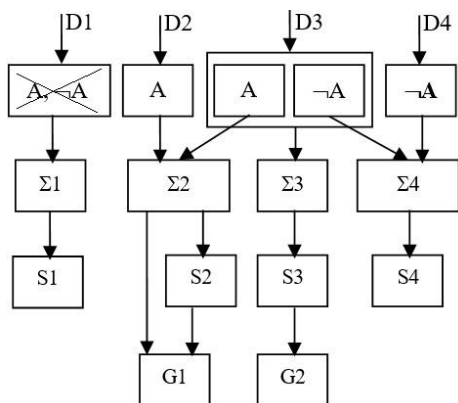
ABOUT MULTIPLE SAVING SOURCES OF FACTS FOR DSS WORK PROBLEM

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There is a problem in processing the facts (data) in separate streams [1], in which the analysis of such events and precedents are unsynchronized. As a result, validation of such facts does not work, and verification requires time that is not present in systems with fact-finding analysis but without their storage (Big Data).



So logical data A and $\neg A$ (not A) are effectively recognized in one flow of facts when validated by experts and if they go in a row (and this is not necessarily a contradiction, it may be just versions of events). But a small interplay between them can already be just two facts. Four streams D1-D4 with variants A and $\neg A$ (see Fig.)

affect the bases of analytical processing $\Sigma 1$ - $\Sigma 4$. The latter can be used in the formation of up to 4 variants of S1-S4 of the S solution already within one DSS. Another possibility is the modification of the solution S template to the new solution T with variants T1, T2.

The problem is that it is virtually impossible to either recognize or neutralize the logical incompatibility after the analytical generalization of individual facts. Thus, the main disadvantage of DSS (in the author's opinion) regarding the lack of unification of solutions [2] adds an even more complicated problem - the cognitive integrity of solutions in the database of DSS solutions with multithreaded analysis of facts without storage of the history of their use.

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MATHEMATICAL MODELING OF FLEXIBILITY IN INVESTMENTS WITH EXAMPLES FROM FORESTRY

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Net present value (NPV) approaches are still predominant in the investment valuation in practice. The current talk surveys methodologies of investment valuation which are capable to incorporate the dynamic structure of decisions related to most real investment projects and how they can contribute to derive improved decisions. The talk highlights the real options approach and relates it to the more classic approach based on dynamic programming. The focus is on the usefulness of both approaches depending on the prevailing assumptions on market conditions, especially on market completeness.

Based on some examples from forestry, where production is highly flexible, it is shown that such approaches can explain the use of artificially low interest rates in practical valuations using the simple NPV approach. To see this, the real options perspective on valuation tasks is developed in rather elementary terms, and examples are given in both discrete and continuous time settings.

Among the conclusions is that future research should investigate more carefully the consequences of imperfect hedging, which leads to questions which are of interest both mathematically and economically.

STOCHASTIC VOLATILITY WITH CONTROL AND SEMI-MARKOV SWITCHINGS

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Stochastic volatility with semi-Markov switchings is analysed. It is described with the equation of the process of price $s(t)$ changes in the form [1]

$$ds(t) = -s(t)[\mu(s(t), x(t))dt + \sigma(s(t), x(t))dw_t], \quad (1)$$

and by the control process and the volatility in the form

$$d\sigma = \alpha(t)[a(\sigma, x)dt + b(\sigma(s, x))dw_t], \quad (2)$$

where $x(t)$, $t > 0$, - semi-Markow process [2], and $\alpha(t) > 0$ is that fulfils the conditions $\int_0^\infty \alpha(t)dt = \infty, \int_0^\infty \alpha^2(t)dt < \infty$.

Here, the function $\alpha(t)$ is the control function, that fulfils the asymptotic stochastic volatility of the process (1)-(2). Asymptotic conditions of the process of price change $s(t)$ is set through the scheme of middle value with the use of small parameter and the compensation operator of the three-component process of Markow's renewal process $s_n^\varepsilon = s(\tau_n^\varepsilon), \sigma_n^\varepsilon = \sigma(\tau_n^\varepsilon), x_n^\varepsilon = x(\tau_n^\varepsilon), \tau_n^\varepsilon = \varepsilon \tau_n$, where τ_n - are the moments of process preservation $x(t)$ [2].

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LOGICAL-MATHEMATICAL RULES FOR DECISION- MAKING OF ASSESSMENT OF KNOWLEDGE

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One of the main objectives of providing high quality of teaching is to make an effective decision on adequate assessment of knowledge. This task belongs to the class of hardly formalized tasks, which is mainly due to the fact that some criteria for knowledge assessment are not numerical. In case of such a problem, the method of artificial intelligence is often used for decision-making, which main basis is the rules of making conclusion- **modus ponens**: $\models A \wedge (A \rightarrow B) \models B$.

In order to build the decision-making rules in the assessment process of knowledge, we set up a system of methodological materials, for which we have the following indications:

K_{dc} – The coefficient of difficulty of the topic to be examined, which is determined by ranking;

K_{cc} – The coefficient of interdisciplinary relationship;

K_{pic} – Student's professional intelligence quotient (**PIQ**);

K_{pap} – Student's predictable academic performance (**PAM**).

The calculation, synthesis and analysis of these data create the core point of the education quality management system functioning.

The system of implementation of this process works in the interactive mode.

Coefficient of difficulty - K_{dc} is determined by the methodologist of the main administration of the educational activity with a group of experts created with the professors and teachers of the discipline. By using the expert method, there is determined the value of K_{dc} and its database is formed. Similarly, before the start of the academic semester, the K_{cc} is determined and its database is formed.

Student's professional intelligence quotient - K_{pic} is a psychological characteristic of a student and does not have a numerical value. Therefore, its determination is based on psychological testing, scientific-methodical laboratory, according to several **Pi** parameters of professional intelligence in the automated mode.

The predictable academic performance - K_{pap} has the complex content and its determination as a result of the processing the statistical data. In order to build the logical-mathematical rules for decision-making of knowledge assessment, we divide the coefficient of difficulty into three: low, medium and high categories: $K_{dc (lo.)}$, $K_{dc (med.)}$, $K_{dc (hig.)}$; coefficient of interdisciplinary relationship: weak, medium and strong relationship coefficients: $K_{cc (we.)}$, $K_{cc (med.)}$, $K_{cc (str.)}$.

Then, we build the logical-mathematical rules of knowledge assessment, according to one hundred score assessment system of a higher education institution. First of all, we create the tree (tree graph) of an assessment decision, as the knowledge base received from the empirical knowledge, which then transforms into the logical rules, where we use the logical links: "denial", "conjunction", "implication".

IMPLEMENTATION OF LOGICAL-MATHEMATICAL RULES FOR DECISION-MAKING IN KNOWLEDGE ASSESSMENT PROCESS

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With the use of the logical-mathematical rules for decision-making of knowledge assessment [1], we build a tree graph of decision. For the assessment criteria, there are the following indications:

K_d - difficulty coefficient:

$$K_d = \{K_{d(\text{low})}, K_{d(\text{average})}, K_{d(\text{high})}\};$$

K_{dc} - Coefficient of disciplinary communications:

$$K_{dc} = \{K_{dc(\text{weak})}, K_{dc(\text{average})}, K_{dc(\text{strong})}\};$$

S - Evaluate knowledge:

$$S = \{S_{\text{best}}, S_{\text{v.good}}, S_{\text{good}}, S_{\text{satisf.}}, S_{\text{suffic.}}, S_{\text{unsatis.}}, S_{\text{bad.}}\}.$$

The logical sequence of the decision tree defines the tree branches, which are given in Fig.1. (**Logical Rules**), these branches are called as deductive branches. In order to transfer the decision tree into a set of logical rules, it is necessary to consider every possible deduction branch. This gives us the opportunity to determine the decision-making rules.

We can write down each way (branch) of the given drawings as a rule. The total number of rules determines the base of knowledge.

The logical rules according to fig.1 are:

1. $1, 2, 3, \Rightarrow 4;$
2. $1, 2, 3, 5, \Rightarrow 6;$
3. $1, 2, 3, 5, 7, \Rightarrow 8;$
4. $1, 2, 3, 5, 7, 9, \Rightarrow 10;$
5. $1, 2, 3, 5, 7, 9, 11, \Rightarrow 12;$
6. $1, 2, 3, 5, 7, 9, 11, 13, \Rightarrow 14.$

And its corresponding logical formulas (which should determine the student's knowledge assessment) will be:

1. $K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge S_{\text{bad}} \Rightarrow (S = S_{\text{bad}});$
2. $K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge \overline{S}_{\text{bad}} \wedge S_{\text{unsatis.}} \Rightarrow (S = S_{\text{unsatis.}});$
3. $K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge \overline{S}_{\text{bad}} \wedge \overline{S}_{\text{unsatis}} \wedge S_{\text{suffic}} \Rightarrow (S = S_{\text{suffic}});$
4. $K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge \overline{S}_{\text{bad}} \wedge \overline{S}_{\text{unsatis}} \wedge \overline{S}_{\text{suffic}} \wedge S_{\text{satisf.}} \Rightarrow (S = S_{\text{satisf.}});$
5. $K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge \overline{S}_{\text{bad}} \wedge \overline{S}_{\text{unsatis}} \wedge \overline{S}_{\text{suffic}} \wedge \overline{S}_{\text{satisf.}} \wedge S_{\text{good}} \Rightarrow (S = S_{\text{good}});$

$$6. \quad K_{d(\text{low})} \wedge K_{dc(\text{weak})} \wedge \bar{S}_{\text{bad}} \wedge \bar{S}_{\text{unsatis}} \wedge \bar{S}_{\text{suffic}} \wedge \bar{S}_{\text{satisf.}} \wedge \bar{S}_{\text{good}} \wedge S_{v.\text{good}} \Rightarrow (S = S_{v.\text{good}});$$

All the branches of the tree and the appropriate conclusion of the assessment of knowledge can be processed with the use of the same method.

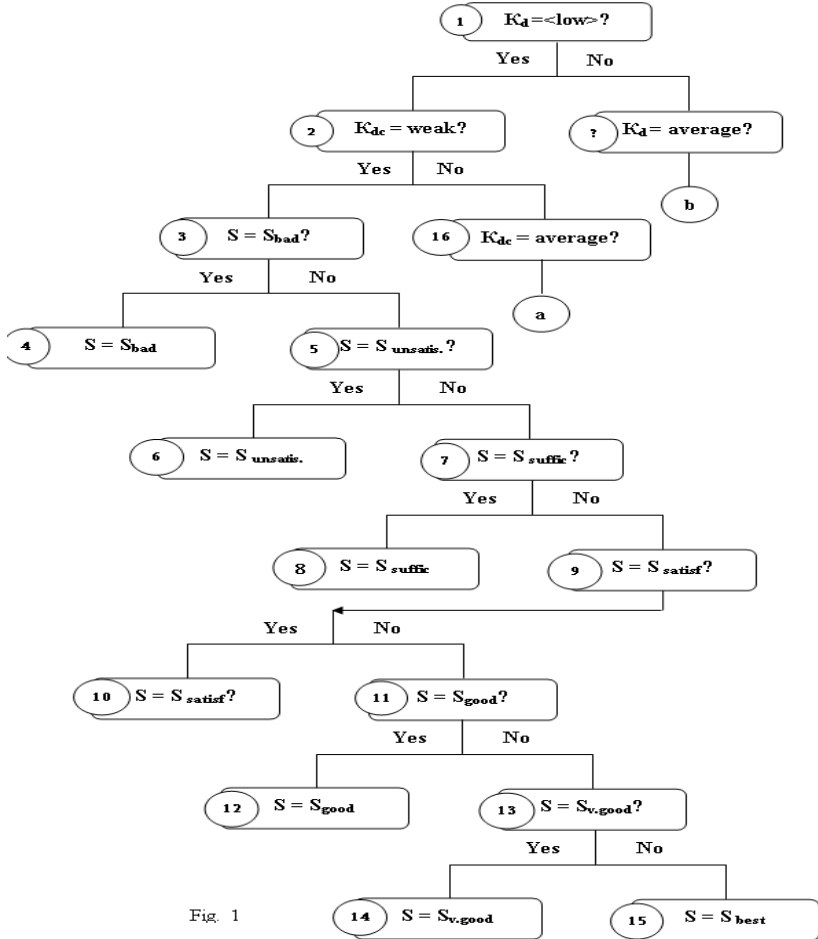


Fig. 1

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INNOVATIVE MECHANISMS FOR MAKING INVESTMENT DECISIONS ON GEORGIAN STOCK EXCHANGE

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Stock Exchanges and Securities Markets are an important basis for social and economic development of the country. Although Georgia was the first country after the collapse of the Soviet Union, where the Stock Exchange was created, which was characterized by dynamic growth, the entire market capitalization of domestic companies throughout the history of the Stock Market has achieved significant scales only for a short time. This problem, which is still on the agenda, was caused by various reasons, including neglect of investment theory and practice, experience of which did not actually exist in our country. One of the ways to solve the market capitalization problem and make investment decisions is to consider the economic conditions of the country. The economic conditions of the country as the main investment objects can only be studied and evaluated by investment readiness and attractiveness of its regions, existing industrial sectors and business organizations. Of course, these attributes clearly determine the prices of the Securities Market, the level of profitability and risk factors for investment decision making. Fundamental analysis and innovative methods are needed to create an investment environment which determines the price prediction and reveals financial condition and reliability of the company. That is why we consider fundamentally significant to develop the modern system of innovative methods of investment decision making and determine the prospects of its development.

To achieve this goal, we will see the following main tasks:

- Analyze the current state of securities existing on the Georgian Stock Exchange and identify the characteristics of investment decisions;
- Study of Investment decision making issues and methods, identify the positive and negative aspects of these methods and identify elements which are more effective to use on the Georgian Stock Exchange;
- Development of innovative methods for formation of stock market stability and securities portfolio.

DIFFUSION PROPERTIES OF THE SERVICE PROCESSES IN JACKSON NETWORK WITH DEPENDENT RENEWAL INPUT FLOWS

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We will consider a Jackson network of the type $[GI / M / \infty]^r$ with a bivariate input flow customers $(v_1(t), \dots, v_r(t))$ where $v_i(t) = y_i(t) + y_{r+1}(t)$, $i = 1, r$ and $y_i(t)$, $i = 1, r+1$ are independent renewal flows.

We will suppose, that the parameters of the model depend from n (number of series) and next conditions are true:

a) $[M\tau_k^i]^{-1} = \lambda_i \neq 0, \beta_i = D\tau_k^i < \infty, \tau_k^i$ is an interval of the k -th revival, $i = 1, r+1$.

b) $\mu_i^{(n)} = \mu_i / n + o(1/n)$, $i = 1, r$, μ_i is a rate of the time of service in our systems.

For sequence of processes

$$\xi_n(t) = (\xi_n^1(t), \dots, \xi_n^r(t)), \quad n \geq 1, \quad t \in [0, T],$$

$$\xi_n^i = n^{-1/2} (X_i^{(n)}(nt) - \alpha_i n), \quad i = 1, r$$

($X_i^{(n)}$ is a number of customers in i -th system), where $\alpha(I - P) = \lambda$, the following theorem is true.

Theorem. The sequence of stochastic processes $\xi_n(t)$ converges in uniform metric to diffusion process with infinitesimal mean $a(x) = (a_1(x), \dots, a_r(x))$ and diffusion matrix B , where

$$(a_1(x), \dots, a_r(x)) = (-\mu_1 x, \dots, -\mu_r x), \quad B = -(D(\alpha)Q + Q^t D(\alpha)) + A,$$

$$A = \|a_{ij}\|_{i,j=1}^r, \quad \text{where } a_{ii} = \lambda_i + \lambda_{r+1} + \beta_i \lambda_i^3 + \beta_{r+1} \lambda_{r+1}^3, \quad i = 1, r$$

$$a_{ij} = \beta_{r+1} \lambda_{r+1}^3, \quad i \neq j$$

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THE RATIONALITY OF PUBLIC DECISION MAKING AS THE MAIN BASIS OF DEMOCRATIC POLITICAL SYSTEM

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Management is a necessary condition for organizing and regulating public life. Management implies the active impact of the management subject to the management objective, which aims to eliminate existing resistance. Terms Policy and management are very close to each other, but management is more art than administrative activity. Political management is especially difficult because it involves the whole community and contains all kinds of sectoral management toward political management which comes in first place. Political management means setting up common goals and mobilizing existing resources to implement these goals. Management is a personal experience, intuition, and therefore it belongs to the arts and not science.

The manager plays an important role. he/she have mechanisms for the implementation of the interests for different social groups, which are practiced in different ways.

Decision making is the main function of management, which means that all issues are resolved from planning to ending, with the controlization of the plan. However, decision is first step, and the second is to make an objective decision, which can only be obtained with the necessary and accurate information, and for that kind of information we need communication.

The decision in politics affects the entire society, and therefore the part of the researchers named it as decision-making science. Each person is trying to find an optimal choice, need to be told: that there is no optimal solution, there is only the optimal choice, it means that during decision is important to choose alternative. The set of alternative models during decision-making process provide comparison and assessment. The rationality of the decision is based on a set of alternative options, and in order to make comparisons we need to have criterions, according this will be possible comparison of alternative variants. in science are occur many methods for reviewing and comparison of alternative options. It is important that all the methods to be way for making optimal decisions.

The main functions of management include planning, analysis, prediction, decision making and control. These functions are not

implemented in sequence, without violations, but are directed to optimize the political process.

The decision is the most responsible function of the management process. It implies the choice of alternatives, as well as the regulation of the society in a way that leads the public to the desired condition.

Conclusion is that political management implies a correct and effective decision to promote the development of the state, to develop democratic consciousness and to build the state.

ABOUT DETERMINATION OF AN OPTIMAL INSURANCE FEE IN CASE OF PAYMENTS WITH LOGNORMAL DISTRIBUTION

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The below statements describe the F -model [1, p.248] as it is. In its case we assume that the number of insurance contracts N , which are in the insurance portfolio, is a random value. Each insurance contract with the number j corresponds to the value S_j that we call the insured amount. Let Y_j - the value of the suit for the j -th agreement. We will also assume that random variables X_j and S_j are independent.

Supposing that for each insurance contract, the insurance fee Z_j is determined $Z_j = zS_j$ where z - some constant for all insurance contracts (insurance rate). It worth mentioning, that in the considered model fees are random variables that depend on S_j which distinguishes it from a classical statement of the problem.

We consider lognormal distribution with parameters $\mu \in \mathbb{R}$, $\sigma > 0$ as an option assuming that claims under insurance contracts are large. Then under these assumptions for z_0 - the optimal insurance rate is valid the following ratio:

$$z_0 \sim e^{\mu + \sigma^2/2} + \frac{\sqrt{(e^{\sigma^2} - 1)e^{2\mu + \sigma^2}} [1 + V^2]^{1/2} \Psi(Q)}{[N - V^2 \Psi^2(Q)]^{1/2}}.$$

We also note that for $V = 0$, this result is practically reduced to classical [2, p.238].

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TEACHING OF COMPUTER TECHNOLOGIES

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We have analyzed the necessity of the conditions, issues and transition to computer-based training of a certain part of traditional educational technologies.

The analyses of educational-methodical base has convinced us that, despite the active application of computer technologies in educational process, there is no computer informational-methodological training; there is no uniform system and principles of computer training system concepts; there is no developed training methods, required by the present standards, and no applied or object-oriented computer base. The application of a such system let the student disclose his independent cognitive activity and creative skills; deeply percept covered topics and events; increase the effectiveness of training; students become more interested in solving issues and the system helps them to get solid knowledge and to develop logical thinking; on the other hand, teachers have the opportunity to redistribute economically the time appointed for the lesson.

Schools teachers and professors and teachers of high educational institutions have great chance to use multimedia technologies as the support of the informatization of the education. This technology ensures: systematization of the processes in the educational system; Formation of new knowledge and modern professional competences; To achieve the aim to educate pedagogically and psychologically widely educated and high qualified persons according to modern trading market.

In the scientific bases of computer technologies, applied in educational process, the main attention is paid to the development of

multimedia models, particularly, the informational ones of technical designation objects. Such models are generally designed for imitative virtual labs and for the expansion of theoretical and experimental researches in order to come closer to the object real properties during physical investigations and to reveal their peculiarities.

All the above issues are discussed in the present work.

ABOUT ELABORATING THE AUTOMATED SYSTEM OF TRAINING CREDITS

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The necessity of elaborating the automated system of training credits is increasingly important in higher educational institutions. Introduction of modern automated systems design and management practices, elaboration of efficient methods of information technologies, development of automated system supporting training of credit cards.

Effective methods of managing the existing and established automated system are analyzed. Based on the presented approach, the management methods and algorithms of management have been developed, which ultimately ensures the effective implementation of the system.

Nowadays, no educational area has a perfect electronic system of credits optimal distribution functions, no attention is paid to determine an optimal ratio of a student's independent work hours and contact hours, what should be based on the specifics of the research subject and focused on the maximum mastery of knowledge, effectively use of the time allocated for a student's educational course.

The work is devoted to the scientific solution of the above issue, the development of its theoretical and methodological concept.

The study deals with the information analysis of documentary standards, existing in the educational system, the mathematical methods of systematic modeling of electronic document turnover, the system modeling algorithms and the standards of introduction in practice.

At present day, an objective task is to create a single, coherent and functional information system by selecting the basic characteristics from a variety of software arsenals. It is necessary to take into account the factor that causes the coherence between different software components,

the ease of mastering them, their use and integration, efficiency, stability, etc.

All the above issues are discussed in the present work.

NEURAL NETWORK'S MODELING PROBLEM

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Neural network modeling problem is viewed as an optimal management discrete problem. Let us analyze a discrete neuron network model, in which transition from 1 to l+1 occurs with the following rule:

$$x_i^{l+1} = f_1 \left(\sum_{j=1}^n w_{ij}^l x_j^l \right), \quad i = \overline{1, n}, \quad l = \overline{0, q-1},$$

$|x_i^l| \leq B_i, i = \overline{1, n}, l = \overline{0, q}$ with phase limits w_{ij}^l weight coefficients are selected from the

$$I(w) = \sum_{l=0}^{q-1} \sum_{i=1}^n \sum_{j=1}^n r_{ij} (w_{ij}^l)^{2p} + \sum_{i=1}^n M_i (x_i^q - A_i)^{2m}$$

functional's minimum condition

Construction of the neuron network in order to solve a specific problem means to determine topology of the neuron network connections, w_{ij}^l weight coefficients of the connections, f_l activation functions, and $I(w)$ target functional. Neuron network acquires its properties throughout the training process, which includes either determination of the weight coefficient of the synaptic connections or introduction of specific rules which will enable change of the weight coefficients of the synaptic connections according to the specific neuron network's output.

Upon the neuron network's properties training, the obtained outcomes should be generalized and obtained properties should be prolonged. This can provide for creation of positive preconditions for creation various prediction systems.

All the above issues are discussed in the present work.

LABOR MARKET AND FORECASTING
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As the literary analysis showed, the demand of the specialists in the region is caused by a number of factors and These factors have undergone significant changes in transition to the market economy. Obviously, this creates the task of reviewing existing methods of prediction and the necessity of developing new methods. This problem is relevant today, requiring scientific study and practical realization of the results.

Analyzing the need for specialists' analysis on the labor market in the region, and afterwards, the regulatory tasks are directly related to the country's education system, which itself includes social, demographic, technical, economic, cultural and most importantly educational tasks.

Many developed countries are actively engaged in both legislative and educational projects in Professional training and specialization of professional structures in the field of forecasting.

Under the conditions of Georgia, direct access to any country's experience cannot bring positive results. In our opinion, on the basis of scientific analysis of these experiences, the adequate model of the national economy should be processed by the general policy of analysis and predictability of experts in the labor market.

The purpose of the work was to set out the main tasks that determine the forecasting of the specialists in the region at the level of the respondent's current market needs. For this, we studied the theoretical and practical studies conducted by the patriarchal and overseas scientists concerning the tasks to predict the requirements of the specialists.

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DEVELOPMENT OF SYSTEM MANAGEMENT OPTIMIZATION PRINCIPLES

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Development of system management optimization principles requires a clear analysis and description of its structure and function, i.e. creating a model of teaching system.

For the cybernetic aspect specific is the growing interest in the organization of the study of the system. The basis for this aspect is the isomorphism between the main notion of concepts (teaching and training activities) and the main concept of system theory (functioning of the system).

Naturally, the structure of the structure will be multi shaped. The main elements of the system are allocated in the model, but they are not reflected in the division.

The functioning of the system is closely linked to its structure. In order to describe the connection between the structure and function of complex systems are developed three methods are designed:

1. A bloc scheme where we detect the main elements of the structure and general links between them;
2. Principle scheme, where are shown the deepest and detailed links between the functional elements of the system and are revealed the principles of their functioning;
3. The installation scheme, which fully describes the system structure.

In the zero level of the bloc, the two main types of element are detected: source of information and consumer - information receiver. The dependence between these elements determines the functioning of the system. The source of information will send the notification to the recipient, in case of reception, this notification is a signal of activity or a thought element for the users.

These are issues the work is focused on.

TECHNOLOGY OF SHIPPING OPERATION BY MARINE TRANSPORT MEANS

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It can be said that the technology of shipping cargo by marine means is a field of science which discusses all the issues, procedures and consequence related to the field.

Technology of shipping cargo by marine means discusses all major issues:

- ◆ Classification, normative base and characteristics of shipping technology;
- ◆ The rights of Consigner and Shipping Line with regards to cargo security and safety;
- ◆ Heat exchange regulation with environment;
- ◆ Bulk, liquid, timber, general, grocery and hazardous cargo shipment;
- ◆ Overweight and heavy dimension cargo, movable technique shipment;

All above mentioned issues are related to loading of cargo, safe and secure shipment and unloading.

It's noticeable to mention that marine transport system, as well as land and air transport systems should be properly managed, flexible and could maintain shipment of maximum cargo in minimal period of time. In order to achieve this it's important to develop the most efficient conception of transportation trajectory, as well as the transfer of loads determined by this transport. It's obvious that it requires scientific researches, analyses and results and optimal decisions taken on the bases of above mentioned.

The efficiency of the road throughput can be viewed in many ways and is possible due to various factors. One of the most important characteristics of the road efficiency is optimization of loading-unloading operations. In optimization we mean develop time parameters, as well as concept of maximum capacity of cargo loading operation.

All the above issues are discussed in the present work.

INFRASTRUCTURE DEVELOPMENT CHALLENGE FOR ELECTRIC VEHICLES

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The paper considers the problem of infrastructure development for electric vehicles in Ukraine and proposes an option for making decisions for this problem. The solution of the problem relies on the construction of ontology [1] from the subject area of "Electric" and uses the methodology of system optimization [2] and is based on the analysis of the market of electric vehicles [3].

Due to the large number of smog, the relevance of electric vehicles is increasing day by day. There is currently a legislative initiative on the introduction of electric vehicles (EVI) - a common policy of different countries to accelerate the production and adaptation of electric vehicles around the world. At the moment, the EVI includes regions such as Africa, Asia, Europe and North America, namely 14 countries: Canada, India, Germany, France, Finland, China, etc.

Unfortunately, Ukraine is not on this list, but it still introduces measures to increase demand for electric vehicles. After all, at the stage of checking the readiness of Ukraine to accept electric vehicles, it turned out that even large Ukrainian cities do not have the proper infrastructure of charging stations. That is why, in the paper, the model of system optimization task of the location of charging stations in Ukraine is built.

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OPTIMAL MANAGEMENT DECISION-MAKING DIRECTIONS OF AIR TRANSPORTATION QUALITY IN GEORGIA

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The deepen involvement in the globalization and integration processes is impossible without the transport communication. The air transport is a complicated system. It is one of the most important and specific areas of the national economy and the fastest type of transport. Therefore, it serves for the transportation of people and cargo over long distances. The Soviet system of economic organization significantly slowed the development of air transport in Georgia after acquiring independence. The aviation vehicles and organizations face the disaster, as we have the old inherited vehicles, low level of flight safety and passenger service, the difficulty of preparing the national professional and scientific staff on site. Although many things have been done during the recent twenty-five years, but the situation is still unfavourable.

Under the market economy, the national air transport entities are under competition in both internal and external markets. Not only airlines, but also airports are involved in the competitive fight.

According to the experience, it is visible that they do not have the sufficient opportunities to compete with foreign air carriers in the conditions of liberal policy of the state government. Consequently, it is advisable to determine the organizational forms and methods for optimal decision-making of transportation quality management, which in turn ultimately leads to improving transportation quality. Therefore, it is necessary:

- ❖ To analyse the principles of international legal regulation on air transport and to determine the state regulation priorities;
- ❖ To consider the quality of air transportation, an economic category, as a system-complex research object;
- ❖ To analyse the basic criteria for determining organizational-methodological problems and quality management services of air traffic;
- ❖ To analyse the licensing-certification condition for ensuring air transportation safety;
- ❖ To improve the existing organizational-methodological basis for state regulation of air transportation quality management;

- ❖ To determine the efficient directions of air transportation quality management modelling;
- ❖ To form the organizational-economic mechanism for efficient interaction of tourism and aviation;
- ❖ To develop the Habur Model.

MODEL OF ADVERTISING EXPENDITURE WITH CUMULATIVE EFFECT

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The urgency of the task is determined by the need to answer the question of how advertising influences income.

Consider the dependence between income (u_t), advertising costs (a_t) and sales volume (q_t) together with the dependence of advertising costs on profits and cumulative advertising (A_t) (accumulated over 3 years) as a system of simultaneous equations:

$$\begin{cases} u_t = f_1(a_t, q_t); \\ a_t = f_2(u_t, A_t); \end{cases}$$

where u_t , a_t are endogenous variables, A_t, q_t are exogenous variables. Indicated model is overidentified. [1]

Exponential dependence [2] is chosen for constructing a model of advertising volume with a cumulative effect.

$$u_t = \beta_0 a_t^{\beta_1} q_t^{\beta_2}; \quad a_t = \gamma_0 u_t^{\gamma_1} A_t^{\gamma_2}; \quad (1)$$

where β_0, γ_0 – constants, $\beta_1, \beta_2, \gamma_1, \gamma_2$ are the corresponding elasticities.

Having estimated the logarithm (1) let us record indicated model as a system:

$$\begin{cases} \ln u_t = \beta_0 + \beta_1 \ln a_t + \beta_2 \ln q_t + \varepsilon_{1t}; \\ \ln a_t = \gamma_0 + \gamma_1 \ln u_t + \gamma_2 \ln A_t + \varepsilon_{2t}; \end{cases} \quad (2)$$

Hotel company data for the period from 2014 to 2017 was taken into account. The data are presented in thousands of euros.

Applying mathematical apparatus to the described model the following results were obtained:

$$\ln \tilde{u}_t = -1,23 + 0,26 \ln \hat{a}_t + 0,75 \ln q_t;$$

$$\ln \tilde{a}_t = 4,67 + 3,8 \ln \hat{u}_t - 2,86 \ln q_t;$$

Indicated coefficients are coefficients of elasticity indicating how much in percentage profitability will be increased. It is estimated at an increase in the percentage of the indicator. The coefficient 3.8 indicates that the advertising elasticity of income is 3.8 in such mathematical model.

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DEVELOP COGNITIVE INTERESTS WITH MULTIMEDIA

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In order to improve the efficiency of education system and improve the quality of knowledge, it is of great importance to introduce modern teaching methods and practical realization. While using innovative methods, the teacher aims not only to enhance the quality of teaching, but to give people the skills that make them full-fledged and develop the country. The use of innovative methods not only strengthens the quality of teaching, but also gives people the ability to make them full-fledged. Innovative methods and, in particular, modern multimedia means makes it possible to increase the activity of students' cognitive interests and develop cognitive interest in school subjects. In addition, the education system significantly alters the learning process methods and content of the study itself. The use of multimedia tools changes the approach to material. We help to achieve better results, because at this time the students are more motivated, they pay more attention to the information and remember the curiosity.

"Multimedia" is a multi-component space (environment) that allows the use of text, graphics, video and multiplex dialog mode, and thus extends the ability to use the computer in the learning process. Image component and critical thinking, in this case, helps the student to fully understand the presented material. The possibility of joint use of theoretical and demonstration materials appears.

School disciplines of multimedia outlets for use as a training discipline contributes to the efficiency of learning, can increase the visibility of learning capabilities (video, audio, computer graphics, modeling), to extend the possibilities of the individual activities and feedback (virtual reality techno Gibe), as well as a variety of opportunities for access to information (Telecommunications).

As modern young generation has more time to deal with media outlets, media aims to transform this relationship as a positive experience based on the development and extent of the person and cognitive sphere.

COMPARATIVE ANALYSIS OF CLASSIFICATION ALGORITHMS ON INSURANCE DATA IN R¹

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This work focuses to compare of classification algorithms on insurance data in R. We used some common machine learning algorithms are included H2O in R, such as random forest, gradient boosting, and deep learning and others. With H2O, can be preparing data for modeling (data munging), creating a model using simple but powerful machine learning algorithms and scoring models. The aim of

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this article are to model the insurance business data by classification algorithms and to compare of evaluating classification model performance, such as confusion matrix, accuracy paradox, curve analysis.

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CONCEPT FOR APPLICATION OF INFORMATION SYSTEMS SUPPORTING DECISION MAKING IN AVIATION CONSULTING ACTIVITIES

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Besides being one of the main sources of the economic and social development of the country, aviation business is also a powerful means of communication between countries. Aviation business is integrated with different directions of human activity. One of these directions is the functioning of Aviation Consulting Group. The efficient functioning of this group depends on the realization of modern methods and tools of decision making.

The Aviation Consulting Group is a certain intermediary which considers and protects the customer's interests in the process of creating the airline. They take on tasks of various directions. By airlines' request, the Consulting Group analyses the airlines, which results in making decisions about which new direction is potentially, commercially

beneficial and interesting. Another important issue is the involvement of the consulting group in airlines in the processes of starting operations, negotiations and making relevant decisions. For example, on request from different interested parties, there is held an analysis, monitoring and supervision of the market or specific issue; working out development plans of different conceptions or business models, such as:

- ❖ Procedures of registration of new airlines, preparation of technical and material documents;
- ❖ Selection of aircraft in accordance with requests and plans;
- ❖ Receiving Air Operator Certificate;
- ❖ Monitoring the main indicators of the operation of airports – passenger transfer, aircraft service, etc.

In case of an investor's wish, the Company carries out technical, commercial or full management of the airline using computer systems with specific software, including databases / servers, etc.

The flow of requests related to management decisions must be performed as quickly as possible, in a timely manner, in order not to cause delays. Separately implemented processes have an important influence on the whole system and their effective functioning. The processes ongoing in the management system are designed to speed up decision making and process the flow of information. At the same time, there is a shortage of resources, power and time. It is clear that continuous flow of data without interruption is provided only when all directions are coordinated with logistics network.

During the decision-making process by the Aviation Consulting Group, there are important and systemic processes which are implemented in accordance with the definite rules on the basis of the flow of organized tasks, using technological and logically connected systems of high-level mass services. The system takes on the obligation to monitor and deal with requirements, is sensitive to dissemination of information streams in the subsystems, the emergence of resources deficit and hindering factors. The logic of execution of tasks and decision making is consistent with the concept of established standards, guaranteeing system readiness and response to technology related changes.

SUBJECT – “SYSTEMIC ENGINEERING” AS THE BASIS FOR FORMING A DECISION-MAKING SKILL

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The use of modern high technological means, such as computer networks and information technology, in the educational process has already proved their educational abilities. These modern possibilities, the formation of social consciousness is quite a big issue. Among them, we will distinguish the issue of formation of noospheric worldview, according to which the surrounding world is a unity in all connections. Humanity will only go through its development at the characteristic speed of the epoch when we consider the interrelation between different sciences and the acquired knowledge.

Our research has shown that the quest for narrow specialization on the primary stage of education deters the establishment of noospheric thinking. For the establishment and modification of modern educational system, cognitive abilities of the children of modern epoch and their psychology should be taken into consideration. We have researched and analyzed the following issues in this respect:

1. Modern vector of establishment and development of information society;
2. Primary school pupils' attitude to computer and information technologies, their cognitive abilities;
3. Innovative approaches to educational process and the research of effective and targeted use of computer technologies by students.

On the basis of the analysis results, we have worked out a project which takes into account a new compulsory subject in primary classes – teaching “systemic engineering”. The topic of the subject covers the integrated use of the achievements of disciplines, sciences in order to create a steady, effective system. Besides subject competencies, the aim of teaching the subject is to develop different competencies among children, such as: experimental, checking hypothesis, learning from their own mistakes, forming thought and, mainly, creating firm basis for formation of the decision making skill.

On the primary stage, it is possible and necessary to establish the mentioned skills so that pupils can think over issues adequately, concentrate on important cognitive aspects at other lessons and,

generally, on the following stages of their education. Having analysed young children's attitude towards informational-communication technologies, we have found out that they spend a lot of time at their computers, that there is a kind of "dependency" and all this has a superficial, subconscious, non-systematic character, which creates psychological, emotional, speech problems.

Thorough investigation revealed that pre-school and primary students have interest and psychological readiness towards technological education. It is important to give this process propedeutic direction relevant to a certain age group, which will support further development of the skills on the following stages and the process of independent decision making. This is what the subject – "**systemic engineering**" serves.

The conception of teaching "systemic engineering" is focused on teaching different subjects by using interesting, amusing and creative methods and their integrated usage. The subject is divided into four levels. Among teaching methods which are used at the lessons, we distinguish project-based teaching, which integrates different disciplines. The method is used at the very first level of teaching the subject. Carrying out practical tasks helps develop the skills and operational (algorithmic) thinking necessary for creation of programmed provision. We make a good use of the case study, inductive methods, methods of analysis and synthesis. Practical examples are followed by theory built by pupils, which is checked in relevance with scientific theories. With the help of their own experience, pupils makes decisions in order to solve a certain problem.

The teaching consists of four stages: establishing relation between subjects, constructing, reflecting and developing. Teaching the subject "Systemic engineering" showed that pupils develop the decision making skill necessary for establishing informational society. This skill will enable them to use them in any life situation.

LOCAL SOLUTION APPROXIMATION OF INFINITE STATIONARY SYSTEMS OF DIFFERENCE EQUATIONS

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The possibility of approximation by cubic splines on base of spline collocation method for bounded on real axes solutions of linear differential equations with unbounded operator coefficients is proved. The popularity of collocation method arises from several advantages which it has over common finite methods.

Properties of solutions of difference equation systems defining parameters of collocational spline are studied.

It is shown that approximation order of bounded solution to differential equation coincides with the approximation order with interpolation splines.

For solutions of infinite system difference equations

$$U_{k+1} - 2AU_k + U_{k-1} = f_k,$$

where $k \in \mathbb{Z}$,

f_k – given sequence of vectors with R^n ,

U_k – unknown system of vectors,

A – square matrix,

classes of uniqueness are described, and formula of local approximation is constructed.

These formulas are obtained by unification creation method of local splines for minimal defect under certain circumstances on matrix A and f_k vector sequence.

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DISSIPATIVITY OF DISCRETE PROCEDURE WITH MARKOV SWITCHING

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Considering the discrete stochastic approximation procedure $u_n^\varepsilon = u^\varepsilon(\tau_n), n \geq 1$ in Euclidean space R^d , which is defined as follows [1]

$$u_{n+1}^\varepsilon - u_n^\varepsilon = \varepsilon C^\varepsilon(u_n^\varepsilon, x_n^\varepsilon), n \geq 0,$$

where sequence of points $u_n^\varepsilon \in R^d$, for which the convergence almost everywhere for sufficiently small $\varepsilon > 0$ holds $\lim_{n \rightarrow \infty} u_n^\varepsilon = u_0$.

The regression function

$$C^\varepsilon(u, x) = C_0(u, x) + \varepsilon^{-1}C(u, x),$$

where $x \in X$ – states of external environment.

Change of x is determined by the ergodic Markov chain $x_n, n \geq 0$, with transition probabilities

$$P(x, B) = P\{x_{n+1} \in B \mid x_n = x\}, x \in X, B \in \mathcal{X},$$

where $\varepsilon > 0$ – small series parameter, $(X, \mathcal{X})$ – phase space of states of Markov process $x(t), t \geq 0$.

Definition. Random evolution with Markov switching is called asymptotic dissipative if the corresponding limited evolution is dissipative [2].

The task is to establish the convergence of the initial process to the limited one, which is a diffusion process and verify the dissipativity property of the limited process. In particular, obtaining the conditions of boundedness of the norm of the limited diffusion and the shift based on the properties of the Lyapunov function of a determined system [3].

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**ON CONSTRUCTION OF GENERALIZED VORONOI
DIAGRAMS WITH FUZZY PARAMETERS
BASED ON THE THEORY OF OPTIMAL SET PARTITIONING
AND NEURO-FUZZY TECHNOLOGIES**

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We consider the additively weighted Voronoi diagram of a finite set $M = \{\tau_1, \tau_2, \dots, \tau_N\} \subset E_n$:

$$AW \text{ Vor}(M) = \bigcup_{\tau_i \in M} AW \text{ Vor}(\tau_i),$$

$AW \text{ Vor}(\tau_i) = \{x \in E_n : c(x, \tau_i) - w_i \leq c(x, \tau_j) - w_j, j = \overline{1, N}, j \neq i\}$, (1)
 $i = 1, 2, \dots, N$, where each generator point $\tau_i \in M$ has weight $w_i > 0$ ($i = 1, 2, \dots, N$) added to the function $c(x, \tau_i)$ specifying metrics in E_n .

In papers [1], a universal approach is proposed for constructing a Voronoi diagram and its various generalizations, which is based on the formulation of the associated continuous problem of optimal partitioning of the set from n -dimensional Euclidean space E_n to disjoint subsets with a partitioning quality criterion providing the appropriate form of the Voronoi diagram for case of clear parameters w_i , $i = 1, 2, \dots, N$ from (1).

In this paper, for the case when the parameters may be fuzzy, inaccurate, unreliable, we propose to apply neuro-fuzzy technologies to remove uncertainty [2].

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COMPUTER-INTEGRATED CONTROL SYSTEM OF QUALITY OF SYNCHOSIGNALS SMART&MICROGRID ELECTRICAL SYSTEMS

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During the functioning intelligent power grids, there are problems managing operating modes, stability, automation and etc. that are directly related to the monitoring of equipment parameters in real-time. According to the international standards MEK 61850-9, 24/7 monitoring of the stability of electrical system parameters using SMART Grid technology must be performed in real time with 10^{-6} s precision.

Taking into account previous paragraph, is being need to carried out relevant research in order to improve the quality and reliability of synchsignals formation in the geographically distributed SMART&Microgrid Electrical Systems objects.

The computer-integrated system for monitoring the quality of synchsignals in the structure of managing the processes of technical operation of the synchronization equipment provides measurement, transmission and storage of data. It provides decision making based on the results of statistical processing of the received data of measurements of the current values of the parameters of synchsignals. As a measuring device, was used multichannel control device MCD "TIMETER". One of the new our decisions in quality control is the method of systematic analysis of parameters of synchsignals, measured simultaneously on the scale of the whole network.

It is established that for the control of synchronous signals on objects of intelligent electric power systems it is expedient to use the signals of the national time scale, which are formed by standard protocol and

transmitted using digital communications, for example IP networks, or using other digital channels. This approach will create the conditions for diversifying the synchsignals provision and reducing the number of failure and like a result increasing energy efficiency of SMART&Microgrid Electrical Systems.

ENSEMBLES FOR CLASSIFICATION BASED ON THEIR AGGREGATION RESULTS

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The report considers and analyzes the principles of the formation and application of classifiers' ensembles. Particular attention is paid to the application of the basic foundations of the ensembles creation. The advantages of using the approaches of classifier aggregation solutions are considered. An analysis of the principles a data redistribution with the extended ensemble made it possible to formulate requirements for the classifiers of the ensemble. On the basis of what was found the conditions for selecting classifiers and criteria for their adequacy. On the basis of the sufficiency criteria, the applicability conditions for the principle of aggregation for boundary sets were established. An analysis of the ambiguity of decision making for symmetric sets of classifiers is carried out. The conditions for forming a set of classifiers and the criteria for its adequacy for solving the recognition problem are determined. It is established that further expansion of the set of classifiers beyond the sufficiency criterion brings classification errors to the set of correct solutions of all classifiers. The extension of the classifier set allows us to form a set of connections that is a Pascal triangle and to analyze the marginal redistribution of data in the process of increasing the ensemble.

The conducted researches in the direction of forming the set of ensembles of classification allowed to reveal approaches that allow to determine the effect on data redistribution as a result of the expansion of the set. It is established that the expansion of the set of ensembles of classifiers forms a set of sets of combinations of model decisions and leads to the redistribution of data of neighbouring sets of combinations. This made it possible to obtain and to test the results practically [1].

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GENERAL REGULARIZATION SCHEME IN SUPERVISED LEARNING

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In supervised learning training data are given as a sequence of examples of $x = x_1, x_2, \dots, x_n \in X$ and corresponding values $y_1, y_2, \dots, y_n \in Y$ of dependent variable y . Having some loss function L the task is to synthesize a function $y = f(x)$ minimizing the expected risk $\varepsilon(f) = \int_{X \times Y} L(f(x), y) d\rho(x, y)$, i.e. for the least squares loss function $L(f(x), y) = (f(x) - y)^2$ the target function is $f_\rho(x) = \int y d\rho(y|x)$.

The ideal estimator $f_\rho(x)$ can not be found in practice, because the conditional probability distribution $\rho(y|x)$ is unknown. Therefore, the goal is to find f minimizing the excess risk $\varepsilon(f) - \varepsilon(f_\rho)$ over some hypothesis space, using empirical version with sampling operator. For a widely used choice of the hypothesis space as a Reproducing Kernel Hilbert Space (RKHS), this leads to an ill-posed linear integral operator equation of the first kind in the chosen RKHS. General regularization scheme allows considering variety of methods for solving linear ill-posed problems, such as regularized least-squares (Tikhonov scheme), Landweber iteration and other, $f_{(X \times Y)}^\lambda = g_\lambda(T_X)S_X' y$, where $\{g_\lambda\}$ is a family of operator functions with regularization parameter λ .

In this setting, we derive the corresponding error estimates for various regularization and loss functions, we estimate upper bounds for

approximation errors and learning rates, discuss strategy for regularization parameter choice.

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OPTIMAL TWO-STAGE LINEAR DISCRIMINATION OF INFORMATION

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The matrix structure of representation of sets of signs vectors in the corresponding Euclidean space is considered, which describes the objects under investigation in solving various applications of digital information processing, which causes a wide range of possibilities for development of the concept of pseudo-inversion of matrices for the creation of mathematical methods for clustering and classification of information [1]. The use of elementary linear structures - hyperplanes - with simple relations for distances between vectors and hyperplanes, between sets of vectors and hyperplanes in the spaces of signs, in conjunction with the results of the perturbation theory of pseudo-inverse projective matrices, provides not only the construction of effective algorithms for solving problems, but also the possibilities of their optimization within the framework of their specific statements. The work of [2] relates the variant of hyperplane clusterization, in which the description of hyperplanes is carried out through hyperplanes, which are solutions (pseudo solutions) of systems of linear algebraic equations (in this case, there is a problem of finding the optimal elements of such systems of linear algebraic equations - the main matrix, the vector of the right-hand sides, for which the algorithms of their calculation are presented).

The analysis of algorithms for solving problems of classification, clustering, suggests that problems that arise in connection with such tasks are often associated with the need to consider a significant number of classes (clusters). Different approaches to the implementation of appropriate discrimination are developed, they have certain advantages in the implementation, minimize the influence of negative factors. The

authors used to use algorithms for separating two classes in the space of signs vectors by hyperplane using the tools of pseudo-inversion in combination with clustering algorithms (for example, k-means), which made it possible to construct algorithms in which the classification rate by the dichotomous classification tree gives advantages, despite some instability, which can be corrected by linear discrimination. The effectiveness of such a combination is confirmed by classical examples of cases such as the task of speech recognition, or the task of image recognition. In the first case, the speech signal - word - is represented by a matrix whose image is called a spectrogram. In the second case, a raster image, which itself is a matrix. The use of advantages and reduction of the influence of negative properties of dichotomous classification is proposed to realize by dividing the classification procedure into two stages. In the first one it is proposed to apply a dichotomy to a set of reference elements. For language use, this means that dichotomy is applied to words pronounced under special conditions: in the absence of noise, by a qualified speaker, etc. It is for such a specially formed set of words, the construction of a dichotomous classification tree is carried out. In the process of constructing a dichotomous tree of classification remains opened the question of the sequence of forming the vertices of a tree. In the report it is proposes for all classes information to construct an optimal linear two-dimensional cluster-hyperplane in which to implement 2-means clustering, which will allow obtaining an approximate image of the location of class projections, and, accordingly, the algorithm for forming the vertices of a tree. Taking into account class distances from the optimal linear two-dimensional cluster, a second link of the cluster is formed if necessary.

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JUSTIFICATION OF THE DECISION MAKING ON THE FINANCING OF EDUCATION IN UKRAINE

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The functions of the management decisions making on the financing of education are provided both by the state (because the most universities are state-owned in Ukraine) and by the higher education institutions (HEI) themselves.

The process of forming of management decision on the forms, types and volumes of education funding should include the following stages:

1. Analysis of competitive positions of the HEI at the market of educational services. Currently, an increasing number of students prefer to study abroad but not in the Ukrainian HEI. Among Ukrainians is especially popular education in Poland. Thus, in this case, the financing of the activities of the Ukrainian HEI should be aimed at creating in these institutions such favourable conditions for learning (for example, the creation of laboratories, multimedia lecture halls, availability of libraries that have an electronic version of their funds, training in foreign languages, etc.), which would reduce the outflow of students and provide the Ukrainian HEI with the necessary contingent.

2. The pricing of educational services should take into account the influence of internal and external factors.

The internal factors include: the qualification level of the teaching staff, the material and technical base of the HEI, the cooperation of the HEI with existing enterprises of the country and with the HEI abroad.

The external factors include: the level of economic development, political stability and cultural traditions of education.

3. Assessment of the dynamics of the trajectory of education development, as well as the determination of the optimal way of its development.

Education funding will vary depending on the results of this assessment. So, if the HEI prepares specialists that are currently in demand in the national economy, then this HEI can rely both on funding from the state and on attracting investments from potential employers.

Sequential passing of these listed stages of the decision making process on financing will contribute to the increase in the efficiency of the activities of the domestic HEI.

ANALYSIS OF THE INFLUENCE OF SOCIO-ECONOMIC STATUS ON POPULATION HEART DISEASES

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Today, in the field of application of the latest information technologies in medicine, there is a transition from medical information retrieval systems to intelligent decision support systems with a developed mathematical tools. Such systems are able to monitor the main diagnostic indicators, to form a computer diagnosis, to control the medical process.

More specifically, the following problem is considered in the work. For a certain region of Ukraine, which is divided into districts, for the 22,000 inhabitants it is known that there are 400 quantitative indicators of the heart. On the other hand, for every district of the region, there are about hundreds of indicators characterizing the socio-economic status of each district of the region. It is necessary to follow these statistical data to monitor the impact of existing socio-economic indicators on the development of cardiac pathologies in the population.

Due to the multidimensionality of the problem to its solution is proposed to apply the methods of multidimensional statistical analysis (factor and regression analysis, classification methods), as well as the original procedures for processing multidimensional arrays of statistical data developed by the authors.

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MODELING OF SYSTEM CHARACTERISTICS DYNAMICS FOR THE SUPPORT INVESTMENT DECISION-MAKING IN FINANCIAL MARKETS

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Financial markets are complex dynamic systems, which are affected by many external and internal factors. The main task of an investor is to make effective economic decisions with their consideration. Given the large number of alternative markets, which have become available to the investor in recent years, the question of building an automated data mining system for the support investment decision-making is very relevant.

The set of alternatives are decisions, that differ by object (financial market segment, investment instrument) and the term of investment. The determinants for choosing and making decisions by the investor are obviously income and the level of the risk associated with obtaining it. Therefore, a comparative analysis of the predicted values of these indicators on certain horizons is a key task of the decision support system (DSS) in financial markets.

This paper presents the concept of DSS developed by the authors that allows us to rank financial instruments in terms of investment attractiveness. The research results application of prices and profitability dynamics of financial instruments by means of statistical and complex fractal analysis, the construction of the set of the system characteristics dynamics (inertia, local stability, local variability and uncertainty [2]), and also the choice of the relevant forecasting method to the market dynamics (efficient, fractal, coherent market [1]), formed the basis of the built decision support system based on the fuzzy output model.

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**BASIC CRITERIA FOR THE PROGRAM MANAGEMENT
SYSTEM CREATION OF UNMANNED AIRCRAFTS
IN THE GEORGIAN AIRSPACE**

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In the airspace of Georgia today there are various manufacturers of unmanned aircraft (UAV -unmanned aircraft vehicle), which have internal software installed on the Linux base. The software is fitted to a remote managing device or mobile application created by this manufacturer.

The use of unmanned aircraft is very demanding: for entertainment, for professional activities (tourism, broadcasting of sporting events, postal mailings, primary aid, road inspection, fire-fighting and so on), for military purpose. The number of users is quite large. The number of consumer-users will increase and will be added at the expense of the technical evolution.

Due to such strong demand, it is crucial to make a decision about the unmanned aircrafts' Program Management System creation (unmanned aircraft systems - UAS), which will bring together all unmanned aircraft users and will monitor their coordination.

The unified system of program management provides: humans physical security, reduction of the risk of personal information; safety of the protected areas (penitentiary institutions, monuments, state reserves, national parks, etc.); safety of civil and military flights. The authorization of unmanned aircrafts is extremely important because from the users' side, it will simplify the management of unmanned aircraft and minimize possible risks.

The main problem for the creation of the unmanned aircrafts Program Management System is in designing programming and network infrastructure, whose main principle will be to register and monitor all unmanned aircraft in Georgia's airspace. The aircraft's registration allows us to identify its owner. At the same time it is important to launch a local program code for every aircraft's software. The code

integration in the management system allows us to have remote access to any registered unmanned aircraft.

The content of the remote access is that the DUAL (Diffusing Update Algorithm) algorithm will be activated from code activation, which includes sending a message to the server periodically. The message should contain all the desired information (such as the coordinates of the aircraft, altitude, etc.).

The information received by the program server will be processed and reflected on available records. The Air Traffic Controller can access this information and display it on their monitor.

One of the main problems in the creation of the unmanned aircrafts' management system is determining effective network connection between the aircraft and the management center. In my opinion, LTE (Long-Term Evolution) should be used for given communication. The availability of communication services in Georgia is carried out by telecommunication providers – Magti, Geocell, Beeline and others. We should partner with these corporate entities so that we don't replicate existing technologies.

NASH'S EQUILIBRIUM IN A GAME WITH FUZZY SET OF PLAYERS

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This report considers the game G in the normal form $(X_i, u_i; i \in N)$, where $N = \{1, 2, \dots, n\}$ is a set of n players, $n \geq 2$; X_i is a set of i -th player strategies; $u_i(x)$ is the winning function of the player $i \in N$, which is defined in a set of game situations $X = \prod_{i \in N} X_i$. $u_i(x)$ takes integer values and maximized. A generalization of the Nash's equilibrium is considered in this game in the case of fuzzy set $\tilde{N}$ of players with membership function $\eta(i)$, $i \in N$. Let

$$BR_i = \{(\hat{x}_i, \hat{x}_{N \setminus i}) \mid u_i(\hat{x}_i, \hat{x}_{N \setminus i}) = \max_{x_i \in X_i} u_i(\hat{x}_i, \hat{x}_{N \setminus i}), \forall \hat{x}_{N \setminus i} \in X_{N \setminus i}\}$$

is the set of best reactions of i -th player on given strategies of all other players. Then

$$FNE = \bigcap_{(i,\eta) \in \tilde{N}} BR_i$$

is the set of "fuzzy" Nash's equilibrium, where $\bigcap_{(i,\eta) \in \tilde{N}} BR_i$ is the intersection [1] of the fuzzy set $\tilde{N}$ of crisp sets BR_i , $i \in N$. This is a type-2 fuzzy set (fuzzy set which membership function takes fuzzy values). It is shown a type-2 fuzzy set is the set of corresponding fuzzy equilibrium. Its membership function is constructed. A two-criterion problem for finding the carrier of fuzzy equilibrium sets is proposed. The degree of membership to the fuzzy set of equilibrium is maximized and the degree of non-membership is minimized in this problem. They are dual characteristics of a type-2 fuzzy set of Nash's equilibrium. The one approach to finding an effective solution to this problem is considered.

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THE CORE OF A GAME WITH A FUZZY SET OF COALITIONS

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Cooperative game theory solves the problem of “fair” distribution of profits among all players that are in cooperation between each other. In case when each group of players has the opportunity to cooperate, a co-op game with a limited co-operation appears.

Let's consider a co-op game in the characteristic form $\langle N, v \rangle$, where $N = \{1, \dots, n\}$ – is the set of $n \geq 2$ players, and $v: 2^N \rightarrow R^1$ is the characteristic function that for each coalition matches its guaranteed gain. Let's assume that players cannot clearly say what coalitions from the set $\Omega = 2^N \setminus N$ of all possible coalitions can be feasible, and only a membership function $\mu(S)$, $S \in \Omega$ of a fuzzy set $\tilde{\Omega} \subseteq \Omega$ is known to them.

In the report the C-core of a co-op game with a fuzzy set of feasible coalitions is being considered. Let's generalize the classical concept of

C-core for this case and then we will have the following problem that can be formulated as follows:

$$\sum_{i \in N} x_i = v(N), \sum_{i \in S} x_i \geq v(S), S \in \tilde{\Omega}, \quad (1)$$

where note (1) means following: if

$$F_S = \{x = (x_1, \dots, x_n) \mid \sum_{i \in N} x_i = v(N), \sum_{i \in S} x_i \geq v(S)\}$$

is the set of x vectors that are satisfying the condition of non-separation of the coalition $S \in \Omega$ then note (1) should mean that a set of feasible solutions of system (1) must be given as $\tilde{F} = \bigcap_{S \in \tilde{\Omega}} F_S$ – the intersection [1] of a fuzzy set of crisp sets, which is a type-2 fuzzy set.

A two-criterion problem for finding a rational solution of system (1) and the approach to obtaining an approximate solution of this problem are proposed.

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DECISION-MAKING PRINCIPLE IN GEORGIA'S MENTAL HEALTH SYSTEM

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World Health Organization's (WHO) recommendations for mental health 2013-2020 call for transition from long-term psychiatric institutions to community-based psychiatric services. Cost efficiency of community based services doesn't differ much from costs of institutional care, but medical and social differences are stark. Nevertheless, funds spent on long-term psychiatric institution are 54% of mental health expenditure in high-income countries and 73% - in low and middle-income countries. In low and middle income countries, only 2% of health care budget is spent on mental health, while in developed European countries it's 8-12%. Consequently, of those who suffer from mental health illnesses, 76-85% do not receive adequate assistance in low and middle-income countries and 35-50% do not receive it in developed countries. Georgia, according to the World Bank's criteria, belongs to low income countries. The total expenditure on health is a

percentage of gross domestic product is 10.14% and the per capita government expenditure on health is \$73.0. In Georgia, neuropsychiatric disorders are estimated to contribute to 22.8% of the global burden of disease (WHO, 2008). After attaining independence Georgian mental health system stood in front of a challenge: to transfer the system that had relied on long-term psychiatric institutions for so long to community-based psychiatric services. Annual State Program for Mental Health has been functioning since 1995. Program's budget is \$7,894.737 and it includes following components: community outpatient services - \$2,094.248, psychosocial rehabilitation- \$29.248, children's mental health - \$56.767, psychiatric crisis intervention services for adults - \$248.985, community based mobile team services - \$290.977, inpatient psychiatric services - \$4,809,662, inpatient psychiatric services for children - \$131.579, care for disabled people with mental disorders - \$233.271. All program components are fully funded by the state. Program analysis shows that funds allocated to mental health by the state dynamically do have a tendency to increase, but the total amount of money intended for mental health component does not change significantly and is far behind European countries. Mental Health Development Strategy in Georgia is focused on balanced (inpatient and community-based) care, integration of medical and social services, and consistent harmonious development.

Therefore, there's a need to make a timely decision on creating modern innovative system that will facilitate improvement of mental health in Georgia.

In this regard, the report will discuss:

- ❖ Aspects of building information systems supporting decision making of mental health improvement measures;
- ❖ Tasks of creating unified system of indicative monitoring and decision-making policy.

GUARANTEED PREDICTIVE ESTIMATION FOR MODELS OF INFORMATION SPREADING PROCESS WITH THE GOMPERTZIAN DYNAMICS UNDER UNCERTAINTY

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Let there be a certain social community of L people, potentially subject N information flows. Functions $x_k(t, f(\cdot)), k = \overline{1, N}, t \in (0, T_1)$ are the time t -depended number of people who have accepted one of the information flows. Information is spread in the community along internal (interpersonal communication of the member of social community) and external threads (mass media).

Let us denote by $x_k(t, f(\cdot)), k = \overline{1, N}, t \in (0, T_1)$ the solutions of differential equations:

$$\begin{aligned} \dot{x}_k(t, f(\cdot)) = & \left[(B(t)f(t), e_k) + \sum_{i=1}^N (A(t)e^i, e^k) \ln x_i(t, f(\cdot)) \right] \times \\ & \times x_i(t, f(\cdot)), x_k(0, f(\cdot)) = x_k^0 \geq 0, k = \overline{1, N}, t \in (0, T_1), \end{aligned}$$

where $A(t) \in R^{N \times N}, B(t) \in R^{N \times m}, t \in (0, T_1)$ are the known matrix with continuous elements, $f(\cdot) \in R^m$ is the unknown function; $e^k, k = \overline{1, N}$ is the k -th unit vector.

The functions $x_k(t, f(\cdot)), k = \overline{1, N}, t \in (0, T_1)$ are observed with certain $f(t), t \in (0, T_1)$:

$$y_i(t) = x_i(t, f(\cdot)) + v_i(t), i = \overline{1, n_0}, n_0 \leq N, t \in (0, T), T \leq T_1,$$

where $v_i, i = \overline{1, n_0}, t \in (0, T)$ – the observed errors.

Let us denote $x(t, f(\cdot)) = (x_1(t, f(\cdot)), \dots, x_N(t, f(\cdot)))^*, t \in (0, T_1)$ and $v(t) = (v_1(t), \dots, v_{n_0}(t))^*, t \in (0, T)$, where $*$ is the designation of transpose.

We assume that $f(t), t \in (0, T_1)$ belong to bounded set $G \subseteq L_2(0, T_1)$; $v_i \in V, i = \overline{1, n_0}, t \in (0, T)$ are the continuous functions on the time-interval $[0, T]$, where

$$V = \{v(\cdot) : \bar{v}_i(t) \leq v_i(t) \leq \underline{v}_i(t), i = \overline{1, n_0}, t \in (0, T)\}$$

Here $\overline{v_i(t)}, \underline{v_i(t)}, i = \overline{1, n_0}, t \in (0, T)$ are known functions.

Let us denote:

$$F_y = \left\{ f(\cdot) : f(\cdot) \in G, \overline{v_i(t)} \leq y_i(t) - x_i(t, f(\cdot)) \leq \underline{v_i(t)}, i = \overline{1, n_0}, t \in (0, T) \right\},$$

$$X_y = \left\{ x(T_1, f(\cdot)) : x_k(T_1, f(\cdot)) \in Q_k, k = \overline{1, N} \right\},$$

where

$$\begin{aligned} Q_k &= \{ x_k(T_1, f(\cdot)) : \inf_{f \in F_y} x_k(T_1, f(\cdot)) \leq x_k(T_1, f_1(\cdot)) \leq \\ &\leq \sup_{f \in F_y} x_k(T_1, f(\cdot)), f_1(\cdot) \in F_y \}, k = \overline{1, N}. \end{aligned}$$

Definition 1. The *guaranteed predictive estimations of values* $x_k(T_1, f(\cdot)), k = \overline{1, N}$ are said $\hat{x}_k(T_1, f(\cdot)), k = \overline{1, N}$ which satisfies the condition:

$$\inf_{x(\cdot) \in X_y} \Phi(x) = \Phi(\hat{x}),$$

where

$$\Phi(x) = \sum_{k=1}^N \sup_{\overline{x_k(T_1, f(\cdot))} \in Q_k} |x_k(T_1, f(\cdot)) - \overline{x_k(T_1, f(\cdot))}| \beta_k.$$

Here $\beta_k \geq 0, k = \overline{1, N}$ are known values and $\sum_{k=1}^N \beta_k = 1$.

Definition 2. Value $\sigma = \Phi(\hat{x})$ is said *the error of guaranteed predictive estimations* $\hat{x}_k(T_1, f(\cdot)), k = \overline{1, N}$.

We apply the numeric algorithm of guaranteed predictive estimation of $x_k(T, f(\cdot)), k = \overline{1, N}$.

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DIDACTIC OBJECTIVES FOR DECISION-MAKING IN THE LEARNING PROCESS

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The ongoing reforms in the educational system require the determination of the didactic objectives for decision-making contributing to the learning process, modeling of non-standard tasks and the scientific research of its solutions. The modern didactic system is the theoretical and practical vector of education reform, which contributes to the optimization of learning process and increase of the education quality. The didactic system should include the modern methods and means for solving the standard and nonstandard tasks.

A large part of the tasks to be solved for the realization of the target function of the learning process is the non-standard tasks of decision-making. Each task is discussed in the area of the study that facilitates the learning process and has the local characteristics, such as: attitude to external factors; non-formalization; failure of some attributes, etc. All these suggest that the decision-making tasks are weakly structured, and some parts are hardly formalized. When solving such tasks, we get the several options for solutions, and each approach to the exact solution depends on the use of the method and the model.

The desired solution from the alternative ones is selected by a decision-maker (DM). Comparison and selection of solution alternatives is processed in the interactive regime.

The structural scheme of tasks and decision-making process is given on the Pic. 1.

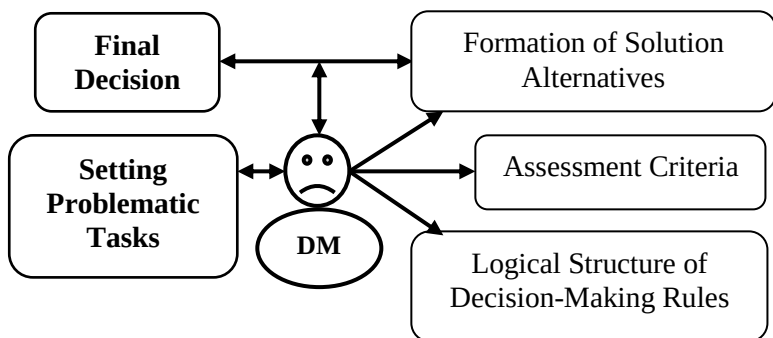


Fig. 1. Structural Scheme

As we can see, the problematic tasks are determined at the initial stage and the number of alternatives is formed based on their solutions, from where the final decision is made by the DM. For making the final decision from the alternatives, the base structure is necessary, which includes the methods of formation of the decision-making alternatives; assessment criteria; logical structure of decision-making rules. A set of alternatives of decision making is formed by considering the methods and means of study, the legislation of learning process management and the internal normative acts. There is some space on the methods of generating, assessing, and selecting the alternatives in the decision making model building process. DM makes the optimal decisions based on logical analysis of the alternatives. DM prefers the alternative that brings a better result. The logical structure of the decision-making rules is the mathematical apparatus of solution-making, or decision-making. It is consisted of the consistent chain of formulas and the rules of making the conclusion in mathematical logic.

SEQUENT CALCULI FOR LOGICS WITH COMPOSITION OF PREDICATE COMPLEMENT

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In this paper we study new program-oriented formalisms: logics of partial quasiary predicates with composition of predicate complement (LPC). Such logics are used in various variants of Floyd-Hoare logics with partial pre- and post-conditions [1–2]. The composition of predi-

cate complement permits to simplify constraints for program logics with partial predicates. We identify LPC of propositional (PLPC), renominative (RLPC), and first-order (QLPC) levels. The main attention is paid to PLPC; for such logics calculi of sequent type are constructed.

We consider partial single-valued predicates – P -predicates. Such a predicate $Q: {}^V A \rightarrow \{T, F\}$ can be defined [1] by two sets: T -domain $T(Q) = \{d \mid Q(d) = T\}$ and F -domain $F(Q) = \{d \mid Q(d) = F\}$. We have that $T(Q) \cap F(Q) = \emptyset$. *Undefinedness-domain* is defined by formula $\perp(Q) = \{d \mid Q(d) \uparrow\}$. In this case $\perp(Q) = \overline{T(Q) \cup F(Q)} = \perp(\neg Q)$.

Propositional compositions (logical connectives) $\neg$ and $\vee$ can be defined using T - and F -domains of corresponding predicates:

$$T(\neg P) = F(P), \quad F(\neg P) = T(P);$$

$$T(P \vee Q) = T(P) \cup T(Q), \quad F(P \vee Q) = F(P) \cap F(Q).$$

Then $\perp(P \vee Q) = (\perp(P) \cap \perp(Q)) \cup (\perp(P) \cap F(Q)) \cup (\perp(Q) \cap F(P))$.

We define a unary composition of predicate complement $\sim$ as

$$(\sim P)(d) = \begin{cases} T, & \text{if } P(d) \uparrow, \\ \text{undefined}, & \text{if } P(d) \downarrow \end{cases}$$

This definition of $\sim$ can be rewritten using T - and F -domains of a corresponding predicate: $T(\sim P) = \perp(P) = \overline{T(P) \cup F(P)}$, $F(\sim P) = \emptyset$.

Then $\perp(\sim P) = T(P) \cup F(P)$.

The composition $\sim$ is a nonmonotonic operation on the set of predicates. The properties of $\sim$: $\sim \neg P = \sim P$; $\sim \sim P = P \vee \neg P$; $\sim \sim \sim P = \sim P$.

Let us describe the language of PLPC. An alphabet: a set V of variables, a set Ps of predicate symbols, a set $C_{PLP} = \{\neg, \vee, \sim\}$ of symbols of basic compositions. We define the set Fr of formulas. First, we say that $Ps \subseteq Fr$, then we use induction: $\Phi, \Psi \in Fr \Rightarrow \neg \Phi, \Phi \vee \Psi, \sim \Phi \in Fr$.

The language is interpreted on composition systems $({}^V A, \text{Pr}, C_{PLP})$. A total single-valued mapping $I: Ps \rightarrow \text{Pr}$ of predicate symbol interpretation is extended to formula interpretation mapping $I: Fr \rightarrow \text{Pr}$: $I(\neg \Phi) = \neg I(\Phi)$, $I(\Phi \vee \Psi) = I(\Phi) \vee I(\Psi)$, $I(\sim \Phi) = \sim I(\Phi)$.

Let $J = (A, I)$ be an interpretation, then predicate $J(\Phi)$ is denoted Φ_J .

We define a relation of logical consequence with undefinedness conditions on sets of formulas of PLPC. Let $\Gamma, U, \Delta \subseteq Fr$. Denote

$$\bigcap_{\Phi \in \Gamma} T(\Phi_J) \text{ as } T^\wedge(\Gamma_J), \quad \bigcap_{\theta \in U} \perp(\theta_J) \text{ as } \perp^\wedge(U_J), \quad \text{and } \bigcap_{\Psi \in \Delta} F(\Psi_J) \text{ as } F^\wedge(\Delta_J).$$

Then Δ is a consequence of Γ with undefinedness conditions U in interpretation J (denoted $\Gamma \models^U \Delta$), if $T^\wedge(\Gamma_J) \cap \perp^\wedge(U_J) \cap F^\wedge(\Delta_J) = \emptyset$.

Δ is a logical consequence of Γ with undefinedness conditions U (denoted $\Gamma \models^U \Delta$), if $\Gamma \models^U \Delta$ for every interpretation J .

The following decomposition properties hold for $\models^U$:

$$\neg_L) \neg\Phi, \Gamma \models^U \Delta \Leftrightarrow \Gamma \models^U \Delta, \Phi; \quad \neg_R) \Gamma \models^U \Delta, \neg\Phi \Leftrightarrow \Phi, \Gamma \models^U \Delta;$$

$$\neg_U) \Gamma \models^{U, \neg\theta} \Delta \Leftrightarrow \Gamma \models^{U, \theta} \Delta.$$

$$\vee_L) \Phi \vee \Psi, \Gamma \models^U \Delta \Leftrightarrow \Phi, \Gamma \models^U \Delta \text{ and } \Psi, \Gamma \models^U \Delta;$$

$$\vee_R) \Gamma \models^U \Delta, \Phi \vee \Psi \Leftrightarrow \Gamma \models^U \Delta, \Phi, \Psi;$$

$$\vee_U) \Gamma \models^{U, \Phi \vee \theta} \Delta \Leftrightarrow \Gamma \models^{U, \Phi, \theta} \Delta \text{ and } \Gamma \models^{U, \theta} \Phi, \Delta \text{ and } \Gamma \models^{U, \Phi} \theta, \Delta.$$

For PLPC calculi of sequent type (PPC-calculi) are constructed.

Sequents are sets of formulas decorated with symbols $\vdash$, $\neg\vdash$ and $\perp$.

Sequents are denoted as $\vdash\Gamma \perp U \neg\vdash\Delta$, in short notation as Σ .

Sequent $\vdash\Gamma \perp U \neg\vdash\Delta$ is *closed* if the following condition holds:

$C_\perp$) exists Φ : $\Phi \in \Gamma$ and $\Phi \in \Delta$ or $\Phi \in \Gamma$ and $\Phi \in U$ or $\Phi \in \Delta$ and $\Phi \in U$.

If sequent $\vdash\Gamma \perp U \neg\vdash\Delta$ is closed then $\Gamma \models^U \Delta$.

The following *sequent forms* are inference rules of PPC-calculi:

$$\begin{array}{l} \vdash\neg \frac{\neg\Phi, \Sigma}{\vdash\neg\Phi, \Sigma}; \quad \neg\vdash \frac{\vdash\Phi, \Sigma}{\neg\vdash\Phi, \Sigma}; \quad \perp\neg \frac{\perp\Phi, \Sigma}{\perp\neg\Phi, \Sigma}; \\ \vdash\vee \frac{\vdash\Phi, \Sigma \quad \vdash\Psi, \Sigma}{\vdash\Phi \vee \Psi, \Sigma}; \quad \neg\vee \frac{\neg\Phi, \neg\Psi, \Sigma}{\neg\Phi \vee \Psi, \Sigma}; \quad \perp\vee \frac{\perp\Phi, \perp\theta, \Sigma \quad \perp\Phi, \neg\theta, \Sigma \quad \neg\Phi, \perp\theta, \Sigma}{\perp\Phi \vee \theta, \Sigma}. \end{array}$$

For PPC-calculus the soundness and completeness theorem holds.

Theorem. Sequent $\vdash\Gamma \perp U \neg\vdash\Delta$ is provable iff $\Gamma \models^U \Delta$.

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STRATEGY OF COMPLEX ECONOMIC SYSTEMS DEVELOPMENT

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The urgency of research direction is to identify new trends, strategic scientific directions, technological achievements, etc., which in the short or long term will have a significant impact on economic, social, and technical development in the future. To solve those tasks, it is expedient to create and intensively develop modern concepts, models, and approaches for combining the methodologies of foresight and cognitive modeling in order to determine the economic perspectives of scientific and technical systems and ways to implement them. Foresee of the future is especially necessary for the reasonable economic and state activities. Here we propose to use these methodologies together as follows: at the first stage, apply the methodology of foresight and use the results as input data in the second stage - for fuzzy cognitive modelling. Such synthesis of methodologies allows to propose a scientifically grounded strategy for implementing of scenario for priority alternative of the various complex systems .

The completion of cognitive modelling should be the choice of the desired scenario for the development of the system, the development and justification of management decisions are aimed at implementing the desired scenario, preventing the consequences of unwanted scenarios [1].

The possibilities of cognitive modelling of complex systems by examples of the interaction of systems A, B, C and the system of interregional economic exchange of two regions A and B are considered. Interaction on certain rules of complex systems can be represented by a general model, for example, for three systems A, B and C

$$IGG_{ABC} = \{I_{GA}, I_{GB}, I_{GC}, R\}$$

Here R is rules for the interaction of hierarchies I_{GA} , I_{GB} and I_{GC} . Scenario of interregional economic exchange of two regions A and B is created.

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SIMULATION AND ANALYSIS OF THE MAGNETIC FIELD DISTRIBUTION IN A MAGNETICALLY HARD LAYER

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Consider an electrically conductive layer of magnetically hard material of thickness l . The layer is under the influence of an external magnetic field, when a *tangential* component of the magnetic field $Z = 0; Z = 1$ strength is given on both surfaces

$$H_y(0;t) = H_y(1;t) = H_0 + H_1 \cos \omega t, \quad (1)$$

where, $\omega = 2\pi\nu$, ν - frequency, H_0 and H_1 - respectively, has become the component and amplitude of the harmonic component of the magnetic field strength.

From the equations of electrodynamics for the layer region we obtain the equation [1]:

$$\frac{\partial^2 H}{\partial z^2} = \lambda t^2 \frac{\partial B}{\partial t}, \quad (2)$$

which connects the components of the magnetic field strength $H_y \equiv H(z;t)$ and magnetic induction $B_y \equiv B(z;t)$.

For magnetically hard materials, the relationship between the induction B and the intensity H of the magnetic field is the form of a dynamic loop of hysteresis, the analytical form of which has the form:

$$B = \beta \cdot \arctg(\alpha H), \quad H = \sqrt{1 - \chi^2} H - \chi \omega^{-1} \dot{H}. \quad (3)$$

Here $\beta = 2B_S / \pi$, $\alpha = \pi(\mu - 1)\mu_0 / (2B_S)$, $\chi = H_c / H_m$, with $H < H_m$ and $\chi = H_c / H_0$ with $H > H_m$; H_0 and H_m - the intensity of the magnetic field on the surface of the body and the corresponding hysteresis saturation; H_c - coercive force, B_S - saturation induction, μ - initial relative magnetic permeability of the medium, μ_0 - magnetic static, λ - electrical conductivity. A point over a quantity means a partial derivative with respect to time.

We look for the solution of problem (1) - (3) in two ways: in the form of a series in a small parameter $\varepsilon_* = H_1/H_0$ ($H_1 < H_0$), and also using bilateral calculation formulas [2].

Analysis of solutions. Consider a layer of magnetically hard material. The most characteristic representative of such a material with a large value of the coercive force, which is used to record information, is the alloy K25X30M3, whose characteristics are as follows:

$$H_c = 62,4 \cdot 10^3 \text{ A/m}, \quad H_m = 62,93 \cdot 10^3 \text{ A/m}, \\ B_s = 1,16 \text{ T}, \quad B_r = 1,15 \text{ T}, \quad \mu_i = 14,67.$$

In this case, we assume $\varepsilon_* = 0,1$, and the thickness of the layer is taken

$l = 2 \cdot 10^{-6} \text{ m}$, since this alloy is made in the form of thin sheets of precisely this thickness. Note that in this case, for the given material characteristics, the relative penetration depth of the magnetic field γ (for nonmagnetic materials) does not exceed unity ($\gamma < 1$) even for frequencies of smaller ones, which are considered in this paper. For magnetic materials, the penetration depth is proportional. Since $\mu_\varepsilon \leq \mu = 14,67$, then $\gamma_\varepsilon < \sqrt{\mu_\varepsilon} \cong 3,83$.

From the calculations and analysis of the results it follows that it is essential to take into account the influence of the coercive force on the distribution of intensity and the induction of the magnetic field in magnetically solid bodies that are under conditions of simultaneous action of a harmonious in time and constant magnetic fields. The depth of magnetic field penetration in magnetically hard materials increases by a factor of $(\sqrt{1+\chi})$ compared to magnetically soft materials, that is, the distribution of the amplitudes of the first harmonic of the voltage and the induction of the magnetic field has a more near-surface character.

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ON THE PROBLEM OF QUALITY OF SERVICE IMPROVEMENT IN RETRIAL QUEUES

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In modern communication systems the Quality of Service (QoS) experienced by customers is a crucial factor that determines the system performance. QoS is a measurement of the overall system performance. To quantitatively measure quality of service, several integral characteristics of the system are often considered such as average waiting time, average queue length, probability of request reject, etc. Most of this characteristics are defined by stationary probabilities of the system. So to measure QoS and (which is more important problem) to improve it one should be able to calculate steady state distribution of the system through its parameters.

In this paper we consider bivariate Markov process $\{X(t), t \geq 0\}$ whose state space is a lattice semistrip $S(X) = \{0, 1, \dots, c\} \times Z^+$. The process $\{X(t), t \geq 0\}$ describes the service process of a multi-server retrial queue in which the input flow rate depends on the number of sources of repeated calls in the system. Number of busy servers are defined by the first component of $\{X(t), t \geq 0\}$, number of sources of repeated calls - by the second.

Explicit representations of a vector-matrix type were obtained for stationary probabilities of the process $\{X(t), t \geq 0\}$. These results allows to calculate main performance measures, that define quality of service through the parameters of the system.

As an application of the obtained results we state and give the algorithm of solution of a multicriteria problem of QoS maximization.

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ON THE MODELLING OF INPUT SIGNAL ON THE LINEAR SYSTEM TAKING INTO ACCOUNT THE OUTPUT SIGNAL

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We consider a Gaussian stochastic processes with discrete spectrum. These processes are supposed to be as input processes to a time-invariant linear system with real-valued square integrable impulse response function. The response on the system is an output process. The model which approximates the process with given accuracy and reliability in Banach space $C([0,1])$ is constructed taking into account the response of the system. For these purposes the methods and properties of Square-Gaussian processes are used.

A stochastic process with discrete spectrum can be written in this way

$$X(t) = \sum_{k=0}^{\infty} b_k (\xi_k \cos \lambda_k t + \eta_k \sin \lambda_k t),$$

where ξ_k, η_k are independent zero-mean random variables,

$$E\xi_k = E\eta_k = E\xi_k \eta_l = 0 \text{ and } E\xi_k \xi_l = E\eta_k \eta_l = \delta_k^l, k \geq 0, l \geq 0.$$

If random variables ξ_k, η_k are Gaussian then the random process $X(t)$ will be also Gaussian. We consider a Gaussian stochastic process with discrete spectrum.

Consider a time-invariant linear system with a real-valued square integrable impulse response function $H(\tau)$ which is defined on a finite domain $\tau \in [0, T]$. This means that the response of the system to an input signal $X(t)$ which is observed on $[-T, T]$ has the following form

$$Y(t) = \int_0^T H(\tau) X(t-\tau) d\tau, \quad t \in [0, T]$$

and $H \in L_2([0, T])$.

Suppose that the impulse response function is known. The response of the system $Y(t)$ can be presented as $Y(t) = \sum_{k=0}^{\infty} (\xi_k \cdot c_k(t) + \eta_k \cdot s_k(t))$, where the functions $c_k(t), s_k(t)$ are equal to

$$c_k(t) = b_k \int_0^T H(\tau) \cos(\lambda_k(t-\tau)) d\tau, \quad s_k(t) = b_k \int_0^T H(\tau) \sin(\lambda_k(t-\tau)) d\tau, \quad t \in [0, T].$$

Definition 1. A random process $X_N(t)$ is called a model of the process $X(t)$ if

$$X_N(t) = \sum_{k=0}^N b_k (\xi_k \cos \lambda_k t + \eta_k \sin \lambda_k t).$$

If the model $X_N(t)$ is considered as an input signal of linear system then the output process is given in this way

$$Y_N(t) = \sum_{k=0}^N (\xi_k \cdot c_k(t) + \eta_k \cdot s_k(t)).$$

Under $\xi_N(t)$ we denote the sum of square of the differences $X(t) - X_N(t)$ and $Y(t) - Y_N(t)$ $\xi_N(t) = (X(t) - X_N(t))^2 + (Y(t) - Y_N(t))^2$.

Definition 2. We say that the model $X_N(t)$ approximates a stochastic process $X(t)$ taking into account the response of the system with given reliability $1-v$, $v \in (0, 1)$, and accuracy $\delta > 0$ in the space $C([0, T])$, if

$$P \left\{ \sup_{t \in [0, T]} |\xi_N(t) - E\xi_N(t)| > \delta \right\} < v.$$

Consider such conditions:

- A)** There exists a constant $c > 0$ that dominates the impulse response function $H(\tau)$ on the domain $[0, T]$ $|H(\tau)| \leq c$.
- B)** The following integral is convergent $I_H = \int_0^T H^2(\tau) d\tau < \infty$.
- C)** The series $\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{2\alpha} < \infty$, $\alpha \in (0, 1]$.

Theorem. Assume that the conditions A, B and C are met. The model $X_N(t)$ approximates a Gaussian stochastic process with discrete spectrum $X(t)$ taking into account the response of the system (1) with given reliability $1-v$, $v \in (0, 1)$, and accuracy $\delta > 0$ in the space $C([0, T])$ if for N the inequalities

$$\max\{\delta_0(N), K(N) \cdot (T/2)^\alpha\} < \frac{\alpha\delta}{2\sqrt{2}}, \quad \alpha \in (0, 1],$$

$$4e^{\frac{3}{\alpha}} \exp \left\{ -\frac{\delta}{2\sqrt{2}\delta_0(N)} \right\} \times \left(\frac{\delta\alpha}{2\sqrt{2}\delta_0(N)} \right)^{2/\alpha} \left(1 + \frac{2\delta}{\sqrt{2}\delta_0(N)} \right)^{1/2} < \nu,$$

hold true where

$$\begin{aligned} (\delta_0(N))^2 &= (8 + 2T^2 \cdot I_H^2) \left(\sum_{k=N+1}^{\infty} b_k^2 \right)^2 + (64c^2 + 2 \cdot I_H^2) \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{-1} \right)^2 \\ &\quad + 4T \cdot I_H^2 \left(\sum_{k=N+1}^{\infty} b_k^2 \right) \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{-1} \right) \\ K(N) &= 2^{3-\alpha} \left[\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{2\alpha} \cdot \sum_{k=N+1}^{\infty} b_k^2 + \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{\alpha} \right)^2 + \right. \\ &\quad \left. 8c^2 \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{2\alpha-1} \cdot \sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{-1} + \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{\alpha-1} \right)^2 \right) + \right. \\ &\quad \left. 16c^4 \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{2\alpha-2} \cdot \sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{-2} + \left(\sum_{k=N+1}^{\infty} b_k^2 \lambda_k^{\alpha-2} \right)^2 \right) \right]^{1/2} \end{aligned}$$

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MONITORING OF HUMAN RESPIRATORY ORGANS

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In practice each doctor uses the method of reduction of some sounds and amplification of other sounds for valuation of biological objects performance. The major problem lays in differentiation and correct

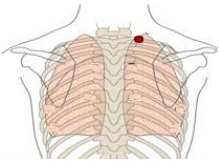
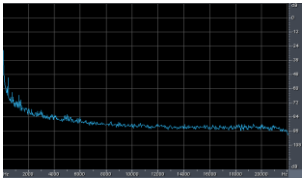
interpretation of sounds perceived by doctor caused by their poor audibility.

At present the methods for automation of diagnostics of respiratory organs with the help of computer software tools are being developed. Meanwhile there is a variety of ways of sensor allocation on human body. However, there is no general opinion around sensors allocation during multichannel data registration. Nevertheless the main requirement during their fitting is the ability to hear either vesicular (clear) or bronchial human breathing.

The aim of the work is the development of computer methods for processing and visualization of registered signals; detection of spectral time characteristics as a method for objectification of common auscultatory signs.

During multichannel data registration such places on human body in front and on back are usually used. Practically, respiratory noises are divided into two classes: respiratory noises of healthy patient; respiratory noises of patients with respiratory organs pathologies.

The registration and analysis of acoustic signals have been held with the help of software Adobe Audition. This software allows to either record and save big volume of audio files or make a multifunctional analysis of received data.

	
Fig. 1. Back sensor allocation scheme	Fig. 2. Experimental amplitude-frequency characteristic taken “on bone”

It is shown that prophylaxis monitoring of state of human respiratory organs can be held without loss of accuracy and faithfulness of the results by means of one acoustic sensor. It is rational to put sensor on back to the right on upper feather of the chest.

VECTOR PROBLEMS WITH LINEAR-FRACTIONAL FUNCTIONS OF CRITERIA AND LEXICOGRAPHICALLY PARETO'S OPTIMIZATION

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Lexicographical optimization can be applied to search optimal solutions of multicriteria optimization problems within any subordination in a certain set of criteria. Most often the problems of multicriteria with such hard order of criteria because of importance arise up at successive introduction of additional criteria to the scalar problems of optimization which can have the ununique solutions.

The optimization problem $P(F, X): \max^P \{F(x) | x \in X\}$ is regarded, where $F = (f_1, f_2, \dots, f_l)$, $f_i = f_i^1 / f_i^2$, $f_i^1 = \langle c^i, x \rangle$, $f_i^2 = \langle d^i, x \rangle$, $c^i, d^i \in R^n$, $i = 1, \dots, l$, $X = \{x \in R^n | Ax \leq b, x \geq 0\}$ – is a limited set, $A \in R^{m \times n}$, $b \in R^m$. Let $\bar{F} = (\bar{f}_1, \bar{f}_2, \dots, \bar{f}_l)$ – be an arranged aggregate of the vector functions $\bar{f}_i = (f_i^1, -f_i^2)$, $i = 1, \dots, l$, each of which is a vector convolution within the subordination of paired equal value. We will regard the problem $LP(\bar{F}, X): \max^{LP} \{\bar{F}(x) | x \in X\}$. Let $\tilde{X}(P)$ and $\tilde{X}(LP)$ be sets of optimal solutions of the problems $P(F, X)$ and $LP(\bar{F}, X)$ correspondingly, which are the extremes of set X .

Theorem 1. $\tilde{X}(P) \neq \emptyset$, $\tilde{X}(LP) \neq \emptyset$.

Theorem 2. Let x^* – be the optimal solution of problem $LP(\bar{F}, X)$. Then $\forall x \in X \quad F(x) \leq^P \bar{F}(x^*)$.

To solve $LP(\bar{F}, X)$ we may apply the methods of multicriteria optimization [1, 2].

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ROBUST SOLUTIONS OF INTEGER OPTIMIZATION PROBLEMS UNDER UNCERTAINTY

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The complex integer optimization problems

$$\max \{ \langle c, x \rangle \mid x \in X \}, \quad X = \left\{ x \in Z^n \mid f_i(x) \leq 0, i \in N_m \right\}, \quad N_m = \{1, \dots, m\}, \quad (1)$$

where Z^n is a set of integer vectors from R^n , with inexact coefficients of the linear objective function and pseudo convex functions of constraints are examined. Let the parameters of model (1) be known not exactly but be defined, for example, by the statistical estimation from available observations [1,2]. Assume that the a priori information on the vector $c \in R^n$ and the functions $f_i(x), i \in N_m$, consists in representing of sets C and F_i such that $c \in C$ and $f_i \in F_i, i \in N_m$. $F_i, i \in N_m$, are sets of pseudo convex continuously differential functions. Exact and approximate methods of decomposition are developed and proved to search for robust solutions to such problems. The methods are based on approximation of initial problems (1) by problems of a simpler structure. They consist in the successive decision of followings subproblems: for $x^j \in Z^n, j=1,2,\dots$, problem *MP*:

$$\max \left\{ x_0 \mid x_0 \leq \min_{j \in N_k} \langle c^j, x \rangle, \quad c^j \in C, \quad k=1,2,\dots; \quad x \in Z^n, \right.$$

$$\left. \max_{f_i^j \in F_i} \max_{j \in N_l} f_i^j(x^j) + \langle \nabla f_i^j(x^j), x - x^j \rangle \leq 0, i \in N_m, l=1,2,\dots, \right\} \text{ and}$$

problem linear programming: $\min \langle c, x^j \rangle \mid c \in C$.

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ON AN IMPROVED CONVERGENCE ANALYSIS OF GAUSS- NEWTON-SECANT METHOD FOR SOLVING NONLINEAR LEAST SQUARES PROBLEMS

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Consider the nonlinear least squares problem

$$\min_{x \in R^p} \frac{1}{2} (F(x) + G(x))^T (F(x) + G(x)), \quad (1)$$

where residual function $F + G : R^p \rightarrow R^m$ ($m \geq p$) is nonlinear by x , F is a continuously differentiable function; G is a continuous function, differentiability of which, in general, is not required.

In [2] we proposed the iterative Gauss-Newton-Secant method for solving problem (1)

$$\begin{aligned} x_{k+1} &= x_k - (A_k^T A_k)^{-1} A_k^T (F(x_k) + G(x_k)), \\ A_k &= F'(x_k) + G(x_k, x_{k-1}), k = 0, 1, \dots, \end{aligned} \quad (2)$$

where $F'(x_k)$ is a Fréchet derivative of the function $F(x)$; $G(x_k, x_{k-1})$ is a divided difference of the first-order of the function $G(x)$ and x_0, x_{-1} are given initial approximations.

In this work, we have proved theorems, which establish the conditions of convergence, the radius and the convergence order of the method (2). To study Gauss-Newton-Secant method we chose technique proposed in [1]. This approach uses weaker hypotheses and leads to a larger convergence domain and the more precise estimates under the same computational cost, as in [2].

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STATIONARY DISTRIBUTIONS FOR SYSTEMS WITH UNRELIABLE DEVICES

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In classical retrial queues a call arriving when all servers are busy leaves the service area but after some random time repeats his demand. One can find main definitions and related results in [1]-[3]. In some models, unreliable devices are considered as well.

We consider a Poisson flow of calls with rate λ arrives at the system input. One unreliable device has an exponentially distributed service time with parameter (intensity) μ . The device failure intensity is α while device repair intensity is β . If the working device breaks down the call becomes a source of retrial calls. Each source of retrial calls, independently on others, generates a Poisson flow of retrial calls with parameter θ as long as device resumes its work and service process of the retrial call begins. The service process $X(t) = (Q(t), A(t))$ is a two-dimensional Markov chain with continuous time, where $Q(t) \in \{0, 1, 2, \dots\}$ is a number of sources of retrial calls and $A(t) \in \{0, 1, 2\}$ describes the device state (waiting, working or out of order).

We will show that the limit distribution of the mentioned process exists under condition $\beta(\mu - \lambda) > \alpha\lambda$ and will demonstrate technique of finding the limit distribution using methods of generating function.

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OPTIMIZATION OF PARAMETRIZED NONLINEAR DYNAMICAL SYSTEMS USING SURROGATE MODELS

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Let us consider optimization problem which consists in finding a control function $u_* \in U \subset R^{n_u}$ and proper state function $y_* \in Y \subset R^{n_y}$, that minimize optimization criterion

$$\psi_0(u_*) = \tilde{\psi}_0(u_*, y_*) = \min_{(u,y) \in U \times Y} \tilde{\psi}_0(u, y)$$

subject to state equation (ordinary differential equations, ODEs)

$$\begin{aligned} y'_t(t) &= f(t, y, u), \quad t \in \Omega_t = (t_0, t_e] \\ y(t_0) &= y_0 \end{aligned},$$

box constraints on the control

$$U = \{u \in R^{n_u} : u^- \leq u \leq u^+, u^- \in R^{n_u}, u^+ \in R^{n_u}\},$$

and possibly additional constraints on state and control

$$\psi_j(u) = \tilde{\psi}_j(u, y) \leq 0, \quad j = 1, \dots, m.$$

We examine two approaches for construction of surrogate models. In both cases we first select sampling strategy and generate a set sampling points $u_i \in U, i=1, \dots, n_s$. For each sample point u_i we solve ODEs and obtain n_s vectors of solutions (snapshots) $y_i \in R^{n_y \times n_t}$ at different time instances $t_0 < t_1 < t_2 < \dots < t_{n_t} = t_e$. According first approach, we calculate values of functionals $\psi_{ji} = \tilde{\psi}_j(u_i, y_i)$. Based on ψ_{ji} we directly construct surrogate models $\hat{\psi}_j(u)$ for each functional $\psi_j(u)$, $j = 0, 1, \dots, m$ using radial basis functions [1].

According second approach we construct surrogate model for solution $\hat{y} = Su$, where matrix S is calculated using proper orthogonal decomposition of snapshot matrix $Y = [y_1, \dots, y_{n_s}]$ and radial basis functions [2]. After that, we calculate the value of functionals $\hat{\psi}_j(u) = \tilde{\psi}_j(u, \hat{y}), j = 0, 1, \dots, m$. Results of various numerical experiments are presented.

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DEVIANT CLASSES OF GND-PREDICATES

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The apparatus of mathematical logic form the basis for information and software systems. Therefore, the problem of constructing new program-oriented logical formalisms is important. In this paper we investigate new classes of such formalisms: logics of general non-deterministic predicates (*GND*-predicates). These logics reflect such properties of programs as nondeterminism, partiality, non-fixed arity. Semantic properties of *GND*-predicates are studied in [1]. Different types of *GND*-predicates are defined, their compositions $\neg, \vee, R_{\bar{x}}^{\bar{v}}, \exists x$ and compositional algebras are described. *GND*-predicates can be modeled as 7-valued total deterministic predicates (*TD7*-predicates) with set of truth values $TV_7 = \{T, F, T\uparrow, F\uparrow, \uparrow, TF, TF\uparrow\}$. We specify the algebra of truth values $ATV_7 = (TV_7, \{\neg_*, \vee_*\})$ and describe all its subalgebras.

Subsets of TV_7 which are not closed under $\vee_*$ and $\neg_*$ don't form subalgebras of ATV_7 . The corresponding classes of *GND*-predicates are not closed under $\vee$. We will call such subsets and classes of *GND*-predicates *deviant*. It is natural to consider sets of truth values closed under $\neg_*$. In this report we study *deviant classes* of *GND*-predicates.

For a deviant class of *TD7*-predicates to form an algebra, we need to modify $\vee_*$, which further leads to modification of $\vee$. Correct modification requires the *TFC* condition (*TF*-correctness): $T(\alpha \vee \beta) = T(\alpha) \cup T(\beta)$, $F(\alpha \vee \beta) = F(\alpha) \cap F(\beta)$.

For the sets of truth values $\{T, F, T\uparrow, F\uparrow, \uparrow, TF\}$, $\{T, F, T\uparrow, F\uparrow, TF\}$, $\{T, F, \uparrow, TF, TF\uparrow\}$, $\{T, F, \uparrow, TF\}$, $\{T, F, \uparrow, TF\uparrow\}$, $\{T\uparrow, F\uparrow, \uparrow, TF\}$, $\{T\uparrow, F\uparrow, TF\}$ modifications of $\vee_*$ and $\vee$ with *TFC* exist, producing the corresponding classes of *GND*-predicates *SAnU*, *TAnU*, *RAU*, *R*, *UAU*,

$nU_{\neq}A$, $TnU_{\neq}A$. At the same time, we distinguish modifications of $\vee_*$ and $\vee$ without *TFC* to obtain *well-deviant* classes AEU , $AEU_{\#}$, AEU_T , $AEU_{\#D}$; $AEU_{4.1}$, $AEU_{4.2}$. For the sets $\{\uparrow, TF, TF\uparrow\}$, $\{TF, \uparrow\}$, $\{TF\uparrow, \uparrow\}$ modifications of $\vee_*$ and $\vee$ with *TFC* don't exist, which gives us a number of well-deviant classes of *GND*-predicates.

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ABOUT TIME-VARYING PARAMETER IDENTIFICATION BY LEAST SQUARES METHOD WITH LEAST DEVIATIONS FROM ‘ATTRACTION’ POINTS FOR BILINEAR DYNAMIC SYSTEMS IN THE PRESENCE OF DISTURBANCES

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Consider the parameter identification problem of unknown slowly time-varying matrices $A, B_1, B_2, \dots, B_m, B$ in bilinear object:

$$x(k+1) = Ax(k) + \sum_{i=1}^m u_i(k)B_i x(k) + Bu(k) + \xi(k), \quad k \in \mathbb{N}, \quad (1)$$

where $x(k), u(k) = (u_1(k), u_2(k), \dots, u_m(k))^T, \xi(k)$ are state, control and disturbance vectors respectively.

The least squares estimate with variable forgetting factor $\lambda(k)$ ($\lambda(k) \in (0, 1]$, $k \in \mathbb{N}$) is considered for system (1) in non-classical situation when this estimate may be not unique and additionally ‘attraction’ points $A_*(N), B_{1*}(N), B_{2*}(N), \dots, B_{m*}(N), B_*(N)$ for matrices $A, B_1, B_2, \dots, B_m, B$ are given at any moment N ($N = 0, 1, 2, \dots$).

The set of all previously mentioned estimates of unknown non-stationary matrices under these assumptions is defined as

$$\text{Arg} \min_{A, B_1, B_2, \dots, B_m, B} Q(A, B_1, B_2, \dots, B_m, B, N), \quad (2)$$

where $Q(A, B_1, B_2, \dots, B_m, B, N) = \sum_{k=1}^N w(k, N) \|\xi(k)\|^2$,

$$w(k, N) = \begin{cases} \prod_{i=k}^{N-1} \lambda(i), & \text{if } k = \overline{1, N-1}, \\ 1, & \text{if } k = N. \end{cases}$$

The desired least squares estimate with variable forgetting factor $\lambda(k)$ and least deviations from given ‘attraction’ points $A_*(N), B_{1*}(N), B_{2*}(N), \dots, B_{m*}(N), B_*(N)$ at any moment N is obtained as unique estimate on estimate set (2). The recurrent representations for this estimate and corresponding weighted residual sum of squares are also proposed.

COMPLEX WAVE BEAM PHASE IN A WEAKLY ABSORBING RANDOMLY INHOMOGENEOUS MEDIUM

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The study of the features of the statistical characteristics of the scattered wave beam of the optical range in a randomly inhomogeneous absorbing medium, using the method of smooth perturbations, sets a single-mode Gaussian wave beam at the aperture

$$E_0(0, \rho) = A_0 \exp \left(-\frac{\rho^2}{2\alpha_0^2} + i \frac{k\sqrt{\varepsilon_0}\rho^2}{2R} \right) = A_0 \exp \left(-\frac{\rho^2}{2\alpha_0^2} \right),$$

α_0 the effective radius of the beam in the plane of the transmitting aperture determines the reduction of the radiation power. Fluctuations of the wave level in a random environment with fluctuations of the dielectric constant and absorption are considered to be statically uniform and isotropic random functions of the coordinates.

The correlation function of the complex phase is expressed in terms of the spectral densities of fluctuations of the refractive index, absorption, and their cross correlation. In the limiting cases of scattering of spherical and plane monochromatic waves in random media with low absorption, correlation functions of fluctuations of the level and phase of the received signal in an absorbing medium are obtained. If $\rho = 0$ then for the variance of the fluctuations of the logarithm of the amplitude and phase of the signal, we obtain expressions that, in the absence of absorption, turn into previously known results.

21ST CENTURY PUPILS' /STUDENTS' DIGITAL SKILLS AND CHALLENGES OF THE TEACHERS

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Every field of education of the 21st century is strongly bound to the application of the digital technologies. Chapter 8 of the National Educational Plan deals with the Prioritized Competences necessary for the secondary school graduates out of which the skills of effective application of the modern technologies under the name “Digital Literacy or Computer Literacy” - are considered to be of outmost importance.

Development of the digital technologies has gained broader idea in the field of education as it functions as the tool of the information search, text analysis and other software systems application of which contributes to the development of creativity and innovative approaches considered to be vital for the citizen of the 21st century.

The presented paper deals with the investigation of the gap between the contemporary pupils and their teachers in terms of being equipped with the computer skills at different levels. In other words, the aim of the research is to reveal the challenge of the teachers of the secondary schools as well as the higher education institutions who have to deal with the students that appear to have more expertise in the application of the technologies than the teachers themselves. The reality that the young generation easily gets familiarized with all the developments in the technologies make some teachers less confident in the process of teaching causing some unconscious fear in the teachers who have to teach the students who demonstrate high competences in the application of technologies.

Consequently the level of usage of the modern technologies at the lessons or lectures is limited or neglected at all in most cases while on the other hand, all sides involved in the education process acknowledge that this is one of the most convenient ways to make the lesson/lecture involving, engaging and appealing to the requirements of the 21st century education.

The objective of our research is to make a deep analysis of the situation in the regard of the mentioned in Georgian secondary schools as well as universities, present the comprehensive picture of the status of the issue to identify the potential for the improvement and make some feasible recommendations. The research results will be obtained through

the survey in the different target groups at the secondary school as well as the university levels. The recommendations will envisage the proper communication with the teachers and lecturers aiming at building up the necessary trust and willingness to defeat so called “Fear” and give more welcome to digital technologies.

FORMATION OF SYMMETRY IN BIOLOGY AND COMBINATORICS

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In both living and inanimate nature there is symmetry, which is studied by different approaches. The literature describes many ways to study symmetry in biology. To this end, geometric explorations are used to study the symmetry of the deployed biological spaces and algebraic approaches for the convolute (DNA). But the question of how symmetry appears in deployed biological spaces has not yet been found.

The literature describes many natural phenomena associated with combinatorial numbers, in particular the "golden" number transmitted by Fibonacci numbers. This suggests that the laws of combinatorics are inherent in nature. In ordered combinatorial sets, numerical sequences, which specify in them the number of combinatorial configurations, also form combinatorial numbers, including the Fibonacci numbers. Since combinatorial numbers are present in biology, the dynamics of the formation of symmetry using combinatorics is considered in the article [1]. In the process of ordering combinatorial sets, it is formed according to certain rules [2]. The symmetry of these sets is modeled by a finite sequence of numbers, whose values increase to the largest of them, and then decrease (or decrease to the smallest, and then increase). The study of combinatorial sets shows that they are characterized by both approximate and exact symmetry.

Significant biological spaces are valid axioms of significant combinatorial, which allows us to investigate how symmetries in biology (expanded biological space) are formed when it is deployed from a rolled (DNA element). Knowing the formation of symmetry in combinatorial sets, we can explain the formation of symmetry in biology.

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ANALYSIS OF RETRIAL SYSTEMS WITH QUEUE

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This work is devoted to the perspective direction of the theory stochastic systems associated with research of retrial systems with queue. Retrial queues widely used in designing of computer networks, in studying of stochastic information processing networks, modern mobile communication systems, etc. Such systems are used in many areas of application ([1],[2],[3],[4]), and their detailed analysis one can find in [1]. In retrial systems with queue, when an arriving customer finds that all servers and all places in the queue are busy, the customer joins a virtual 'orbit' and repeat its request after a random time until the customer gets into the service area. Such attempts become a source of repeated calls.

A class of bivariate migration processes is introduced to describe the service process of the system. We consider a Markov model of retrial queuing system with the finite number of servers, a finite length queue and a finite orbit. It introduces a class of two-dimensional migration processes, within which we can describe the service process for different retrial queuing systems. The way of receiving and servicing calls (system type) is selected due to the control parameters of migration. In this work we search an explicit formulas for stationary probabilities of two-dimensional service process through the parameters of the service process model. In the case of one service device and one place in the queue, the vector-matrix representation of stationary probabilities is greatly simplified. The result obtained is used for construction of explicit formulas for stationary probabilities of one service device and one place in the queue.

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FINITE ELEMENT METHOD WITH SECONd ORDER ELEMENTS FOR ANALYSIS OF THE POLLUTION DISTRIBUTION IN A HYDROTECHNICAL RAMPART- TERRACE

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The finite element method, as an effective engineering method that works in arbitrary spatial domains, allows one to obtain with sufficient accuracy computational models for areas with complex boundaries and complex boundary conditions. So, we develop the ways to solve the problem of mass transfer of a pollutant in a hydrotechnical rampart-terrace with a piecewise smooth surface where surface contamination occurred at some moment [1]. Solution of this task makes it possible to estimate the propagation of pollutant in the soil.

In our research, we have the following initial model:

$$Zu \equiv \frac{\partial u}{\partial t} + Lu \equiv \frac{\partial u}{\partial t} - \sum_{i=1}^2 \frac{\partial}{\partial x_i} \left(D(x) \frac{\partial u}{\partial x_i} \right) + \sum_{i=1}^2 V \frac{\partial u}{\partial x_i} = f(x, t) \equiv -\lambda u_0 \varphi(x) \delta(t - 0)$$

$$u(x, 0) = 0, \quad x \in \Omega,$$

$$\left(-\sum_{i=1}^2 D(x) \frac{\partial u}{\partial x_i} + Vu \right) \Big|_{x \in \Gamma} = k(\Gamma) c_0 q_0(x), \quad t \in [0, T],$$

$$\left(-\sum_{i=1}^2 D(x) \frac{\partial u}{\partial x_i} + Vu \right) \Big|_{x \in \partial\Omega \setminus \Gamma} = 0, \quad t \in [0, T],$$

in the bounded area $Q = \Omega \times (0 \leq t \leq T)$, $\Omega \subset R^2$ with piecewise smooth surface $\partial\Omega$, λ – half-decomposition factor, $\varphi(x_1, x_2)$ – the function describing the surface of the shaft-terrace Γ , $\varphi(x_1, x_2) \in L_2(\Omega)$, u_0 – surface contamination, $u(x, t)$ – the concentration of the substance in the point $x = (x_1, x_2)$ at the moment t , $u(x, t)$ is twice continuously differentiated by x on Ω and continuously differentiated by t on $[0, T]$, $D(x)$ – an integral and limited, continuously differentiable function in $\bar{Q}$, V – positive constant, $k(\Gamma) = k \cdot \cos(\alpha(\Gamma))$, k – the coefficient of conductivity (absorption) for surface, $\alpha(\Gamma)$ – the slope of the segment of terraces, q_0 – the flow of water coming from atmospheric precipitation with a substance concentration c_0 ; $u(x, t)$ – the concentration of substance in $x = (x_1, x_2) \in \bar{\Omega}$ at the moment t .

Also we consider the space H with the norm

$$\|u\|_H = \int_Q (u_t^2 + \sum_{i=1}^2 \left(\frac{\partial u}{\partial x_i} \right)^2) dQ. \text{ Then for any } u \in H \text{ we have:}$$

$$(Zu, u)_{L_2(Q)} \leq c \|u\|_H^2, \quad c = \text{const} > 0 \quad [1];$$

$$\|Lu\|_{H^-} \leq c_1 \|f\|_{L_2(Q)}, \quad c_1 = \text{const} > 0.$$

In [1] has been shown the existence of a unique generalized solution of this problem in the abovementioned space.

In area $\bar{\Omega}$ grid

$$\omega = \{x | x = (x_1, x_2), x_1 = \frac{iL}{N} \cos \alpha, i = \overline{0, N+1}, x_2 = \frac{jL}{N} \sin \alpha, j = \overline{0, 2M+N-1}, \\ x_2 = x_1 \tan \alpha + \frac{i2L}{N} \sin \alpha, i = \overline{0, M}, x_2 = -x_1 \tan \alpha + \frac{j2L}{N} \sin \alpha, j = \overline{0, M+N-1}\}$$

was built. Using the change of variables in the form

$$\psi = x_1 / \cos \alpha, \chi = x_2, \text{ where } \begin{vmatrix} \frac{\partial x_1}{\partial \psi} & \frac{\partial x_1}{\partial \chi} \\ \frac{\partial x_2}{\partial \psi} & \frac{\partial x_2}{\partial \chi} \end{vmatrix} = \cos \alpha \neq 0, \text{ we have got the}$$

opportunity to proceed to the consideration of a rectangular area $\bar{\Omega}'$, in

which we can take MN rectangular finite elements of square $s_e = \Delta\psi\Delta\chi = \frac{2L^2}{N^2} \sin\alpha$ each.

An approximate solution of the problem for each element we represent as a function [2]:

$$u_h^e(t, \psi, \chi) = \sum_{i=1}^n g_i^e(t) w_i^e(\psi, \chi),$$

where $w_i^e(\psi, \chi)$ - functions of orthonormal basis in $L_2(\Omega)$, which are twice continuously differentiable in $\bar{\Omega}$ and satisfy the boundary conditions. In order to meet these requirements, second-order quadratic elements are used. In them we consider nine nodes in each element and, accordingly, nine basic functions.

Functions $g_i^e(t)$ satisfy the initial condition and following system:

$$(Zu, w_j)_{L_2(\Omega)} = (f, w_j)_{L_2(\Omega)}, \quad j = \overline{1, n}.$$

As a result, we arrive at the next system of ordinary differential equations to determine the functions $g_i^e(t)$:

$$\begin{aligned} \frac{dg_i^e(t)}{dt} + \sum_{i=1}^n (g_i(t)(A+B)w_i, w_j)_{L_2(\Omega)} &= (f, w_j)_{L_2(\Omega)}, \quad j = \overline{1, n}, \\ g_i^e(0) &= 0, \quad i = \overline{1, n}. \end{aligned}$$

Given the choice of basis functions and also taking into account the numerical implementation of the δ -function [3] which included in the right-hand side, we arrived at a difference system of the following form:

$$\begin{aligned} \frac{g_i^{ke} - g_i^{k+1e}}{\tau} + \sum_{i=1}^9 (g_i^{ke}(A+B)w_i, w_j)_{L_2(\Omega)} &= (f^k, w_j)_{L_2(\Omega)}, \quad j = \overline{1, n}, \quad k = \overline{0, K}, \\ g_i^{0e} &= 0, \quad i = \overline{1, n}. \end{aligned}$$

It is also important here that due to the numerical implementation of the delta function, the system of equations in this case quickly becomes homogeneous and at the boundary nodes. The orthonormal basis makes the matrix quite sparse, which also greatly simplifies the solution of the system of equations.

The fulfillment of the kinematic conditions of conjugation of finite elements, the choice of basis functions and generalized coordinates leads to consistency of finite elements.

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MATHEMATICAL MODELING OF INFLUENCE OF HEAT AND MASS TRANSFER ON DEFORMATION PROCESSES OF MULTILAYERED SOIL ARRAY IN THREE-DIMENSIONAL CASE

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The mathematical model of the problem of the influence of heat and mass transfer of multilayered soil array with free surface in general accepted notation can be described as the next three-dimensional boundary value problem [1-2]:

Lame equations describing the stressed-strained state of the soil for displacements with account for the heat and mass transfer in it:

$$\begin{aligned} \mu_i \Delta U_i + (\lambda_i + \mu_i) \frac{\partial}{\partial x} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \frac{\partial \lambda_i}{\partial x} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \\ + 2 \frac{\partial \mu_i}{\partial x} \frac{\partial U_i}{\partial x} + \frac{\partial \mu_i}{\partial y} \left(\frac{\partial U_i}{\partial y} + \frac{\partial V_i}{\partial x} \right) + \frac{\partial \mu_i}{\partial z} \left(\frac{\partial U_i}{\partial z} + \frac{\partial W_i}{\partial x} \right) - \\ - \left(\left(3 \frac{\partial \lambda_i}{\partial x} + 2 \frac{\partial \mu_i}{\partial x} \right) T_i + (3\lambda_i + 2\mu_i) \frac{\partial T_i}{\partial x} \right) \alpha_T^{(i)} + X_i = 0, \end{aligned}$$

$$\begin{aligned}
& \mu_i \Delta V_i + (\lambda_i + \mu_i) \frac{\partial}{\partial y} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \frac{\partial \lambda_i}{\partial y} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \\
& + 2 \frac{\partial \mu_i}{\partial y} \frac{\partial V_i}{\partial y} + \frac{\partial \mu_i}{\partial x} \left(\frac{\partial U_i}{\partial y} + \frac{\partial V_i}{\partial x} \right) + \frac{\partial \mu_i}{\partial z} \left(\frac{\partial V_i}{\partial z} + \frac{\partial W_i}{\partial y} \right) - \\
& - \left(\left(3 \frac{\partial \lambda_i}{\partial y} + 2 \frac{\partial \mu_i}{\partial y} \right) T_i + (3\lambda_i + 2\mu_i) \frac{\partial T_i}{\partial y} \right) \alpha_T^{(i)} + Y_i = 0, \\
& \mu_i \Delta W_i + (\lambda_i + \mu_i) \frac{\partial}{\partial z} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \frac{\partial \lambda_i}{\partial z} \left(\frac{\partial U_i}{\partial x} + \frac{\partial V_i}{\partial y} + \frac{\partial W_i}{\partial z} \right) + \\
& + 2 \frac{\partial \mu_i}{\partial z} \frac{\partial W_i}{\partial z} + \frac{\partial \mu_i}{\partial x} \left(\frac{\partial U_i}{\partial z} + \frac{\partial W_i}{\partial x} \right) + \frac{\partial \mu_i}{\partial y} \left(\frac{\partial V_i}{\partial z} + \frac{\partial W_i}{\partial y} \right) - \\
& - \left(\left(3 \frac{\partial \lambda_i}{\partial z} + 2 \frac{\partial \mu_i}{\partial z} \right) T_i + (3\lambda_i + 2\mu_i) \frac{\partial T_i}{\partial z} \right) \alpha_T^{(i)} + Z_i = 0, \quad X \in \Omega,
\end{aligned} \tag{1}$$

where components of mass force are calculated by the formulas

$$X_i = \begin{cases} \frac{dp_1^{(i)}}{dx}, & X \in \Omega_{i^*}, \\ 0, & X \in \Omega_{i^*}^*, \end{cases} \quad Y_i = \begin{cases} \frac{dp_2^{(i)}}{dy}, & X \in \Omega_{i^*}, \\ 0, & X \in \Omega_{i^*}^*, \end{cases} \quad Z_i = \begin{cases} \gamma_{36}^{(i)} + \frac{dp_3^{(i)}}{dy}, & X \in \Omega_{i^*}, \\ \gamma_{np}^{(i)}, & X \in \Omega_{i^*}^*, \end{cases} \tag{2}$$

the normal and shear strains

$$\begin{aligned}
& \varepsilon_x^{(i)} = \frac{\partial U_i}{\partial x}, \quad \varepsilon_y^{(i)} = \frac{\partial V_i}{\partial y}, \quad \varepsilon_z^{(i)} = \frac{\partial W_i}{\partial z}, \\
& \varepsilon_{xy}^{(i)} = \frac{1}{2} \left(\frac{\partial U_i}{\partial y} + \frac{\partial V_i}{\partial x} \right), \quad \varepsilon_{xz}^{(i)} = \frac{1}{2} \left(\frac{\partial U_i}{\partial z} + \frac{\partial W_i}{\partial x} \right), \quad \varepsilon_{yz}^{(i)} = \frac{1}{2} \left(\frac{\partial V_i}{\partial z} + \frac{\partial W_i}{\partial y} \right), \quad X \in \Omega,
\end{aligned} \tag{3}$$

the normal and shear stresses

$$\begin{aligned}
& \sigma_x^{(i)} = \lambda_i \varepsilon_\theta^{(i)} + 2\mu_i \varepsilon_x^{(i)} - (3\lambda_i + 2\mu_i) \alpha_T^{(i)} \bar{T}_i, \\
& \sigma_y^{(i)} = \lambda_i \varepsilon_\theta^{(i)} + 2\mu_i \varepsilon_y^{(i)} - (3\lambda_i + 2\mu_i) \alpha_T^{(i)} \bar{T}_i, \\
& \sigma_z^{(i)} = \lambda_i \varepsilon_\theta^{(i)} + 2\mu_i \varepsilon_z^{(i)} - (3\lambda_i + 2\mu_i) \alpha_T^{(i)} \bar{T}_i, \\
& \tau_{xy}^{(i)} = 2\mu_i \varepsilon_{xy}^{(i)}, \quad \tau_{xz}^{(i)} = 2\mu_i \varepsilon_{xz}^{(i)}, \quad \tau_{yz}^{(i)} = 2\mu_i \varepsilon_{yz}^{(i)}, \quad X \in \Omega
\end{aligned} \tag{4}$$

with appropriate boundary and conjugation conditions for displacements, stresses, concentration of salt solution, temperature and pressure.

$$\text{Here: } X \in \Omega, \quad \Omega = \Omega_{i_k} \cup \Omega_{i^*}, \quad \Omega_{i_k} = \bigcup_{i=1}^k \Omega_i, \quad \Omega_{i^*} = \bigcup_{i=k+1}^n \Omega_i;$$

$\lambda_i = \lambda_i(c_i, T_i)$, $\mu_i = \mu_i(c_i, T_i)$ are Lamé coefficients.

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IDENTIFICATION PROBLEM FOR THE LINEAR NONSTATIONARY QUASI OPTICS EQUATION WITH A SPECIAL GRADIENT TERMS

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We consider the identification problem for the linear nonstationary quasi optics equation with a special gradient terms of finding the minimum of functional:

$$J_{\alpha}(v) = \|\psi_1 - \psi_2\|_{L_2(\Omega)}^2 + \alpha \|v - \omega\|_H^2 \quad (1)$$

on the set:

$$V \equiv \left\{ v = v(x) = (v_0(x), v_1(x)) : v_m \in L_2(0, l), |v_m(x)| \leq b_m, m = 0, 1, \forall x \in (0, l) \right\}$$

under conditions:

$$i \frac{\partial \psi_k}{\partial t} + i a_0 \frac{\partial \psi_k}{\partial z} - a_1 \frac{\partial^2 \psi_k}{\partial x^2} + i a_2(x) \frac{\partial \psi_k}{\partial x} + a(x) \psi_k + \\ + v_0(x) \psi_k + i v_1(x) \psi_k = f_k(x, t, z),$$

$$k = 1, 2, (x, t, z) \in \Omega, \quad (2)$$

$$\psi_k(x, 0, z) = \varphi_{0k}(x, z), k = 1, 2, (x, z) \in \Omega_L \equiv (0, l) \times (0, L), \quad (3)$$

$$\psi_k(x, t, 0) = \varphi_{1k}(x, t), k = 1, 2, (x, t) \in \Omega_T \equiv (0, l) \times (0, T), \quad (4)$$

$$\psi_1(0, t, z) = \psi_1(l, t, z) = 0, (t, z) \in Q_{TL} \equiv (0, T) \times (0, L), \quad (5)$$

$$\frac{\partial \psi_2(0, t, z)}{\partial x} = \frac{\partial \psi_2(l, t, z)}{\partial x} = 0, (t, z) \in Q_{TL} \equiv (0, T) \times (0, L), \quad (6)$$

where $i = \sqrt{-1}$ imaginary unit, $l > 0, T > 0, L > 0, a_0 > 0, a_1 > 0, \alpha \geq 0, b_1 > 0, b_2 > 0$ are given numbers, $0 \leq x \leq l, 0 \leq t \leq T, 0 \leq z \leq L, \Omega_{tz} = (0, l) \times (0, t) \times (0, z), \Omega = \Omega_{TL}, \psi_k = \psi_k(x, t, z), k = 1, 2$ - are wave functions, $a(x), a_2(x)$ are measurable real-valued functions that satisfy the conditions:

$$\tilde{\mu}_0 \leq a(x) \leq \mu_0, \forall x \in (0, l), \tilde{\mu}_0, \mu_0 = \text{const} > 0; \quad (7)$$

$$|a_2(x)| \leq \mu_1, \left| \frac{da_2(x)}{dx} \right| \leq \mu_2, \forall x \in (0, l), a_2(0) = a_2(l) = 0, \mu_1, \mu_2 = \text{const} > 0; \quad (8)$$

$\varphi_{0k}(x, z), \varphi_{1k}(x, t), f_k(x, t, z), k = 1, 2$ are given complex-valued functions satisfying the conditions:

$$\varphi_{01} \in W_2^{0, 2, 1}(\Omega_L), \varphi_{11} \in W_2^{0, 2, 1}(\Omega_T) \quad (9)$$

$$\varphi_{02} \in W_2^{2, 1}(\Omega_L), \frac{\partial \varphi_{02}(0, z)}{\partial x} = \frac{\partial \varphi_{02}(l, z)}{\partial x} = 0, z \in (0, L), \quad (10)$$

$$\varphi_{12} \in W_2^{2, 1}(\Omega_T), \frac{\partial \varphi_{12}(0, t)}{\partial x} = \frac{\partial \varphi_{12}(l, t)}{\partial x} = 0, t \in (0, T), \quad (11)$$

$$f_k \in W_2^{0, 1, 1}(\Omega), k = 1, 2; \quad (12)$$

$\omega = (\omega_0, \omega_1) \in H \equiv L_2(0, l) \times L_2(0, l)$ - is given element, the symbol $\overset{0}{\forall}$ means "for almost everywhere".

In this paper, the existence and uniqueness of solution of considered identification problem is investigated and a necessary condition in variational inequality form for its solution is obtained [1, 2].

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THE PRINCIPLE OF LARGE DEVIATIONS FOR RANDOM EVOLUTIONS IN THE SCHEME OF POISSON APPROXIMATION

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Consider random evolution in the scheme of nonlinear Poisson approximation

$$\xi^\varepsilon(t) = \xi^\varepsilon(0) + \int_0^t \eta^\varepsilon(ds; x) \left(\frac{s}{(g_1(\varepsilon))^2} \right), t \geq 0,$$

$$\eta^\varepsilon(t) = g_1(\varepsilon) \eta^{f(\varepsilon)} \left(\frac{t}{(g_1(\varepsilon))^2} \right), t \geq 0,$$

where $\eta^{f(\varepsilon)}(t)$ - process with independent increments, $x(s)$ - Markov process. In this normalization $g_1(\varepsilon)$, $g_2(\varepsilon)$, $f(\varepsilon)$, $\varepsilon \rightarrow 0$.

Processes $\eta^\varepsilon(t)$ are defined by generator

$$\Gamma^\varepsilon(x) \phi(u) = (g_2(\varepsilon))^{-1} \int_R [\phi(u + g_1(\varepsilon)v) - \phi(u)] \Gamma^{f(\varepsilon)}(dv; x), x \in E,$$

where $\phi(u)$ is a twice differentiable function in R , which tends to 0 at infinity and with sup-norm, $\phi(u) \in C_0^2(R)$.

The purpose of this work is to prove, that $\xi^\varepsilon(t) \Rightarrow \xi(t)$ in the scheme of nonlinear Poisson approximation.

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ECONOMIC MODELS EVALUATION OF EDUCATION

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The work is devoted to the construction of regression models for assessing the level of education on the basis of specific statistical data of our planet countries.

To date, this issue is relevant because it is one of the main criteria used when countries are divided into developed, developing and least developed countries.

First of all, we will build a table for the level of education for 150 countries of the world. To construct a regression model, the following factors are also added to the table: social support, freedom of choice, globalization index, and others.

The level of education of European countries for 2012-2016 is also researched, and the index of education for 2018 is projected.

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THE INTELLIGENT SYSTEM FOR THE ESTIMATION OF TECHNICAL STATE OF CONSTRUCTION STRUCTURES

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Companies that develop construction objects are responsible for the reliability and safety of buildings and structures and for the identification of causes related to deviation of parameters of technical condition from normative values in the process of operation of these sites. The process of exploitation is long in time so they must process controlled parameters taking into consideration an accumulation of damage and changes in the parameters over time. Analysis of input information is considerably complicated due to a growth in the number of monitored parameters of technical state, which leads to an increase in the risk of the human factor at a rapid decision-making in emergencies.

The objective of this study is to model an intelligent system for the estimation of technical state of construction structures based on one of the modifications of a Takagi-Sugeno-Kang (TSK) fuzzy network.

We substantiated the topology of the Takagi-Sugeno-Kang fuzzy neural network. Specifically: we defined the network architecture, we defined the rule, according to which a number of elements is determined at the input and the output, we showed the structure of links and described designation of elements of each layer in detail. Building standards determine belonging of a construction to one of the states at the output.

We can use results of modeling of random loads, accumulation of damage and forecasting of dynamics of defects in structures in the input data in the process of learning of an intelligent system. An analysis of rules used by experts to identify categories of technical states of building structures showed that Mamdani or Larsen fuzzy implications are best suited for engineering rules according to which it is possible to estimate the technical state.

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NOTES

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