

*Taras Shevchenko National University of Kyiv (Ukraine),
General Jonas Zemaitis Military Academy of Lithuania,
Ivan Franko National University of Lviv (Ukraine),
International Institute for Applied Systems Analysis (Austria),
Glushkov Institute of Cybernetics of NAS of Ukraine,
Higher School Academy of Sciences of Ukraine,
Noosphere Ventures Corporation (Ukraine),
European Education Center (Georgia)*

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ABSTRACTS

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ABOUT ONE APPROACH TO MODELING THE INFORMATION DISSEMINATION PROCESS USING FRACTIONAL ANALYSIS

L.T. Adzhubey

Taras Shevchenko National University of Kyiv, Ukraine

adzhubey@ukr.net

The paper proposes one of the approaches to the formalization and numerical modeling of the information dissemination process based on the diffusion equation with the Gerasimov-Caputo fractional differential derivative with respect to spatial and temporal coordinates [1]. The processes of information penetration and influence are studied based on the use of fundamental features of fractional analysis and the construction of hybrid models, where fractional analysis is used for the purpose of analyzing time series of experimental data in the tasks of monitoring the levels of information dissemination in social groups, taking into account the diffuse nature of information dissemination processes.

The content of the proposed methodology is to apply the principle of analogies to describe the level of dissemination, influence and accumulation of information in the target social group based on solutions to the diffusion equation, variations in the intervals for determining the spatial coordinate, solving systems of differential equations that describe the processes of dissemination of information processes. Considering the self-similarity of information dissemination processes, hybrid diffusion models with elements of fractional analysis are considered. Solutions of the homogeneous and inhomogeneous diffusion equations are obtained for individual cases of a fractional derivative and an inhomogeneity specified on the right side of the equation, which determines in time the external influence on the information propagation medium.

The features of the dynamics of the processes of information penetration are analyzed, further development of the methodology based on the formalization of relations in the target group is proposed. The considered approach makes it possible to solve the problem of monitoring the levels of information dissemination in social groups [2].

References

1. Petras I. Fractional nonlinear systems: modeling, analysis and simulation/ I.Petras. – HEP, Springer, Nonlinear Physical Science, 2011. – 235 p.

2. Nowak A. Social Processes, Computational Models of / A.Nowak, R.R.Vallacher // Encyclopedia of Cognitive Science. – 2006. – P.81-84.

DIFFERENCES BETWEEN MAN'S AND WOMAN'S LANGUAGES USING THE EXAMPLE OF COMMENTS IN SOCIAL MEDIA

Neli Akhvlediani

Batumi Shota Rustaveli State University, Georgia

neli:akhvlediani@bsu.edu.ge

The present work deals with the topic of gender linguistics, or with the differences between the sexes in German language. The aim of the paper was to provide an overview of the theory, to test it through empirical investigation, to show the role of various social, biological and other factors in the development of language, and to determine the extent to which written language differs between the sexes. The work focuses on examining the comments in German-language social media that have been written by men and women. The language of the sexes was examined and compared.

The study examined vocabulary, style, and syntax as the parts of language that show the most differences. Both the grammatical and the social level of language have been studied since it is impossible to separate language from the society, specific groups or nation.

In summary, it can be stated that men and women show differences in their language. The results of the study show that both men and women deal with different topics and there are striking differences in their written forms of expression.

Men are more likely to use authoritative language and more formal speech than women. They respond more negatively in interactions, as well, whereas women use 'warmer' and more positive words. Women also use words more emotionally. It's even possible to identify the gender of social media users by looking at their writing style.

These issues are the focused in this paper.

PECULIARITY OF TECHNICAL TEXT TRANSLATION

Zeinab Akhvlediani

Batumi Shota Rustaveli State University, Georgia

zeinab.akhvlediani.1977@gmail.com

Modern era is characterized by technological advancement and provision of information, which first of all provides accessibility to international databases of statistics and results of researches in various fields.

Rapid development of science and technologies nowadays created replete number of new fields, resulting in emergence of new vocabulary and terms. The stated fact led to the specialization of translators with a narrow profile, however it should be noted that all fields of activity in the modern world are tightly interrelated with each other, therefore, only the study of a foreign language and narrow field terminology cannot fully ensure the implementation of adequate translation. Finding a universal translator who knows all branches of the modern scientific and technical fields and is therefore completely familiar with the terms is impossible.

Therefore, the development of encyclopedic scientific-technical dictionaries by professionals is a prerequisite for the implementation of a perfect translation in the technical field. Such dictionaries, perfectly describing the specifics of the existing fields, will provide us with exhaustive definitions and examples of the use of terms, will thoroughly ease the translator's work, and at the same time, based on the correct use of terms, will ensure the implementation of an adequate translation.

The meaning of a single word in many cases does not match its contextual definition in a sentence, so the range of use of the word should be described as widely as possible, because the computer will be able to adequately respond to an existing request only on the basis of fixed material.

These issues are the focused in this paper.

**ON THE LOCAL CONVERGENCE
OF THE EIGHTH-ORDER METHOD**
I.K. Argyros¹, S.M. Shakhno², H.P. Yarmola²

¹Cameron University, USA

²Ivan Franko National University of Lviv, Ukraine

**iargyros@cameron.edu, stepan.shakhno@lnu.edu.ua,
halyna.yarmola@lnu.edu.ua**

Let us consider a nonlinear equation [1, 2]

$$F(x) = 0. \quad (1)$$

Here X and Y denote Banach spaces, Ω is a convex subset of X and $F: \Omega \subseteq X \rightarrow Y$ is a Fréchet-differentiable operator. To find the approximate solution x^* of the equation (1) we use the following multi-step method

$$\begin{aligned} y_n &= x_n - \alpha F'(x_n)^{-1} F(x_n), \\ z_n &= d_4(x_n, y_n), \\ x_{n+1} &= d_8(x_n, y_n, z_n), \quad n \geq 0, \end{aligned} \quad (2)$$

where α is a real or complex parameter, and $d_4: \Omega \times \Omega \rightarrow X$, $d_8: \Omega \times \Omega \times \Omega \rightarrow X$ are continuous operators. If $X = Y = R^k$, $\alpha = 1$, and d_4, d_8 , are iterative functions of order four and eight respectively, then method (2) was shown to be of order eight in [2].

We study a local convergence of the method (2) under ω -type conditions for the derivatives and divided differences only of the first order. The radius of convergence ball, error estimates and a region containing only one solution of the equation (1) are determined. Different cases of iterative functions d_4, d_8 are considered and functions appearing in error estimates are defined. The numerical experiments validate the theoretical ones and show the influence of the real parameter α on the convergence rate of the method (2).

References

1. Dennis J.E., Jr. Schnabel Robert B. Numerical methods for unconstrained optimization and nonlinear equations. Prentice-Hall, Englewoods Cliffs, 1983.
2. Sharma J.R., Arora H. A new family of optimal eighth order methods with dynamics for nonlinear equations // Appl. Math. Comput. – 2016. – Vol. 273. – P. 924-933.

THE DESCRIPTION AND USAGE OF GUIDED EXPERIMENT FOR REINFORCEMENT OF INSTRUMENTAL BEHAVIOR BY INTRAVENOUS SELF-ADMINISTRATION OF DRUGS

T. Asanidze, A. Noselidze

Batumi Shota Rustaveli State University, Georgia

I.Beritashvili center of experimental biomedicine, Tbilisi, Georgia

The use computers in physiology was limited chiefly to data processing and model making. Rarely, in behavioral science, computers directly acquire data and control some parameters and the moment of application of the stimuli. Others are feedback design of experiments. In such cases one has always to deal with original hardware and software and specially constructed sensory and operating facilities.

Presented in the paper is an original programmable feedback loop with the intravenous drug delivery and bar-pressing data acquisition system, which is of great interest for behavioral pharmacology.

The devise is an automatic controlling system that provides continuous steady work, for every small technical handicap has a negative effect on instrumental behavior device. A block diagram of the overall system is presented in fig.1.

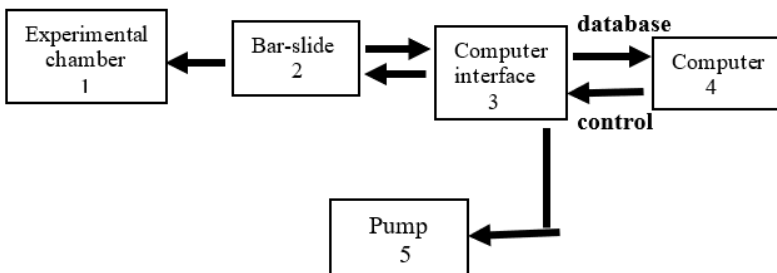


fig.1

As the diagram indicates the computer monitoring system consists of five basic blocks: 1. A chamber for the animal, 2. installed bar slide 3. metering pump. 4. computer interface, and 5. computer chamber for the animal. The pump involves a pulse engine, an automatic system for drug administration into the animal s organism, and a pulse generator operation TTL device for a manual activation. The computer interface is connected between the computer and the bar-metering pump via bits

input and output ports and provides their operation via output control base port by computer (according to the relevant algorithm) . For bar-slide the data are transferred to the computer via an input base port.

REGULARITIES OF DRUG ADDICTION DEVELOPMENT IN THE RATS

T. Asanidze, A. Noselidze

Batumi Shota Rustaveli State University, Georgia
I.Beritashvili center of experimental biomedicine, Tbilisi

In this study the method of intravenous (i.v.) self-administration was used to show that the rate of the acquisition of fentanyl addiction is dependent on the received drug dose and the frequency of pressing an active lever represents an important determinant for the acquisition of compulsive drug self-administration behavior.

The determinants that effect on the rate of formation of addiction to reinforcing psychotropic substances are pharmacological properties of substances, doses, manners of taking. Prehistory of food taking behavior, taste of the taken food and its caloricity, food availability, prehistory of drug taking, sex and age of the animal, the level of the locomotor activity are also important. Since drug abusers are divided into two groups: “light” and “heavy” drug users, definition of the factors which determine formation of the heavy drug user after development of drug addiction is of major importance. The aim of our study was to determine the importance of frequency of performance of drug self-administrative instrumental behavior during the fentanyl i.v. self-administration in rats while the single administration dose was altered. This investigation is important for determining the strategy of prevention of drug addiction and formation of the so called “heavy” user.

These issues are the focused in this paper.

FOR THE ETHICAL PROBLEMS OF DIGITAL EDUCATION IN DECISION-MAKING PROCESS

I. O. Bagrationi

Batumi Shota Rustaveli State University, Georgia

irma.bagrationi@bsu.edu.ge

The present scientific report deals with the basic and fundamental theoretical aspects of axiological biases of some worldview issues and ethical problems in scope of Education science through the digital technology system. The research idea of the report is that the process of digitalization of educational reality will be successful only with the support of the regulative practical ethical standards and values adequate to the ethical formation of informational and educational technologies.

The report tells us that we all already live in the era of cyber-socialization of society. The technical concept of cyber-sociality is understood by the semantically thought as a set of qualities acquired by a person, ensured by his ability to organize life in cyberspace in the context of performing various functions as a network community, and not in the role of a sovereign personality. In connection with this thought of the viewpoint, with which we agree - the question arises whether the aggregate later, acquired by a person in the process of digital operate, efficient, safe and morality performance of social and professional functions? Let's reflect on the answer to this question, meaning a spontaneously emerging cyber-socialized society with all its metaphysical and immanent features, and digital education specially organized in the intellectual world system.

The report outlines the greatest difficulty is the transition from information circulating in the training system to independent practical actions and deeds, in other words, from a sign system as a form of information presentation on the pages of a textbook, a monitor screen, etc. to a system of practical actions performed on the basis of knowledge and having a fundamentally different logic than the logic of organizing a semiotic system. This is the classic problem of applying knowledge in practice, and in axiological language - the problem of the transition from worldview thought to relevant valuable action; for example, “the types of educational research fall along the following main continua; Experimental research is based on the goal of trying to find generalized answers to specific” [1], as much as the problematical ethical and worldview questions.

In the ethical worldview context the report must notes here also

about the point of view of Georgian Professors Ibraim Didmanidze and Irma Bagrationi's work "On Educational Technologies for the Aesthetic Synesthesia Research" through moral values and axiological theory. "In addition the research shows that teachers' beliefs about the value of digital technology for learning and the nature of successful learning environments are important in teachers' pedagogical reasoning" and "these are usually the first personal concepts that educational systems require children to learn. Difficulties have been recognized in adequately defining synesthesia. Many different phenomena have been included in the term synesthesia and in many cases the terminology seems to be inaccurate" [2] Thus, a multidimensional problem has arisen of choosing a scientifically based strategy for the digitalization of education, which would make it possible to use all the enormous advantages of a computer and avoid losses that will affect the quality of the formation of the personality from the standpoint of not only their professional and practical, but also social competence, civic position and moral character. Thus, the "purpose of the research is to present some educational questions, such as: Educational practice shows, that the people allocated by business abilities, as a rule, are inventive and vigorous. They prefer to make independently the decisions aimed at reception of concrete ethical results are susceptible to innovations and ready to risk" [3]

The report is interested in the methodological approaches of a Russian professor of the Perm National Research Polytechnic University, Doctor of Philosophy Vladimir Nikolaevich Zheleznyak who points that "there can be no dialogue with a machine by definition. What is called "interactive mode" is only a variation in the sequence or the amount of information given out" [5]. These procedures exhaust the possibilities of operating with ready-made information fixed in the memory of the machine. And a real dialogue is an objective dialectical contradiction of the subject of discussion realized in communication, which even the most modern machine cannot master, it does not understand the contradiction. The computer evaluates the introduction of conflicting information with a symbolical assessment. The only advantage of the computer, we will add, is the incredibly high speed of the electrical signal passing along the path specified by the moral program of the decision-making process.

This means that the machine does not provide the processes of creativity even in the case when it carries out educational simulation, sets the mode of "intellectual game" [4], although it is indisputable that

it is in this function that the use of a computer is most promising. It helps the teacher to create a learning environment that does not provide the formation of students' thinking, but contributes to it. Thus, digital teaching devices are the embodiment of rigorous mathematical, engineering, technocratic thought, and the educational process is based on psychological and pedagogical, largely subjective patterns of the activities of teachers and students, starting with their human motivation and ending with intuitions and personal meaning of transmitted and received educational information.

The report concludes that if we go along the path of total individualization of teaching with the help of personal computers, we can come to the conclusion that the very possibility of forming creative thinking, which by its origin is dialogical, will be missed. There is another danger: the curtailment of social contacts, a reduction in the practice of social interaction and communication, which leads to individualism and loneliness. This does not mean that digital learning should not be used, quite the opposite. But it is important to find a pedagogically and methodologically grounded ethical balance between using the capabilities of a personal computer and live dialogical communication between the moral subjects of the educational decision-making process.

References

1. Bagrationi I. For the Issues of the World-View Online Foreign Language Learning // Proceedings: “SGEM 2018–5th International Multidisciplinary Scientific Conference on Social Sciences and Arts”, Vol.5, Iss.2.2, „Alexander Malinov“ Blvd., 1712 Sofia, Albena Co., Bulgaria. 2018.
2. Didmanidze I., Bagrationi I. On Educational Technologies for the Aesthetic Synesthesia Research//Cross-Cultural Studies: Education and Science (CCS&ES)”, Vol. 5, Iss. II, Publisher: Beyer Thomas Robert, Vermont: “Middlebury College”, 2020. DOI: “10.24411/2470-1262-2020-10078” - pp. 67-78.
3. Didmanidze I., Beridze Z., Bagrationi I. On the Ethical Values of Business and Technology Education According to Erich Fromm’s Social Pedagogy Views// “6th International Multidisciplinary Scientific Conference on Social Sciences and Arts - SGEM 2019”, Proceedings: Vol.6, Iss.6.1; STEF92 Technology Ltd., 51 „Alexander Malinov“ Blvd., 1712 Sofia, Bulgaria, 2019.
4. Vygotsky L.S. Collected Works in Six Volumes, Volume 3, Problems of Mental Development, Edition by A.M. Matyushkin, Moscow, “Pedagogy”, 1983. – pp. 19-20.
5. Zheleznyak V. Logos and Technologies// Bulletin of the Perm National Research Polytechnic University: Culture, History, Philosophy, Law, № 2, 2015. - pp. 21-28.

PROBLEMS OF THE EFFICIENCY OF BUDGET FUNDING IN EDUCATION

V.E. Bakhrushin

National University "Zaporizhzhia Polytechnic", Ukraine

Vladimir.bakhrushin@gmail.com

Under the low (compared to other European countries) Ukraine's GDP per capita, the issue of effective use of available resources, including budget financing of education, becomes particularly relevant. From this point of view, for funding the training of specialists with higher education, it is appropriate, in accordance with the European experience, to choose one of the block funding mechanisms of HEIs, which takes into account the results of their educational, scientific and other activities. But the results of the simulation show that these mechanisms are very sensitive not only to the choice of indicators, but also to specific methods of their calculation. Therefore, additional data are needed to verify the adequacy of the selected objective function. It should be noted that the optimal distribution should ensure the maximization of future budget revenues due to the acceleration of the development of high-tech industries, which further complicates the problem and may involve the establishment of funding quotas for specialties or fields of study.

The approach to optimizing funding in secondary education should be significantly different. The possibility of application for this purpose the Data envelopment analysis is considered. An integral indicator of resource provision in each region was calculated using amounts of educational subvention per student and per class. The integral performance indicator was calculated on the basis of EIE indicators, taking into account the percentages of persons who did not overcome the pass/fail threshold in the relevant subjects and persons who received a result of 180+ points. An additional non-trivial problem is the choice of the objective function. As in the previous case, the results are also sensitive to specific ways of constructing integral indicators. Therefore, it is need an independent assessment of adequacy to choose the best option. An additional complication is the need to take into account other performance indicators of schools for which there are no quantitative estimates. One of the approaches to its elimination may be to separate a part of the educational subsidy, which then will be distributed according to other rules.

ON SOME METHODS FOR SOLVING NON-LINEAR EQUATIONS WITH OVER QUADRATIC CONVERGENCE

M.Y. Bartish, N.P. Ohorodnyk

Ivan Franko National University of Lviv, Ukraine

mykhailo.bartish@gmail.com, ogorodnyk.nataly@gmail.com

Let's consider the problem

$$F(x) = 0 \text{ where } F: R^n \rightarrow R^n \quad (1)$$

There are some number of algorithms for solving problem (1). We proposed new approach for building methods that could help us to solve problem (1). The new algorithm achieves a solution with fewer calculations than basis and has next view

$$u_k = \Phi(x_k); \quad x_{k+1} = x_k - F(x_k, \Phi(x_k))^{-1} F(x_k). \quad (2)$$

Theorem. Let's next conditions are satisfied.

1. $\Phi(x)$ operator that satisfies condition $\|\Phi(x) - x_*\| \leq C \|x_k - x_*\|^\tau$, where $C > 0$, $\tau \geq 1$, x_* - solution of the problem (1).

2. For $x, y \in X$, $X = \{x \in R^n : F(x) \leq \|F(x_0)\|\}$: $\|P(x, y)^{-1}\| \leq B$, where $B > 0$.

3. For $x, y, z \in X$: $\|F(x, y) - F(x, z)\| \leq M \|y - z\|$, where $M > 0$.

4. The initial approximation x_0 is chosen to satisfy the condition $q^\tau = BMC \|x_0 - x_*\|^\tau < 1$, then the sequence x_k is defined correctly and next evaluation can take place $\|x_k - x_*\| \leq q^{(1+\tau)^k - 1} \|x_0 - x_*\|$.

Propose to consider some cases of choosing operator $\Phi(x)$.

1. Let $F(x) = x - P(x)$ and $\|P'(x)\| < q_1 < 1$. If $\Phi(x) = P'(x)$ and when certain conditions are met, the next evaluation occurs

$$\|x_k - x_*\| \leq C_1 (qq_1)^{2^k - 1} \|x_0 - x_*\|. \quad (3)$$

For sequence (3) the quadratic convergence is obtained and it increases significantly due to q_1 .

2. Algorithm (2) can be presented as

$$u_k = x_k - F(x_{k-1}, u_{k-1})^{-1} F(x_k),$$

$$x_{k+1} = x_k - F(x_k, u_k)^{-1} F(x_k), \quad k = 0, 1, \dots$$

When the certain conditions are met, the sequence $\{x_k\}$ correctly defined and convergent.

**FORECAST AND OPTIMAZATION OF DYNAMICS
OF NUMBER OF PERSONS WITH STRESS SYNDROME
UNDER UNCERTAINTY**

S. Bekesiene¹, O. Nakonechnyi², O. Kapustian², I. Shevchuk²

¹General Jonas Zemaitis Military Academy of Lithuania

²Taras Shevchenko National University of Kyiv, Ukraine

a.nakonechnyi@gmail.com

In emergency situations, the problems of determining the number of persons in a state of stress are particularly relevant.

We propose to use differential equations to describe the evolution of stress-processes over time in a population and the role of influences (leading to a decrease or increase in the number of such individuals).

To solve such a problem, we will use the equation of population dynamics in the form:

$$\frac{dx(t)}{dt} = f(t, x(t)), t \in (t_0, +\infty), x(t_0) = x_0 \geq 0,$$

where $x(t)$, $t \in (t_0, +\infty)$ is the total number of people in a state of stress.

We investigate cases where the value $x(t)$, $t \in (t_0, +\infty)$ is unknown and function $f(t, x(t))$, $t \in (t_0, +\infty)$ can be represented as:

- 1) $f(t, x(t)) = \mu(t)x(t) + b(t)u(t), t \in (t_0, +\infty)$;
- 2) $f(t, x(t)) = \mu(t)x(t) + b(t)u(t)x^2(t), t \in (t_0, +\infty)$;
- 3) $f(t, x(t)) = \mu(t)(N - x(t)) + b(t)u(t), t \in (t_0, +\infty)$

Here $\mu(t)$, $t \in (t_0, +\infty)$ is a rate of change of number of persons under a stress; $u(t)$, $t \in (t_0, +\infty)$ is external influence, N the number of persons in the group under investigation.

First, with additional data on the values $x(t)$, $t \in (t_0, +\infty)$ at different moments of time, functions $\mu(t)$, $t \in (t_0, +\infty)$ are evaluated with known influences $\mu(t)$, $t \in (t_0, +\infty)$ and then with known functions, we find functions that are optimal in some sense are determined $u(t)$, $t \in (t_0, +\infty)$.

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References

1. Bekesiene S., Smaliukiene R., Vaicaitiene R. Using artificial neural networks in predicting the level of stress among military conscripts. *Mathematics*. – 2021. – №9(6). – P. 626-649.
2. Bekesiene S., Smaliukiene R., Vaičaitienė R., Mažeikienė A., Larsson G., Karčiauskaitė D., Mazgelytė E. Three-faceted approach to perceived stress: A longitudinal study of stress hormones, personality, and group cohesion in the real-life setting of compulsory basic military training. *Sustainability*. –2022. – № 14(3). – P. 1046.
3. Nakonechnyi O., Shevchuk I. Stability under stochastic perturbation of solutions of mathematical models of information spreading process with external control. // *Mathematical modeling and computing*. – 2018. – Vol. 5(1). – P 66–73.
4. Balaka H., Fokaf O., Kuzminova K., Myrvoda S., Shevchuk I. A Practical Assessment of the Potential Public Health Consequences of Russian Military Aggression in Ukraine. // *CNDCGS2022*. – 2022. – P. 85–86.

MAXMIN-STRATEGIES IN ANTAGONISTIC GAMES

I.V. Beyko

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnical Institute", Ukraine
ivan.beyko@gmail.com

Consider antagonistic games $J = (F, U, V, Z, W)$, where U, V are given sets of admissible game strategies $(u, v) \in U \times V$; Z is a given set of admissible values of variables $z \in Z$; W is a given set of random variables $w \in W$; $F: U \times V \times Z \times W \rightarrow R$ is the given payoff function of the first player. J -games and matrix games are examples of mathematical models of singles and doubles in sport. In matrix games we have $U = \{u_1, u_2, \dots, u_n\}$, $V = \{v_1, v_2, \dots, v_m\}$, and optimal strategies (u_{i^*}, v_{j^*}) are found as solutions of inequalities

$$\forall i, j \quad F(u_i, v_{j^*}) \leq F(u_{i^*}, v_{j^*}) \leq F(u_{i^*}, v_j).$$

If the optimal strategy (u_{i^*}, v_{j^*}) does not exist, then we built

optimal mixed strategy $(u_{\bar{i}^*}, v_{\bar{j}^*})$, where the random value \bar{i}^* accepts the values i with probabilities p_i^* , the random value \bar{j}^* accepts the values j with probability q_j^* , and p_i^*, q_j^* are found as solutions of inequalities

$$i = 1..n, \quad 0 \leq p_i \leq 1, \quad p = (p_1, p_2, \dots, p_n), \quad p_1 + \dots + p_n = 1,$$

$$j = 1..m, \quad 0 \leq q_j \leq 1, \quad q = (q_1, q_2, \dots, q_m), \quad q_1 + \dots + q_m = 1,$$

$$M(p, q) := \sum_{i=1}^n \sum_{j=1}^m p_i q_j F(u_i, v_j),$$

$$M(p, q^*) \leq M(p^*, q^*) \leq F(p^*, q).$$

In cases of different incomplete data we construct different types of optimized strategies using:

(1) maxmin-algorithms

$$(a) \hat{u} = \arg \max_{u \in U} \min_{z \in Z} F(u, v, z),$$

$$(b) \bar{u} = \arg \max_{u \in U} \min_{v \in V, w \in W} M_w F(u, v, w),$$

$$(c) \tilde{u} = \arg \max_{u \in U} \min_{z \in Z, v \in V, w \in W} M_w F(u, v, z, w),$$

(2) saddles (optimal stabilization),

(3) mixed strategies (probabilistic optimization).

OPTIMAL CONTROL FOR THE MATHEMATICAL MODEL OF HIV/AIDS TRANSMISSION

Ya.E. Borysyuk, M.V. Shcherbatyy

Ivan Franko National University of Lviv, Ukraine

yaryna.borysyuk@lnu.edu.ua, mykhaylo.shcherbatyy@lnu.edu.ua

We considered the mathematical model of HIV/AIDS transmission which described by the initial value problem for ODEs [1]:

$$\left\{ \begin{array}{l} \frac{ds}{dt} = b(1-s(t)) - (1-u(t))\beta(i(t) + \eta_c c(t) + \eta_a a(t))s(t) + da(t)s(t); \\ \frac{di}{dt} = (1-u(t))\beta(i(t) + \eta_c c(t) + \eta_a a(t))s(t) - (\rho + \varphi + b)i(t) + \\ \quad + \alpha a(t) + \omega c(t) + da(t)i(t); \\ \frac{dc}{dt} = \varphi i(t) - (\omega + b)c(t) + da(t)c(t); \\ \frac{da}{dt} = \rho i(t) - (a + b + d)a(t) + da^2(t)c(t); \end{array} \right. \quad (1)$$

$$s(0) = s_0 \geq 0, \quad i(0) = i_0 \geq 0, \quad c(0) = c_0 \geq 0, \quad a(0) = a_0 \geq 0 \quad (2)$$

$$s(t) + i(t) + c(t) + a(t) = 1 \text{ for all } t \in [0, T].$$

In model: s – proportion susceptible individuals in population, i – HIV-infected individuals with no clinical symptoms of AIDS but able to transmit HIV to other individuals, c – HIV-infected individuals under ART treatment, a – HIV-infected individuals with AIDS clinical symptoms, $u(t)$ – control function, which represents the effort on HIV prevention measures; $b, \beta, \eta_c, \eta_a, d, \rho, \varphi, \omega, a$ – fixed parameters.

The optimal control problem consists in finding such control function $u(t)$ that minimize distance of susceptible individuals $s(t)$ and

$$\text{their desirable value } s_d : \min J(u) = \int_0^T (s(t) - s_d)^2 dt \quad (3)$$

subject to state equation (1)-(2) and box control constraint $0 \leq u(t) \leq u_{\max}$. Results of qualitative analysis of the system (1)-(2) and various numerical experiments of direct problem and optimal control problem are presented.

References

1. Campos C., Silva C.J., Torres D.F.M. Numerical Optimal Control of HIV Transmission in Octave/MATLAB // Mathematical and Computational Applications. – 2020. – Vol. 25, No 1. URL: <https://doi.org/10.3390/mca25010001> – 2020.

EXTRAPOLATION METHOD BASED ON AVERAGED POLYNOMIAL FORECASTS

A.Ya. Bomba¹, Y.V. Turbal¹, M.Y. Turbal¹, B.Y. Turbal²

¹National University of Water and Environmental Engineering,
Rivne, Ukraine

²Taras Shevchenko National University of Kyiv, Ukraine
abomba@ukr.net, turbaly@gmail.com

We considered the extrapolation problem from the point of view of polynomial-based forecasting. It is well known that using of polynomials for extrapolation often raises a number of problems. There is a problem of too fast growth of the polynomial of a large degree on the extrapolation interval and a large extrapolation error. At the same time, the forecast based on a polynomial of small degree can be very inaccurate. In [1] proposed an algorithm for optimally choosing of the degree of extrapolation polynomial. The prediction method proposed here is based on the following property.

Let $f_i = f(i\Delta), i = n, n-1, \dots, n-m$ are the known values of some function at the points $i\Delta$ respectively. Then the predictive value at the point $(n+1)\Delta$, based on the interpolation polynomial degree $m-1$, can be found according to the relation:

$$P_2^{m-1}((n+1)\Delta) = \sum_{k=1}^m (-1)^{k-1} C_m^k f_{n-k+1}. \quad (1)$$

Let us denote $f_{n+1}^i = P_2^i((n+1)\Delta)$. Main idea of our approach based on construction of the predictive value $f_{n+1} = f((n+1)\Delta)$ in the form:

$$f_{n+1} = \frac{1}{\hat{m}} \sum_{i=1}^{\hat{m}} f_{n+1}^i, \quad (2)$$

$$\hat{m} = \arg \min_m \left| \frac{1}{m} \left(\sum_{k=2}^m (-1)^{k-1} C_m^k (f_{n-k+1} - f_{n-k+2}) + \sum_{i=1}^m f_{n+1}^i \right) - f_n \right|. \quad (3)$$

Thus, we can find the predictive value as the average of the polynomial prognoses.

References

1. Turbal Y., Bomba A., Turbal M., Drivi A. Some aspects of extrapolation based on interpolation polynomials. Physico-mathematical modeling and information technologies. Vol. 19. 2021. P. 112-118. <https://doi.org/10.15407/fmmit2021.33.175>

HYSTERESIS STRATEGY FOR A RETRIAL QUEUE WITH A CHANGEABLE SERVICE RATE

M. Bratiichuk¹, I. Usar²

¹Silesian University of Technology, Poland

²Taras Shevchenko National University of Kyiv, Ukraine

Mykola.Bratiichuk@polsl.pl, usar69@ukr.net

The simplest single server retrial queueing system $M/M/1/\infty$ can be describe as follows. Customers arrive according to a Poisson process with rate λ . We call these customers *primary calls*, and if the server is free at the time a primary call arrives, then this call begins to be served immediately and leaves the system after service completion. If the server is busy, the arriving customer hits the so-called *orbit* and becomes a *repeated call*. Every repeated call tries to get the server in a random time, which is supposed to have an exponential distribution with parameter ν . If a repeated call finds the server is free, the repeated call is served and leaves the system after service completion. Otherwise, it remains on the orbit, and the process repeats. The service time distribution is exponential with parameter μ for both primary and repeated calls.

The generalization of this system was proposed in [1]. It was supposed that the parameter of service time distribution depends on the number of calls in the system. This parameter is defined as follows. Let a call (primary or repeated) get the server at the epoch τ , and at that moment we have j calls in the system. (It is clear that if at the epoch $\tau-0$ we have i calls on the orbit, then $j=i+1$ if a primary call gets the server, and $j=i$ if a call on the orbit gets the server). Then, the parameter of service time distribution of that customer is μ_j . The similar systems were considered in the framework of the so-called *threshold* strategy, when the number of customers on the orbit is less then some level T , then the service rate is μ_1 otherwise the service rate is μ_2 . In this case, we can consider the queueing system from a somewhat different perspective. Let us say that the server follows the *first regime* if the service rate is μ_1 , and it follows the *second regime* if the service rate is μ_2 . Now, the level T is a threshold where the switching of the regimes occurs, and the model itself can be considered as a version of models with controllable service rate, which has many practical applications.

Here, one problem arises. It can happen that the number of switchings from the first regime to the second one and vice versa is too large, which is unacceptable from a practical point of view. To solve

this problem, in [2] the hysteresis strategy was considered. The main idea of that strategy lies in the fact that switching from the first regime to the second occurs on the level b , whereas from the second regime to the first one occurs on the level $a < b$. Between these levels, the system follows the regime that it has in the previous step.

In the present paper, we deal with a hysteresis strategy for retrial queueing systems $M/M/1/\infty$ with a state-dependent service rate. The existence condition and the formulae for ergodic distribution of the number of calls in the system are obtained.

References

1. Bratiichuk M., Chechelnskiy A., Usar I. M/M/1 retrial queueing system with variable service rate. // Ukrainian Mathematical Journal. – 2020. – Vol. 72(3). – P. 403-415.
2. Klimenok V. Optimizing the dynamic control of an operating mode of data systems with repeated calls. // Avtomatika i vychislitel'naya tekhnika. – 1990. – P. 25-30.

RANDOM EVOLUTIONS UNDER LEVY APPROXIMATION SCHEME AT SEMI-MARKOV ENVIRONMENT

Ya.M. Chabanyuk¹, A.V. Nikitin², U.T. Khimka¹

¹Ivan Franko National University of Lviv, Ukraine

²National University of Ostroh Academy, Ukraine

yaroslav.chabanyuk@lnu.edu.ua, anatolii.nikitin@oa.edu.ua,

ulyana.khimka@lnu.edu.ua

An exceptionally important case is the study of the behavior of dynamical systems in a random semi-Markov environment. A large number of works are devoted to the study of such systems, for example, [1,2]. The concept of a semi-Markov process is a natural generalization of Markov chains and Markov processes.

We study the case when the perturbations of the system are determined by the impulsive process in the nonclassical Levi approximation scheme. We focus on the question of the asymptotic behavior of the generator of this system.

A stochastic evolutionary system in an ergodic semi-Markov environment is defined by a stochastic differential equation

$$du^\varepsilon(t) = C(u^\varepsilon(t), x(t/\varepsilon))dt + d\eta^\varepsilon(t), \quad u^\varepsilon(t) \in \mathbb{R}^d, \quad (1)$$

where $u^\varepsilon(t), t \geq 0$ is a random evolution, ε is a small parameter, $x(t), t \geq 0$ is a semi-Markov process in standard phase space (X, \mathcal{X}) generated by the Markov renewal process $x_n, \tau_n, n \geq 0$ and which is defined using the semi-Markov kernel

$$Q(t, x, B) = P(x, B)G_x(t)$$

$$Q\varphi(x) = q(x) \int_X P(x, dy) [\varphi(y) - \varphi(x)],$$

on the Banach space $B(X)$ of real-valued bounded functions $\varphi(x)$.

Establishing sufficient conditions for the convergence evolutionary system (1) to the limit process is carried out using Koroliuk's model theorems [1].

References

1. Koroliuk V.S. Stochastic Systems in Merging Phase Space / V.S. Koroliuk, N. Limnios // World Scientific, Singapore, 2005. – 330 p.
2. Y.Chabanyuk, A.Nikitin, U.Khimka Asymptotic Analyzes for Complex Evolutionary Systems with Markov and Semi-Markov Switching Using Approximation Schemes. – Monograph (ISBN: 978-1-119-77973-5), November 2020, Wiley-ISTE. – 240 p.

HYPERSINGULAR INTEGRALS METHOD FOR COMPUTATIONAL TECHNOLOGIES

Dmytro Cherniy^{1,2}, Pavlo Vasin², Ivan Pylypchenko²

¹Institute of Telecommunications and Global Information Space, NASU

²Taras Shevchenko National University of Kyiv, Ukraine

Dmytro.Cherniy@gmail.com

Approaches to the creation of quadrature-difference schemes for the numerical solution of Cauchy problems are presented. Equations with hypersingularities on the right side are considered.

$$\begin{cases} z = \omega_\nu(t) \in L_\nu(t), t > t_0 : \\ \frac{d\bar{\omega}_\nu(t)}{dt} = \frac{1}{2\pi i} \int_{L_\nu} \frac{f(\omega, t) d\omega}{(\omega_\nu - \omega)^n}, \\ n = 1, 2, 3, \dots \\ \omega_\nu(t_0) = \omega_{\nu,0} \in L_\nu(t_0). \end{cases} \quad (1)$$

The function $f = f(\omega)$ have to satisfies the condition

$$|f(\omega_1) - f(\omega_2)| \leq A |\omega_1 - \omega_2|^\lambda, \lambda = \mu + n - 1, 0 \leq \mu \leq 1, n = 1, 2, 3, \dots \quad (2)$$

It is shown that for approximation and stability of computational schemes, it is important to correctly, in the sense of Hadamard (3) - Cauchy (4), calculate the final value of the discretized integral on the right side of the equation.

$$\int_{L_{ab}} \frac{f(\omega)d\omega}{(\omega - \omega_0)^n} = \lim_{\substack{\omega' \rightarrow \omega_0 \\ \omega'' \rightarrow \omega_0}} \left[\int_a^{\omega'} \frac{f(\omega)d\omega}{(\omega - \omega_0)^n} + \int_{\omega''}^b \frac{f(\omega)d\omega}{(\omega - \omega_0)^n} - \frac{f(\omega_0)}{(n-1)} \left(\frac{1}{(\omega'' - \omega_0)^{n-1}} - \frac{1}{(\omega' - \omega_0)^{n-1}} \right) \right], \quad (3)$$

$$\lim_{\substack{\omega' \rightarrow \omega_0 \\ \omega'' \rightarrow \omega_0}} \frac{|\omega' - \omega_0|}{|\omega'' - \omega_0|} = 1. \quad (4)$$

The evidence presented in the report makes it possible to use the discrete singularity method (DSM-method for solving singular / hypersingular integral equations [1,2]) for constructing universal computing technologies, the computer implementation of which provides simulation of dynamic processes in real time. It will be demonstrate advantages and limitations of using DSM for evolution problems.

References:

1. Dovgiy S.A., Lifanov I.K., Cherniy D.I. The method of singular integral equations and computational technologies. – Kyiv:"Yuston", 2016.
2. Dovgiy S.O., Lyashko S.I., Cherniy D.I. Algorithms of Discrete Singularities Method of Computational Technologies. // Cybernetics and System Analysis. – 2017. – № 6. – P.147-159.
3. Lifanov I.K., Poltavskii L.N., Vainikko G.M. Hypersingular integral equations and their applications. – A CRC Press Company:"Chapman&Hall/CRC", 2004. – 398 p.

PARAMETRIC OPTIMIZATION OF THE PLACEMENT, LINK CONFIGURATIONS AND MOVEMENT OF THE TWO- LINK MANIPULATION SYSTEMS

M.V. Demydyuk¹, V.M. Demydiuk²

¹Pidstryhach Institute for Applied Problems of Mechanics and
Mathematics NAS of Ukraine, Ivan Franko National University of Lviv,
Ukraine

²LLC “DevCraft”, Lviv, Ukraine

myroslav.demydyuk@lnu.edu.ua

We study the controlled motion of a two-link manipulator, which under the action of controls (torques at joints) performs a transport operation in the horizontal plane: transfers the cargo from a given initial position to a given final position. The speeds of the cargo at the beginning and end of the operation are considered zero, the duration of the movement is given. During the preparation of the manipulator for the execution of the given operation, it is possible to change the placement of the manipulator in the working zone (position of the joint connecting of the manipulator with a fixed base). Also, at the beginning and the end of the operation, the different angular configurations of the links of the manipulator are possible. The problem is formulated for aggregate optimization of the coordinates of the base joint, the boundary configurations of the links of the manipulator and its movements, provided that the quadratic (over the controls) functional is minimized. We propose the numerical-analytical algorithm for the construction of suboptimal solutions of the problem based on the parameterization of the angular coordinates of the manipulator by the sum of a cubic polynomial and a finite trigonometric series with unknown parameters. The coefficients of the polynomial are found from the initial and final conditions of the transport operation. As a result, the initial problem is reduced to the problem of nonlinear programming with an objective function depending on the coordinates of the base joint, boundary configurations and coefficients of the trigonometric series. The constraints on the position of the manipulator and its movement are satisfied by the method of penalty functions. We use the standard numerical procedures for minimization of the objective function.

The results of numerical modeling of two-link manipulator suboptimal motion are described, and the influence of the base joint coordinates on the characteristics of this motion is numerically investigated. The analysis of numerical calculations shows that the position of the base joint and the boundary configurations of two-link

manipulator influence on its energy consumption during the transport operation significantly.

INFORMATION TECHNOLOGIES AND DECISION MAKING

I.Sh. Didmanidze, M.I. Didmanidze, G.T. Imnaishvili, D. Geladze

Batumi Shota Rustaveli State University, Georgia

ibraimd@mail.ru

The report tells that the *electronic information science keeps the decisions of the* basic directions of world practice of management of industrial firms, and also in this connection its social and economic aspects. The concept of industrial firm as open social system has been in detail shined, classification of the industrial enterprises is given. Very big attention is given in research to classical functions of management - planning, the organization, motivation and to the control. At discussion of strategic planning process of a choice of the purposes of the organization and ways of their achievement has been considered. Very big section is devoted to management of manpower to social production management which problem consists, in essence, an increase of a social maturity of collective.

The report concludes that many informational technologists, digital scientists and programmer teams of the different countries recognize that planning – “the most difficult and responsible site in all work on the organization of efficient control not only because process of definition of the purposes, a final choice of a direction of activity and development of the corresponding program in conditions of the market is exclusively combined, but also owing to complexity of all subsequent work on performance of plans because of variability of a conjuncture and necessity of specification and updating of plans”. They warn industrial firms against simplicity and recommend defining, on the one hand, at the organization of system of planning interrelation of problems and steps on creation of hierarchy of plans, and with another to provide the monitoring system of work of firm and necessary corrections. For this purpose, the management is obliged to find an effective way of a combination of the key variables describing problems and people. The motivation and the control also play an essential role in maintenance of efficiency of performance of tasks. For the manager each specific goal opens an opportunity for its individual creativity which development should be promoted by sufficient organizing independence.

ON THE SOCIAL SENSE OF THE INFORMATION OPERATIONS IN DECISION-MAKING PROCESSES

I.Sh. Didmanidze, G.D. Tsitskishvili, D.Z. Didmanidze, M. Kuchava

Batumi Shota Rustaveli State University, Georgia

Batumi State Maritime Academy, Georgia

ibraimd@mail.ru

The present report aims to analyze the decision of some actual theoretical problems of acquaintance to the practice of informational technologies in the world by institutional objects and consideration of its social and digital aspects. Achievement of the given purpose, in opinion of the author, is carried out through the decision of following problems: discussion and decision of a contemporary general characteristic of the informational environment as open system.

The report emphasises that the effective informational control assumes constant interaction with all other social functions of management - planning, organizational activity, distribution of resources and a management of people. It is connected with expansion and complication of activity of major concerns, concentration and diversification. The administrative control, being a necessary condition of functioning of any economic mechanism, in modern conditions receives the further theoretical development and practical perfection on the basis of improvement of methods of the administrative account and the automated processing of the information, application of analytical methods of decision-making the system analysis.

Efficiency of the administrative control plays the major role in maintenance of ability to live of industrial firm. The problem of the administrative control consists in maintenance of achievement of the planned purposes, realization of scheduled decisions by the organization of streams of the industrial information. The control includes gathering, processing and an estimation of the information on results of activity of various industrial divisions, drawing up of the reporting, revealing of deviations from the established purposes and the reasons of these deviations and definition of the actions necessary for achievement of the purposes.

PRINCIPAL DIRECTIONS FOR OVERCOMING UNEMPLOYMENT

Manana Didmanidze, Ia Motskobili
Georgian Technical University, Georgia
Batumi State Maritime Academy, Georgia

Thorough and sophisticated analysis of integrated household survey databases is essential to uncover profound patterns in unemployment trends. To conduct a comprehensive study of unemployment and devise a more efficient employment policy, we deem it essential to compute the unemployment rate using both the International Labor Organization's standards and an aggregate indicator, which encompasses hidden unemployment and underemployment. To formulate a successful employment policy, it is necessary to implement a consistent system for registering unemployed individuals and available job vacancies.

Promoting the growth of small businesses stands out as a crucial and effective approach to boost the country's gross domestic product and consequently mitigate cyclical unemployment. The advantage of a small business lies in its ability to be established quickly, with minimal expenses, and is distinguished by greater freedom, independence, and operational efficiency. He fosters direct connections with customers and strives to better cater to their requirements.

"Active labor market policy" (ALMP), a globally proven method for fostering employment, provides diverse services to citizens, aiding them in discovering and securing new job opportunities. One of the primary objectives is to diminish the disparity between labor market demand and labor supply. In this regard, the government should enhance the alignment of education quality with the demands of the labor market, particularly crucial for the employment prospects of young individuals. The foremost emphasis should be on delivering education to foster the establishment of a knowledge-based economy.

The analysis has revealed that reducing unemployment in the country requires a comprehensive approach, rather than relying solely on a single method.

DYNAMIC MODEL "AGGRESSOR-VICTIM-SAVIOR"

G.O. Dolenko¹, D.Y. Khusainov¹, D.O. Manovytska²

¹Taras Shevchenko National University of Kyiv, Ukraine

²Glushkov Institute of Cybernetics NAS of Ukraine

dolenkogalyna@gmail.com, manovytska_dariia@ukr.net

One of the differences in the field of analysis and forecasting of the dynamics of armaments is the consideration of economic and military-political aspects. One of the common mathematical models of the dynamics of interaction in society is the Lancaster model. The simplest "aggressor-victim" model has the form of a system of two linear differential equations with constant coefficients. Each of the two sides (blocks) builds up its weapons in proportion to the volume of the opponent's weapons. If $x_1(t), x_2(t)$ are the armament levels of the two sides, then the dynamics of the buildup of armaments can be described by a system of two ordinary differential equations: $\dot{x}_1(t) = kx_2(t)$, $\dot{x}_2(t) = lx_1(t)$.

The coefficients $k > 0, l > 0$ are interpreted as the coefficients of the reaction of each of the parties to the armament of the other. The equilibrium state of the system is a saddle. And, if the initial conditions do not lie on stable separatrixes, then the solutions grow according to the exponential law. Thus, the armed forces of the parties build up to infinity. There are modifications of the model [1], such as the following.

1. The effect of the economic factor is a restraining factor. It reduces the armament rate by an amount proportional to the existing armament. The corresponding model of weapons dynamics has the form of a system of differential equations: $\dot{x}_1(t) = kx_2(t) - ax_1(t)$, $\dot{x}_2(t) = lx_1(t) - bx_2(t)$.

Coefficients $a > 0, b > 0$ are called "fatigue" coefficients. And, if they are greater than "claims for armaments", then armaments are headed for zero.

2. The parties are constantly increasing their armaments, regardless of the state of the conflict and the material base. Then the system expands to a linear inhomogeneous system.

$$\dot{x}_1(t) = kx_2(t) - ax_1(t) + g,$$

$$\dot{x}_2(t) = lx_1(t) - bx_2(t) + h.$$

$$\dot{x}_3(t) = mx_1(t) + nx_2(t) + sx_3(t) + r.$$

If we take into account the time spent in the development of weapons

and the delay in implementation, then a system with a delayed effect is even more adequate.

The report examines the dynamics of the parties' armaments in various cases.

References

1. Puzha B., Khusainov D.Ya., Novotna V., Shatyрко A.V. Investigation of Uniform by Delay Stability of Nontrivial Equilibrium Point of One Population Model // Journal of Automation and Information Sciences. – 2018. –Vol. 50(9). – P.25-37.

MARKOV MODEL FOR SIGNAL CLASSIFICATION

Andriy Drebot

Ivan Franko National University of Lviv, Ukraine

andredrebot@gmail.com

In the world of smart beds it is important to detect sleep stages so the bed can adjust its settings to achieve the most comfort for the sleeper. Usually, the bed contains very thin air membrane that are able to detect change in pressure caused by the factors such as breathing, heart beating, and just simple movements.

In practice, we have data collected by the membrane or likes of it with a defined sampling rate. Additionally, data is labeled with another sampling rate. As usual, we split the collected data set on training, validation, and test data set. Also, it is safe to assume that train and validation data sets come from different distributions than test dataset.

As was mentioned earlier, one of the most important challenges is to detect the stage of the sleep using the pressure data from the sensors. Depending on the literature there are four or five stages during the sleep cycle. Essentially, a person can attend different sleep stages multiple times during the sleep session.

There are existing methods for solving this task. These methods are mainly based on deep learning techniques. These techniques are basically neural networks that combine convolutional and recurrent blocks. However, more often than not, there is room for improvement for the performance of such models. Another challenge is that these algorithms suffer from overfitting. Additionally, there is the noise present in the signal.

Having this setup, it is worth trying to frame the problem using the Markov Model. We have a finite number of states and pressure signals

that characterize the state. Also, we can assume that each state can be characterized by the mixture of distributions. Finally, we can fit our Markov Model to the data so we can answer crucial questions:

- Having the sequence of observations and observed data in the current period, what is the most probable current state?
- Having the sequence of observations, what is the most probable sequence of states?

THE CAUCHY PROBLEM FOR QUASILINEAR EQUATION WITH NONSTATIONARY DIFFUSION COEFFICIENT

Ya. Drin², I. Drin², S. Drin³

¹Yuriy Fedkovych Chernivtsi National University, Ukraine

²Chernivtsi Trade and Economic Institute of the State Trade University, Ukraine

³National University “Kyiv-Mohyla Academy”, Ukraine and Örebro University, Sweden

y.drin@chnu.edu.ua, iryna.drin@gmail.com

Svitlana.Drin@ukma.edu.ua & Svitlana.Drin@oru.se

The initial problem for the heat conduction equation with the inversion of the argument are considered and Green’s function are determined. The theorem declared that the Poisson’s formula determines the solution of the Cauchy problem considered and proved.

Let $A > 0$, $h > 0$ be real numbers; $x \in \mathbb{R}, t \in \mathbb{R}^+$, are independent variables; f, φ, D are known continuous function; $u(x, t)$ is the desired function. We will study the problem:

$$\begin{aligned} u_t(x, t) - D(t)u_{xx}(x, t) + \int_0^1 u(\xi, t) d\xi u_x(x, t) - Au(x, t) = \\ = f(x, t, u(x, t - h)), \quad t > h, \quad x \in \mathbb{R}, \end{aligned} \quad (1)$$

$$u(x, t) = \varphi(x, t), \quad x \in \mathbb{R}, \quad -h \leq t \leq 0. \quad (2)$$

The problem of type (1), (2) for equation without argument delay was studied in [1], [2], [3]. Using [1, p. 120] conditions (3), (4) and (5) we get the problem

$$v_t(y,t) - D(t)v_{yy}(y,t) = e^{At} f(y,t; e^{-At}v(y,t-h)), \quad (3)$$

$$t > h, \quad g \in \mathbb{R},$$

$$v(y,t) = \varphi(y,t), \quad y \in \mathbb{R}, \quad -h \leq t \leq 0, \quad (4)$$

which is solved using step method and fundamental solution of which

$$\Gamma(x - \xi, t) = \frac{1}{2\sqrt{\pi\mathbf{I}(t)}} \exp\left\{-\frac{(x - \xi)^2}{4\mathbf{I}(t)}\right\}, \quad \mathbf{I}(t) = \int^t D(\tau) d\tau.$$

Integral equation which is obtained from (3), (4) is solved while $kh \leq t \leq (k+1)h$, $k \in N$ using successive approximations method, which has limit in some functional space $H(\mathbb{R}_+^2)$ [1, p.125]. The following theorem is true.

Theorem. Let function f is continuous and satisfies conditions (3), (4) from [1, p. 125]. Then exists number $\delta > 0$, that while $\varphi \in H(\mathbb{R})$ and $\langle \varphi \rangle_{\mathbb{R}} < \delta$, then problem (1), (2) has unique solution $u \in H(\mathbb{R}_+^2)$, for which $\langle u \rangle_{\mathbb{R}_+^2} \leq C$.

Keywords: quasilinear, diffusion equation, integral coefficient, Cauchy problem, Green function, deviation argument

References

1. Lavrenthyk V.P. The Cauchy problem for kvazilineare parabolic equation second order this integral coefficient. //Boundary problems this different degeneration and special feature. – Chernivtsi, 1990. – 199 p.
2. Kantaro Hayskawa. On nonexistence of global solutions of some semilinear parabolic differential equations //Proc. Japan Acad. – 1973.– V.49, №7. – P. 503-505.
3. Imanaliev M.I., Ved' I. A. About partial differential equation of 1-th order with integral coefficient //Diff. equations. – 1989. – T. 25, №3. – P. 466-477.

THE DISTRIBUTION OF THE SUPREMUM OF THE HYPERBOLIC EQUATION'S SOLUTION

B.V. Dovhai

Taras Shevchenko National University of Kyiv, Ukraine

bogdov@gmail.com

We consider the first boundary-value problem for a non-homogeneous hyperbolic equation with zero initial and boundary conditions

$$\frac{\partial^2 u}{\partial x^2} - q(x)u - \frac{\partial^2 u}{\partial t^2} = -\xi(x, t), \quad x \in [0, \pi], \quad t \in [0, T],$$

$$u|_{t=0} = 0, \quad \frac{\partial u}{\partial t}\Big|_{t=0} = 0, \quad u|_{x=0} = 0, \quad u|_{x=\pi} = 0,$$

where $T > 0$ is a certain constant, $q(x), x \in [0, \pi]$ is a continuously differentiable function and $q(x) \geq 0$, $\xi(x, t), x \in [0, \pi], t \in [0, T]$ is sample continuous with probability one, centered, strictly Orlicz random field.

Denote

$$V_N(x, t) = \sum_{k=N+1}^{\infty} X_k(x) \frac{1}{\mu_k} \int_0^t \sin \mu_k(t-u) \zeta_k(u) du,$$

where $\zeta_n(t) = \int_0^\pi \xi(x, t) X_n(x) dx$, $\mu_n = \sqrt{\lambda_n}$, $X_n(x), n = \overline{1, \infty}$ is a sequence of orthonormalized eigenfunctions and $\lambda_n, n = \overline{1, \infty}$ are eigenvalues ($\lambda_n \leq \lambda_{n+1}, n \geq 1$) of the corresponding Sturm-Liouville boundary-value problem

$$\frac{d^2 X}{dx^2} - qX + \lambda X = 0,$$

$$X(0) = X(\pi) = 0.$$

For our problem, under the condition of the existence of a solution in the form of uniformly convergent in probability series $V_0(x, t)$, the upper estimate is obtained for

$$P \left\{ \sup_{x \in [0, \pi], t \in [0, T]} |V_N(x, t)| > \varepsilon \right\}, \varepsilon > 0, N = \overline{0, \infty}.$$

References

1. Dovhai B.V. The estimation of supremum distribution of solution of hyperbolic equations with Orlicz right side // Carpathian Mathematical Publications. – 2013. – Vol.5, No.2. – P. 231-241. (in Ukrainian)
2. Dovhai B.V. The equations of string oscillation with Orlicz right part // Scientific Bulletin of Uzhgorod University. Series of Mathematics and Informatics. – 2013. – Vol.24, No.1. – P. 34-45. (in Ukrainian)

USING ARTIFICIAL NEURAL NETWORKS IN MACHINE LEARNING

R. Dutsko

Glushkov Institute of Cybernetics NAS of Ukraine

romdsk@gmail.com

In the modern world, the majority of machine learning methods are based on the use of artificial neural networks. Due to significant computational power growth, these networks have become extremely popular and are applied in various fields. Neural networks provide an intellectual advantage, allowing them to participate in the implementation of various programs in the modern world. Machine learning (ML) is a process in which computer systems acquire knowledge and develop based on their own experience and accumulated data. This approach is considered a component of artificial intelligence. One of the main approaches to ML is the use of artificial neural networks, which can recognize patterns in input data and make autonomous decisions. Machine learning algorithms can be divided into three main approaches: supervised learning, unsupervised learning, and reinforcement learning. Supervised learning is the most common approach used to perform various machine learning operations. It is used with data where there is a clear correspondence between input and output data. In this approach, the algorithm explicitly recognizes features and makes predictions or classifications based on them. Examples of supervised learning algorithms include linear regression, gradient boosting, random forests, logistic regression, support vector machines, and artificial neural networks. Unsupervised learning is used when there are no labeled data, and the model needs to discover patterns and structure in the data on its own. It learns from implicit data properties such as structure, density, related fragments, and so on. Examples of unsupervised learning algorithms include clustering,

anomaly detection, autoencoders, principal component analysis, and deep belief networks [1]. The use of artificial neural networks in machine learning allows systems to make decisions autonomously based on the acquired data. This opens up countless possibilities for automation and optimization of various processes in different fields, including business, medicine, transportation, and many others.

References

1. Goel, A., Goel, A.K. & Kumar, A. The role of artificial neural network and machine learning in utilizing spatial information. *Spat. Inf. Res.* 31, 275–285 (2023). <https://doi.org/10.1007/s41324-022-00494-x>

MODELING AND SOLVING PROBLEMS WITH VARIABLE BOUNDARIES

I.I. Dyyak¹, I.H. Makar¹, I.I. Prokopyshyn²,
I.A. Prokopyshyn¹

¹Ivan Franko National University of Lviv, Ukraine

²Pidstryhach Institute for Applied Problems of Mechanics and
Mathematics, Lviv, Ukraine
ivan.dyyak@lnu.edu.ua

We consider the problem of unilateral contact between a massive elastic body and a composite body consisting of a thin coating in the form of a Tymoshenko-type shell and a massive elastic base connected with the coating via a nonlinear Winkler layer. We present a weak formulation of this problem in the form of a nonlinear variational equation. To solve this equation, we propose a parallel Robin-type domain decomposition method that reduces the original contact problem to the iterative solution of independent linear variational equations corresponding to elasticity problems for massive bodies and a problem of the Tymoshenko-type shell theory for the thin coating [1]. We analyze the dependence of the contact and interface stresses on the height of the coating and the Winkler layer parameter. The results obtained for the coatings modeled using the Tymoshenko-type shell theory and the classical elasticity theory are compared.

Here we also consider a robust and novel approach using the finite element method to simulate the complex process of a screw drilling into wood, a problem characterized by variable boundaries and elastic-plastic material behavior. Utilizing 2D quadratic triangular finite elements, the wood media is accurately discretized, and a dynamic meshing

strategy is employed to rebuild the mesh and boundary conditions at each penetration level [2]. Through rigorous modeling and simulation, the torque exerted during each stage of penetration is precisely estimated. Our methodology provides new insights into the underlying mechanics of screw drilling and has broad implications for the design and optimization of tools and industrial processes.

References

1. Prokopyshyn I. I., Styahar A. O. Investigation of contact between elastic bodies one of which has a thin coating connected with the body through a nonlinear Winkler layer by the domain decomposition methods // J. Math. Sci. – 2021. – Vol. 258, No. 4. – P. 477-506.
2. Coimbra M. C., Rodrigues A.E., Rodrigues J.D., Mendes R.J. Moving Finite Element Method. – Fundamentals and Applications in Chemical Engineering. – Taylor & Francis Group, 2016. – 245 p.

ANALITICS AND DESIGN OF THE CHAIN MANAGEMENT DECISIONS THE WORLD STRUCTURES IN THE PROCESS OF POST WAR UKRAINE'S RECOVERY

Irada Dzhalladova, Oleksandr Bartasz

Kyiv National Economic University named after Vadym Hetman,
Ukraine

idzhalladova@gmail.com, petrgabriluch@gmail.com

The purpose of the article is to analyze the structure of the chain of managerial decisions for managing the post-war reconstruction of Ukraine and to develop the design and structure of the framework for its support, which contains big data and many dimensions - managerial, organizational, and technological. Defined of conceptual guidelines for the potential and implementation of end-to-end [1,2,3]. The developed framework contains some innovative ideas for the organization of ensuring end-to-end management transparency during the recovery of Ukraine based on the application of digital technologies. In particular, conceptual guidelines have been developed for digital supply chain management and the use of technology to increase their resilience by creating and leveraging transparency in information-poor environments. Using the example of Ukraine's post-war reconstruction plan, the analysis of digital applications is expanded to ensure the stability of the control chain in indefinitely conditions. A multidimensional framework

consisting of management, organizations, and digital technology components are proposed. It has been determined that proposed model end-to-end transparency can help improve supply chain. A multidimensional framework consisting of management, organization, and digital technology components is proposed. It has been determined that end-to-end transparency can help improve supply chain resilience in an efficient manner without creating excessive and costly reserves.

References

1. Ganeshan, R., & Harrison, T. P. (1995). An introduction to supply chain management. *Department of Management Science and Information Systems*, 303.
2. Li X., Li Y. J., Cai X. Q. et al., “Service channel choice for supply chain: who is better off by undertaking the service?” *Production and Operations Management*, 2016. vol. 25, pp. 516–5343.
3. Choi T.-M. and Lambert, J.H. (2017), *Advances in Risk Analysis with Big Data. Risk Analysis*, 37: 1435-1442. <https://doi.org/10.1111/risa.12859>

ON THE DEVELOPMENT OF INTELLIGENT INTERFACES OF COMPUTER SYSTEMS FOR SCIENTIFIC RESEARCHES AND SEMI-NATURAL MODELING

V. Eresko, V. Vyshinskiy, O. Vyshinska, O. Kononenko, A. Slipets
Glushkov Institute of Cybernetics NAS of Ukraine
fkp500@i.ua, vyshinskiy@ukr.net, vyshinskaya@ukr.net,
kononenko17@i.ua, alla_volod@ukr.net

The growing need and popularity of remote work requires the development and use of virtual tools and virtual workplaces for computer monitoring systems, process control, automation of scientific research, in semi-natural modeling, and the study of elements of complex objects in various fields. This allows you to complete work tasks from anywhere using common digital devices and communication technologies.

Intelligent interfaces are a critical component of these virtual tools and workplaces. They should provide users with a simple, convenient, intuitive, effective interaction with the system. Intelligent interfaces should provide information and functions to support user tasks, provide intelligent assistance. This includes the possibility of convenient visualization of the required technological process with standard

software and hardware tools available to the user. Other important requirements are: ensuring joint uninterrupted real-time operation of a large number of heterogeneous devices and various equipment, security and protection against unauthorized access, reliability. Interfaces must interact and exchange data with different tools and systems in an efficient way, provide processing and analysis of large amounts of data in real time, support multitasking, provide access to different data sources in real time, and allow control of complex technological processes. They must also be integrated with other systems and technologies, be adapted to different platforms, including new generation computers based on a promising element base. When creating intelligent interfaces, it is convenient and promising to use Internet of Things devices and intelligent sensors. This allows to make devices more autonomous, reliable and efficient in processing information. The development of intelligent interfaces, virtual instruments for information processing tools of distributed information systems is of decisive importance for the development of technologies, for the development of new generation computers, for a significant increase in the efficiency of computer control systems for technological processes and technical means of scientific researches.

THE INFLUENCE OF THE FULL-SCALE RUSSIAN INVASION ON THE PRICE OF GOLD

O.O. Frankov, H.V. Livinska

Taras Shevchenko National University of Kyiv, Ukraine
frankovoleksii@gmail.com, livinskaav@gmail.com

In the work the time series of the price of gold from 01.01.1991 to 01.02.2023 is considered. Data is downloaded from [1]. This time period is divided into two ones by the date of beginning of the full-scale Russian invasion: 24.02.2022. Time series are aggregated from daily period to monthly.

We create and analyse forecasting models based on the first part of time series and compared generated forecasts with real movement of the price of gold after 24.02.2022.

For analysis, ARIMA and exponential smoothing models are chosen. The best result among variety of ARIMA models is obtained with ARIMA(0,1,1) with drift. Double exponential smoothing model is not good for a such long-term forecast.

The forecasts are built with 80% and 95%-confidence intervals. We can see that the real movement of the price decreases significantly and does not fall within any modelled confidence intervals. Similar situation was observed in 2013-2014. So, we can conclude that the full-scale Russian invasion had strong impact on the price of gold.

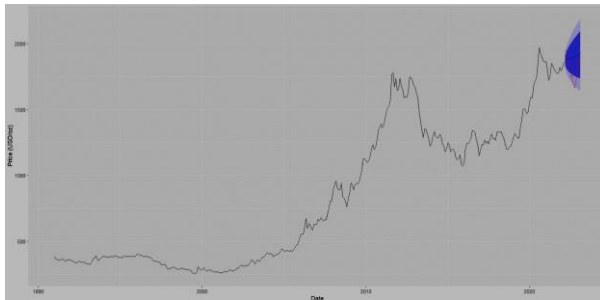


Figure 1 – forecast with ARIMA(0,1,1) with drift

References

1. Historic Gold Price Data

<https://auronum.co.uk/gold-price-news/historic-gold-price-data/>

THE REGULARITY OF SOLUTIONS OF NONLINEAR PARABOLIC EQUATIONS IN WEIGHTED GENERALIZED MORREY SPACES

T.S. Gadjiev

Institute of Mathematics and Mechanics, Architecture and Construction
University, Azerbaijan
tgadjiev@mail.az

In this paper, we prove the generalized Morrey and weighted generalized Morrey estimates for the gradient of the weak solutions for a class of nonlinear parabolic equations in a very general irregular domains. The nonlinearity is assumed to be merely measurable only in the time variable t and belongs to the small bounded mean oscillation (BMO) class as functions of the spatial variable x .

Keywords: Nonlinear parabolic equation; regularity; Reifenberg flat domain; generalized Morrey spaces; gradient estimate; Calderon-Zigmund estimates, weighted generalized Morrey spaces.

TELEGRAM CHAT-BOT AND THE SELECTION OF IMAGE COMPRESSION ALGORITHMS

V. Haslo, I. Vergunova

Taras Shevchenko National University of Kyiv, Ukraine

vladhaslo@knu.ua, iryna.vergunova@knu.ua

The increase in the number and weight of images in daily use poses the task of building various tools for effective work with them.

To solve this problem, we suggest using a chatbot to compress images by choosing the desired algorithm in a given set of algorithms. The user provides an image, selects the required algorithms and the desired parameters. The parameters of the algorithms allow you to control the level of loss and the time of operation during compression. The following algorithms were included in the set: uniform quantization, median slice, K-means method, vector quantization, octant tree method.

For the uniform quantization algorithm, with a fixed parameter k of the number of regions for the color channel ($k = \overline{2,16}$), compression from 46% to 50% is achieved. For the median slice algorithm, at a fixed value of 6 of the separation depth parameter (from 1 to 8), compression from 47% to 51% is achieved. For K-means, which is a machine learning algorithm, for RGB color images, the parameters are the number of clusters (equal to the number of resulting colors, from 2 to 64) and the maximum number of operations (up to 20). At fixed parameters, compression from 48% to 52% is given. For a better match to the original, you need to specify more operations, but then the algorithm becomes slow. For the vector quantization, the parameters are: the size of the codebook (from 1 to 64), the distortion threshold (decimal fraction from 0.1 to 1), the size of the pass window (from 1 to the fourth part of the image parameters). The values of the parameters significantly affect the running time of the algorithm. For parameters (64, 0.5, (4, 4)), compression is achieved from 60% to 67%, for parameters (64, 0.5, (16, 16)) – from 79% to 88%. For the octant tree method, the parameter is the number of resulting colors (from 8 to 128). At the average value of the parameter, compression from 46 to 50% was obtained.

For the selection of algorithms, it should be taken into account that the fastest in the chatbot is the median slice, the slowest is the K-means method. The vector quantization algorithm with parameters (64, 0.5, (16, 16)) is not only quite fast, but also has the smallest increase in

running time as the image weight increases. Uniform quantization and median slice algorithms have the greatest increase in working time with increasing image weight.

ON ONE APPROACH TO MODELING THE DISSEMINATION OF INFORMATION IN SOCIAL NETWORKS WITH AGENTS

E. Ivohin, D. Afonin

Taras Shevchenko National University of Kyiv, Ukraine

ivohin@univ.kiev.ua, afonindi@gmail.com

Recent research in the field of mathematical modeling of information dissemination processes in social networks with agents focuses on expanding and improving models, taking into account various aspects, such as network dynamics, the role of influencers, temporal factors, emotional context, analysis of the structure of social networks, the impact of fake news, etc.

The paper proposes an approach to study the process of information dissemination in social networks based on the impact model with a decrease and increase in user activity. This model allows us to consider the influence of one agent on others in a social network. Each agent has an influence weight that determines its ability to influence its nearest neighbors. The level of information dissemination depends on the total influence of agents in the network.

The social network is represented as a graph, where the nodes are the agents, and the edges are the connections between them. Under such conditions, the change in the activity of agents in the social network can be represented by reducing or increasing the number of edges in the graph. For convenience and to achieve the goals of the study, it is assumed that the number of nodes remains the same, and the removal of edges while reducing their number does not violate the connectivity of the graph.

To generate the graph, the Barabashi Albert model [2] was chosen for generating scaleless networks. For the obtained model, modeling of information dissemination processes was carried out, taking into account changes in the activity of edges in the removed and added networks with a certain probability. An analysis of the results for different rates of increase and decrease in indicators was carried out..

References

1. Centola, D. (2010). The spread of behavior in an online social network experiment. *Science*, 329(5996), p.1194-1197.
2. Boccaletti, S., Latora, V., Moreno, Y., Chavez, M., & Hwang, D.-U. (2006). *Complex Networks: Structure and Dynamics*. *Physics Reports*, 424(4-5), p.175-308.

ON ONE APPROACH TO STORAGE VIRTUALIZATION IN THE PROBLEMS OF UPDATING STREAMING DATA

E.V. Ivohin, A.P. Bondarets

Taras Shevchenko National University of Kyiv, Ukraine

ivohin@univ.kiev.ua, tyombond@gmail.com

Virtualization is a technology that allows you to create virtual versions of physical computer resources. Software is used to create multiple virtual instances of a single physical resource, making virtualization more efficient, flexible, and scalable for computing infrastructure [1].

Virtualization allows you to consolidate multiple physical resources on a single physical machine, reducing costs and increasing hardware usage. This enables rapid deployment of applications and application management services, disaster recovery of critical services, and business continuity based on virtual backups of physical servers and services. Data virtualization provides a state of the art data that includes the ability to access, aggregate, transform and provide data service with high speed and economic efficiency.

With data virtualization, you can use a range of analytics (visualized, predictive, and streaming analytics) that guarantee consistency, high quality, and data protection.

Virtual storage software intercepts I/O requests from physical or virtual machines and sends these requests to the appropriate physical location of the storage devices that are part of the shared storage pool in the virtualized environment.

The basic form of storage virtualization is represented by the software virtualization layer between the storage resource's hardware and the host - a PC, server, or any device accessing the storage.

As part of the work, research was carried out on modern data storage virtualization tools to ensure the actualization of streaming data

and their further use in decision support procedures based on big data analysis. Approbation of the processes of accumulation and processing of data in virtual storage using Apache Kafka was carried out [2].

References

1. Campbell S., Jeronimo M. Applied Virtualization Technology / S. Campbell, M. Jeronimo. – Intel Press, 2006. – 252 p.
2. Bejeck Jr., W.P. Kafka Streams in Action/ William P. Bejeck Jr. – Manning Press, 2018. – 280 p.

ON ONE METHOD OF SOLVING THE TRAVELER PROBLEM WITH REGARD TO THE SUBJECTIVE PERCEPTION OF TIME ACCOUNTING

E.V. Ivohin, V.O. Rets, K.V. Kipyk

Taras Shevchenko National University of Kyiv, Ukraine

ivohin@univ.kiev.ua, mrk.k.0003@gmail.com

The paper investigates the use of fuzzy numbers and the annealing method to find solutions to the traveling salesman problem, taking into account the subjective perception of time accounting in real traffic conditions, which allows us to formulate a fuzzy optimization traveling salesman problem for finding the best time route, determined by the amount of time required to travel between cities [1].

To formalize the uncertainty of the input data associated with the influence of subjectivity in the estimates of time intervals, fuzzy numbers are used. Their application makes it possible to constructively describe the conditions and restrictions that affect the speed of the traveling salesman on certain sections of the route. An annealing method [2] is considered to optimize the solution of the traveling salesman problem by gradually reducing the energy of the system, which makes it possible to explore various solutions and avoid local minima.

In the course of the study, an implementation of the annealing method was proposed for solving the traveling salesman problem, taking into account the subjective perception of taking into account the time to overcome road sections between cities. Within the framework of the approach, the representation of time intervals based on fuzzy numbers is formalized and a multi-threaded computational software implementation is used. The center of gravity method is used to calculate the rank of fuzzy numbers.

An analysis of the numerical results of the traveling salesman route

duration obtained using different methods is carried out. The comparison was carried out on the basis of estimates of the route travel time without taking into account the factors influencing traffic and realistic estimates of the travel time obtained by the proposed method.

References

1. Schrijver, Alexander. On the history of combinatorial optimization (till 1960)/ In K. Aardal; G.L. Nemhauser; R. Weismantel (eds.). Handbook of Discrete Optimization (PDF). Amsterdam: Elsevier, 2005. – P. 1–68.
2. Grabusts, P., Musatovs, J., Golenkov, V. The application of simulated annealing method for optimal route detection between objects// Procedia Computer Science. – 2019. – 149. – P. 95-101.

ON ONE WAY OF GENERALIZING THE COLLABORATIVE FILTERING METHOD TAKING INTO ACCOUNT SEMANTIC AND TIME FACTORS

E.V. Ivohin, G.V. Shelyakin

Taras Shevchenko National University of Kyiv, Ukraine

ivohin@univ.kiev.ua, shelyakingleb17@gmail.com

There are many approaches to the creation of recommender systems [1], the most famous of which are based on the use of neural networks and statistical models.

The application of practical methods for the implementation of recommendations is often associated with the involvement of filtering methods based on content, collaborative filtering based on user information (user-based) and based on comparisons of recommendation objects (item-based) [2]. With the growing number of content and users, the requirements for the computing power of software systems that ensure the efficient operation of recommender schemes are increasing.

This paper proposes a technique to speed up the processing of data received about users, an attempt is made to take into account the fact that users' interests change over time and the possibility of splitting the content of statistical data into a subset according to certain criteria. The implementation of the approach was carried out on the basis of the collaborative filtering method with the comparison of objects, taking into account the time factor and semantic similarity, as well as the cluster analysis method. The paper considers and analyzes a naive item-based collaborative filtering method.

Appropriate software was developed, the adequacy of the proposed method was tested using data sets from various problem areas. Based on the results obtained, the constructiveness of the proposed methodology was confirmed, which allows improving the speed and quality of recommender systems in various problem areas.

References

1. Aggarwal C. C. (2015) Recommender Systems. Springer, 518 p.
2. Мелешко Є. В. (2018) Проблеми сучасних рекомендаційних систем та методи їх рішень. Системи управління, навігації та зв'язку, 2018, 4(50), с.120-124.

INFLUENCE OF LATTICE SUBSTRATE ACOUSTIC HIGH FREQUENCY OSCILATION LOKALIZATION ON INP GROWTH

O.M. Janelidze, I. G. Takidze

Batumi Shota Rustaveli State University, Georgia
Batumi State Maritime Academy, Georgia

This paper presents the model of influence a host A-atom surface substrate substitutional impurity on surface adsorption a normality, consistency and parameters of elementary cell, polytype and structure of deep space charge scattering centers of epitaxial layer.

The higher is the growth temperature, the more effective is the process of substitutional atom pumping up with the energy of lattice substrate high frequency acoustic oscillation. The localization of oscillation and the force acting pressing on the substitutional atom (iron) are rising, when relative difference of mass is rising

Rising makes the highest level of the acoustic branch shift toward high frequency. At high frequency range of the acoustic branch (at the edge of the Brillouin zone) only heavy atoms (iron, indium) oscillate, while the light atoms (oxygen, phosphorus) stay unmovable, that, particularly, leads to the reduction of the symmetry.

Unharmonism of very power high frequency oscillation of substitutional atom determines the increase of (c) lattice parameter. At the growth temperature the iron ion, being in resonance, involves rightly bounded with it and comparably resting atoms of oxygen and phosphorus, and fostering reduction of the lattice parameter - at the growth plate. Entropy increases and free energy decreases. The initial symmetry decreases.

Symmetry decrease causes splitting of electronic levels or taking orbital degeneration off. Electrovalence varies. Several levels are formed, some of deeper disposal. As bigger is the iron nuclei displacement, as greater is splitting. During the lattice substrate acoustic oscillation localization on iron ion the Jahn-Teller type symmetry distortion the most effectively occur at the growth temperature because of participation of infinitude number of the most energetic high frequency phonons.

**THE SKILL-BASED APPROACH TO YOUNG OFFICERS
RESILIENCE TRAINING: A PILOT STUDY AT GENERAL
JONAS ŽEMAITIS MILITARY ACADEMY OF LITHUANIA**

R. Kanapeckaitė¹, D. Bagdžiūnienė², S. Bekesiene³

General Jonas Zemaitis Military Academy of Lithuania

¹ rosita.kanapeckaitė@lka.lt; ² dalia.bagdziuniene@lka.lt;

³ svajone.bekesiene@lka.lt

The pilot study as skill-based approach to young officers' resilience training (RT) was conducted at the Military academy of Lithuania (MAL). The study focused on the evaluation of a newly developed 16-hour psychological resilience training programme that focused primarily on six modules: (i) *Understanding Resilience*; (ii) *Self-awareness and emotion regulation*; (iii) *Positive thinking and optimism*; (iv) *Development of personal competence and independence*; (v) *Building supportive relationships (networking)*; and (vi) *problem solving and stress coping strategies*. This study was approved by an institutional review board of the LMA. The study participants were second-year LMA cadets. The baseline survey measures T1 were taken at the beginning of the RT and the measures T2 six weeks later. The six-week training took place in 1.5-hour blocks separated by 1-3 days. The present study aims to explain the main activities that gradually increase the level of RT using an ANN-based prediction model. Numerous ANN structures were constructed and tested to determine the optimal number of neurones, hidden layers, and transfer functions. The highest precision was obtained by the multilayer perceptron neural network with 5-3-2 partition. The best ANN model was determined showing the smallest cross-entropy error, the correct classification rate, and the area under the ROC curve. The findings show with high precision that modules such as (i) *understanding resilience* and (iv) *development of personal*

competence and independence are critical and have the greatest impact on the level of resilience training.

Keywords: skill-based approach, young officers, resilience training, pilot study, multilayer perceptron neural network, cross-entropy error.

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ANALYSIS OF THE ACCURACY OF POLYNOMIAL INTERPOLATION IN EUCLIDEAN SPACE E_2

O.F. Kashpur

Taras Shevchenko National University of Kyiv, Ukraine

olena.kashpur@gmail.com

The problem of polynomial approximation of operators is an interest both in the theoretical and in the applied aspect. One of the methods of its solution is interpolation. The basics of the theory of operator interpolation in abstract Hilbert and vector spaces are outlined in [1]. A partial case of this problem is the polynomial interpolation of functions of many variables [2]. In this paper, the interpolation of a polynomial function $f : E_2 \rightarrow R_1$, by the minimum norm interpolant [1], [2] is considered. Let the interpolate nodes $\gamma_i, i = \overline{1, m}$ from the set $\{\gamma_0 = e_0, \gamma_i = e_{i_1} + e_{i_2}, k = \overline{1, 2}, i_j = \overline{1, m}, m \geq 2\}$, where $e_0 = (0, 0)$, $e_1 = (1, 0)$, $e_2 = (0, 1)$. The function is given by its values in the interpolation nodes $f(\gamma_i), i = \overline{1, m}$.

To study the accuracy was used an interpolation polynomial $P_2(\gamma)$, which was built by the method of orthogonal moments

$$P_2(\gamma) = l_0 + \sum_{i=1}^2 l_i(\gamma, e_i) + \sum_{i,j=1}^2 l_{ij}(\gamma, e_i)(\gamma, e_j),$$

$\gamma = (x, y)$, $l_0 = f(e_0)$, the unknown coefficients $l_i, l_{ij}, i, j = 1, 2$ are based on a recurrent procedure [3]. It is shown [4] that the minimum norm interpolant and interpolation polynomial [3] are identically the same. For polynomials of the second degree, it is proved that the interpolation error equals zero in the case when the dimension of the polynomial

space p and the number of interpolation nodes m are the same. Under conditions of uncertainty $m < p$, the accuracy of the interpolation formula of the minimum norm is analyzed. The dependence of the interpolation error on the function values, which are not specified, is founded.

References

1. Makarov V., Khlobystov V., Yanovich L. Methods of operator interpolation. – Kyiv, NASU, Inst. of mathematics, v.83, 2010. – 516c.
2. Kashpur O., Khlobystov V. Invariance and uniqueness of solutions of polynomial interpolation problems in Euclidean space // Journal of Comp. and Applied Mathematics. – 2015. – Vol.2(119). – P.8-14.
3. Khlobystov V., Kashpur O. On interpolation of polynomial operators // Cybernetics and Systems Analysis. – 1996. – Vol.32(3). – P.398-403.
4. Khlobystov V. Kashpur E. On Weak Convergence of an Iteration Process with Minimal Norm in a Hilbert Space // Journal of Mathematical Sciences. – 2002. – Vol. 109(4). – P.1791 – 1794.

WHY AND HOW TO STUDY THE NOOSPHERE?

I. Khanin

Association Noosphere, Ukraine

khanin.ig@gmail.com

The concept of the noosphere is necessary for the successful cognition of nature and society on a rational basis. The spread of symbolic modeling in cognition, including "artificial intelligence", means a deviation from the classical traditions of rationalism and leads cognition to a dead end or abyss. The human factor (spatial and temporal limitations) calls into question the possibility of objective cognition, which has manifested itself in the theory of relativity, wave and quantum mechanics, Godel's theorem and cognition of cognition.

Subject-object coordination is a sign, information and communication process, and the growth of interest in the iconic sphere is not accidental. However, in the Cartesian model of the world, there is no place for sign/informational phenomena. Solving this problem, we need to move from the meaning to the essence (ontology) of the noosphere. According to Vernadsky, it began to form from the beginning of the Pleistocene, so it cannot be a human creation. It can be the universe as a whole, a global sign effect of such a phenomenon as human thought. Its structure is given in the Quasi-Physical Model of Cognition and Economical Activity (QPMCEA).

According to the model of Paradigmatic Innovative Development (PIDev), which is part of the QPMCEA, knowledge originates in practical activity (the pre-paradigm phase of cognition) in the form of effects of phenomena of consciousness, represented as embodied, sensually given forms of individual and multiple things, as well as processes occurring with them (temporal things). The content of the paradigm phase is the systematization of empirical knowledge. There is a division of knowledge and labor by their creation and practical application. The architecture of knowledge is being formed: scientific disciplines and their connections with the empirical base and with each other. The results form the knowledge base for the next (post-paradigm) phase of cognition. Thomas Kuhn called it "normal science" and "puzzle solving." Cognition of the noosphere lasts millions of years. Before the discoveries made by Vernadsky, it went in parts (nature and society are parts of the noosphere). Today, the sign essence of the real world is affecting more and more. The cognition of parts and the whole came across the subject/object character of the being-consciousness continuum and into the problem of the ontology of signs.

To solve it, an empirical base, a conceptual basis have been formed and a quasi-physical model of cognition (QPMCEA) has been developed, aimed at solving the problems of cognition of the infosphere: the barrier of semantic diversity and variability of data; the permanent programming crisis; the paradox of semiotics productivity in IT and economics; the slowdown in the development of fundamental knowledge, primarily in the information sphere, and, accordingly, the threat of a technological crisis.

These problems relate to the paradigmatic phase of cognition, in which new knowledge is not yet divided, respectively, with the spheres of phenomena and levels of abstraction, as required by the model of Vertical Integration and the parabola of Knowledge included in the QPMCEA. Knowledge that can be empirical, theoretical, hypothetical, grounded, physical, informational, fundamental, applied, philosophical, methodological, mathematical, etc., is reassembled into a single structure that represents an integral unit of knowledge. In accordance with it, there is a division of knowledge and, accordingly, labor for their further theoretical and practical application. Extracting economic benefits from knowledge changes reality and leads to the beginning of a new cycle of cognition.

Keywords: cognition model, noosphere, sign, paradigmatic innovative development, vertical integration of knowledge.

THE REGULARIZED OPERATOR EXTRAPOLATION METHOD FOR VARIATIONAL INEQUALITIES AND SADDLE POINT PROBLEMS

O.S. Kharkov, V.V. Semenov

Taras Shevchenko National University of Kyiv, Ukraine

olehharek@gmail.com, semenov.volodya@gmail.com

Variational inequalities provide a universal instrument of formulating many problems of machine learning, data analysis, optimal control, and operations research.

With the advent of generating adversarial neural networks (GANs), strong interest in the use and investigation of iterative algorithms for solving variational inequalities arose in the ML-community [1].

Non-smooth optimization problems can be solved effectively if they are reformulated as saddle problems, and modern approximate algorithms for solving variational inequalities are applied to the obtained saddle problems [2].

In this report proposed and investigated a new algorithm for solving monotone variational inequalities in Hilbert spaces. The proposed iterative algorithm is a regularized (by applying the Halpern scheme) variant of the operator extrapolation method [3].

In terms of the number of calculations required to perform an iterative step, this algorithm has an advantage over the extragradient method and the method of extrapolation from the past.

For variational inequalities with monotone Lipschitz continuous operators, acting in Hilbert space, the strong convergence theorem of the method is proved.

References

1. Gidel G., Berard H., Vincent P., Lacoste-Julien S. A Variational Inequality Perspective on Generative Adversarial Networks. arXiv preprint arXiv:1802.10551. 2018.
2. Nemirovski A. Prox-method with rate of convergence $O(1/T)$ for variational inequalities with Lipschitz continuous monotone operators and smooth convex-concave saddle point problems. SIAM Journal on Optimization. 2004. Vol. 15. P. 229-251.
3. Vedel Y., Semenov V., Denisov S. A Novel Algorithm with Self-adaptive Technique for Solving Variational Inequalities in Banach Spaces, in: Advances in Optimization and Applications, volume 1514 of Communications in Computer and Information Science, Springer, Cham, 2021, pp. 50–64.

METHODS OF STRUCTURAL ORGANIZATION OF VIRTUAL COMPUTER SYSTEMS AND WORKPLACES OF VARIOUS PURPOSES FOR SOLVING COMPLEX TASKS

A. Khudiakov

Glushkov Institute of Cybernetics NAS of Ukraine

akhudiakov97@gmail.com

The client-server architecture is a popular method of structuring virtual computer systems and workplaces. In this architecture, a central server provides services to multiple clients. The clients request services from the server and the server processes the requests and returns the results. This architecture is suitable for solving complex tasks because it allows for centralized management and control of the system. Virtual private networks (VPNs) provide a secure and encrypted connection between computers and networks. VPNs are often used to structurally organize virtual computer systems and workplaces for solving complex tasks because they provide a secure and reliable connection between the client and server. This is particularly useful for organizations that require secure communication and data transfer between remote locations. Cloud computing is a method of delivering computing services over the internet. Cloud computing allows for the use of virtual computer systems and workplaces for solving complex tasks because it provides a scalable and flexible infrastructure for computing resources. This allows organizations to scale their computing resources as needed, without having to invest in additional hardware. Grid computing is a method of structuring virtual computer systems and workplaces for solving complex tasks by pooling resources from multiple computers. Grid computing allows for the distribution of computing tasks across multiple computers, increasing the overall processing power available for solving complex tasks. This method is particularly useful for organizations that require large amounts of computing resources for solving complex tasks. Virtual computer systems and workplaces play an important role in solving complex tasks. The structural organization of these systems plays a crucial role in their performance, reliability, and scalability. These methods of structural organization provide organizations with a range of options for structuring their virtual computer systems and workplaces for solving complex tasks. By understanding these methods, organizations can design and implement virtual computer systems and workplaces that meet their specific requirements and support their decision-making processes.

**COMPUTER INTENSIVE TECHNICS OF DEVICES
SYNCHRONIZATION MONITORING FOR DECISION
MAKING IN THE COORDINATE-TIME AND NAVIGATION
SYSTEM**

¹Koval V.V., ¹Lysenko V.P., ²Samkov O.V.,

³Piskun O.M., ¹Ostapovich D.M.

¹National University of Life and Environmental Sciences of Ukraine

²Institute of Electrodynamics of the NASU, Ukraine

³National Space Facilities Control and Test Center, Ukraine

v.koval@nubip.edu.ua

Modern electricity networks, digital telecommunications, information and measurement systems, and other objects that use high technologies require high-quality and reliable coordinate-time support. Hardware synchronization with computer-intensive technologies is used to solve time uncertainties. Ensuring high reliability of synchronization tools, especially at critical infrastructure facilities, is an important and definitely relevant problem. The National Space Facilities Control and Test Center is responsible for performing the functions of the operator of the State coordinate-time and navigation support system.

The results of the analysis of the statistical data of the measurements of the time characteristics of the synchronization signals reproduced by the synchronization devices from the information of the satellite navigation systems confirm the insufficient reliability of their formation both in the conditions of the standard operating mode and in emergency situations.

In order to increase the reliability of signal formation by synchronization devices, an automated computer-integrated system of multi-channel monitoring was developed. The automated system, built with the use of computer-intensive technologies, provides continuous monitoring of the parameters of synchronous signals and processing of the received data in real time, which are necessary for the operator to make decisions. The developed system is a component of the automated control of the technical operation of hybrid high-reliability synchronization devices of the domestic coordinate-time complex.

References

1. <http://spacecenter.gov.ua/> National Space Facilities Control and Test Center.

DEVELOPMENT OF A HISTOPATHOLOGICAL IMAGE DETECTION SYSTEM FOR IDENTIFYING PATHOLOGIES IN LUNG TISSUES

B.F. Koshovyi, I.M. Shevchuk

Taras Shevchenko National University of Kyiv, Ukraine

shevchuk.iuliia@knu.ua

In this work, we present a classifier of histopathological images of lung cancer tissues, developed methods of normalization of such images based on the physical properties of H&E staining. The proposed algorithm uses several approaches to image preprocessing and normalization, including contrast enhancement and green channel elimination methods. We used Convolutional Neural Networks (CNN) for image analysis and classification of cancerous and non-cancerous cells.

The developed classifier demonstrates high results, effective modern requirements and its potential for application in the medical field.

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References

1. Ramya Mohan. Automatic Detection of Tuberculosis Using VGG19 with Seagull-Algorithm.// Life. – 2022. – Vol. 12, № 11. – P. 1848.
2. Beneš M. Performance evaluation of image segmentation algorithms on microscopic image data.// Journal of microscopy. – 2014. – Vol. 1. – P. 65 –85.
3. Nilanjan Dey. Customized VGG19 architecture for pneumonia detection in chest x-rays. // Pattern recognition letters. – 2021. – Vol. 143. – P. 67 – 74.

A LAW OF THE ITERATED LOGARITHM FOR SUMS OF INDEPENDENT INDICATORS, WITH APPLICATION TO KARLIN'S OCCUPANCY SCHEME

V. Kotelnikova¹, O. Iksanov²

Taras Shevchenko National University of Kyiv, Ukraine

¹valeria.kotelnikova@unicyb.kiev.ua, ²iksan@univ.kiev.ua

Let $X(t)$ be an infinite sum of independent indicators parameterized by t . Our main result is a law of the iterated logarithm (LIL) for $X(t)$. We shall explain that if the expectation b and the variance a of the sum are comparable, then the normalization in the LIL includes the iterated logarithm of a . If the expectation grows faster than the variance, while the ratio $\frac{\log b}{\log a}$ remains bounded, then the

normalization in the LIL includes the single logarithm of a . Finally, we shall discuss an application of the LIL to the number of occupied boxes and related quantities in Karlin's occupancy scheme.

The talk is based on the joint work with Dariusz Buraczewski (Wroclaw). This paper is available at <https://arxiv.org/abs/2306.15027>.

ON THE OPTIMAL DIVERSIFICATION OF THE INVESTMENT PORTFOLIO

V. Kulian¹, O. Yunkova²

¹ Taras Shevchenko National University of Kyiv, Ukraine

² Vadym Getman National Economy University of Kyiv, Ukraine

v.kulyan@gmail.com, olenaukova@gmail.com

The problem of optimal diversification of an investment portfolio with fixed one end of the trajectory and a fixed time [1] is considered

$$\frac{dr_p(t, \alpha)}{dt} = f(r_p(t), x(t), \alpha, t), \quad r_p(t_0) = r_{p0},$$

$t_0 \leq t \leq T$, $x(t) \in U$, where U – set of valid controls; $\alpha \in A$ – vector of model parameters. For a parametrically specified mathematical model, we will formulate an optimization problem with a quality criterion

$$I(x(t), t, \alpha) = \min_{x(t) \in U(t)} \int_{t_0}^T f^0(r_p(t), x(t), \alpha, t) dt + \Phi(r_p(T)).$$

Function $\Phi(r_p(T))$ known, moments of time t_0, T – given; management $x_i(t)$ are piecewise continuous functions on a given segment. Thus, we proceed to solving the problem

$$x^0 = \operatorname{argmin}_{x \in U} \max_{\alpha \in A} I(x, r_p, \alpha),$$

where the symbol x^0 denotes the optimal control at the corresponding step of the iterative procedure.

References

1. Garashchenko F.G., Kulyan V.R., Rutitskaya V.V. Qualitative analysis of mathematical models of investment management. // Cybernetics and computer technology. - 2018. - 148. –p. 3-10.

FORECASTING THE DEVELOPMENT OF THE IT MARKET OF UKRAINE IN CONDITIONS OF WAR USING ECONOMETRIC MODELING AND FUZZY TECHNOLOGIES

M.M. Kvasniy

Ivan Franko National University of Lviv, Ukraine

kvasnijmary@gmail.com

Based on the assumption that the volume of IT products and services sold depends not only on the GDP of Ukraine, but also on the level of the volume of IT products and services sold in the previous period, and statistical data [1] we will build an autoregression model in the form:

$$y_t = b_0 + b_1 x_t + b_2 y_{t-1} + e. \quad (1)$$

The parameters of the autoregressive model can be found using the method of auxiliary variables. We will use the lagged independent variable x_{t-1} as an auxiliary variable for y_{t-1} .

The autoregressive model will look like this:

$$y_t = -4798,8183 + 0,0330x_t + 0,3858y_{t-1}. \quad (2)$$

Such a model will describe 86.51% of the fluctuations and is adequate for more than 93%. Parameters are statistically significant. Therefore, the model is suitable for forecasting and economic policy.

For the purpose of forecasting, we present model (2) in the form:

$$y_{t+1} = -4798,8183 + 0,0330x_{t+1} + 0,3858y_t. \quad (3)$$

About that in the conditions of war, etc. challenges in Ukraine is the problem of estimating x_{t+1} , GDP in the future period. To overcome this problem, it is proposed to consider the value of GDP as a fuzzy number and to use Fuzzy technology for its estimation. This leads to the fact that the numerical value ceases to have a single value, but can be expressed as a set of values, each with its own degree of confidence.

The combination of econometric modeling and Fuzzy technologies allows taking into account the factor of uncertainty in forecasting [2].

References

1. Economic statistics. National accounts. State Statistics Service of Ukraine. URL: http://www.ukrstat.gov.ua/operativ/menu/menu_u/nacr.htm (09.05.23)
2. Kvasniy M.M. Integration of modeling methods for forecasting the quality of the bank's loan portfolio //Actual problems of the economy. – 2014. – Vol. 154, No.4. – P. 387-394. (in ukrainian)

THE MOVEMENT OF AN INTELLIGENT AGENT IN A MULTI-AGENT ENVIRONMENT

Y. Kyrylov, I. Vergunova

Taras Shevchenko National University of Kyiv

yevgenii.kirillov@gmail.com, iryna.vergunova@knu.ua

Modeling the behavior of agents, their ability to navigate and move in space, their behavior strategies are important modern tasks.

In this work, behavioral strategies are considered for choosing the path of movement of intelligent agents and modeling the movement process itself (for example, how to get an agent from one point of space to another, while avoiding collisions with other agents and some boundaries and obstacles of a given area or to move with a group of agents). A multi-agent system consists of an autonomous intelligent agent (Actor), a controlled agent, and walls and obstacles (which can be replaced by additional autonomous agents). There are certain relations between agents that are part of each agent's complete value system. The main thing about Actor's behavior is that it should chase the controlled agent, but it should avoid walls and obstacles. Priorities are also set (there are avoiding destructions of the Actor).

It is clear that the Actor must evaluate the directions of movement and choose the best. To highlight this aspect, a special tool for

displaying coordinate axes is used which contains given directions (number of vector directions determines the speed of information processing by the agent, and therefore the speed of its reaction). The selected directions are evaluated by the Actor when deciding on the direction of movement at the next moment. To implement intelligent behavior, a scalar product between the given direction and the desired direction is added to each element of the array of direction weights. This provides an Actor's desire gradient to move towards an autonomous agent. In addition, each type of interaction of the Actor with the multi-agent environment is also provided with a separate tool for displaying the coordinate axes. The results of the work for all interaction layers are summarized the evaluation of the environment by the Actor.

The system for recognizing the environment around the Actor uses the same given directions and provides the ability to form arrays of direction weights for each type of interaction and form opinions, as well as the optimal direction for the Actor. According to the state of the Actor, the optimal movement behavior is calculated.

The constructed MAS is flexible to changes, addition of new agents and transition to a three-dimensional environment.

3D IMMERSION OF OPTIMAL MORSE-SMALE FLOWS ON THE PROJECTIVE PLANE

M.V. Loseva^{*}, A. O. Prishlyak

Taras Shevchenko National University of Kyiv, Ukraine

mv.loseva@gmail.com, prishlyak@yahoo.com

We are looking for Morse-Smale flows on the Boy's and Girl's surfaces [1,3]. The Boy's and Girl's surfaces are the images of the projective plane when immersed in \mathbb{R}^3 or S^3 . We prove that these flows can be extended to Morse-Smale flows on S^3 [2] iff there is a numbering of fixed point that each trajectory of separatrix diagram go from low to upper point. We construct examples of flows that have a such extensions. A flow is optimal if it has a minimal number of singular points among all flows [4].

Lemma. If the union of sources and one-dimensional stable manifolds of a projective flow on the boundary of the interior of the Boy's (Girl's) surface after cutting along 1-dimensional cells is not connected, then this flow cannot be extended to an almost Morse flow without additional fixed points in the interior of the Boy's (Girl's)

surface. A similar assertion holds for sinks and one-dimensional unstable manifolds.

Morse index of a singular point is the dimensional of its stable manifold.

Theorem. A projective Morse flow can be extended to a three-dimensional Morse flow if and only if, for any separatrix or 1-strata trajectory, the Morse index of the alpha limit point is less than the Morse index of omega limit point.

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References

1. Di Beo L., Prishlyak A.O. Flows with minimal number of singularities on the Boy's surface // Proceedings of the International Geometry Center. – 2022. – Vol.15(1). – P. 32-49.
2. Prishlyak A.O. Complete topological invariants of Morse–Smale flows and handle decompositions of 3-manifolds // *Fundamentalnaya i Prikladnaya Matematika*. – 2005. – Vol. 11(4). – P. 185-196.
3. Prishlyak A., Loseva M. Topological structure of optimal flows on the Girl's surface // Proceedings of the International Geometry Center. – 2022. – Vol.15(3-4). – P. 184-202.
4. Prishlyak A.O., Loseva M.V. Optimal Morse-Smale flows with singularities on the boundary of a surface.// *J. Math. Sci., New York*. – 2019. – Vol. 243(2). – P.279-286.

METHOD AND TYPES OF STRUCTURAL ORGANIZATION OF AN INTELLIGENT MEMORY SYSTEM WITH RING TIRES FOR THE IMPLEMENTATION OF TASKS OF VARIOUS COMPLEXITY

A. Luzan, Y. Yakovliev

Glushkov Institute of Cybernetics NAS of Ukraine

aluzan@kse.org.ua, yakyurlen@ukr.net

Intelligent memory systems have gained immense popularity in recent years due to their ability to perform complex tasks with a high degree of efficiency. These systems have the ability to store and retrieve information, as well as to manipulate and analyze data. In this paper, we

propose a design method and various types of structural organizations for an intelligent memory system with ring tires. We also determine the features of each structure and its impact on system performance. Intelligent memory systems are designed to store, process and analyze vast amounts of data in a manner that is both efficient and effective. These systems have the ability to perform complex tasks, such as decision-making, problem-solving and information retrieval, in a way that is far more advanced than traditional memory systems. They are capable of storing and retrieving data, as well as analyzing and manipulating it. The design method for intelligent memory systems with ring tires involves the use of a hierarchical structure that is based on the organization of data into ring tires. The ring tires are divided into several sections, each of which is responsible for a specific type of information. This allows for a more efficient use of memory, as well as a faster retrieval of information. The first step in the design method is to determine the types of data that need to be stored and processed. This includes data such as text, images, audio and video. The next step is to organize the data into categories based on its type, and to assign each category to a specific ring tire. The final step is to optimize the structure of the ring tires for efficient storage and retrieval of information. There are several types of structural organizations for intelligent memory systems with ring tires, each of which has its own unique features and impact on system performance. Some of the most common types include: Hierarchical Structure, Matrix Structure, Network Structure. The structural organization of an intelligent distributed memory system with a ring bus provides a scalable, flexible, reliable, and resilient solution for the implementation of tasks of various complexity.

ABOUT OPTIMIZATION PROBLEMS FOR CONTROLLED MULTI-CHANNEL NETWORKS

I. Makushenko, I. Usar

Taras Shevchenko National University of Kyiv, Ukraine

iamak@ukr.net

The article is devoted to perspective direction of queuing theory connected with investigation of queuing systems and networks with controlled parameters. For multi-channel stochastic networks the characteristics of accumulative process of income are firstly investigated. In the case of fixed and periodical-variable rate of input

flow goal functions of optimization problems are found. Asymptotical analysis of systems of integral equations for semi-Markov stochastic networks is realized. For multi-channel stochastic networks with controlled input flow the type of optimization problems is determined. Obtained results indicate that the problem of finding of the average income maximum value for all possible parameters of $[GI|GI|∞]^r$ -networks is linear programming problem. If variation coefficient is equal to 1 then the risk minimization problem as well becomes linear programming problem. It is obviously that the condition $\rho=1$ is fulfilled for Poisson input flow that is for $[M|GI|∞]^r$ -network. If $\rho \neq 1$, risk minimization problem is the problem of square programming. To calculate of goal functions for stochastic networks in heavy traffic the method of Gaussian approximation is developed.

Effective algorithms, evident and approximate formulas for the goal functions of optimization problems via model parameters are constructed on the basis of the performed research.

References

1. Massey W.A., Whitt W. Networks of infinite-server queues with nonstationary Poisson input // Queueing systems. – 1993. – N 13. – P. 183-250.
2. Lebedev E.A. Networks of infinite server queues // ESM-2001 Conference Proceedings. – 2002. – Darmstadt, Germany.
3. Lebedev E.A. Risk optimization for multi-channel stochastic network / E.A. Lebedev, I.A. Makushenko. – Kyiv: National Library of Ukraine. – 2007.

ON STABILITY RESEARCH OF SQUARE LATTICE MODEL WITH SPATIALLY VARYING DIFFUSION

¹V. Martsenyuk, ²N. Kit, ³A. Sverstiuk, ⁴I. Andrushchak

¹University of Bielsko-Biala, ²Ternopil National Technical University,

³Ternopil National Medical University, ⁴Lutsk National Technical
University

vmartsenyuk@ath.bielsko.pl, natkakoo@gmail.com

sverstyuk@tdmu.edu.ua, 9000@lntu.edu.ua

We consider the model on square lattice which is based on the system of delayed differential equations

$$\frac{dV_{i,j}}{dt} = (\beta - \gamma F_{i,j}(t-r) - \delta_v V_{i,j}(t-r))V_{i,j}(t) + \hat{S}\{V_{i,j}\},$$

$$\frac{dF_{i,j}(t)}{dt} = (-\mu_f + \eta\gamma V_{i,j}(t-r) - \delta_f F_{i,j}(t))F_{i,j}(t)$$

with the spatial operator describing spatially varying diffusion

$$\hat{S}\{V_{i,j}\} = \begin{cases} \Delta^{-2} [D_{1,2}^{1,1} V_{1,2} + D_{2,1}^{1,1} V_{2,1} - nD_{1,1}^{1,2} V_{1,1} - nD_{1,1}^{2,1} V_{1,1}] & i, j = 1 \\ \Delta^{-2} [D_{2,j}^{1,j} V_{2,j} + D_{1,j-1}^{1,j} V_{1,j-1} + D_{i,j+1}^{1,j} V_{i,j+1} - nD_{i,j}^{2,j} V_{i,j} - nD_{i,j-1}^{1,j-1} V_{i,j} - nD_{i,j+1}^{1,j+1} V_{i,j}] & i = 1, j \in \overline{2, N-1} \\ \Delta^{-2} [D_{1,N-1}^{1,N} V_{1,N-1} + D_{2,N}^{1,N} V_{2,N} - nD_{1,N}^{1,N-1} V_{1,N} - nD_{1,N}^{2,N} V_{1,N}] & i = 1, j = N \\ \Delta^{-2} [D_{i,N}^{1,N} V_{i,N} + D_{i+1,N}^{1,N} V_{i+1,N} + D_{i,N-1}^{1,N} V_{i,N-1} - nD_{i,N}^{i-1,N} V_{i,N} - nD_{i,N}^{i+1,N} V_{i,N} - nD_{i,N}^{1,N-1} V_{i,N}] & i \in \overline{2, N-1}, j = N \\ \Delta^{-2} [D_{N-1,N}^{N,N} V_{N-1,N} + D_{N,N-1}^{N,N} V_{N,N-1} - nD_{N,N}^{N-1,N} V_{N,N} - nD_{N,N}^{N,N-1} V_{N,N}] & i = N, j = N \\ \Delta^{-2} [D_{N-j}^{N,j} V_{N-j} + D_{N,j-1}^{N,j} V_{N,j-1} + D_{N,j+1}^{N,j} V_{N,j+1} - nD_{N,j}^{N-1,j} V_{N,j} - nD_{N,j-1}^{N,j-1} V_{N,j} - nD_{N,j+1}^{N,j+1} V_{N,j}] & i = N, j \in \overline{2, N-1} \\ \Delta^{-2} [D_{N,1}^{N,1} V_{N,1} + D_{N,2}^{N,1} V_{N,2} - nD_{N,1}^{N-1,1} V_{N,1} - nD_{N,1}^{N,2} V_{N,1}] & i = N, j = 1 \\ \Delta^{-2} [D_{i-1,1}^{i,1} V_{i-1,1} + D_{i+1,1}^{i,1} V_{i+1,1} + D_{i,2}^{i,1} V_{i,2} - nD_{i,1}^{i-1,1} V_{i,1} - nD_{i,1}^{i+1,1} V_{i,1} - nD_{i,1}^{i,2} V_{i,1}] & i \in \overline{2, N-1}, j = 1 \\ \Delta^{-2} [D_{i-1,j}^{i,j} V_{i-1,j} + D_{i+1,j}^{i,j} V_{i+1,j} + D_{i,j-1}^{i,j} V_{i,j-1} + D_{i,j+1}^{i,j} V_{i,j+1} - nD_{i,j}^{i-1,j} V_{i,j} - nD_{i,j}^{i+1,j} V_{i,j} - nD_{i,j-1}^{i,j-1} V_{i,j} - nD_{i,j+1}^{i,j+1} V_{i,j}] & i, j \in \overline{2, N-1} \end{cases}$$

The model with constant diffusion was studied in the previous works [1], [2], [3], [4]. Here we start from investigating the problems of positiveness of the solution. Then we obtain the conditions of local asymptotic stability. The research of qualitative behaviour is also performed with the help of numerical simulations.

References

1. Martsenyuk V., Klos-Witkowska A., Sverstiuk A. Stability, bifurcation and transition to chaos in a model of immunosensor based on lattice differential equations with delay. *Electronic Journal of Qualitative Theory of Differential Equations*: No. 2018 (27). P. 1–31.
2. Martsenyuk V.P., Andrushchak I.Ye., Zinko P.M., Sverstiuk A.S. On Application of Latticed Differential Equations with a Delay for Immunosensor Modeling. *Journal of Automation and Information Sciences*. 2018. Vol. 50 (6). P. 55–65.
3. Martsenyuk V.P., Sverstiuk A.S., Andrushchak I.Ye. Approach to the Study of Global Asymptotic Stability of Lattice Differential Equations with Delay for Modeling of Immunosensors. *Journal of Automation and Information Sciences*. 2019. Vol. 48 (8). P. 58–71.
4. Martsenyuk V., Klos-Witkowska A., Sverstiuk A. Stability investigation of biosensor model based on lattice difference equations. *Difference Equations and Discrete Dynamical Systems with Applications*. Springer Proceedings in Mathematics and Statistics. 24th ICDEA, Dresden, Germany. 2020. Vol. 312. P. 297–322.

LINEAR REGRESSION FOR A FUZZY SET OF DATA SAMPLES

S.O. Mashchenko

Taras Shevchenko National University of Kyiv, Ukraine

s.o.mashchenko@gmail.com

Let $N = \{1, \dots, n\}$ be the set of indices of fuzzy data samples $\{\tilde{y}_i, \tilde{x}_{i1}, \dots, \tilde{x}_{ip}\}$, $i \in N$ in the form of FNs with the MFs $\mu_{\tilde{x}_{is}}(x_{is})$, $x_{is} \in \mathbb{R}$, $s = 1, \dots, p$, $\mu_{\tilde{y}_i}(y_i)$, $y_i \in \mathbb{R}$, $i \in N$, respectively. Furthermore, the degrees $\mu_l(j)$, $j \in N$ of membership to the FS $I = \{(j, \mu_l(j)) : j \in N\}$ of data samples indices are known. We denote by $\tilde{X}(K) = \{\tilde{x}_{is}\}_{i \in K, s=0, \dots, p}$, $\tilde{y}(K) = (\tilde{y}_i)_{i \in K}^T$ the matrix of independent variables and the vector of dependent variables, respectively, where for each $i \in K$, $\tilde{x}_{i0} = 1$ is the crisp number which is equal to 1; \tilde{x}_{is} , $s = 1, \dots, p$ and \tilde{y}_i are fuzzy numbers (FNs) with the MFs $\mu_{\tilde{x}_{is}}(x_{is})$, $x_{is} \in \mathbb{R}$, $s = 1, \dots, p$ and $\mu_{\tilde{y}_i}(y_i)$, $y_i \in \mathbb{R}$, $i \in K$, respectively.

The report is devoted to the linear regression for a fuzzy set of fuzzy data samples [1]. This model allows one to take into account the data of different quality. It is shown that regression parameters are type-2 fuzzy sets. Furthermore, the corresponding type-2 membership functions are given. The decomposition approach is used to investigate the T2FSs of linear regression parameters. It is shown that each T2FS of regression parameter can be decomposed according to secondary membership grades into a finite collection of fuzzy numbers. Each of these fuzzy number is the corresponding fuzzy regression parameter for a set of data numbers. This set is the corresponding α -cut of the original fuzzy set of fuzzy data samples. The illustrative example is given. One direction of future investigation of regressions with a fuzzy set of data sample indices may be related to the development of a similar approach for possibilistic regression analysis.

References

1. Mashchenko, S., Marchenko, O. (2023) On linear regression for fuzzy data of different quality. In: Proceedings of The Sixth International Workshop on Computer Modeling and Intelligent Systems, Zaporizhzhia (2023), CEUR Workshop Proceedings. 3392. Pp. 37–51. <https://doi.org/10.32782/cmis/3392-4>.

**THE PROBLEM OF LINEAR ESTIMATION OF UNKNOWN
MATHEMATICAL EXPECTATIONS BASED ON
OBSERVATIONS OF RANDOM MATRIX SEQUENCES**

O.G. Nakonechniy, G.I.Kudin, P.M. Zinko, T.P. Zinko
Taras Shevchenko National University of Kyiv, Ukraine
a.nakonechnyi@gmail.com, petro.zinko@gmail.com

We consider matrix observations of the form:

$$Y_k = \rho_k(x(k)) + \eta_k, \quad k = \overline{0, N-1},$$

where $\rho_k(x(k)) = \sum_{s=1}^m A_s(k)x_s(k)$, $k = \overline{0, N-1}$,

$A_s(k) \in H_{n \times p}$, $s = \overline{1, m}$, $k = \overline{0, N-1}$ are known matrices;

$H_{n \times p}$ is the space of matrices $n \times p$ dimensions;

$x(k) = (x_1(k), \dots, x_m(k))^T$, $k = \overline{0, N}$ are unknown vectors, belonging to a limited set

$$G = \left\{ x(k), k = \overline{0, N} : \sum_{k=0}^{N-1} |f(k)|^2 q_k^2 \leq 1 \right\},$$

$$f(k) = x(k+1) - x(k), \quad k = \overline{0, N-1},$$

(to simplify the calculations, we will assume that $x(0)$ is known vector and, without limiting the generality, we will put $x(0) = 0$);

q_k^2 , $k = \overline{0, N-1}$ are known positive real numbers;

T is the transpose symbol;

$\eta_k \in H_{n \times p}$, $k = \overline{0, N-1}$ are the sequence of random matrices.

It is assumed that the average value of the random matrices η_k , $k = \overline{0, N-1}$ is equal to the null matrix, i.e. $E\eta_k = 0$ (E is a symbol of mathematical expectation), and correlation matrices $R_k \in H_{n \times n}$, $k = \overline{0, N-1}$ are known and determined by ratios:

$$E\eta_k, Z_1\eta_k, Z_2 = R_k Z_1, Z_2, \forall Z_i \in H_{n \times p}, \quad i = \overline{1, 2}, \quad k = \overline{0, N-1},$$

where $\eta_k, Z_i = sp(\eta_k Z_i^T)$ are the scalar product of matrices.

Let's introduce linear operators that act from space R^l into space $H_{n \times p}$:

$$\bar{\rho}_k(U_k)(z) = \sum_{i=1}^l U_{ik} z_i, \quad k = \overline{0, N-1},$$

$$U_{ik} \in H_{n \times p}, \quad U_k = (U_{1k} \dot{\vdots} \cdots \dot{\vdots} U_{lk}), \quad z = (z_1, \dots, z_l)^T, \\ i = \overline{1, l}, \quad k = \overline{0, N-1},$$

and operators conjugated to them $\bar{\rho}_k^*(U_k)(Y_k)$:

$$\bar{\rho}_k^*(U_k)(Y_k) = (U_{1k}, Y_k, \dots, U_{lk}, Y_k)^T, \\ U_{ik} \in H_{n \times p}, \quad Y_k \in H_{n \times p}, \quad i = \overline{1, l}, \quad k = \overline{0, N-1}.$$

It is necessary to evaluate the vector $Vx(N)$, where $V \in H_{l \times m}$.

Definition 1. A linear estimate of a vector $Vx(N)$ is called a vector $Vx(N)$ view

$$Vx(N) = \sum_{k=0}^{N-1} \bar{\rho}_k^*(U_k)(Y_k) + c = \\ = \sum_{k=0}^{N-1} (U_{1k}, Y_k, \dots, U_{lk}, Y_k)^T + c, \quad c \in R^l.$$

Definition 2. The guaranteed root mean square error of the linear estimate $Vx(N)$ is called the value

$$\sigma^2(U_0, \dots, U_{N-1}) = \max_G E \left[Vx(N) - Vx(N) \right]^2.$$

Let's introduce vectors $(k) \in R^m$, $k = \overline{0, N}$, which are solutions of the difference equation:

$$z(k) = z(k+1) - \rho_k^* \bar{\rho}_k(U_k)(a), \quad k = \overline{N-1, 0}, \quad z(N) = V^T a, \quad a \in R^l, \quad (1)$$

where ρ_k^* , $k = \overline{0, N-1}$ operators are conjugated to ρ_k .

Denote by $z^i(k)$, $i = \overline{1, l}$ the solutions of the difference equation (1) at $a = e^i$,

where e^i , $i = \overline{1, l}$ be a base vectors of space R^l , and also enter the matrix Z :

$$Z = (z_{ij})_{i, j = \overline{1, l}}, \quad z_{ij} = \sum_{k=0}^{N-1} (z^i(k+1), z^j(k+1)) q_k^{-2}, \quad i, j = \overline{1, l}.$$

The vectors $z^i(k+1)$, $i = \overline{1, l}$ finds from the difference equations:

$$z^i(k) = z^i(k+1) + b^i(k), \quad z^i(N) = V_{(i)},$$

where $b^i(k) = (A_1(k), U_{1k}, \dots, A_m(k), U_{ik})^T$,

$$V_{(i)} = (V_{i1}, \dots, V_{im})^T, \quad i = \overline{1, l}, \quad k = \overline{0, N-1}.$$

There is a formula

$$z^i(k+1) = V_{(i)} + \sum_{j=1}^{N-(k+1)} b^j(N-j), \quad i = \overline{1, l}, \quad k = \overline{0, N-1}.$$

Statement 1. Let $x(k), k = \overline{0, N} \in G$, then there is parity:

$$\sigma^2(U_0, \dots, U_{N-1}) = \max_{|a|=1} \left((Za, a)^{1/2} + |(c, a)| \right)^2 + \sum_{k=0}^{N-1} \sum_{i=1}^l R_k U_{ik}, U_{ik}.$$

Corollary 1. There is equality:

$$\min_{U, c} \max_G E \left| Vx(N) - Vx(N) \right|^2 = \lambda_{\max}(\hat{Z}) + \sum_{k=0}^{N-1} \sum_{i=1}^l R_k \hat{U}_{ik}, \hat{U}_{ik}, \quad \hat{c} = 0,$$

where $\hat{Z} = Z = (z_{ij})_{i, j = \overline{1, l}}$, $z_{ij} = z_{ij}(\hat{U})$, $\lambda_{\max}(\hat{Z})$ is the maximum eigenvalue of the matrix \hat{Z} , and $\hat{U}_{ik} \in H_{n \times p}$, $i = \overline{1, l}$, $k = \overline{0, N-1}$ found from the condition:

$$(\hat{U}_{ik}, i = \overline{1, l}, k = \overline{0, N-1}; \hat{c}) \in \text{Arg} \min_{c; U_{ik}, i = \overline{1, l}, k = \overline{0, N-1}} \sigma^2(U_0, \dots, U_{N-1}).$$

Corollary 2. Let $l = 1$. The estimation error $(V, x(N))$, (where $V \in R^m$ is the arbitrary vector), is as follows:

$$\begin{aligned} \sigma^2(U_0, \dots, U_{N-1}) &= \max_G E \left| Vx(N) - Vx(N) \right|^2 = \\ &= \sum_{k=0}^{N-1} \left| z(k+1) \right|^2 q_k^{-2} + \sum_{k=0}^{N-1} R_k U_{1k}, U_{1k} + c^2, \end{aligned}$$

where $z(k), k = \overline{0, N}$ is a solution of the difference equation $z(k) = z(k+1) - \rho_k^*(U_{1k})$, $k = \overline{N-1, 0}$, $z(N) = V$, for this case $\hat{c} = 0$.

Statement 2. Let statement 1 a parameter $l = 1$, then:

- 1) guaranteed root mean square estimate for $V_{(1)}x(N)$ has the form:

$$\overline{\overline{V_{(1)}x(N)}} = \sum_{k=0}^{N-1} sp(\hat{U}_{1k} Y_k^T);$$

- 2) the guaranteed root mean square error of the linear estimate $V_{(1)}x(N)$ has the form:

$$\sigma^2\left(\hat{U}_{10}, \dots, \hat{U}_{1, N-1}\right) = (p(N), V_{(1)}),$$

where $\hat{U}_{1k} = R_k^+ \mathcal{P}_k(p(k))$, $k = \overline{0, N-1}$; R_k^+ is the pseudo-inverse operator;

$p(k)$, $k = \overline{0, N}$ are the vectors that are determined from the system of equations:

$$\begin{cases} z(k) = z(k+1) - \rho_k^* (\hat{U}_{1k}), & k = \overline{N-1, 0}, & z(N) = V_{(1)}, \\ p(k+1) = p(k) + q_k^{-2} z(k+1), & k = \overline{0, N-1}, & p(0) = 0, \end{cases}$$

The problem of linear estimation of unknown mathematical expectations based on observations of realizations of random matrix sequences are investigated. Constructive mathematical methods have been developed for finding linear guaranteed RMS estimates of unknown non-stationary parameters of average values based on observations of realizations random matrix sequences. It is shown that such guaranteed estimates are obtained either as solutions of boundary value problems for systems of linear differential equations, or as solutions of the corresponding Cauchy problems. We establish the form and look of errors for the guaranteed RMS quasi-minimax estimates of the special forecast vector and parameters of unknown average values. In the presence of small perturbations of known matrices in the model of matrix observations, quasi-minimax RMS estimates are found, and their guaranteed RMS errors are obtained in the first approximation of the small parameter method. Two test examples for calculating the guaranteed root mean square estimates and their errors are given.

References

1. Sheng Yue, Application of random matrix theory in Statistics and machine learning // Publicly Accessible Penn Dissertations, 4146, 2021. – 240 p. <https://repository.upenn.edu/edissertations/4146>
2. Stanislav Minsker, Sub-gaussian estimators of mean of a random matrix with heavy-tailed entries // The Annals of Statistics, 2018, 46 (6A). – P. 2871 – 2903.
3. Jun Tong, Rui Hu, Jiangtao Xi, Zhitao Xiao, Qinghua Guo, Yanguang Yu., Linear shrinkage estimation of covariance matrices using complexity cross-validation // Signal Processing, 2018, 148. – P. 223 – 233.
4. Roberto Cabal Lopes, Robust estimation of the mean a random matrix: a non-asymptotic study // Centro de Investigacion en Matematicas, A.C., 2020. – 187 p. : [посилання TE 785 robust matrix.pdf](#)
5. Battey H., Fan J., Lu J., Zhu Z., Distributed testing and estimation under sparse high dimensional models // The Annals of Statistics, 2018, 46 (3). – P. 1352 – 1382.
6. Cai T.T., Wei H., Distributed Gaussian mean estimation under communication constraints: Optimal rates and communication-efficient algorithms // arXiv preprint arXiv: 2001.08877, 2020.

7. Sourav Chatterjee, Matrix Estimation by Universal Singular Value Thresholding // The Annals of Statistics, 2015, Vol. 43, No. 1. – P. 177 – 214.
8. Наконечный А.Г., Кудин Г.И., Зинько П.Н., Зинько Т.П. Метод возмущений в задачах линейной матричной регрессии // Проблемы управления и информатики, 2020. – №1. – С. 38–47.
9. Наконечний О.Г., Кудін Г.І., Зінько П.М., Зінько Т.П. Наближені гарантовані оцінки матриць у задачах лінійної регресії з малим параметром // Системні дослідження та інформаційні технології, 2020. – № 4. – С. 88 – 102.
10. Наконечный А.Г., Кудин Г.И., Зинько П.Н., Зинько Т.П. Гарантированные среднеквадратические оценки линейных преобразований матриц в условиях статистической неопределённости // Проблемы управления и информатики, 2021. – №2. – С. 24–37.
11. Наконечный А.Г., Кудин Г.И., Зинько П.Н., Зинько Т.П. Минимаксные среднеквадратические оценки матричных параметров в задачах линейной регрессии в условиях неопределённости // Проблемы управления и информатики, 2021. – №4. – С. 28 – 37.

ESTIMATES OF THE PARAMETERS OF MATRIX DIFFERENTIAL EQUATIONS WITH A QUADRATIC RIGHT-HAND PART UNDER UNCERTAINTY

O. Nakonechniy¹, P. Zinko¹, M. Kotsur², M. Loseva¹

¹Taras Shevchenko National University of Kyiv, Ukraine

²Yuriy Fedkoych Chernivtsi National University, Ukraine

a.nakonechnyi@gmail.com, petro.zinko@gmail.com,

m.kotsur@chnu.edu.ua, mv.loseva@gmail.com

Let the matrix function $X(t)$ of dimension $n \times n$ be the solution of the equation

$$\frac{dX(t)}{dt} = A_1 X(t) + X(t)A_2 + X(t)A_3 X(t) + B(t)F(t),$$

$$X(t_0) = X_0,$$

where $A_i, i = \overline{1,3}$, are some matrices of dimension $n \times n$, $B(t)$ and $F(t)$ are continuous matrix functions of dimension $n \times m$ and $m \times n$ respectively.

Suppose that with unknown matrices $A_i, i = \overline{1,3}$, and an unknown function $F(t)$ the values of $X(t_k)$ and the values of the matrix function $Y(t_k)$ are given, where

$$Y(t_k) = \frac{dX(t_k)}{dt} + V_k, \quad k = \overline{1, N},$$

V_k are the unknown matrix errors of the data. Let the set G be also given, and the set of $(F(t_1), \dots, F(t_N), V_1, \dots, V_N) = (F, V)$ matrices belongs to the set G .

On the set of possible values of the parameters $A_i \in (Y, X), i = \overline{1, 3}$ for the given values of $Y(t_k), X(t_k), k = \overline{1, N}$, and the given set of G , we introduce the function

$$\sigma(A_1^{(1)}, A_2^{(1)}, A_3^{(1)}) = \max \left\{ \sum_{i=1}^3 sp(A_i^{(1)} - A_i)(A_i^{(1)} - A_i)^T \right\}^{\frac{1}{2}},$$

$$(A_1, A_2, A_3) \in G(Y, X).$$

For special set G , we find the matrices $\hat{A}_i, i = \overline{1, 3}$, on which the minimum of the guaranteed estimation error $\sigma(A_1^{(1)}, A_2^{(1)}, A_3^{(1)})$ is reached, as well as the value $\sigma(\hat{A}_1, \hat{A}_2, \hat{A}_3)$.

We also study the case of observing the matrix function $P(t)$ of dimension $n \times n$, which at the points of $P(t_k), k = \overline{1, N}$, is a solution of the equation

$$\frac{dP(t)}{dt} = A(t)P(t) + P(t)B(t) + PC(t)P,$$

$$P(t_0) = P_0,$$

where the matrices $A(t), B(t)$ are known continuous matrices on segment $[t_0, T]$ and the elements of unknown matrix $C(t)$ are integrated with the square.

We find optimal in a certain sense estimates of the unknown matrix $C(t)$ as a function of the observations $P(t_k), k = \overline{1, N}$, under the conditions $\det P(t_k) \neq 0, \det P_0 \neq 0$.

References

1. Наконечний О.Г., Зінько П.М. Математичні методи аналізу матричних даних в умовах невизначеності: Навчальний посібник. – К.: ПП «Р.К. Майстер-принт», 2022. – 208 с.
2. Наконечний О.Г., Шевчук Ю.М. Нелінійні задачі популяційної динаміки та їх застосування. – К., Видавничо-поліграфічний центр "Київський університет", 2020. – 188 с.
3. Nakonechnyi O., Podlipenko Y. Guaranteed Estimation Problems in the

ON PREDICATE ALGEBRAS WITH UNCERTAINTIES

M.S. Nikitchenko

Taras Shevchenko National University of Kyiv, Ukraine

mykola.nikitchenko@gmail.com

There are various types of uncertainties (see, e.g. [1]). Here we consider uncertainties that are associated with predicate algebras. Such algebras form a base for various logics used in computer science and artificial intelligence. We treat predicates as functions from a class of data into the set of Boolean values. Data themselves can be also treated as functions from a set of variables into a set of their values. Such treatment permits to specify data and predicate uncertainties as derived from uncertainties of the notion of function. Traditionally, a function from A to B is defined as a special subset of the Cartesian product $A \times B$. Based on this definition the following classes of functions can be specified: (t) *total* single-valued (deterministic) functions, (p) *partial* functions, (r) *relational* (nondeterministic) functions. However, there is one more class not representable via Cartesian product $A \times B$ – (g) *general nondeterministic* functions. Such functions can be generated, say, by nondeterministic Turing machines. Thus, classes (p), (r), and (g) represent certain function uncertainties – partiality and nondeterminism while (t) represent determinacy. Combining these classes for data and predicates we obtain 16 predicate algebras.

Google forms for meetings give examples for predicates over general nondeterministic data. Indeed, the participants propose several timeslots for possible meeting. The answers may be completed or uncompleted. The latter case corresponds to undefinedness value. A meeting predicate will be true if there is a timeslot appropriate for all participants.

We study obtained algebras and establish their relations with various classes of many-valued algebras, in particular, with 3-valued, 4-valued, and 7-valued algebras; also relations with many-valued logics are investigated [2].

References

1. Pelz, P.F. *et al.* (2021). Types of Uncertainty. In: Pelz, P.F., Groche, P., Pfetsch, M.E., Schaeffner, M. (eds) Mastering Uncertainty in Mechanical

Engineering. Springer Tracts in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-78354-9_2

2. Nikitchenko M.S., Shkilniak O.S. and Shkilniak S.S. (2018). Algebras of general non-deterministic predicates. In Problems in Programming. N 1. P. 5–21 (in Ukrainian).

MULTIDIMENSIONAL INFORMATION WARFARE MODEL WITH INTERNAL CONFLICT

A. Nikitin¹, B. Kراسиук¹

¹The National University of Ostroh Academy, Ukraine
anatolii.nikitin@oa.edu.ua, bohdan.krasiuk@oa.edu.ua

We study a p -dimensional discrete model of information struggle in the form

$$\begin{cases} N_1^{(n+1)} = (\alpha_{11} + \beta_{11}N_1^{(n)} + \dots + \beta_{1p}N_p^{(n)})(N_0 - N_1^{(n)} - \dots - N_p^{(n)}) + N_1^{(n)}, \\ N_2^{(n+1)} = (\alpha_{21} + \beta_{21}N_1^{(n)} + \dots + \beta_{2p}N_p^{(n)})(N_0 - N_1^{(n)} - \dots - N_p^{(n)}) + N_2^{(n)}, \\ \vdots \\ N_p^{(n+1)} = (\alpha_{p1} + \beta_{p1}N_1^{(n)} + \dots + \beta_{pp}N_p^{(n)})(N_0 - N_1^{(n)} - \dots - N_p^{(n)}) + N_p^{(n)}. \end{cases}$$

The conflict involves p information types, I_1, I_2, \dots, I_p , within a conditional community. We'll position this community on territory and divide it into regions, aligning with practical conditions and integration into the model. Community members can be I_1 or I_2 or \dots, I_p adherents or neutral personalities.

We also define conflict as a physical system with substances, A_1, \dots, A_p competing for control over a shared field of interest Ω . This field is divided into regions Ω_i , and A_i aim to claim as many positions as possible. They're represented by non-negative coordinate vectors $A_i = (A_{i1}, \dots, A_{im})$, reflecting their presence in these regions. Conflict changes A_i via discrete-time dynamics

$$\{A_1^N, \dots, A_p^N\} \xrightarrow{*} \{A_1^{N+1}, \dots, A_p^{N+1}\}, N = 0, 1, \dots$$

The map $*$ symbolizes the unknown conflict interaction law between substances A_i . We aim to depict the model of internal conflict-driven information struggle akin to Lotka-Volterra's cyclic migration [2]. To capture migration, our interaction law, we'll adopt the discrete-time

conflict model involving indestructible rivals [1], aligning with our struggle model's assumptions.

References

1. Albeverio S., Koshmanenko V., Samoilenko I. The conflict interaction between two complex systems. Cyclic migration // Journal of Interdisciplinary Mathematics. – 2008. – Vol. 11, No. 2. – P. 163–185.
2. Mykhaylov A.P., Marevtseva N.A. Models of the information struggle // Mat. modeling. – 2011. – Vol.23(10). – P.19–32.
3. Samoilenko I.V., Nikitin A.V., Verovkina G.V. Peculiarities of Construction and Analysis of the Information Warfare Model with Markov Switchings and Impulse Perturbations Under Levy Approximation Conditions // Cybern. Syst. Anal. – 2021. – Vol. 57. – P. 621–628.

INTELLIGENT SYSTEM FOR DISPLAYING AND CALCULATING PATHOLOGIES AND DISEASES ON X-RAY IMAGES OF TEETH

R.V. Nikitin, I. M. Shevchuk

Taras Shevchenko National University of Kyiv, Ukraine
shevchuk.iuliia@knu.ua

The main goal of our work was the development of the effectiveness of artificial intelligence algorithms for evaluation the oral cavity based on dental X-rays.

We made an overview of similar means of diagnosis using deep machine learning in the context of dental X-ray analysis. Results our work is a software product based on artificial intelligence and deep neural networks for displaying and calculate pathologies and diseases on X-ray images of teeth.

The proposes system uses the PyTorch framework for programmatic implementation, identification, and marking of features and characteristics on X-ray images of teeth using the RoboFlow platform; Python for programming and implementing an artificial intelligence model, Jupyter Notebooks for running and debugging code, analyzing results, and interacting with data.

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References

1. Jiang H., Zhang P., Che C., Jin B. RDFNet: A Fast Caries Detection Method Incorporating Transformer Mechanism. //Computational and mathematical methods in medicine. – 2021. – 9773917.

CREATION OF DIGITAL TWIN FOR CYBER-PHYSICAL SYSTEMS UNDER CONDITIONS OF UNCERTAINTY

N.D. Pankratova, V.A. Pankratov

Institute for Applied System Analysis

Igor Sikorsky Kyiv Polytechnic Institute, Ukraine

natalidmp@gmail.com, pankratov.volodya@gmail.com

Digital twins are created to implement rational production management as cyber-physical systems (CPS) in real time and support strategic and operational decision making. The basic concept of digital twin includes a physical object, a virtual object and ensuring the information exchange between them. The digital twin concept is part of the fourth industrial revolution and is designed to help enterprises detect physical problems faster, predict their results more accurately, and produce better products. The digital twin use makes it possible to simulate the entire life cycle of the intended object. Most often, digital twins are created to simulate objects directly related to industrial production or being an important element of technical systems

The design of digital twins is based on simulation modelling methods that provide the most realistic representation of a physical environment or object in the virtual world. A mathematical description of digital twins can be obtained via statistical modelling, machine learning or analytical modelling methods. The mathematical models of a digital twin for supporting and predicting the functioning of a physical process of a real object are used. The parametric and structural uncertainties of the mathematical description of the physical process are taken into account. As an example, the design of a digital twin is given on the example of an analytical model of an electric heater [1].

The use of digital twins in CPS makes it possible to identify process bottlenecks, improve product quality, and reduce the risks of abnormal operation throughout its object lifecycle. Digital twins can be used to optimize equipment modes, predict and detect faults, and find-modifications to the structure of a real physical system based on its observed effects in the future.

References

1. Nataliya Pankratova, Igor Golinko. Digital Twin Simulation for Cyber-Physical Systems on Electric Heater Example // Proceedings of IEEE third International Conference on System Analysis & Intelligent Computing conference (SAIC) 04-07 October, 2022. p.22-28. Kyiv, Ukraine. DOI:10.20535/SRIT.2308-8893.2022.1.01

CHATGPT AND TASKS OF ARTIFICIAL INTELLIGENCE

Anatoli Pashko

Taras Shevchenko National University of Kyiv, Ukraine

aap2011@ukr.net

On 30 November 2022, the world changed - Artificial Intelligence became publicly available through the ChatGPT tool. ChatGPT gained one million users in just five days, which is an absolute record for any platform.

ChatGPT is an artificial intelligence-based chatbot. Externally, ChatGPT looks like a dialogue box, in which we write a query of interest, and the bot gives an answer to it. The ChatGPT model itself has been trained using a huge dataset from information on the internet.

The paper explores the structure of the neural networks that underlie the chatbot, and examines the applications of , ChatGPT. Among them are: business correspondence, research work, dating, composing news articles, programming, interactive tutor, advertisements, professional copywriter, personal coaching, slogan and joke generator, social media post generator, story and poem generator, text games, scripting, and many others.

Realizing the full potential of ChatGPT, many users have already started using this chatbot to expand their range of services for clients or create new businesses.

ChatGPT is a relatively new technology and the model has not been sufficiently trained yet. Therefore, it has its own limitations. Already on their homepage, the developers of ChatGPT warn about the limitations in the current version. Among them, the chatbot can sometimes generate incorrect information, can sometimes provide harmful instructions or biased content, has limited knowledge about the world and events after 2021.

ChatGPT is just the tip of the iceberg when it comes to artificial intelligence. Artificial intelligence is already surrounding us everywhere right now. Artificial intelligence ranges from simple systems designed to help users complete tasks, such as chatbots or machine translation, to more complex ones such as image and code generation, genetic engineering, unmanned cars, or increasing productivity and efficiency in businesses.

It is no longer possible to stop the development of artificial intelligence technologies because the benefits of its implementation and utilization are limitless. Artificial intelligence is a part of human

development and technological progress. Artificial intelligence will soon become a kind of filter through which we will perceive our world and a tool for more effective interaction with this world.

BUFFER CONTENT DISTRIBUTION FOR SELF-SIMILAR TRAFFIC PATTERNS

Anatolii Pashko, Iryna Rozora

Taras Shevchenko National University of Kyiv, Ukraine
aap2011@ukr.net

One of the most valuable results of traffic over the last years is the property of self-similarity in packet networks. In this paper, a self-similar traffic model driven by FBM is investigated. The estimation of upper bound probability buffer overflow for the traffic model is obtained. We also consider traffic that enters as input on some time-invariant linear system and find the estimation of buffer content distribution taking into account input traffic and response of the stochastic system.

The experimental and numerical researches carried out in the last decades show that the traffic in many telecommunication and multimedia networks has fractal structure. This traffic has a particular property that is preserved during scaling. It differs from ordinary traffic in a number of specific characteristics: it has the properties of self-similarity and long-term dependence.

In the development of telecommunications networks, their intellectual analysis and methods of statistical modeling are often used. The modeling method is well suited for problems that cannot be solved by classical mathematical methods. Statistical modeling is used to collect characteristics and parameters that reflect the behavior of complex systems, also taking into account the influence of possible external factors. Multifractal characteristics of traffic have been intensively studied.

These studies were started in [1-2].

References

1. A. Pashko and I. Rozora, Estimation of Probability Overflow for Self-Similar Traffic. 2021 IEEE 8th International Conference on Problems of Infocommunications, Science and Technology, PICS and T 2021 - Proceedings, 2021, pp. 28–32.
2. I. Rozora and A. Pashko, Accuracy of simulation for the network

traffic in the form of Fractional Brownian Motion, 14th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering, TCSET 2018 – Proceedings 2018-April, pp. 840-845. DOI: <https://doi.org/10.1109/TCSET.2018.8336328>

DEVELOPMENT OF COMPUTER SYSTEMS FOR MANAGING TECHNOLOGICAL PROCESSES AND TECHNICAL MEANS OF SCIENTIFIC RESEARCH

O. Peregontsev

Glushkov Institute of Cybernetics NAS of Ukraine

alex_timashov@outlook.com

In recent years, there has been a growing interest in the development of computer systems for managing technological processes and technical means of scientific research. These systems are designed to improve the efficiency and effectiveness of scientific research by providing researchers with advanced tools for data analysis, modeling, and simulation. One promising approach to designing these systems is the use of Field Programmable Gate Arrays (FPGAs). They offer several advantages over traditional microprocessors, including high performance, low power consumption, and the ability to be reprogrammed in the field. The use of FPGAs allows for the implementation of complex algorithms in hardware, resulting in faster processing times and improved performance. Additionally, FPGAs can be used to implement parallel processing architectures.

To fully realize the potential of FPGAs in these systems, it is necessary to develop principles for their use. This includes the development of methods for designing FPGA-based systems, as well as techniques for parallelizing user algorithms to take advantage of the parallel processing capabilities of FPGAs.

The first step in designing an FPGA-based system is to identify the requirements of the system. This includes determining the types of data that will be processed, the algorithms that will be used, and the performance requirements of the system.

Once the requirements have been identified, an appropriate FPGA can be selected. Factors to consider when selecting an FPGA include its performance, power consumption, and cost.

The algorithms used in the system can then be implemented in hardware using a hardware description language (HDL) such as VHDL or Verilog. In conclusion, the use of FPGAs in computer systems for managing technological processes and technical means of scientific research has the potential to significantly improve the efficiency and effectiveness of scientific research. Further research is needed to develop principles and methods for their use in these systems.

A QUEUEING MODEL FOR A CASE STUDY OF INTENSIVE CARE UNITS IN KYIV HOSPITALS

A. Pererva, H. Livinska

Taras Shevchenko National University of Kyiv, Ukraine

tont0n@knu.ua, hanna.livinska@knu.ua

In the work we use a queueing model of $M|M|n|n$ -type for estimating performance measures in intensive care units of Kyiv hospitals, where certain urgent support is required. We assume the beds in the units to be servers of the queueing model, patients flow to be a Poisson one with a constant rate, service time to have exponential distribution.

Basing on the data for 2021-2022 years in Oleksandriv Hospital of Kyiv (Data is taken from [1]Kyiv City Council), by the modelling, we estimate parameters of the model, and obtain stationary distribution for the number of patients, mean loading of the unit, the rejection probability for a patient.

By modelling the unit as a queueing system, we can evaluate the performance measures and, for instance, determine the optimal number of beds in the unit, not only for current data, but also for situations when the flows of customer decrease or dramatically increase because of an epidemical situation or the war. Therefore, such models gives a possibility for hospitals to be flexible and to act according to the situation, in case it is changed crucially. Moreover, different optimization problems for the cost of the system service can be formulated and solved in order to find a balance between the average workload and the probability of failure.

References

1. Kyiv City Council

https://kyivcity.gov.ua/likarni_ta_medytsyna/zdatni_zupiniti_400608/za_povnenist_opornikh_likaren_persho_khvili_khvorimi_na_Covid-19/

APPLYING THE GENERALIZATION PRINCIPLE TO SOLVE FUZZY MATRIX GAMES

D.M. Piven

Taras Shevchenko National University of Kyiv, Ukraine

pivden2000@gmail.com

A matrix game with fuzzy payoffs $G = (S^n, S^m, \tilde{A})$ is a finite zero-sum game for two players, where $S^n = \{1, 2, \dots, n\}$ and $S^m = \{1, 2, \dots, m\}$ are the sets of pure strategies of Players I and II, respectively $\tilde{A} = (\tilde{a}_{ij})_{\substack{1 \leq i \leq m \\ 1 \leq j \leq n}}$ is an $m \times n$ matrix representing the fuzzy payoffs of

Player I. It can be meant as a game similar to a regular matrix game, but with the only difference being that the payoff matrix is fuzzy. Fuzzy numbers (FNs) \tilde{a}_{ij} , $i \in M$, $j \in N$ are defined on the real line \mathbb{R} .

In [1] develops a solution method for the two-person zero-sum game where the payoffs are only approximately known and can be represented by fuzzy numbers. Because the payoffs are fuzzy, the value of the game is fuzzy as well. Based on [2] the extension principle, a pair of two-level mathematical programs is formulated to obtain the upper bound and lower bound of the value of the game at possibility level α . By applying a dual formulation and a variable substitution technique, the pair of two-level mathematical programs is transformed to a pair of ordinary one-level linear programs so they can be manipulated. From different values of α , the membership function of the fuzzy value of the game is constructed. It is shown that the two players have the same fuzzy value of the game.

Also, a Java-based program has been proposed to solve such problems. This program accepts an input file containing the matrix of FN's. It then parse this matrix, solves for specified α -cuts, and provides the result in both tabular and visual formats.

References

1. LUI, S.T., KAO, C. (2007) Solution of fuzzy matrix games: an application of the extension principle, *International Journal of Intelligent Systems* 22, pp. 891–903.
2. LARBANI, M. (2009) Non cooperative fuzzy games in normal form: A survey, *Fuzzy Sets and Systems*, 160, pp. 3184–3210.

ON THE PROBLEM OF MULTI-FACTOR ANALYSIS OF CROP YIELDS

Vadym Ponomarov

Taras Shevchenko National University of Kyiv, Ukraine

vponomarov@gmail.com

In this presentation, we consider the construction of the model of crop yields. The input data set contains observations of corn yield (dependent variable) along with 78 factors (independent variables) that describe field configuration, climate conditions, fertilizer application, etc. The ultimate goal is to detect dependency structure among the variables, estimate factors that have a significant effect on the dependent variable, and provide recommendations for yield improvement.

First, on the data exploration step, we estimated the basic statistical characteristics of the data set and removed factors that have an insufficient number of values or are significantly skewed. Correlation analysis showed the existence of significant dependencies between dependent variable and continuous factors. However, no strong linear dependencies were detected. Dependencies between the dependent variable and categorical factors were analyzed via One- and Two-way ANOVA.

Domain experts have identified that one of the most significant yield factor is the type of culture. This supposition was also confirmed by statistical analysis. However, the number of observations for different cultures does not allow to include this factor in the model directly. In order to overcome the described issue, the cultures were clustered into 5 groups using multiple comparison analysis: the cultures inside the group are not significantly different but differ from the cultures in other groups.

Based on the model comparison technique, we have identified the linear model that describes the dependency structure the best. This model has high R-squared statistics (0.75), good predictive accuracy (based on the provided test data set), and residual analysis does not show systematical departures. The obtained model can be used for further analysis, optimal decision-making, and optimization of corn yield.

DEVELOPING RESILIENCE IN MILITARY PERSONNEL: CHALLENGES AND PROSPECTS

D. Prakapienė¹, R. Kazlauskaitė – Markelienė²

General Jonas Žemaitis Military Academy of Lithuania

¹dalia.prakapiene@lka.lt; ²rolanda.kazlauskaite@lka.lt

Resilience is a phenomenon that occurs as a result of natural human reactions to adapt to various challenges through the ability to cope with or respond to threats. Resilience is not just a passive human reaction to threatening conditions, but an active and constructive response to the current situation. Therefore, it is argued that resilience can and must be continuously developed. Taking into account the specifics of the work of military personnel and the increased need for military personnel resilience training, the aim of this study is to identify the challenges and opportunities for Lithuanian military personnel resilience training. The qualitative method of expert interviews was chosen for the study. The study involved eight experts selected according to the following selection criteria: military psychologists currently working/serving in the Lithuanian Armed Forces, with at least 2 years of service in the Lithuanian Armed Forces and related to military resilience training.

The results of the study revealed that: 1) there is a recent focus on and need for resilience development in the Lithuanian Armed Forces; 2) the basic soldier training course contributes to the development of resilience in military personnel; 3) there is a higher level of engagement with the need for resilience development among military personnel. However, key challenges have also emerged: 1) lack of time and resources for resilience development; 2) lack of a systematic resilience support system after the resilience training, i.e. lack of continuity; 3) lack of a systematic collection of lessons learned (after missions, international exercises, etc.) and their application to resilience development in the Lithuanian Armed Forces.

Keywords: military resilience, resilience development, military resilience training, military personnel, Lithuanian Armed Forces.

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TECHNOLOGY INTEGRATION IN THE ESL CLASSROOM

N. Putkaradze , L. Khardina, S. Dumbadze

Batumi State Maritime Academy, Georgia

n.putkaradze@bsma.edu.ge, l.khardina@bsma.edu.ge,

s.dumbadze@bsma.edu.ge

Times have changed and we have to change our teaching methods too regardless of the age group or level we are teaching. Technology integration in ESL classes is seamless and thoughtful, it makes students more engaged, more motivated and enthusiastic. In addition to using laptops, projectors PowerPoint slides we can use different tools to teach English with using technology that can make ESL classes more engaging and enjoyable.

Integration of technology in education refers to the use of technology to enhance the students learning possibilities and boost their motivation. Integrating technologies and educational apps in the classroom such as (storybird, internet homework assignment, online grading system, Kahoot, PowerPoint, Quizlet and many others) can change classroom climate , generate students growth in the classroom and keep students engaged whether they are working independently or collaboratively. The use of technology can also allow students to work at their own paces.

Conclusion. Presented paper tries to highlight the benefits of integrating technologies in teaching English process as a second language (ESL) , also highlights different attitudes that encourage English language learners to improve their learning skills through the use of technology. Technological tools used in English language teaching and learning can make many contributions both to teachers and students, provide great opportunities to learn something new and to have to experience. Integrating technologies into classroom settings can lead to increased student motivation and interest in learning as well as improved self-regulation and collaboration while supporting the development of all four language skills including listening, reading, speaking and writing. As a result of this study, it can be said that the process of technology integration needs to be carried out precisely and in a planned way in order to make significant contributions to the use of technology, which is an essential task for teachers.

DIGITAL TEACHING TOOLS IN TEACHING ENGLISH AND GEORGIAN LANGUAGES

Nino Putkaradze, Ketevan Zoidze

Batumi State Maritime Academy, Georgia

n.putkaradze@bsma.edu.ge

Computer is the most important technological achievements in our life nowadays. We use it in various field of life considering its high efficiency in performance. One of these is the field of language teaching and learning. Times have changed and we have to change our methods too. At present, computer is used in linguistic activity providing multiple teaching tools for teaching language when teaching English as a second language (ESL) and Georgian language as a second language in the classroom.

Innovative digital teaching tools, platforms, resources are useful to keep our learners focused and motivated. When technology integration in the classroom is seamless and thoughtful, learners not only become more engaged, they begin to take more control over their own learning too. Using different digital tools, platforms, resources such as “Kahoot”, “Quizlet”, “Storybird” or “Learn English with Cambridge”, and other multimedia elements such as pictures, voice, films, interactive video, can make learning more engaging and boost learners autonomy and motivation, develop learners listening, writing, reading and speaking skills. Using technology in teaching the language would not only help our learners learn more effectively but also ease teachers work and help teachers save more time for classroom practice. Learners could reach their full potential in shorter time and in a more enjoyable environment.

This paper tries to highlight the benefits and uses of computers, digital technologies in teaching English as a second language (ESL) and Georgian language as a second language. More over the benefits of using computer technology in improving the four language skills and its significant contribution in the classroom that is useful to enrich the educational process. Cleverly and precisely chosen digital resources can encourage engagement of learners, can also open up communication in the classroom, make the teaching and learning environment more effective and enjoyable.

RISK DECISION MODELS IN CYBER INSURANCE

V. Reshetnikov, I. Rozora

Taras Shevchenko National University of Kyiv, Ukraine

vadymreshetnikov@ukr.net, irozora@knu.ua

Modern IT business requires modern solutions in the matter of insurance against potential threats. Cyberattacks on key infrastructure, as well as the prospect of cyberterrorism and even cyberwarfare, pose a threat to society. Cyber risk is a growing concern for both the public and private businesses. Over the past 30 years, the field of cyber insurance has developed rapidly, combining the latest technologies and traditional mathematical models.

We consider the general model of cyber business insurance. This model includes calculations of the payout P under a cyber insurance contract and the optimal deductible x_1^* . It's offered a Pareto-optimal cyber insurance contract that exceeds the deductible by x_1 . The insurer requires the insurance company to make an advance payment [1]:

$$P = q(1 + \lambda) \int_{x_1}^{\infty} (x - x_1) f(x) dx.$$

Knowing the exact strategy of a claim in the event of a private breach and the accompanying payment of compensation, we can find the optimal value of the deductible x_1^* that an insurer needs to conclude a contract.

For the purpose of cyber risk assessment and definition of insurance conditions for a cyber insurance company the computing software package was developed. C++ programming language and the QT5 framework were used to create the program's visual interface.

References

1. Breuer, Michael, "Optimal Insurance Contracts without the Non-Negativity Constraints on Indemnities Revisited", University of Zurich Working Paper No. 0406, April 2004.

SOLVING THE THREE-INDEX TRANSPORT PROBLEM FOR OPTIMIZATION OF GRAIN TRANSPORTATION

I.V. Reznichenko¹, O.A. Kapustian²

Taras Shevchenko National University of Kyiv, Ukraine

¹barsareznich@gmail.com, ²olena.kap@gmail.com

Today, the problem of organizing economically sound transportation of grain is extremely urgent in order to preserve the competitiveness of agricultural production and avoid a catastrophic drop in the profitability of agricultural production. Economic-mathematical methods and models [1], including the transport problem, are called to solve this problem. In our case, the transport problem is aimed at finding the optimal plan for grain transportation from production (or storage) points to destinations, taking into account different types of transport for transportation, which allows minimizing the costs associated with this process. Previously, in the paper [2], a balanced, clearly formalized three-index transport problem was posed and considered, and the existence of its solutions was proved. In this work, we focus on obtaining a solution to this problem.

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References

1. Вітлінський В.В. Економіко-математичні методи та моделі: оптимізація: навч. посібник [Електронний ресурс] — К. : КНЕУ, 2016. — 303 с.
2. Резніченко І.В., Капустян О.А. Транспортна задача для економічного обґрунтування перевезення зерна // Матеріали XXI Міжнародної науково-практичної конференції «Шевченківська весна – 2023», 14 квітня 2023 р., м. Київ, Україна. - С.102.
https://probability.knu.ua/shv2023/ShV_2023.pdf

**COORDINATION OF NODES PARAMETERS RATIOS
OF THE CRYPTOCURRENCY USAGE COGNITIVE MAP
BASED ON IMPULSE PROCESS MODELS
WITH MULTIRATE SAMPLING**

V. Romanenko, Yu. Miliavskiy, H. Kantsedal

National Technical University of Ukraine

“Igor Sikorsky Kyiv Polytechnic Institute”, Ukraine

iasa@kpi.ua, yuriy.milyavsky@gmail.com,

g.kantsedal@protonmail.com

The cognitive map (CM) of cryptocurrency usage in financial markets was developed. Impulse process models (Roberts equations [1]) with multirate sampling were created based on CM. They describe the dynamics of fast and slow measurable CM nodes coordinates in the format of systems of difference equations. Control subsystems with multirate sampling for fast and slow measurable CM nodes coordinates respectively were designed to stabilize the coordinates at the specified levels under the influence of external and internal disturbances. External control vectors in closed-loop subsystems with fast and slow measurable CM nodes coordinates were implemented by means of varying some coordinates that a decision-maker can alter in closed-loop control subsystems. In the control subsystem with fast measurable coordinates dynamic coordination of the ratio of CM nodes, describing cryptocurrency's supply and demand volumes on financial exchanges, was implemented. Efficiency of the designed control subsystems with multirate sampling was researched using numerical simulation.

References

1. Roberts F. Discrete Mathematical Models with Applications to Social, Biological and Environmental Problems. Englewood Cliffs: Prentice-Hall. – 1976.

COVID-19 EPIDEMIC MODELLING FOR COMPLEX SYSTEM WITH MIGRATION

I.V. Samoilenko¹, T.A. Samoilenko²

¹ Taras Shevchenko National University of Kyiv, Ukraine

²National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, Ukraine

isamoil@i.ua, tsamoil@i.ua

We discuss a SIR-type model that simulated the actual behavior of the spread of COVID-19 in India during April 2020 [1]. The influence of internal conflict on the described epidemiological model were evaluated in terms of inter-regional interaction and migration, similarly to the Lotka–Volterra model with cyclic migration [2]. The principles of migration are presented schematically in the next Figure. The direction of each arrow indicates the group or set under the influence of which the participant is migrating from its original side. A bilateral dotted arrow indicates mutual influence on redistribution during conflict interaction of each part. Computer modelling of system’s dynamics is presented.

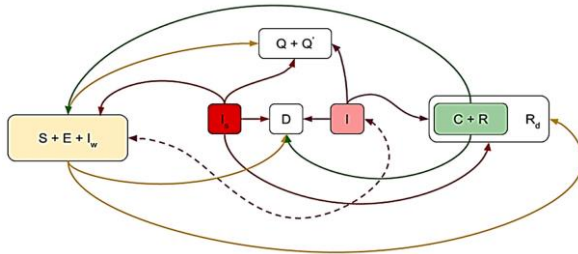


Figure. The basic migration principles indicated for group under the influence of which the participant is migrating by the proposed SIR model: susceptible (S), non-contagious (E), infected people who ignore the symptoms (I_s), infected (I), asymptomatic infected (I_w), in quarantine (Q), in the intensive care unit (Q'), carriers (C), recovered (R), recovered immobilized (R_d), deaths (D).

References

1. Ashish M., Nithin K.R., Anish C., Girish S. Modelling and simulation of COVID-19 propagation in a large population with specific reference to India // medRxiv 2020, DOI:10.1101/2020.04.30.20086306.
2. Albeverio S., Koshmanenko V., Samoilenko I. The conflict interaction between two complex systems: Cyclic migration // J. Interdisciplinary Math. – 2008 – Vol. 11, No.2. – P. 163–185.

ENHANCING EFL INSTRUCTION THROUGH INTERACTIVE VIDEOS

Nino Samnidze

Batumi Shota Rustaveli State University, Georgia

Interactive videos have proven to be a highly effective tool in English as a Foreign Language (EFL) instruction, fostering active learning, engagement, and retention among students. By integrating interactive videos into the curriculum, educators can empower students with various learning benefits. Interactive videos facilitate a hands-on approach, encouraging students to actively participate in the learning process. Through interactive elements, such as quizzes, discussions, and decision-making scenarios, students can strengthen their problem-solving and critical thinking skills while immersing themselves in the language. What's more, videos offer a rich combination of auditory, visual, contextual, verbal, and non-verbal cues, which are essential for language comprehension. By incorporating these different modes of input, students can better grasp language nuances and cultural context, leading to improved language acquisition. They are also beneficial for personalized Learning. Interactive videos allow students to learn at their own pace, promoting independence and personalized learning experiences. With the flexibility to pause, rewind, and revisit content, students can fully digest the material without feeling rushed, fostering a deeper understanding of the language concepts.

Edpuzzle, an effective educational platform, can take video-based learning to the next level that allows educators to make videos more interactive by embedding questions, comments, and quizzes within the content.

In conclusion, interactive videos are a powerful tool in EFL instruction, offering a plethora of benefits such as active learning, multimodal input, personalized learning. Utilizing platforms like Edpuzzle can further enhance the interactivity of videos and improve student engagement and language acquisition. As educators strive to create effective and engaging learning environments, integrating interactive videos into the EFL curriculum is an essential addition to the Teacher's Toolkit.

ANALYSIS OF STUDENTS' QUALITY OF LIFE ASSESSMENT BASED ON THE SF-36 QUESTIONNAIRE

Y.A. Sazontova, I.M. Shevchuk, M.V. Loseva

Taras Shevchenko National University of Kyiv, Ukraine

shevchuk.iuliia@knu.ua

We conducted a poll of Ukrainian students from various courses, majors, and population categories using the SF-36 poll-bot (we created python-bot in Telegram) and analyzed the quality of life of Ukrainian students (physical and mental health) based on the answers received.

Based on the obtained results, we plan to continue research.

First, it is worth expanding the scope of the study, including more participants from different regions and population groups. It will allow for obtaining more representative results and making generalizations at the level of the entire country.

Secondly, it is possible to conduct further analysis of the dependence of the quality of a student's life on other factors, such as socioeconomic status, level of education, degree of fatigue, and others.

A result of our investigation expansion of our understanding of the quality of life of Ukrainian students and contribute to the development of educational programs and the improvement of their learning conditions.

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References

1. Ware J.E. SF-36® Health Survey Update. Ware Access: <http://www.sf-36.org/tools/sf36.shtml>
2. Hays R. D., Morales L. S. The RAND-36 measure of health-related quality of life. *Annals of medicine.* – 2001. – № 33(5). – P. 350–357.
3. McDowell I. *Measuring health: a guide to rating scales and questionnaires.* – Oxford university press, 2006.

ASYMPTOTIC PROPERTIES OF THE MARKOV-MODULATED POISSON PROCESS

S. Semenyuk

Lviv National Polytechnic University, Ukraine

semenyuk@gmail.com

Let's consider Markov-modulated Poisson process (MMPP) as a two-component process $(x(t), N(t))$.

Here the process $x(t), t \geq 0$ is uniformly ergodic Markov process in the standard phase space (X, \mathcal{X}) with stationary distribution $\pi(B)$ and infinitesimal operator (generator)

$$Q\varphi(x) = q(x) \int_X P(x, dy) [\varphi(y) - \varphi(x)], \varphi \in B(X) \quad [1].$$

The Poisson process $N(t), t \geq 0$ is a counting process for the number of events that have occurred up to time t . The arrival rate of events at time t is given by $\lambda(x(t))$ i.e., rate parameter is modulated by the state Markov process.

Such models are commonly used in network traffic modeling, maintenance and reliability, financial modeling, and epidemiology.

Asymptotic properties of the process have been investigated in this work. To achieve this infinitesimal operator for the MMPP has been built. Then we use small parameter approach [1] and averaging schema.

References

1. Korolyuk V.S, Limnius N. Stochastic Systems in Merging Phase Space. – World Scientific, 2005. – 330 p.

CONSTRUCTION AND INVESTIGATION OF TWO-SIDED METHODS FOR SOLVING VARIATIONAL PROBLEMS

P.S. Senio

Ivan Franko National University of Lviv, Ukraine

petrosny@ukr.net

The two-sided approximation of the solution of the variational problem is obtained by solving its analogue in the mathematics of functional intervals. To construct this analogue, the concept of the integral of functional intervals of a function was used, given its known and unknown analytical expression [2]. Then, the solution of the

variational problem is based on reducing it to the problem of minimizing the corresponding interval-valued function of multiple variables, by constructing rather narrow interval extensions [1] of the desired function $y(x)$ and its derivatives between adjacent quadrature nodes and its residual term $R_n(r_\xi)$. It is proved that that for sufficiently smooth functions and their Hermitian cubic splines, the following condition holds:

$$\|s^{(r)}(z) - y^{(r)}(z)\|_\infty = o(h^{4-r}), \quad (r = 0, 1, 2, 3), \quad (1)$$

where $h = \max h_i$, $z = (x - x_i)/h_i$, $y_i = y(x_i)$, y_i ($i = 0, 1, \dots, n$) are values of a function $y(x)$ in the nodes of net $\Omega = \{x_i \mid x_0 = a < x_1 < x_2 < \dots < x_n = b\}$.

This and Embedding Theorem from W_2^p onto L_∞ imply that

$$\bar{r}_j(x) = [-1, 1] \min \{K_j h^{p-j} \|y(x)\|_{p,\infty}, K_k h^{p-k} \|y(x)\|_{p,2} (x - x_i)^{k-j} / (k - j)!\} \quad (2)$$

for each $x \in [x_i, x_{i+1}]$, $i = 0, 1, \dots, n - 1$, where K_j are constants, which do not depend on $y(x)$ and h . Thus, the stripes have been constructed to contain the values of the j -th derivative of the function $y(x)$.

References

1. Завьялов Ю.С. Методы сплайн-функций / Ю.С. Завьялов, Б.И. Квасов, В.Л. Мирошниченко – М.: Наука, 1980. – 342 с.
2. Senio P.S. Methods of boundary problem solving based on the mathematics of functional intervals / P.S. Senio // Mathematical and Computer Modelling. Series: Physical and Mathematical Sciences. – 2018. – Issue 17. – P. 133 -144.

INFORMATION AND COMMUNICATIONS TECHNOLOGIES IN EDUCATION

N.R. Sherozia

Batumi Shota Rustaveli State University, Georgia

In the present day, it is inconceivable to envision progress in any realm of governmental and societal endeavors without the use of information and communications technologies (ICT).

Contemporary information technology plays a pivotal role in shaping the forthcoming landscape of education. This establishes the bedrock for standard developmental conditions and the ability to align with the global environment. The advancement of technology necessitates the educational system to stay abreast of innovations. This will enable the educator to modify instructional techniques and approaches. As evident from the observations, the integration of information technology expedited the educational process and elevated its quality, inducing a substantial transformation in both the teaching procedure and its outcomes: - played a role in enhancing students' motivation and their societal integration; led to the development of new skills of students; resulted in efficient time management for studying; Based on ready-made sources, they acquired knowledge and became adept at conducting independent research. This establishes the cornerstone for the standard parameters of global advancement and the harmonious integration of humanity with it.

Technological innovations are seamlessly integrated across all spheres of human endeavor, effectively conserving substantial time and effort. Incorporating information communication technologies into the lesson serves as a potent visual aid, rendering the assimilation of new information by students comprehensible and accessible.

Ultimately, as previously noted, information technology assumes a pivotal role in effectively conducting the educational procedure within the forefront global educational establishments of today's era. Attaining tangible outcomes requires a substantial segment of society to grasp the beneficial dimensions of information technologies and optimize the use of available resources within the realm of education.

AUTOMATIC PROCESSING OF DIGITAL IMAGES OF DIFFERENT TYPES OF HUMAN CELLS

G. Shevchenko, S. Gerasimenko, V. Belozubenko

Association Noosphere, Ukraine

nikk.gena@gmail.com, sgerasimenko3792@gmail.com,

bvs910@gmail.com

The analysis of biomedical images has long become an integral component, both in diagnosing diseases and as applied to therapeutic purposes. This is due to the fact that a fairly large proportion of the total volume of all data in medicine is images. It is an important source of patient health data. Biomedical imaging technologies use a wide range of different opportunities such as X-rays, magnetism (MRI), computed tomography scan (CT scan), SPECT, OCT, ultrasound, endoscopy, etc.

Since recently, an analysis of digital images of biological fluids, primarily, blood cells, cerebrospinal fluid, buccal epithelium scrapings and others, has been added to this list. A biological fluid swab often provides the primary and, sometimes, the only evidence of a specific diagnosis, remaining an important diagnostic tool even in the molecular analysis era of molecular analysis with the ability to isolate DNA, RNA and other material in the cell structure. An interest in this topic is driven, first of all, by an opportunity to automate the process of diagnostics, which is reduced to analysis of digital images of the respective human cells.

At the present time, there are few automated tools that would help doctors fulfill the routine duties of analyzing images, helping to process and analyze such information. Most of these systems are built on the use of neural network data processing technologies (artificial intelligence) with their inherent disadvantages - the need for training on a very large amount of data and the inability to interpret the results.

Our approach is based on the extraction of various features of cells and the formation of a training sample from it for subsequent classification, provides visibility of the results and shows high accuracy on test data. The system was developed on the basis of the work results that are provided by our specialists in the field of image processing. As a result, we built a system, which is able to segment the images of cells and extract the necessary features from them to build an object-feature table. The developed software is designed to improve the efficiency of medical personnel, (including research), in the diagnosis, treatment and monitoring of various diseases that have manifestations at the cellular level.

MODAL LOGICS OF NON-MONOTONE QUASIARY PREDICATES WITH EXTENDED RENOMINATION

O.S. Shkilniak

Taras Shevchenko National University of Kyiv, Ukraine

oksana.sh@knu.ua

Modal logics have many applications in various fields including theoretical and applied computer science. Temporal logics are used for dynamic systems modelling, software systems specification and verification; epistemic modal logics are used for description of artificial intelligence systems, databases and knowledge bases with incomplete information. Traditional modal logics are based on classical predicate logic, which has some fundamental restrictions that don't allow taking into account sufficiently such properties of subject-domain information as incompleteness, partiality, uncertainty. Thus, construction of new program-oriented logical formalisms is needed. Composition nominative modal logics of partial predicates [1] could be such an approach. They combine capabilities of logics of partial quasiary predicates without monotonicity restriction and traditional modal logics. Modal transitional logics, their important variant, can adequately represent changes and development of subject-domains.

In this paper, we propose new classes of modal transitional logics of partial predicates (MTL). Their characteristic feature is the use of compositions of extended renomination [2], which permits taking into consideration the incompleteness of information. We specify languages and semantic models of first-order modal transitional logics with extended renomination (\perp MTL). Semantic properties of \perp MTL, in particular modal compositions' interactions with extended renominations and quantifiers, are described. We define various logical consequence relations for sets of formulas specified with states. Then, basing on properties of these relations, we construct corresponding sequent calculi. The soundness and completeness theorems for the introduced calculi are proved.

References

1. O. Shkilniak. Modal logics of partial predicates without monotonicity restriction. In Proceedings FOI-2015. August 24–29, 2015, Chisinau, Moldova, pp. 198–211.
2. M. Nikitchenko, O. Shkilniak, S. Shkilniak. First-order composition-nominative logics with generalized renominations. In Problems in Programming, 2014, 2–3, pp. 17–28 (in Ukrainian).

LOGICS OF PARTIAL PREDICATES OVER COMPLEX-NAMED DATA WITH EXTENDED RENOMINATIONS

O.S. Shkilniak, S.S. Shkilniak

Taras Shevchenko National University of Kyiv, Ukraine

oksana.sh@knu.ua, ss.sh@knu.ua

Using of partial mappings over complex hierarchically structured data is typical for programming. However, traditional first-order logic is based on algebras of atomic, non-structured data. This prompts the construction of logics of partial predicates over complex nominative data. Logics over hierarchical strictly nominative data are introduced and studied in [1]. In [2], logics of partial predicates over nominative data with complex names (complex-named data, or *CND*) are considered. Description of first-order logics of predicates over *CND* (*CND*-predicates) is given and sequent calculi are constructed.

In this paper, we propose a generalization of logics of predicates over complex-named data presented in [2] by adding operations of extended renomination over *CND* $r_{\bar{x},\perp}^{\bar{v},\bar{u}}$ and corresponding compositions of extended renomination over predicates $R_{\bar{x},\perp}^{\bar{v},\bar{u}}$. Extended renominations allow explicitly specify undefinedness of certain names' values, thus permitting taking into consideration the incompleteness of information. We describe properties of $r_{\bar{x},\perp}^{\bar{v},\bar{u}}$, and introduce standard notation for these operations and their convolution. Algebra of *CND*-predicates with extended renomination is constructed; compositions of extended renomination $R_{\bar{x},\perp}^{\bar{v},\bar{u}}$ and existential quantification $\exists x$, where x is a complex-name, are defined, and their properties are given. We describe the first-order language of the presented predicates, specify logical consequence relations for sets of formulas, and describe their properties. For these logical consequence relations we construct calculi of sequent type.

References

1. M. Nikitchenko, S. Shkilniak. Composition-nominative logics over hierarchical data. In *Problems in Programming*, 2010, 2–3, pp. 48–57 (in Ukrainian).
2. M. Nikitchenko, O. Shkilniak, S. Shkilniak. Sequent calculus for a program-oriented predicate logic over complex-named data // 10th Int. Conf. on Advanced Comp. Inform. Technologies (ACIT), Deggendorf, Germany, 2020, pp. 497–500.

FIRST-ORDER LOGICS OF PARTIAL QUASIARY PREDICATES WITH EQUALITY

S.S. Shkilniak

Taras Shevchenko National University of Kyiv, Ukraine

ss.sh@knu.ua

The apparatus of mathematical logic forms the basis for modern artificial intelligence systems and software systems. Therefore, development of program-oriented logical formalisms is a topical problem. In this paper we study new classes of such formalisms: first-order logics of partial quasiary predicates. These logics are called L_{\perp}^Q (logics of quantifier level), their characteristic feature is the use of compositions of extended renomination. We consider extension of L_{\perp}^Q with predicates of equality [1] and a special composition of predicate complement [2]. Logics with predicate complement were introduced to extend the well-known Floyd-Hoare program logic for partial pre- and post-conditions.

Therefore, we can extend L_{\perp}^Q with:

- special predicates of weak equality $=_{xy}$ and of strong equality \equiv_{xy} , thus obtaining logics $L_{\perp}^{Q=}$ and $L_{\perp}^{Q\equiv}$;
- composition of predicate complement \sim , thus obtaining logic L_{\perp}^{QC} ;
- composition \sim and predicates of equality $=_{xy}$ and \equiv_{xy} , thus obtaining logics $L_{\perp}^{QC=}$ and $L_{\perp}^{QC\equiv}$.

We describe composition algebras and languages of logics L_{\perp}^Q , $L_{\perp}^{Q=}$, $L_{\perp}^{Q\equiv}$, L_{\perp}^{QC} , $L_{\perp}^{QC=}$, $L_{\perp}^{QC\equiv}$ and specify for these logics a number of logical consequence relations for sets of formulas. For the introduced relations, we describe conditions for their guaranteed presence, decomposition conditions for formulas, and properties of quantifier elimination. The corresponding first-order sequent calculi are constructed basing on properties of these relations; for the proposed calculi the correctness and completeness theorems are proved.

References

1. S. Shkilniak. First-order composition-nominative logics with predicates of weak equality and of strong equality. In Problems in Programming, 2019, 3, pp. 28–44 (in Ukrainian).
2. M. Nikitchenko, O. Shkilniak, S. Shkilniak. Sequent Calculi of First-order Logics of Partial Predicates with Extended Renominations and Composition of Predicate Complement // Proceedings of the 12th International Scientific and Practical Conference of Programming (UkrPROG 2020). Kyiv, Ukraine, September 15-16, 2020. – P. 182-197.

OPERATOR EQUATIONS FOR PARTIAL DENSITIES

Yu.V. Shusharin, S.V. Degtyar

Kyiv National Economic University named after Vadym Hetman,
Ukraine

shusharin@meta.ua

We consider a system of linear difference equations with semi-Markov coefficients.

$$X_{k+1} = A(k, \zeta_k) X_k, \quad (k = 0, 1, 2, \dots), \quad (1)$$

where $\zeta(t)$ is a semi-Markov chain that takes a finite number of values $\theta_1, \dots, \theta_n$ with intensities $q_{jS}(k)$ ($j, S = 1, \dots, n$) of transition from state θ_S to state θ_j at the moment k . The intensities satisfy the conditions:

$$q_{jS}(k) \geq 0, \quad \sum_{j=1}^n q_{jS}(k) = q_S(k), \quad (S = 1, \dots, n),$$

$$\sum_{k=1}^{\infty} q_S(k) = 1, \quad \sum_{k=1}^{\infty} q_{jS}(k) = \pi_{jS}, \quad (j, S = 1, \dots, n) \quad (2)$$

$\Pi = \|\pi_{jS}\|$ is stochastic matrix, $\sum_{j=1}^n \pi_{jS} = 1$.

Functions are also introduced $\psi_S(k)$

$$\psi_S(k) = \sum_{j=k+1}^{\infty} q_S(j); \quad \psi_S(0) = 1, \quad (S = 1, \dots, n; k = 0, 1, 2, \dots)$$

$$\lim_{k \rightarrow \infty} \psi_S(k) = 0, \quad (S = 1, \dots, n).$$

We assume that the system of difference equations of the system of linear differential equations

$$\frac{dX(t)}{dt} A(t, \zeta(t)) X(t),$$

has jumps of solutions that occur simultaneously with jumps of the random chain ζ_k .

Consider a continuous-discrete random process (X_k, ζ_k) and write the distribution density in the form

$$f(k, X, \zeta) = \sum_{k=1}^n f_k(k, X) \delta(\zeta - \theta_S). \quad (3)$$

We introduce the vector of partial distribution densities

$$F(k, X) = \begin{pmatrix} f_1(k, X) \\ \dots \\ f_n(k, X) \end{pmatrix} \quad (k = 0, 1, 2, \dots) \quad (4)$$

and find a stochastic operator $L(s)$ ($s = 0, 1, 2, \dots$) such that

$$F(s + k_j, X) = L(s)F(k_j, X) \quad (j, s = 0, 1, 2, \dots) \quad (5)$$

In this case, we assume that the operator $L(s)$ has the form of a matrix with operator elements

$$L(s) = \begin{pmatrix} L_{11}(s) & L_{12}(s) & \dots & L_{1n}(s) \\ L_{21}(s) & L_{22}(s) & \dots & L_{2n}(s) \\ \dots & \dots & \dots & \dots \\ L_{n1}(s) & L_{n2}(s) & \dots & L_{nn}(s) \end{pmatrix}. \quad (6)$$

we introduce stochastic operators $R_s(k)$, S_{Sk} defined by the formulas

$$R_s f(X) \equiv f(N_s^{-1}(k)X) \cdot |\det N_s^{-1}(k)| \quad (S = 1, \dots, n) \quad (7)$$

$$S_{Sk} f(X) \equiv f(C_{Sk}^{-1}X) \cdot |\det C_{Sk}^{-1}| \quad (S = 1, \dots, n) \quad (8)$$

In this case, we obtain a system of operator equations

$$L(k)F(0, X) = \psi(k)R(k)F(0, X) + \sum_{j=1}^k L(k-j)S(j)R(j)F(0, X), \quad (9)$$

where the designations are used

$$\begin{aligned} \psi(k) &\equiv \|\delta_{ri}\psi_i(k)\|_1^n, \quad R(k) \equiv \|\delta_{ri}R_i(k)\|_1^n, \\ S(k) &\equiv \|q_{ri}S_{ri}\|_1^n, \quad (k = 0, 1, 2, \dots) \end{aligned} \quad (10)$$

The operator equation for the stochastic operator $L(k)$ takes the form

$$L(k) = \psi(k)R(k) + \sum_{j=1}^k L(k-j)S(j)R(j), \quad (11)$$

The solution of equation (11) can be found by the method of successive approximations.

References

1. Valeev K.G., Karelova O.L., Gorelov V.I. Optimization of linear systems with random coefficients: M., izd. RUDN, 1996. – 258 p.
2. Shusharin Yu.V. Investigation of the stability of solutions of a system of linear stochastic differential equations with Markov

coefficients // Obchisluvana ta prikladna matematika. – 2011. – №3. – P.183 – 189.

3. Shusharin Yu.V. Recurrent equations for characteristic functions of solutions of linear difference equations with random coefficients. //Visnik Taras Shevchenko National University of Kyiv: Seria fiz.-mat. nauk. – 2014. – №3. – P. 206-209.

4. Nakonechnyi O.G., Kudin G.I., Zinko P.N., Zinko T.P., Shusharin Y.V. Guaranteed root mean square estimates of linear matrix equations solutions under conditions of uncertainty //Mathematical Modeling and Computing. – 2023. – Vol. 10, No. 2. – P. 474–486.

5. Degtyar S. V., Shusharin Yu. V., Zhuk Ya. O. Oscillations of a Pendulum under the action of Random Impulses. //International Applied Mechanics. – May 2023. – Vol. 59. – P. 333-341.

COINCIDENCES OF A SEMI-MARKOV STOCHASTIC PROCESS WITH A MARKOV ONE

Yu.V. Shusharin, S.V. Degtyar

Kyiv National Economic University named after Vadym Hetman,
Ukraine

shusharin@meta.ua

Let us find the conditions under which the semi-Markov random process coincides with the Markov process defined by the system of differential equations

$$\frac{dP(t)}{dt} = AP(t), \quad A = \|a_{ks}\|_{k,s=1}^n. \quad (1)$$

For a Markov process, jump transitions from a state θ_k to the same state θ_k are not considered. Therefore, we assume

$$q_{kk}(t) \equiv 0 \quad (k = 1, \dots, n).$$

Let us pass from the Markov process (1) to the Markov chain

$$P(t_k + h) = P(t_k) + hAP(t_k), \quad t_k = kh \quad (k = 1, \dots, n)$$

On the main diagonal of the matrix $E + hA$ are the elements $1 + ha_{kk}$ ($a_{kk} < 0$). Therefore, the probability of remaining in a state θ_k over time $t = nh$ is defined by the expression

$$P\{\zeta(t_j) = \theta_k\} = (1 + ha_{kk})^{jh-1} \xrightarrow{h \rightarrow 0} e^{a_{kk}t}. \quad (2)$$

Therefore, for the Markov process we have the equality

$$\psi_k(t) = e^{ta_{kk}} \quad (k = 1, \dots, n; a_{kk} < 0). \quad (3)$$

From the system of equations (1) it follows, that from state θ_k to another state θ_s ($s \neq k$) Markov chain goes over time $\Delta t = h$ with probability ha_{sk} . Based on this, we assume

$$q_{sk}(t) = a_{sk}\psi_k(t) = a_{sk}e^{ta_{kk}} \quad (s \neq k; k, s = 1, \dots, n).$$

Final intensity $q_{sk}(t)$ for the Markov random process $a_{kk} < 0$ ($k = 1, \dots, n$) we get in the form

$$\begin{aligned} q_{kk}(t) &\equiv 0, \quad q_k(t) = -a_{kk}e^{ta_{kk}}, \quad \psi_k(t) = e^{ta_{kk}} \quad (k = 1, \dots, n) \\ q_{sk}(t) &= a_{sk}e^{ta_{kk}} \quad (s \neq k; k, s = 1, \dots, n). \end{aligned} \quad (4)$$

Formulas (4) determine the intensities for the Markov process (1), defined as a semi-Markov random process.

References

1. Shusharin Yu.V. Investigation of the stability of solutions of a system of linear stochastic differential equations with Markov coefficients // *Obchisluvana ta prikladna matematika*. – 2011. – №3. – P.183 – 189.
2. Degtyar S. V., Shusharin Yu. V., Zhuk Ya. O. Motion of Symmetric Gyroscope under Action of Gravity with Discrete Random Change of Parameters of System. // *International Applied Mechanics*. – November 2022. – Vol. 58. – P. 634-644. Published: 12 June 2023.
3. Degtyar, S. V.; Shusharin, Yu. V.; Zhuk, Ya. O. Oscillations of a Pendulum under the action of Random Impulses. // *International Applied Mechanics*. – May 2023. – Vol. 59. – P. 333-341.

TIME-VARYING PARAMETER ESTIMATION BY THE LEAST SQUARES METHOD WITH VARIABLE FORGETTING FACTOR AND LEAST DEVIATIONS FROM ‘ATTRACTION’ POINTS FOR NON-LINEAR DYNAMIC SYSTEMS UNDER UNCERTAINTIES

A.S. Slabospitsky

Taras Shevchenko National University of Kyiv, Ukraine

sl@univ.kiev.ua

The estimation problem of slowly time-varying parameter vector α is investigated for dynamic object

$$x(k+1) = F(x(k), u(k), k)\alpha + g(x(k), u(k), k) + \xi(k), \quad k \in \mathbb{N},$$

when for unknown vector α its ‘attraction’ point $\alpha_*(k)$ is known at any moment k , where $x(k), u(k), \xi(k)$ 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 this system under non-classical assumptions when this estimate may be not unique.

The set of all such estimates is defined as

$$\text{Arg min}_{\alpha} Q(\alpha, N),$$

where

$$Q(\alpha, N) = \sum_{k=1}^N w(k, N) \|\xi(k)\|^2,$$

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

The required unique estimate $\hat{\alpha}(N)$ on above-mentioned estimate set is suggested as least squares estimate with variable forgetting factor $\lambda(\bullet)$ and least deviation from given ‘attraction’ point $\alpha_*(N)$ at any moment N in this situation.

Explicit form of representation for estimate $\hat{\alpha}(N)$ is derived using the Moore-Penrose pseudo-inverse operator. Also, recurrent algorithms for $\hat{\alpha}(N)$ and corresponding weighted residual sum of squares are proposed, which don’t require the applying of the Moore-Penrose pseudo-inversion for matrices.

A DESIGN METHOD AND AN ARCHITECTURAL-STRUCTURAL MODEL OF AN ALD WHICH IS MADE ON A NANO-ELECTROMECHANICAL ELEMENT BASE

D. Sokhan

Glushkov Institute of Cybernetics NAS of Ukraine

dsokhan@gmail.com

The Internet of Things (IoT) has revolutionized the way we live and work. With the increasing popularity of IoT, the use of intelligent interfaces and embedded systems in controlling technological processes and scientific research has become increasingly important. IoT has become an essential tool in modern technological processes, providing a seamless connection between physical and digital systems. The use of IoT in technological processes has allowed for the creation of smart factories, where machines and devices communicate with each other to optimize production processes. One of the key benefits of using IoT in technological processes is the ability to gather and analyze large amounts of data. This data can be used to identify patterns and trends, allowing for the development of predictive maintenance models. Predictive maintenance models can help reduce downtime and improve the overall efficiency of the production process. IoT has also become an important tool in scientific research, providing new and innovative ways to gather and analyze data. The use of IoT in scientific research has allowed for the creation of intelligent systems that can monitor and control experiments in real-time. This has resulted in improved accuracy, increased efficiency, and reduced costs. Nano-electromechanical systems (NEMS) have recently become a topic of great interest in the field of electronics. The development of NEMS-based arithmetic-logic devices (ALD) has the potential to revolutionize the electronics industry by providing a new level of performance, reliability, and miniaturization. The aim of this article is to research and develop a design method and an architectural-structural model of an ALD made on a nano-electromechanical element base, with a justification of the principles of its structural organization and possible areas of application. The design method for a NEMS-based ALD must take into account the unique properties of NEMS, such as their small size, high sensitivity, and low power consumption. This requires the use of new design techniques and optimization methods that are specifically tailored to NEMS. One of the key design considerations for a NEMS-based ALD is the choice of materials and fabrication methods.

METHODS OF IMAGE RECOGNITION IN SYSTEMS FOR MANAGEMENT OF TECHNICAL INSTRUMENTS OF SCIENTIFIC RESEARCH

K. Sosnenko, T. Samoliuk

Glushkov Institute of Cybernetics NAS of Ukraine

sosnenko.kate@ukr.net, tamara.samoliuk@ukr.net

Image recognition is a critical component of technological process control systems and scientific research. It is used in a variety of applications, including data acquisition, preprocessing, display, and data transmission.

Algorithms of deep learning, computer vision methods and machine learning methods were used to research, develop and improve the image recognition technology. To create a research and development methods of image recognition computer vision methods were applied. They are based on mathematical and computational algorithms used to interpret and analyze digital images. Computer vision techniques are used to extract information from digital images and improve the accuracy of image recognition algorithms. The use of deep learning algorithms, computer vision techniques, and machine learning techniques bring more accuracy and efficiency to image recognition technology, allowing them to support their operations and improve overall decision-making processes.

Algorithms for image recognition in subsystems of data collection, preprocessing, display and transmission for control systems of technological processes and technical means of scientific research have been developed.

A convolutional neural network (CNN) was used in the work. CNN is a special type of neural network that works effectively with images. The main difficulty lies in the fact that artificial neural networks (ANNs) are still unable to independently guarantee sufficient accuracy in detecting all image components and translating the overall composition into adequate semantic (especially technical) characteristics. The most effective method for detailing graphic images is a neural network-syntactic (or neurological) tool for recognizing and describing arbitrary images and videos. Modern deep learning frameworks, such as Tensorflow and PyTorch, were also used in the training of the neural network for image recognition, which made it possible to increase the accuracy and performance of the neural network.

INFORMATION TECHNOLOGY OF THE DEVELOPMENT OF MOBILE TREATMENT AND DIAGNOSTIC COMPLEXES

E. Timashov

Glushkov Institute of Cybernetics NAS of Ukraine

busurmanin@gmail.com

In the ever-evolving landscape of healthcare, technology has played a pivotal role in transforming the way medical services are delivered. Among these technological advancements, the development of Mobile Treatment and Diagnostic Complexes (MTDCs) has emerged as a game-changer, revolutionizing patient care, diagnosis, and treatment.

These complexes integrate various medical instruments, wireless communication technologies, data analysis, and mobile applications to enable real-time monitoring, diagnosis, and treatment.

From remote patient monitoring systems to telemedicine platforms facilitating virtual consultations, the possibilities presented by MTDCs are vast. However, alongside the benefits come challenges, including security and privacy concerns, regulatory considerations, and ethical implications.

Understanding the fundamentals of medical instrumentation is crucial for the successful development and deployment of Mobile Treatment and Diagnostic Complexes. These instruments serve as the eyes and ears of healthcare providers, enabling them to make informed decisions and provide optimal care to patients.

The design and operation of medical instruments are guided by specific principles to ensure accuracy, reliability, and patient safety:

Sensitivity: Medical instruments must be sensitive enough to detect even subtle changes in physiological parameters. This sensitivity is crucial for early disease detection and monitoring.

Accuracy: Accuracy refers to the closeness of a measurement to the true value. Instruments should provide results that are as close to the actual physiological value as possible.

Precision: Precision reflects the consistency and repeatability of measurements. A precise instrument will produce consistent results when measuring the same parameter multiple times. **Calibration:** Regular calibration ensures that medical instruments maintain accuracy over time. Calibrating instruments against known reference standards prevents measurement deviations.

THE MODIFIED K-MEANS ALGORITHM FOR THE SEGMENTATION OF CEREAL CROP IMAGES

Y. Tretiakov, I. Vergunova

Taras Shevchenko National University of Kiev, Ukraine

egorken3v@knu.ua, iryna.vergunova@knu.ua

Image segmentation, as a task of finding objects and their boundaries, is an important scientific problem. The choice of segmentation methods depends on the tasks to be solved.

The considered task refers to the problems of image processing, in which the description of images must take place taking into account the qualitative characteristics of objects (geometric spatial, spectral, textural). Since in the research we are dealing with images of agricultural plots, where the background color is green, the task of establishing the exact contour of a separate cereal crop is quite specific.

To solve the problem, a modified k-means method is proposed using the differential evolution algorithm based on the DE/Best/1/Bin strategy [1].

By using differential evolution, the segmentation problem becomes a multiparameter optimization problem, where parameters can be used to control the segmentation result. The parameters of the algorithm are: threshold value (as a measure of the difference between segments); a measure of pixel connectivity (as an estimate of whether neighboring pixels are placed together in a segment); total deviation of pixels in a fixed segment (uniformity); the number of segments. The differential evolution algorithm uses the variable population size mechanism [2].

References

1. Zoua D. A novel modified differential evolution algorithm for constrained optimization problems / D. Zoua, H. Liu, L. Gaob, S. Li // *Computers & Mathematics with Applications*. – 2011. – V. 61. – Is. 6. – P. 1608–1623.
2. Wang H. Adaptive Differential Evolution with variable population size for solving high-dimensional problems / H. Wang, S. Rahnamayan, Z. Wu // *The proceedings of 2011 IEEE Congress of Evolutionary Computation (CEC)*, 5-8 June 2011. – 2011. – P. 2626–2632.

ESTIMATION OF PARAMETERS FOR TWO-REGIME LEVY THRESHOLD PROCESS

H. Tsai¹, A.V. Nikitin²

¹Institute of Statistical Science, Academia Sinica, Taiwan

²National University of Ostroh Academy, Ukraine

htsai@stat.sinica.edu.tw, anatolii.nikitin@oa.edu.ua

Threshold-effect models for Gaussian-type stochastic processes that account for shift and diffusion are well studied, see for example, works [2,3].

At that time, models with a threshold effect in the form of Lévy processes, which can be determined as a solution of Ito and Skorohod stochastic differential equations [1, 4], in addition to the specified shift and diffusion, take into account jumps, which is important from the point of view of applications. For example, the set over which the integral for the measure of jumps is taken can determine the range of possible sizes of price jumps that affect asset prices.

$$\begin{aligned} X_t = & \{(\beta_{10} + \beta_{11} X_t)I(X_t \leq r) + (\beta_{20} + \beta_{21} X_t)I(X_t > r)\} dt + \\ & + \{\sigma_1 I(X_t \leq r) + \sigma_2 I(X_t > r)\} dW_t + \\ & + \int_U \{\gamma_1 I(X_t \leq r) + \gamma_2 I(X_t > r)\} \tilde{\nu}(dt, du) \end{aligned} \quad (1)$$

where β denotes the drift term, σ is the diffusion term and γ is function of jumps intensity, r is the threshold value of the process, W_t is a Wiener process and $\tilde{\nu}(dt, du)$ is a centered Poisson measure.

We approximate stochastic differential equation (1) by the difference equation using generalized Euler's method and using approximate maximum likelihood method we estimate parameters of two-regime Levy threshold process.

References

1. A.V. Skorohod. Studies in the theory of random processes / Dover Publication, Reprint 1962.
2. T.-H. Yu, H. Tsai and H. Rachinger. Approximate maximum likelihood estimation of a threshold diffusion process. / Computational Statistics and Data Analysis 142 (2020).
3. H. Rachinger, Edward M. H. Lin and H. Tsai. A bootstrap test for threshold effects in a diffusion process / Computational Statistics in press (2023+).
4. Y.Chabanyuk, A.Nikitin, U.Khimka Asymptotic Analysis for Complex Evolutionary Systems with Markov and Semi-Markov Switching Using Approximation Schemes. – Wiley-ISTE, 2020. – 240 p.

METHODS AND MODELS OF BUILDING COMPUTER SYSTEMS FOR MANAGING TECHNOLOGICAL PROCESSES, BASED ON INTELLIGENT INTERFACES AND ON A PROMISING ELEMENT BASE

O. Tymashov

Glushkov Institute of Cybernetics NAS of Ukraine

alex_timashov@outlook.com

The development of computer systems for managing technological processes is a complex task that requires the use of advanced methods and models. One approach to building such systems is to use intelligent interfaces and a promising element base. This approach involves the use of model-based systems engineering (MBSE), which is a formalized methodology that supports the requirements, design, analysis, verification, and validation associated with the development of complex systems.

In contrast to document-centric engineering, MBSE puts models at the center of system design. This allows for a more efficient and effective approach to managing technological processes, as it enables engineers to capture system attributes in models and perform threat-modeling analysis early in the system-development process¹. By incorporating mitigation strategies into the system design, engineers can reduce the system's overall security-related risks and ensure that it is secure by design.

Intelligent interfaces are another key component of building computer systems for managing technological processes. These interfaces enable human managers to interact with algorithm-powered systems in a meaningful way, allowing them to make informed decisions about how to manage these systems². There are several management models that can be used to manage AI decision-making tools, including human in the loop (HITL), human in the loop with feedback (HITLFE), human on the loop (HOTL), and human out of the loop (HOOTL). Each of these models varies based on the level and nature of human intervention, and it is important for managers to carefully consider which model is best suited to their needs. In conclusion, building computer systems for managing technological processes requires the use of advanced methods and models, such as MBSE and intelligent interfaces. By using these tools, engineers can develop systems that are secure by design and enable human managers to make informed decisions about how to manage them. This approach

has the potential to greatly improve the efficiency and effectiveness of technological processes.

SOME METHODS OF REDUCING UNSOLVABLE PROBLEMS OF ARTIFICIAL INTELLIGENCE TO SOLVABLE

N.K. Tymofieva

International Research and Training Center for Information
Technologies and Systems under NAS and MES of Ukraine
tymnad@gmail.com

Artificial intelligence is related to pattern recognition, so the complexity of solving problems of this class depends not only on the number of operations spent on solving them, but also on the chosen measure of similarity and the method of its calculation. Measures of similarity play the main role in them and the solution itself largely depends on their choice. In this case, the difficulty of the problem is assessed on a "yes" or "no" scale, where "yes" means that the selected method of similarity assessment allows finding a global solution and it is solvable, and "no" means that the selected method of similarity assessment is not gives no solution. In addition, the global solution obtained from the modeled objective function does not always coincide with the purpose of the study. Therefore, the problem arises of reducing unsolvable problems of artificial intelligence to solvable ones.

One of the methods of such bringing together is the selection of subclasses of solvable problems according to the following characteristics: a) according to the structure of input data; b) according to the measures of similarity; c) according to the structure of the argument [1].

Let $u^+(a, \tilde{a})=1$ us denote the measure of similarity, with the help of which we obtain a global solution, a a given object, which is compared with a standard \tilde{a} . If $u^-(a, \tilde{a})=0$, then we do not find any solution according to the chosen measure of similarity. If $u(a, \tilde{a}) \in \{\delta, \dots, 1\}$, then the chosen similarity measure allows finding an admissible solution, where δ is the smallest value of the similarity measure for which an admissible solution exists. If for a certain problem $u^+(a, \tilde{a}) = 1$, then it is solvable by measures of similarity.

Since in artificial intelligence given objects are recognized and

compares them with a standard, it is necessary to structure the library in order to find a standard in real time.

References

1. Гриценко В.І., Тимофієва Н.К. Знаходження підкласів розв'язних задач в комбінаторній оптимізації та штучному інтелекті за структурою вхідної інформації // Кібернетика та обчислювальна техніка. – 2022. – №1 (207). С. 5–17.

DYNAMIC SYSTEM AND DECISION MAKING UNDER UNCERTAINTIES

Y. Tupalo

Glushkov Institute of Cybernetics NAS of Ukraine

Typaloyaroslav91@gmail.com

Research shows that uncertainty is an integral part of decision-making in dynamic systems where conditions are constantly changing, data can be fuzzy, and factors unpredictable.

Mathematical models of dynamic systems prove to be a useful tool for analyzing and predicting system behavior under uncertainty, providing us with a basis for making rational decisions. Intelligent algorithms and artificial intelligence systems, such as neural networks, genetic algorithms, pattern recognition, can be used to improve decision making in dynamic systems with uncertainty.

In addition, risk management and decision-making under uncertainty is an important aspect of dynamic systems where safety, cost-effectiveness and stability are key factors. We also noted that the integration of big data, sensor networks, cloud computing, and other technologies can help reduce uncertainty and improve decision making in dynamic systems.

Making decisions under uncertainty is an important challenge for many fields of activity, including project management, financial analysis, logistics, and medicine. There is no single correct answer or solution in such circumstances, as we are dealing with uncertain factors and risks.

One of the approaches to decision-making under conditions of uncertainty is the use of risk analysis. This approach involves the identification of potential dangers and possible consequences of the decisions made. The application of risk analysis allows you to make an informed decision, taking into account possible consequences and their probability of departure.

METHODS FOR THE DISTRIBUTION OF ALGORITHMS AMONG PROCESSORS IN A SYSTEM FOR IMPROVED PRODUCTIVITY THROUGH PARALLELIZATION AND THE USE OF FPGA AND PSI-EXPRESS

Y. Tupalo, O. Tymashov

Glushkov Institute of Cybernetics NAS of Ukraine

typaloyaroslav91@gmail.com, alex_timashov@outlook.com

Parallel processing is becoming increasingly important in the field of computer systems, as it allows for the execution of complex algorithms in a shorter amount of time. To effectively parallelize large fragments of an algorithm, it is important to distribute the algorithm among the processors of the system in an efficient manner. This article presents a research and development of methods for the distribution of algorithms among processors in a system for improved productivity through parallelization. The report also discusses the use of FPGAs and the PSI-Express standard in the implementation of these methods. The first step in the distribution of algorithms among processors is the division of the algorithm into smaller tasks. These tasks should be as independent as possible, as this allows for the greatest amount of parallelism. The tasks should also be of roughly equal size, as this helps to ensure that each processor has an equal workload.

Once the tasks have been divided, the next step is to assign the tasks to the processors. This can be done in several ways, including load balancing, work-stealing, and dynamic task allocation. Load balancing involves assigning tasks to processors in a balanced manner, so that each processor has a similar workload. Work-stealing involves allowing processors to take tasks from other processors if they have completed their own tasks and have idle processing time. Dynamic task allocation involves assigning tasks to processors based on their current workload and availability. The distribution of algorithms among processors in a system is an important aspect of parallel processing. Effective distribution can lead to improved productivity through parallelization, as it allows for the efficient utilization of the processing power of the system. The use of FPGAs and the PSI-Express standard in the implementation of methods for the distribution of algorithms can provide a highly efficient platform for parallel processing. The research and development of methods for the distribution of algorithms among processors is an ongoing area of study, with the goal of improving the efficiency and performance of parallel processing systems.

REGENERATION MODELS IN LOGISTICS PROCESSES

O. Voina

Taras Shevchenko National University of Kyiv, Ukraine

avoina@hotmail.com

Models of the regenerative type of inventory control of logistics systems under conditions of uncertainty are considered. The stochastic structure of the system is determined by the random process $\xi(t)$, $t \geq 0$, with the phase space (Z, B_Z) and the initial distribution $P\{\xi(0) \in A\} = \mu_A$, $A \in B_Z$. The real state of the logistics system and the actual amount of stock is determined by the random process $\tilde{\xi}(t)$. For this process the condition $P\{\tilde{\xi}(\theta_k) \in A\} = \mu_A$ is fulfilled for all k . Here θ_n , $n = 0, 1, 2, \dots$ is of some known point process. Then the inventory control model $\{Z(t), X(t), Y(t)\}$, $t \geq 0$, of this system will be a model of regeneration type. The management decisions in logistics systems are closely related to the form of the risk function of the corresponding inventory control model. This function determines which of the solutions is "better", and this makes it possible to choose methods and build control strategies. This work is devoted to this problem. Several approaches to determining the purposeful function are considered. The model which based on the principles of the balance between the cost of storage of stocks and the losses caused by their absence are studied. Inventory management consists in returning its level to zero from time to time. Three independent processes determine the stochastic structure of the model. These are the processes of replenishment, use and regulation of stock levels. If $Z(t)$ is the size of the stock at time t , then the costs of storage

for time T are equal to $L(v, T) = l \cdot \int_0^T \max\{Z(t); 0\} dt + h \cdot \int_0^T \max\{-Z(t); 0\} dt + K \cdot v(t)$, where p is the cost of stock storage, h is

the losses for its absence, K is the cost of level adjustment. Let the replenishment, use, and regulation of stock level be described by Poisson processes with parameters λ , μ and v , respectively. It has been proved that the limit $L(v) = \lim_{T \rightarrow \infty} (L(v, T)/T)$ exists. In case, when the parameters $\{(\lambda, p); (\mu, h); K\}$ are fixed, a constructive algorithm for

finding the optimal strategy $L(v_{opt}) = \min_{v>0} (L(v))$ is proposed. In particular, if $\lambda = \mu$ the explicit form of v_{opt} is found.

WAYS OF DEVELOPMENT OF THE MEANS OF INFORMATION PROCESSING

V. Vyshinskiy, O. Vyshinska, O. Kononenko, A. Slipets, V. Eresko
Glushkov Institute of Cybernetics NAS of Ukraine
vyshinskiy@ukr.net, vyshinskaya@ukr.net, kononenko17@i.ua,
alla_volod@ukr.net, fkp500@i.ua

In cybernetics, there is a section that is devoted to the development of digital means of information processing, traditionally related to computer technology. Research work aimed at creating a next generation digital computer should be based on the requirements that, first of all, apply to fundamental work. The first and most importantly, in this case, is that it is necessary to subordinate the process of research work to the laws of the development of nature. The second is not to give the opportunity to deviate in the development of the hardware basis of a computer and its information processing technology in the direction of mysticism, i.e. get away from the materialistic understanding of the developed technology. For this, the research process itself must be based on the laws of such a natural phenomenon as its development. These include, first of all, the process of accumulating knowledge that was obtained at the previous stage of this development, as well as applying the law of unity and struggle of opposites.

At the present stage of development of new means of computer technology, such opposites are the integration of hardware solutions of a new generation computer and the absence of similar integration in units of information. At the same time, this raises the problem of resolving this contradiction. It is known that the traditional approach is based only on the integration of hardware costs, and as for information processing, it is performed only in bits. However, there is also the possibility to take advantage of the idea of representing matter in nature from the so-called quantum physics, which is based on mysticism. From which it follows that the project of a computer, created on the basis of such an ideology, will also have a mystical character.

To resolve the above contradiction, that is, the main problem of the modern development of computer technology, it is proposed to use such

a branch of mathematics as algebra. For example, by a regular matrix representation of the algebra of real and complex numbers, polynomials, Fourier series, and other linear algebraic structures.

A DIFFERENCE METHOD FOR SOLVING THE OPTIMAL CONTROL FOR THE SCHRÖDINGER EQUATION WITH A SPECIAL GRADIENT TERM AND WITH A COMPLEX POTENTIAL

G. Yagub¹, N.S. Ibrahimov²

¹Kafkas University, Turkey

²Lankaran State University, Azerbaijan

gabilya@mail.ru, natiq_ibrahimov@mail.ru

In this paper, we consider the optimal control problem with the final quality criterion for the Schrodinger equation with a special gradient term and with a complex time-dependent potential, where the role of control is played by real and imaginary parts of the complex potential, which are measurable bounded functions.

Let be required to minimize the functional:

$$J(v) = \|\psi(.,T) - y\|_{L_2(0,l)}^2 \quad (1)$$

in the set:

$$V \equiv \left\{ v = (v_0, v_1) : v_s \in L_2(0,T), |v_0(t)| \leq b_0, 0 \leq v_1(t) \leq b_1, \forall t \in (0,T) \right\}$$

under conditions:

$$\begin{aligned} i \frac{\partial \psi}{\partial t} + a_0 \frac{\partial^2 \psi}{\partial x^2} + ia_1(x,t) \frac{\partial \psi}{\partial x} - a(x)\psi + \\ + v_0(t)\psi + iv_1(t)\psi = f(x,t), \quad (x,t) \in \Omega \end{aligned} \quad (2)$$

$$\psi(x,0) = \varphi(x), x \in (0,l), \quad (3)$$

$$\psi(0,t) = \psi(l,t) = 0, \forall t \in (0,T), \quad (4)$$

where $i = \sqrt{-1}$; $a_0 > 0, b_s > 0, s = 0,1$ - given numbers, $a(x), a_1(x,t)$ -

given real-valued measurable bounded functions satisfying the conditions:

$$0 \leq a(x) \leq \mu_1, \left| \frac{da(x)}{dx} \right| \leq \mu_2, \left| \frac{d^2a(x)}{dx^2} \right| \leq \mu_3, \quad (5)$$

$$\overset{0}{\forall} x \in (0, l), \quad \mu_1, \mu_2, \mu_3 = \text{sabit} > 0;$$

$$0 \leq a_1(x, t) \leq \mu_4, \left| \frac{\partial a_1(x, t)}{\partial x} \right| \leq \mu_5, \left| \frac{\partial^2 a_1(x, t)}{\partial x^2} \right| \leq \mu_6, \overset{0}{\forall} (x, t) \in \Omega,$$

$$\mu_4, \mu_5, \mu_6 = \text{sabit} > 0; \quad (6)$$

$\varphi(x), f(x, t), y(x)$ - given complex-valued measurable functions satisfying the conditions:

$$\varphi \in W_2^0(0, l), f \in W_2^{0, 2, 0}(\Omega), y \in W_2^1(0, l). \quad (7)$$

Applying the difference method, a discrete analogue of this problem is constructed. First, in this work, the constructed difference scheme corresponding to the initial boundary value problem is investigated for each $v \in V$ and an estimate of the stability of the solution of the difference scheme is established. Using this estimate, the error of approximation of the difference scheme is established. Further in this paper, the convergence of difference approximations over the functional is proved. It should be noted that similar questions for the optimal control problem for the Schrodinger equation without a special gradient term and a real-valued potential have been previously considered in the work [1].

References

1. Iskenderov A.D., Yagubov G.Ya., Musaeva M.A. Identification of quantum potentials. – Baku, publishing house ‘Çaşıoğlu’, 2012. – 552 p.

COMPUTER TECHNOLOGICAL SIMULATOR AS PART OF THE TRAINING SMART SYSTEM

Y. Yakovliev, L. Kurzantseva

Glushkov Institute of Cybernetics NAS of Ukraine

yakyurlen@ukr.net, larku@ukr.net

Training on a computer technological simulator (CTS) allows you to quickly and efficiently in a safe environment to purchase professional competencies necessary for personnel when working on automated technological process control systems (TP). The main requirement for CTS in the process of training is the achievement of both the physical similarity of the control systems of the TP and the psychological similarity of the operator's activity of its real work. CTS is a fairly laborious product. Its cost depends on the functionality and configuration, as well as the cost of equipment and technologies used in its creation.

The main structural unit of the simulator, and the most costly, is the model of TP. High -precision models are created on the basis of simulation modeling using methods of machine and deep learning, expanded and virtual realities, cloud technologies and integration of real data, which allows the emulation of TP and reproduce the dynamics of the state of equipment in real time. However, despite the variety of TP, their models are created on the basis of a sort of description mechanism, which allows, according to publications, to reduce costs on account of the development of a universal software and hardware platform and a set of special models of simulators.

In this work, it is proposed to reduce the costs of the creation, maintenance and modernization of CTS by integrating it into the training smart system as part of the creation of a virtual integrated information and educational smart environment. Such a system is an interdisciplinary system for continuous education (school, higher educational institution, corporate training) with comfortable conditions for staff training. The proposed training smart system will not only support the learning process in accordance with the tasks, but also will increase the number of simultaneously studying future operators, will improve the quality and speed of their training, will form additional knowledge, skills by integrating other virtual simulators and laboratories into the system, and will reduce load on the instructor. At the same time will allow you to get skills of teamwork, will support user adaptation to system and system to user and the state of the external

environment, and, in general, will increase the efficiency of the training.

ANALYTICAL MODEL OF AN IMMERSIVE INTERFACE: ANALYSIS, DESIGN, AND APPLICATION

Y. Yakovliev, O. Yelisiieva

Glushkov Institute of Cybernetics NAS of Ukraine

yakyurlen@ukr.net, evo55555@ukr.net

Immersive interfaces (ImI) are technologies that allow users to immerse themselves in a virtual or augmented space for a more realistic interaction with them. The development and optimization of ImI is a complex and labor-intensive task that requires a systematic approach and the use of an analytical model. The aim of this research is to develop and apply an analytical model of an ImI.

The analytical model is a structured approach based on analysis and modeling, which allows developers to gain a deeper understanding of the interaction between the user and the interface, predict user behavior, and optimize its functionality. The main components of the analytical model of an ImI are identified: input data, mathematical equations and algorithms, analytical methods, and output data. Input data refers to the information that enters the model and serves as the basis for analyzing and predicting the behavior of the interface (environmental parameters, user interactions, sensor data, and others). Mathematical equations and algorithms define the dependencies and relationships between different aspects of the interface and user interaction. General mathematical formulas for describing the analytical model of IMI establish the correspondence between dependent variables - interface characteristics that require research or optimization, and independent variables that represent model parameters (degree of realism of graphics, intensity of interaction, level of presence, etc.). Analytical methods are used to analyze data obtained from the model and obtain information about the performance of the interface. They may include statistical analysis, user behavior modeling, and interface efficiency evaluation. The output is the results obtained after analysis and modeling, contains the predicted interface performance, optimal settings and recommendations for improving the interface and other useful information.

The proposed analytical model of an immersive environment considers aspects such as graphical representation, interaction, spatial perception, physical modeling, and user emotional experience. The

model is intended to help researchers and developers better understand the functioning of an ImI and its impact on the user. The model is based on the perception, engagement, and communication of the user with the system. The results of the research can lead to improvements in ImI and enhance its efficiency.

ASYMPTOTIC SOLUTION OF THE MULTIDIMENSIONAL RENEWAL EQUATION

O.A. Yarova

Ivan Franko National University of Lviv, Ukraine

oksana.yarova@lnu.edu.ua

Consider the renewal equation in matrix form

$$X^\varepsilon(t) = A^\varepsilon(t) + F^\varepsilon * X^\varepsilon(t), \quad t \geq 0, \quad \varepsilon > 0,$$

where $X^\varepsilon(t)$ - a family of sought matrix-valued functions, $A^\varepsilon(t)$ - a family of given non-negative matrix-valued functions and $F^\varepsilon(t)$ - a family of matrix-valued finite integral measures on $[0; \infty)$.

Theorem. Let the family of functions A_{ij}^ε , $i, j \in E$, is uniformly directly Riemann integrable on $[0; \infty)$ and exist

$$\lim_{\varepsilon \rightarrow 0} \int_0^t A_{ij}^\varepsilon(t) dt \equiv D_{ij}.$$

Then exist matrix C in size $r \times r$ and normalization factor $g(\varepsilon) \rightarrow 0$, when $\varepsilon \rightarrow 0$, such as

$$X_{ij}^\varepsilon \left(\frac{t}{g(\varepsilon)} \right) \rightarrow \frac{q_{sk}(t)}{\pi_k} \left[\overline{1^{(s)}} \times \overline{p^{(k)}} D^k \right]_{ij}.$$

References

1. Nishchenko I.I. Transition phenomena for many-dimensiona renewal equation of spetial kind. // Theory of Stochastic Processes. – 2000. – Vol. 6(22), 1-2. – P. 107-115.
2. Koroliuk V.S. Stochastic systems in merging phase space / V.S. Koroliuk, N. Limnios. – Singapore: World Scientific Publishing, 2005. – 330 p.

ABOUT THE SCALES OF INFINITESIMAL FUNCTIONS AND THE EXISTANCE OF DERIVATIVES

Ya.I. Yeleyko, O.A. Yarova

Ivan Franko National University of Lviv, Ukraine

yikts@yahoo.com, oksana.yarova@lnu.edu.ua

Consider the standard expansion of the function in the Taylor series

$$f(x_0 + \Delta x) - f(x_0) = f'(x_0)\Delta x + \frac{1}{2}f''(x_0)(\Delta x)^2 + \dots + o(\Delta x)^n.$$

In this case, the infinitesimal scale is functions $\Delta x, (\Delta x)^2, \dots, (\Delta x)^n$.

But there are many other scales of infinitesimal functions

$$\delta_1(x), \delta_2(x), \dots, \delta_n(x)$$

such as

$$\delta_i(x) \rightarrow 0, \quad x \rightarrow 0 \quad \text{and} \quad \frac{\delta_{i+1}(x)}{\delta_i(x)} \rightarrow 0, \quad i = 1, 2, \dots, n-1.$$

Very often the function may not have a Taylor series expansion in the classical scale $\Delta x, (\Delta x)^2, \dots, (\Delta x)^n$, then we can use expansion in the scale

$$\delta_1(\Delta x), \delta_2(\Delta x), \dots, \delta_n(\Delta x).$$

Then the presentation takes place

$$f(x_0 + \Delta x) - f(x_0) = a_1(x_0)\delta_1(\Delta x) + a_2(x_0)\delta_2(\Delta x) + \dots + \\ + a_n(x_0)\delta_n(\Delta x) + o(\delta_n(\Delta x)).$$

References

1. Skorokhod A.V. Lectures on the theory of random processes.: Study manual. – L.: Lybid, 1990. – 168 p. (Ukraine)

INVESTIGATION OF SOLVABILITY AND ATTAINABILITY FOR OPTIMAL CONTROL PROBLEM FOR NON-LINEAR DEGENERATE PARABOLIC VARIATION INEQUALITY IN THE CLASS OF H-ADMISSIBLE SOLUTIONS

T.Yu. Zhuk¹, N.V. Kasimova¹, O.P. Kупenko²,
I.M. Tsyganivska¹, A.I. Korol³

¹Taras Shevchenko National University of Kyiv, Ukraine

²Dnipro University of Technology, Ukraine

³Uzhhorod National University, Ukraine

zhuktetiana6@gmail.com, kasimova@knu.ua,

kupenko.olga@gmail.com, itsy8009@knu.ua,

korol.andrii@student.uzhnu.edu.ua

We consider the optimal control problem for degenerate non-linear variation parabolic inequality in the «weak» statement. It is well known that degenerate control problems of this type may admit non-uniqueness of admissible solution classes, which implies non-uniqueness of optimal solutions of particular kind and the optimal control problem in the coefficients can be stated in different forms depending on the choice of the class of admissible solutions. Under assumptions for degenerate weight function the nonlinear differential operator in our inequality is not coercive in the classical sense. Thus, we have to consider such conditions for degenerate weight function that our optimal control problem has the solution. In application a degenerate weight occurs as the limit of a sequence of non-degenerate weights for which the corresponding «approximate» optimal control problem is solvable. Thus, naturally, it arises the question: if limit points of the family of admissible solutions to the perturbed problems appear to be admissible solutions to the original problem, whether all optimal solutions are attainable in this sense? Thus, considering the weight Sobolev space H as the phase space, we deal with the problem of solvability and attainability of mentioned optimal control problem in the class of H -solutions [1].

References

1. Kasimova N.V., Kупenko O.P., Tsyganivska I.M. Optimal control problem for non-linear degenerate parabolic variation inequality: solvability and attainability issues // Journal of Optimization, Differential Equations and Their Applications (JODEA). – 2023. – Vol. 31, No 1. – P. 1-21.

BALLEANS IN DICISION MAKING PROBLEMS
Nakonechnyi O.G., S.O.Mashchenko
Taras Shevchenko National University of Kyiv, Ukraine
a.nakonechniy@gmail.com

Let X is a set of alternatives and $B(X)$ is a ballean on the set X . The selection function is called the mapping $B(X)$ into itself. In the theory of decision-making, we find sets that are optimal in a certain sense according to a known selection function.

If an order is entered in X , then the corresponding selection functions are constructed taking this order into account.

At the same time, topological properties of coarse spaces and balleans related to set X , which were studied, for example, in [1-3], are important for the study of decision-making problems.

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References

1. Наконечний О.Г., Гребеннік І.В., Романова Т.Є., Тевяшев А.Д. Методи прийняття рішень: навч. посіб. для студентів. - Харків : ХНУРЕ, 2016. - 131 с.
2. Волошин О. Ф., Мащенко С.О. Моделі та методи прийняття рішень. 2-ге вид., перероб. та допов. – К.: ВПЦ "Київський університет", 2010. – 336 с.
3. Protasov I. Selectors and orderings of coarse spaces// Ukrain. Mat. Bull. – 2021. – Vol. 18. – P. 70–78.

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“Видавництво Людмила”
03148, Київ, а/с 115.
Тел./факс: +38 050 469 7485, 068 340 8332
E-mail: lesya3000@ukr.net