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NONLINEAR ANALYSIS AND APPLICATIONS

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BOOK of ABSTRACTS

In the book collection of questions of the nonlinear analysis, multiple-valued reflection, theories of optimization, the management and modeling theory and also application of mathematical methods are considered.

В сборнике рассматриваются вопросы нелинейного анализа, многозначных отображений, теории оптимизации, теории управления и моделирования, а также применение математических методов.

У збірнику розглядаються питання нелінійного аналізу, багатозначних відображень, теорії оптимізації, теорії керування та моделювання, а також застосування математичних методів.

Venue

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PLENARY LECTURES

Ivanenko V.I.	On the statistical regularities of mass events
Zgurovsky M.Z., Kasyanov P.O.	Qualitative and quantitative analysis of nonlinear systems
Sharkovsky A.N.	Descriptive theory of the deterministic chaos
Chikrii A.O.	Set-valued mappings in the theory of conflict-controlled processes
Kapustyan O.V.	Global attractors of infinite-dimensional dynamical systems and their stability under multi-valued perturbations
Makarenko A.S.	New aspects in cellular automata approach

CONTENT

CHECKING OF THE MARKOV RENEWAL PROCESS WITH SMALL PROBABILITY OF ABSORPTION

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It is necessary to observe or to control the states of the complex system. The optimal control problem for the simplest situation of two states was considered in [1], more complicated situation with different states was considered in [2].

The sequence of checking moments defines the checking strategy. It is assumed that the cost of one checking is equal to $a > 0$ and does not depend on the time of checking. It is also assumed that the sojourn time t in the absorbing state leads to the penalty bt, where $b > 0$.

The checking stops, once the system reaches the absorbing state, the improper state.

We consider the checking strategy for the Markov renewal process system with small probability of absorption, finite set $E := E_0 \cup \{0\}, E_0 := \{1, 2, \ldots, N\}, \{0\}$ – non-absorbing states (proper states) and one absorbing state $\{0\}$ (improper state). The Markov renewal process is defined by the semi-Markov kernel $Q_{kr}^\varepsilon(t) = p_{kr}^\varepsilon \cdot G_k(t/\varepsilon), \ k, r \in E, \ 0 \le \varepsilon \le 1$. $F_\varepsilon(t)$ and $f_\varepsilon(t)$ denote the cumulative distribution function and the probability density function of the moment τ_ε before absorption respectively. The strategy involves checking in the growing sequence of moments $\nu_0, \nu_1, \ldots$ and leads to the cost W_ε. Here W_ε consists of the cost of checks performed in the states E_0 and the penalty for late detection of the absorption state.

We find the optimal strategy based on the necessary optimality conditions $\partial \overline{W_\varepsilon} / \partial \nu_m = 0$, $m = 1, 2, \cdots$, that correspond to average losses $\overline{W_\varepsilon}$. The strategy is given in the recurrent form. In particular cases the simplification of the function $\lim_{\varepsilon \to 0} F_\varepsilon(t)$ [3] defines the strategy in the terms of explicit solutions of transcendental equations [2].

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ON QUASILINEAR DIFFERENTIAL-DIFFERENCE GAMES OF APPROACH

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The paper is devoted to the games of approach, which are central to the theory of conflict-controlled processes. We consider a controlled object whose dynamics is described by the linear differential system with pure time delay or the differential-difference system with commutative matrices in Euclidean space. The approaches to the solutions of these problems are proposed which based on the Method of Resolving Functions and the First Direct Method of L.S. Pontryagin. For dynamical systems whose evolution is described by differential-difference system with a cylindrical terminal set under the condition of L.S. Pontryagin introduces a resolving function, through which the game's end time is determined.

The pursuit process is divided into two stages. On the first one $[0, t_*)$, where t_* is the moment of switching, the Method of Resolving Functions with using by the pursuer at the time t of the entire run-time control prehistory works. When at the instant t_* the integral of the resolving function turns into unity, the process of pursuit is switched to the First Direct Method of L.S. Pontryagin which is realized within the class of countercontrols in quasistrategy. The players choose their controls in the form of certain functions. Thus, the pursuer and the evader affect the process, pursuing their own goals. The goal of the pursuer is in the shortest time to bring a trajectory of the process to a certain closed terminal set; the goal of the evader is to avoid a trajectory of the process from meeting with the terminal set on the whole semi-infinite interval of time or if is impossible to maximally postpone the moment of meeting.

The guaranteed times of the game termination are found, and corresponding control laws are constructed. The results are illustrated by a model example.

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WAVELET ANALYSIS
OF THE NATIONAL CURRENCY MARKET DYNAMICS

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Researches of the national currency market, which based on mathematical modeling methods, are the most urgent problem of the modern economy. Especially this is true for predicting and minimizing losses from global financial crises.

Nowadays, applying of wavelet transform is relevant for solving problems, which are fundamentally impossible to solve with applying of traditional Fourier transform. The wavelet analysis permits to determ not only the spectral composition of the time series, but also the time of occurrence oscillations of a certain frequency, which is critical information for the analysis of financial speculative markets.

A wavelet transform is decomposition of a one-dimensional signal by soliton-like function (wavelet) base by its stretching (compression) and moving along the time axis. Any function that comply with certain requirements (the function must be well-localized, have a zero mean and a finite second moment) can be used as a basis wavelet. Examples of such functions are WAVE-wavelet, MHAT-wavelet, Daubechies wavelet and others. For researches of time series which have mutable spectral composition, the most widespread is the Morlet wavelet — a planar wave modulated by a Gaussian wave.

Applying of wavelet transformation to the time series of the dynamics of the national currency rate permits to get a scalogram, where can be highlighted high-frequencies (noises) and low-frequencies (trends) and observe their change along the time. The obtained results can be used for other research of the currency market system, in educational practice, and also in developing investment strategies.

'LIFE COURSE' AS A VIRTUAL NETWORK OF NETWORKS WITHIN AND BEYOND HUMANS' RISKS AND UNCERTAINTY

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The study proposes an inter/trans-disciplinary construct: "'Life Course' *as a* **Virtual Network** of Networks". This **Virtual Network links (hypothetical)real/realities, models, and ideals n**etworks – assessing the *primarily virtual reality* of the 'Life Course' – referring our lives deep-subtle continuity beyond the physical time-space continuum – within/from/by the 'Quality of Life' *dual construct* on. These *primal and dual constructs* imply *praxis alongside* the current [*theoretical-comprised*] risks and uncertainty *of our* **work-education-action-research tetra-helix** ('daily-activated' individuals/communities, our nature, our Cosmos/Universe), *of the* **societal efforts and leisure quasi-double-helix**, and of the **biodiversity-spirituality mosaics** of direct-items, avatars, sociological else.

This **Virtual Network of Networks** *construct* is intended to grasp the heritage, challenge and {*probabilistic* 15–16's centuries **realm(s)** / L.A. Zadeh's *fuzziness* regained: 1965, and J.A. Goguen 's *logic of inexact concepts* regained: 1969 / *subtleness*} perspectives-possibilities edge(s) beyond the contemporary **Orthogonal Networks** [of computers] *concept*.

These primal-dual constructs [their correspondent theoretical/praxis tensions] do not imply a keen and crisp *historian archivist basement more* than the obvious existing one, but virtually tends to acquired the *set of the step over step subtle traces of our humans' lives continuity – to attain* new and old risks and uncertainties – to understand/explain the '**Life Course**' **networking within/from/by the contemporary** changes on a national and global level. The study addresses the **society-economy-industry-technique larger and larger embedded nuclei** as more and more step by step *dynamical constructions (re)made by the humans-technique aggregates* BUT conditioned by the **human dynamics of our communities** as well – i.e. *individuals* (males, females – matures, elders and children), *('longer term') families*, *('incidental') societal group-*

entities (related to peace/war, material and spiritual constrains and/or extensions, predominant ideals within and/or beneath the hypothetical-reality and universal real, last but not least: *probabilistic, fuzzy and subtle occurrence of humans' consonance*.

The study tries to elicit the **limits, paradoxes, paradigms, heritage and perspectives of the construct:** "'Life Course' **as a Virtual Network** of Networks" – underlying on the **systemic and sociological challenge** – within the *[overwhelmed **risks and uncertainty**] multi*-crisis from the 'first' *Neanderthals-Cro-Magnons* communities' junctions *to the current multi-ethnic, …, and/or multi-faiths post-modern* communities' junction*s* as well.

This study tries to elicit the contemporary significance [within the recent proposed **'Science-Culture-Religion-Dialogue' international (re)search and praxis co-operation**] of the profoundness possible to seen today – after 500 years – from **Albrecht Dürer**'s (1471–1528) view on **"Christ in Limbo"** *['Limbo' as edge of Hell / Christ's Hell entered within the three days from Crucifixion toward the Resurrection*].

RANDOM VERSUS STOCHASTIC MODELING IN EPIDEMIOLOGY

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Stochastic and random models are being used to model many realistic phenomena from the real world. In fact, every happening in our world is affected by some randomness or stochasticity. Therefore, it is very important to decide which kind of stochastic or random models is the most appropriate to describe the behavior of the real one in the best way. Here we will provide some features about this problem. Instead of providing a general or abstract theory on this topic, we will consider a random and another stochastic version of an epidemic model previously introduced and analyzed by Kloeden and Kozyakin [2]. In particular, the existence of a random attractor is proved for the random model and the persistence of the disease is analyzed as well. In the stochastic case, we consider some environmental effect on the model, in fact, we assume that one of the coefficients of the system is affected by some stochastic perturbation, and analyze the asymptotic behavior of the solutions.

We will emphasize on the comparison between the two different models in strategies and the use fullness of the theory of random attractors to analyze this and other models from the applied sciences (see [1] for more details).

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ATLAS GEOINFORMATION SYSTEM. PRINCIPLES OF USAGE FOR THE SOLUTION OF REGION SUSTAINABLE DEVELOPMENT TASKS

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The paper investigates the problems of applicability and practicality of the so-called Agenda2030 (http://www.un.org/ga/search/view_doc.asp?symbol= A/RES/70/1&Lang=E), in which 17 goals and targets of sustainable development of the planet for the period up to 2030 are formulated. In the adaptation of Agenda2030 to Ukraine (Strategy2030, https://igu.org.ua/sites/default/files/ Strategy-StaticDevelopment.pdf), these problems are formulated as Strategy2030 implementation tasks. To solve these tasks, it is proposed to build a model of sustainable development of Ukraine/region as a specialized Atlas GeoInformation System (AGIS). This AGIS should be an integrated echelon system constructed from systems of three classes: Electronic Atlases (Operational Echelon), Atlas Information Systems (Application Echelon) and GeoInformation Systems (Infrastructure Echelon).

Systems of the Operational Echelon are a kind of presentation layer of AGIS. They are end-user oriented and in a simplified, mainly cartographic form, are presenting the indicators of the state of the sustainable development system at a particular time point. Systems of the Application Echelon are intended for use by experts who are able to calculate and present sustainable development indicators. Systems of the Infrastructure Echelon are designed to prepare data, information and knowledge that will be used in the Applicant Echelon systems.

The main principles which justify the correct application of the AGIS for the modeling of sustainable development systems are considered. These principles can be formulated as follows: 1) the applicability of atlas solutions, 2) the existence of similarity of national atlases, 3) the need to use echelon systems, and 4) the need to take into account the evolution of atlas solutions. The prototype of the AGIS is described and an action plan is proposed that will provide simple quantitative approaches to planning and evaluation of sustainable development of the region at the initial stage of AGIS creation.

PRACTICAL BACKGROUND OF RELATIONAL CARTOGRAPHY IN THE WORKS OF"INTELLIGENCE SYSTEMS GEO, LTD."

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The paper briefly describes some Electronic Atlases (EA), Atlas Information Systems (ATIS) and Geographic Information Systems (GIS) created by Intellectual Geo Systems Ltd. (LLC ISGeo) with the participation of authors. Some of these atlas systems are created in cooperation with the Institute of Geography of the National Academy of Sciences of Ukraine.

Relational cartography is considered in the unpublished monograph "Chabanyuk V.C. (2018) Elements of Classical Relational Cartography ». It should be understood as "orthogonal" to the Classical Cartography according to the following definitions:

• Classic (or Subject) cartography is the arts, sciences and technologies of making and using maps.

• Relational cartography — Agreed arts, science and technology for the production and use of relationships in and between cartographic systems.

• (System or Geomatics or simply) cartography — coherent and uncoordinated arts, science and technology for the production and use of maps and cartographic systems.

Relational cartography is based on so-called systemic, informational and cartographic (geographic) preconditions. Mapping preconditions, in turn, consist of theoretical and practical prerequisites. Below is an overview of Atlas systems — the practical cartographic preconditions of Relational Cartography that were used explicitly or implicitly in abductive inferences when obtaining the main relational patterns of Relational Cartography: Conceptual Frameworks (Chabanyuk V., Dyshlyk A., 2014) and Carcasses of Solutions (Dyshlyk A., et al. 2003) . Most of the results obtained by abductive inferences are also proved by means of more well-known inductive and deductive inferences.

MODELING OF MACROECONOMIC RISKS IN UKRAINE

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A further direction of Ukrainian economics development underlies in the area of solving economic and financial problems, in particular, internal issues such as terrorist groups; demographic catastrophe; criminal exchange rate policy; systemic and enormous corruption among authorities; unreasonable interest rate policy; reduction of consumption; destroyed bank system; budget deficit; etc.

One of the main directions of overcoming problems of Ukrainian economic development is otimization of management process of macroeconomic risks.

Among the main macroeconomic indicators that should be monitored in the system are indications for monetary stability, real interest rate, the ratio of financial balance to the gross domestic product, indicators of budgetary policy, ratio indicator of the size of assets to the debt, current pension and indicators of health care obligations, the size of the shadow market, the exchange rate, the current account balance, the growth rates of the real gross domestic product, the loan as a percentage of the gross domestic product, inflation, the real exchange rate, the dynamics of exports, and others.

The dynamics of the majority of above mentioned indications is nonlinear and poorly predictable. Yet many of indicators are interconnected by dependencies that are well suited for modelling. Therefore, it is appropriate to use linear regression in process simulation in order to construct simple short-term models. For constructing a more complex one methods of neural networks can be applied.

A model provides important support in the management of usage of economic policy tools. The model reflects changes in the structure of the global economy and global capital markets. But with the analysis of macroeconomic risks dynamics, there are certain problems: it is not always possible to clearly identify economic or financial instruments that will reduce risks or other unwanted events. An example can be the dynamics of the central bank discount rate. The correlation dependence clearly indicates the negative impact of the interest growth rate on the industrial production index. In turn, industry is the largest component of the country's GDP. And this determines that raising the discount rate, which is usually justified by the need to curb inflation, has a negative impact on GDP dynamics. We have a systemic contradiction that can only be solved on the level of experts such as managers (decision makers).

COMPARATIVE ANALYSIS OF METHODS OF BANKRUPTCY FORECASTING FOR UKRAINIAN COMPANIES

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Bankruptcy forecasting for Ukrainian companies is quite a complicated problem because, firstly, there is a few companies in the stock market in Ukraine. Secondly, the mathematical models do not display part of the financial indicators of the company's current state. Finally, there is no correct definition of the concept of bankruptcy in Ukraine, so some of the domestic companies continue working despite extremely low economic indicators.

Comparison of discriminant [1], comparative methods and methods based on neural networks [2] was carried out to predict and calculate the probability of bankruptcy based on domestic and foreign models. The main advantages, disadvantages and practical significance of the models considered in modern management conditions, as well as the possibility of using foreign models for domestic companies, are determined.

Comparison of approaches described above showed the advantage of using neural networks for financial analysis of Ukrainian companies. The approach based on neural networks has a high accuracy of predicting bankruptcy and the ability to detect hidden latent forms of a company's financial crisis.

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PROCESS PATTERNS OF ATLAS SOLUTIONS FRAMEWORK AND EXAMPLES OF THEIR USAGE

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In the computer science and industry in the activities on creation of information systems, the fundamental duality (dualism) of 'product-process' is investigated. The process in the Atlas Solutions Framework AtlasSF1.0+ is defined as series of actions, in which one or more inputs are used to get one or more outputs. The process pattern of development is defined as a verified in practice, repetitive collection of common methods, actions and/or tasks (activities) of the information systems development.

In the AtlasSF1.0+ are defined such types of development processes patterns:

- **Task process patterns.** This type of process pattern depicts the detailed steps to perform a specific task, such as the Transformations T1-T5 described below.

- **Stage process patterns.** This type of process pattern depicts the steps, which are often performed iteratively, of a single project stage. A project stage is a high-level form of process pattern, one that is often composed of several task process patterns.

- **Phase process patterns.** This type of process pattern depicts the interactions between the stage process patterns for a single project phase, such as the Initiate and Delivery phases. A phase process pattern is a collection of two or more stage process patterns.

Process patterns are an integral part of the AtlasSF1.0+ and are responsible for controlling and organizing the atlas system development processes on the three interrelated levels: Datalogical ↔ Infological ↔ Usage Logical. They are also referred to as Technological, Linguistic and Organizational Contexts respectively. Horizontal ↔ (transformation) relations are fair for all the cartographic information system extensions including Electronic atlases and Atlas Information Systems.

Examples of task process patterns are the Transformations T1-T5 performed for the maps constructing.

- Transformation T1 is connected with the knowledge of the topic under consideration and is the transformation of geographical entities into cartographic objects.

- Transformation T2 consists of transformation [XY] (structuring, generalization, change of spatial base, etc.), and transformation [Z] (research, generaliza-

tion, modeling, etc.). As a result of this transformation, for each phenomenon there are certain elements of the table.

• Transformations T3 (cartographic — geometric representation, coordinate system) and T4 (semiotic – a system of symbols displayed in the corresponding environment) transform it into an Infological level map. That is, the transformations T3 and T4 implement transformation Datalogics (T2) → Infologics (T3, T4) of Operational stratum.

• Finally, the transformation of T5 (display presentation – visual, tactile, sound, static on a dynamic object) coincides with the transformation of Infologics → Organologics of Operational stratum.

The process patterns of the AtlasSF1.0+ were tested on atlas information systems development. In practice, the processes of software development and data processing were carried out by 5 typical phases of the atlas system development: the preparation of initial data (Initiate); atlas design (Atlas Creation); editing (Edited); creating a version (Consistent); version release/delivery (Delivery).

Each phase consists of a set of process components such as tasks, working products and manuals and other patterns that can be used for successful creation of the atlas information systems.

THE PHILOSOPHY OF NATURE 2018 – PRESENTATION FOR SURVIVAL, LONGEVITY AND PROSPERITY OF HUMANKIND IN BIOSPHERE OF THE REQUISITELY HOLISTIC PLANET EARTH

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The presentation is prepared by Prof Dr, Dr h c Timi Ecimovic, as for the International Scientific Conference in April 2018, Kiev, Ukraine.

The Philosophy is search for knowledge and understanding of the Universe, Nature and Life, which is treasure of the Global Community of Humankind.

The changes needed for better tomorrow of humankind are to introduce "The Universal Upbringing, Education and Lifelong Learning" and "Individual Social Responsibility" of humans forgotten after industrial revolution and last centuries of wrong doing of the global community of humankind leaders and leading international and national institutions.

The Universe and Nature according to the contemporary scientific research is basic environment and environment of the requisitely holistic Universe, Nature, star Sun and planet Earth systems to have longevity and prosperity.

The presentation is offering contemporary knowledge and understanding needed for survival, longevity and prosperity of humankind under the challenging changes in the Biosphere of the planet Earth.

Two monotheistic religions – Christianity and Islam and other polytheistic religions of the world of humans have made it possible for humankind to reach 21ˢᵗ century of our times. Their role was great but it is questionable whether they are doing well for survival, longevity and prosperity of Homo sapiens civilization nowadays.

In the history of the Homo sapiens religions were important modus vivendi and present difficult times are summary of results of the religious leadership, which should accept responsibilities for the present.

Unfortunately religions rules humankind by the religious principles and for many centuries supported religious approach without scientific knowledge and understanding of natural realities and present truth about humankind and Nature of the planet Earth.

The present biosphere is much more different as it was in medieval times, due to extreme global community of humankind pollution all three basic environments.

The present contemporary research is opening the treasure of the knowledge and understanding of the Nature, Universe, star Sun and the planet Earth opera-

tional complexity principles of interconnectedness, interdependences, interaction, co-operation, synergies, anti-synergies, networking, swarm research etc.

With mentioned operational principles the world of human religions are actively in the opposition, because of the lack of knowledge and understanding of the present. It is and it was in the past just to mention Galileo, Copernicus, Leonardo Da Vinci and many more scientists of the past and present.

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THE GOLDEN RULE FOR OVERLAPPING GENERATIONS

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The net profit of representative firm is equal to $\pi_t = Y_t - L_t w_t = L_t f(k_t) - L_t w_t - K_t r_t$, where: $Y_t = F(K_t, L_t)$ is its output function; K_t and L_t is its level of capital and labor supply, respectively, at the period t; $w_t = \dfrac{W_t}{p_t} = x_t^t + \dfrac{x_t^{t+1}}{1+r_{t+1}}$ is the real wage; $W_t = p_t(x_t^t + s_t)$ is the nominal wage; p_t is the price of consumption good; x_t^t and x_t^{t+1} is the level of consumption by generation t during its first period t and during its second period ($t+1$), respectively (each generation has two periods of life); $r_{t+1} = \dfrac{p_t - p_{t+1}}{p_{t+1}} = \dfrac{p_t}{p_{t+1}} - 1$ is the interest rate at the period ($t+1$); $k_t = \dfrac{K_t}{L_t}$; $s_t = k_{t+1}$ is the level of savings by generation t; $f(k_t) = \dfrac{Y_t}{L_t}$. If the labor market is competitive, then maximization of the net profit with respect to L_t implies $w_t = f(k_t) - k_t f'(k_t)$, and maximization of the net profit with respect to K_t implies $r_t = f'(k_t)$.

Note $K_{t+1} = H_t(w_t - x_t^t)$, where $L_t = H_t = (1+n)H_{t-1}$ is the population, n is the rate of population growth. Then in a steady state the values of x_t^t, x_t^{t+1}, k_t, w_t, r_t are constant at any time period t and equal to certain quantities x^1, x^2, k, w, r, respectively: $x^1 = f(k) - k f'(k) - k(1+n)$; $x^2 = k(1+n)[1 + f'(k)]$.

The total consumption of both overlapping generations t and $(t-1)$ at the period t equals to $x_t^t H_t + x_{t-1}^t H_{t-1} = H_t\left(x_t^t + \dfrac{x_{t-1}^t}{1+n} \right)$. Then the economy in a steady state is characterized by the total consumption per capita $x^1 + (1+n)^{-1}x^2 = f(k) - nk$. Its maximization implies the Golden rule $f'(k^*) = n$ for the optimal capital k^* per labor.

FLOW CONTROL IN HYDRODYNAMIC SYSTEMS BASED ON THE PROPERTIES OF TRAPPED VORTICES

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The problem of energy saving is one of the most important in recent decades in many areas of human activity. Flow control is one of the ways to improve the energy efficiency of hydrodynamic systems.

We obtain new properties of trapped vortices near the surface irregularities in the presence of flow perturbations [1]. The nonlinear control method of the near-wall flow in cylindrical grooves is proposed. The method differs by using the modified trapped vortex model and provides the necessary requirements for the formation of the flow structure [2].

The nonlinear controller of the near-wall flow, which differs in that it takes into account the equation of equilibrium of the caught vortex and the unseparated flow condition in the groove edges and provides active feedback control in a non-stationary flow is developed. The developed controller is used to calculate the parameters of an active control circuit with feedback in a non-stationary flow, when the system responds to external perturbation. The examples of the implementation of this scheme, when the speed of the external flow changes periodically or according to the linear law are given [3].

The method of solving the problem of reducing the hydrodynamic loads of the square cylinder is investigated [4]. It differs by using the trapped vortex model and provides the creation of the required flow structure with stable vortices generated by two symmetrical plates attached to the front edge of the square cylinder. With the help of the developed method, the control parameters of the flow near square cylinder with control plates are found. Found parameters allow to reduce hydrodynamic loads, especially at large Reynolds numbers of the considered range. The efficiency of the control scheme was verified by numerical simulation of the viscous flow around the cylinder with plates in the middle range of Reynolds numbers. The obtained results showed a significant regularization of the flow structure in the trace, especially at large Reynolds numbers. The results showed that the Struhall number in a controlled flow increases, especially when the Reynolds number increases. Due to the regularization of the trace under control, the mean resistance and the fluctuating forces acting on the cylinder are decreased. Flow control reduces the hydrodynamic resistance of the square prism

from 20% at Re = 100 to 35% at Re = 500. The control allows to reduce the amplitude of the lifting force from 50% to 70% depending on the Reynolds number.

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QUALITATIVE ANALYSIS OF BUDYKO-SELLERS CLIMATOLOGY MODEL

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The investigation of climate processes is one of the most actual problems in modern science. In this direction, the research of climate energy balance models is of great importance. In these models as unknown variable the temperature of Earth surface is considered. We study the climate energy balance model introduced by Budyko M.I. [1] and Sellers W.D. [2] on the manifold without boundary. The investigated object contains parabolic inclusion with subgradient interaction function.

We use the methods, principles and ideas of nonlinear and set-valued analysis, theory of nonlinear evolution equations and inclusions, global and trajectory attractors theory, and theory of manifolds. The main results are following [3]:

1) the existence of solution for arbitrary initial data is proved;
2) the properties of solutions, their regularity are studied;
3) the Lyapunov function is found;
4) the convergence theorems are obtained;
5) the existence of global and trajectory attractors are justified;
6) the structural and topological properties of attractors are investigated.

The obtained results can be useful for future theoretical and practical research of climate processes. In particular, the proposed theoretical apparatus allows us to study the dynamics of changes for some climatic characteristics as $t \rightarrow \infty$.

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OPTIMIZATION OF LINEAR FUNCTION ON ARRANGEMENTS UNDER PROBABILISTIC UNCERTAINTY

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Actual trend of the modern theory of optimization is to study the problems of combinatorial type under uncertainty, including probabilistic. Earlier the authors proposed an approach for stochastic optimization problems formalization through the introduction of the order relation on the set of random variables.

Let us consider linear unconstrained problem of stochastic combinatorial optimization on the common set of arrangements when elements of multiset G are discrete random variables. The interrelation of problems under stochastic uncertainty with the determined problems is shown. Determined problems are specially constructed: coefficients of objective function are powers of coefficients of objective function of initial stochastic problem, feasible region is the general set of arrangements when multiset elements are equal to numeric characteristics of elements of given multiset G. Properties of the solution of considered optimization problem are obtained. We also proposed the reducing method of solution of linear unconditional problem of combinatorial stochastic optimization which is based on obtained solution's properties.

For the problem of stochastic optimization of linear function on arrangements under additional (not combinatorial) constraints the algorithm of the branch and bound method is proposed as well as rules of branching and truncation of sets.

ON THE STATISTICAL REGULARITIES OF MASS EVENTS

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1. From the history of 17 years scientific researches in the department leading by V.S. Melnik.

2. Existence theorem on the statistical regularities of mass events.

APPROXIMATE OPTIMAL REGULATOR FOR DISTRIBUTED CONTROL PROBLEM WITH SUPERPOSITION FUNCTIONAL AND RAPIDLY OSCILLATING COEFFICIENTS

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In this work, we focus on the finding effective methods of control for complicated systems with distributed parameters on infinite time interval, initiated in the works [1–3]. Finding control in the feedback form (regulator) plays important role here. In [4] it was proposed and substantiated a procedure for constructing approximate optimal feedback control for a wide class of infinite-dimensional processes in micro-inhomogeneous medium both on finite and infinite time interval. We use some known facts on G-convergence theory from [5]–[7]. In this paper from this point of view we consider the optimal control problem on infinite time interval for a parabolic equation with rapidly oscillating coefficients and non-decomposable quadratic cost functional with superposition type operator. The case of finite time interval was considered in [8]. In general, to find the exact formula of optimal regulator is not possible for such a problem, because we cannot directly apply the Fourier method. But the transition to the homogenized parameters greatly simplifies the structure of the problem. Assuming that the problem with the homogenized coefficients already admits optimal feedback form, we ground approximate optimal regulator for the initial problem. We give an example of superposition operator for specific conditions in this paper.

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GLOBAL ATTRACTORS OF MULTI-VALUED IMPULSIVE DYNAMICAL SYSTEMS: EXISTENCE, INVARIANCE AND ROBUSTNESS

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In this paper, using the theory of global attractors for multi-valued semiflows [1], describes the dynamics of infinite-dimentional impulsive systems without uniqueness of solution of the Cauchy problem. Considering global attractor as a compact minimal uniformly attracting set [2] we construct abstract theory of multi-valued impulsive dynamical systems and obtain sufficient conditions of existence, invariance property and robustness of global attractor for such systems. Obtained results are applied to weakly non-linear impulsive parabolic system:

$$
\begin{cases}
\dfrac{\partial u}{\partial t} = a\Delta u + \varepsilon f_1(u,v), \\[2mm]
\dfrac{\partial v}{\partial t} = a\Delta u + 2b\Delta u + \varepsilon f_2(u,v), \\[2mm]
u\big|_{\partial\Omega} = v\big|_{\partial\Omega} = 0;
\end{cases}
\tag{1}
$$

$$
M = \left\{ z = \begin{pmatrix} u \\ v \end{pmatrix} \in H \,\middle|\, |u,\psi_1| \le \gamma, \alpha(u,\psi_1) + \beta(v,\psi_1) = 1 \right\}, \quad I : M \to M', \tag{2}
$$

$$
M' = \left\{ z = \begin{pmatrix} u \\ v \end{pmatrix} \in H \,\middle|\, |u,\psi_1| \le \gamma, \alpha(u,\psi_1) + \beta(v,\psi_1) = 1 + \mu \right\}
$$

where $a > 0$, $\beta > 0$, $\gamma > 0$, $\mu > 0$, $|b| < a$, nonlinear continuous functions f_1, f_2 satisfy the boundedness condition and trajectories of problem (1) – (2) have impulsive perturbation I in moments of intersections with the impulsive set M. For sufficiently small $\varepsilon > 0$ is proved that (1) generates multi-valued dynamical system G_ε which has global attractor Θ_ε and in a particular case the invariance and robustness properties are proved.

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MULTIPLICATIVE OPTIMAL CONTROL FOR PARABOLIC-HYPERBOLIC EQUATIONS WITH NONLOCAL BOUNDARY CONDITIONS

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In this paper we consider the problem of optimal multiplicative control for parabolic-hyperbolic equations with nonlocal boundary conditions. The main feature of this problem for fixed control is that, firstly, it is not self-adjoint and, secondly, its solution depends on the control value at the switching point of the equations.

Let's consider the following problem of optimal control: on solutions of the boundary-value problem:

$$L(\hat{u})y(x,t) = 0, y(x,-\alpha) = \varphi(x), \tag{1}$$

$$y(0,t) = 0, \frac{\partial y(0,t)}{\partial x} = \frac{\partial y(1,t)}{\partial x}, -\alpha \le t \le T, \tag{2}$$

where

$$L(\hat{u})y = \begin{cases} y_t & y_{xx} + u(t)y, t \ge 0, \\ y_{\tau\tau} - y_{xx} + v(t)y, t < 0, \end{cases} \quad \hat{u}(t) = \begin{cases} u(t), t \ge 0, \\ v(t), t < 0. \end{cases}$$

It is necessary to minimize the functional

$$I(\hat{u}) = 0.5\left(\left(\int_0^1 q(x)\big(y(x,T)-\psi(x)\big)dx\right)^2 + \right. \tag{3}$$

$$\left. + \gamma\left(\int_{-\alpha}^0 v^2(t)dt + u^2(0) + \int_0^T u^2(t)dt\right)\right),$$

Where $\psi(x)$ is fixed function, $\gamma = \text{const} > 0$

$$u(t) = u(0) + \int_0^t \xi(\tau)d\tau,$$

$$0 < \tilde{u}_1 \le v(t) \le \tilde{u}_2, t \in [-\alpha,0], \tilde{u}_1 \le u(0) \le \tilde{u}_2, |\xi(\tau)| \le l.$$

Using the Riesz basis with the completed biorthogonal systems and the method of variables separation the problem (1)–(3) reduces to an infinite-dimensional problem of optimal control with the Fourier coefficients of the origi-

nal boundary value problem solutions. The coefficients satisfy an infinite-dimensional system of a special type integral equations. Such a reduction allows to establish the unique solvability of the boundary value problem (1)–(2) and obtain constructive optimality conditions. In the case when control enters the right side of the equation (1) the problem (1)–(3) is investigated in work [1].

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METHOD FOR DETERMINATION OF THE HEAD-CAPACITY CURVE OF CENTRIFUGAL PUMP

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The method relates to the determination of the head and the head-capacity characteristic of the centrifugal pump when the wheel is turned on the outside diameter in order to use such a characteristic for calculating the pump-pipe systems in the simulation and optimization of such systems and consists of three stages.

In the first stage, for pumps of a certain type with a certain type of rotor wheel by means of using their passport characteristics, the bearing reference characteristic $h_v(Q)$ of hydraulic shock vortex losses of the head (pressure) in the flow part of the pump is finding in the following sequence and it is taken the same for all such pumps.

Step 1. It is building the theoretical head characteristic of $H_{t,psp}(Q_t)$ of the passport pump in accordance with the formulas of the theory of centrifugal pumps in the form of a straight line. It is found the points of intersection of the line with the coordinate axes and the theoretical value $Q_{t,nimp}$ of the feed for the non-impact input of the flow of the pumped fluid into the wheel.

Step 2. The theoretical head characteristic of $H_{t,psp}(Q_t)$ is recalculated using the formulas of the theory of centrifugal pumps on the theoretical head characteristic $H_{sc,psp}(Q)$ of the theoretical head dependence on the flow feed Q, which takes into account the volumetric costs of the passport pump through the slit compaction.

Step 3. By deducting from the function $H_{sc,psp}(Q)$ the values of the passport characteristic-function $H_{psp}(Q)$ it is getting the function — the passport characteristic $h_{hy,psp}(Q)$ of the total hydraulic values of head losses in the flow part of the pump (hydraulic in length and in the diffuser and shock eddy).

Step 4. It is performing the "splitting" by a special algorithm of the passport characteristic $h_{hy,psp}(Q)$ on the characteristic $h_{v,psp}(Q)$ of the hydraulic shock vortex losses of the head, taking it on the bearing reference characteristic $h_v(Q)$, and the characteristic $h_{d,psp}(Q)$ of hydraulic head losses on the length and in the diffuser.

At the second stage, it is taking the next step.

Step 5. For a real pump of a certain type with a certain type of rotor, if the parameters of the slit compaction of the pump and the geometric parameters of the wheel coincide with the corresponding parameters of the passport pump and

the wheel, it is making the refinement based on the actual data on the operation of the real pump, its characteristic hd, pas (Q) from In order to obtain the performance characteristic $\mathbf{h_{d,pf}}$(Q) of the hydraulic head losses on the length and in the diffuser.

If necessary, such a clarification is carried out taking into account the actual parameters of the slit compaction of the actual pump.

In the third stage, the calculation of the head characteristic of the centrifugal pump when the wheel is turned on the outer diameter of d_{out} is making in the following sequence:

Step 6. Similarly to step 1, it is constructing the theoretical head characteristic of the $\mathbf{H_{t,ch}}$(Q_t) of an arbitrary pump at known geometric parameters of the wheel corresponding to the parameters of a certain type of the passport wheel and the chosen value of the external diameter of the $d_{out,ch}$ to which the wheel must be sharpened.

Step 7. The theoretical head characteristic of $\mathbf{H_{t,ch}}$(Q_t) is counted in the same way as step 2 on the theoretical head characteristic $\mathbf{H_{sc,ch}}$(Q), which takes into account the volumetric flow rates of a particular pump through a slit compaction with known geometric parameters.

Step 8. By deducting from the characteristic-function $\mathbf{H_{sc,ch}}$(Q) of the characteristics-functions $\mathbf{h_v}$(Q) and $\mathbf{h_{d,pf}}$(Q) (in any sequence) it is obtaining the desired head characteristic of the pump with the wheel to be sharpened.

The given method was used in the creation of a set of programs for modeling and optimizing modes of operation of the Pridneprovsk main oil pipelines system (Kremenchuk city) as part of the Automated Process Control System of this system in 2006–2007.

COMBINING OF APPROXIMATION AND DECOMPOSITION METHODS FOR RESOURCE DISTRIBUTION NONLINEAR OPTIMIZATION PROBLEMS

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An approach to solving nonlinear optimization problems with binding variables and with coupled constraints is developed. It is based on a combination of approximating schemes of nonlinear optimization and decomposition methods. At the upper level of the hierarchical iterative algorithm, the original problems are replaced by problems with additive-separable objective functions and block constraints. At the second level, the coordinating problems formed with the information received at the lowest level from the solution of independent block sub problems are solved.

For a problem with coupled constraints, the rate of convergence in solving a dual coordinating problem depends on the behavior of its objective function in the neighborhood of the optimal point [1]. When applying a direct decomposition scheme, the solution of the coordinating problem is always obtained in a finite number of steps [2]. This is important, because coordinating problems in the proposed scheme should be solved many times. They play the role of auxiliary in the process of higher level.

The approach to solving non-linear optimization problems, based on a combination of approximation and decomposition techniques, allows solving complex nonlinear problems and opens up additional possibilities for investigating large spatially or functionally distributed systems.

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ON OPTIMAL CONTROL PROBLEM FOR AN ILL-POSED STRONGLY NONLINEAR ELLIPTIC EQUATION WITH *P*-LAPLACE OPERATOR AND *L*^{1}-TYPE OF NONLINEARITY

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We consider the following optimal control problem for a nonlinear elliptic equation with *p*-Laplacian:

$$\text{Minimize } J(u, y) = \frac{1}{2}\int_{\Omega} | y - y_d |^2 \, dx + \frac{1}{q}\int_{\Omega} | u |^q \, dx, \tag{1}$$

subject to constrains

$$-\Delta_p y = f(y) + u \quad \text{in } \Omega, \tag{2}$$

$$y = 0 \quad \text{on } \partial\Omega, \tag{3}$$

$$u \in L^q(\Omega), \; y \in W_0^{1,p}(\Omega), \tag{4}$$

where $2 \le p < N$, $q > \dfrac{p}{p-1}$, Ω is a bounded domain in $\mathbb{R}^N$ with sufficiently smooth boundary $\partial\Omega$, $f(y) = F'(y)$, $F \in C^1(K)$ for any compact set $K \subset \mathbb{R}$, $F(z) \ge \exp(C_F^{-1} z)$ for all $z \in \mathbb{R}$ and some constant $C_F > 0$, $\Delta_p y = \text{div}(| \nabla y |^{p-2} \nabla y)$ is the p-Laplacian, and $y_d \in L^2(\Omega)$ is a given distribution.

The main characteristic feature of the indicated BVP (2)–(3) is the fact that because of the specificity of non-linearity $f(y)$, we can not obtain any a priori estimate for the weak solutions in the standard Sobolev space $W_0^{1,p}(\Omega)$. Moreover, since we cannot assert that the BVP (2)–(3) admits at least one solution for a given control $u \in L^q(\Omega)$, our main intention is to show that the original BVP possesses a special type of weak solutions satisfying some extra state constraints. To do so, we introduce a special family of fictitious optimization problems

$$\text{Minimize } J_\varepsilon(u, z) = \varepsilon^{-1}\int_{\Omega} | v - T_\varepsilon(f(z)) |^{p'} \, dx, \tag{5}$$

$$-\Delta_p z = v + u \quad \text{in} \ \Omega, \quad z = 0 \quad \text{on} \ \partial\Omega, \tag{6}$$

$$v \in L^{p'}(\Omega), z \in W_0^{1,p}(\Omega), \tag{7}$$

where $T_\varepsilon : \mathbb{R} \to \mathbb{R}$ stands for the cut-off operator, and we show that the indicated fictitious optimization problem can be involved to the analysis of solvability of the original BVP (2)–(3).

Theorem 1. Let Ω be a bounded open convex subset of $\mathbb{R}^N$ and $p \in [2, N)$. Let $u \in L^q(\Omega)$ with $q > 2$ be an arbitrary admissible control such that the boundary value problem (2)–(3) is solvable. Then the Dirichlet boundary value problem (2)–(3) admits a weak solution $z \in W_0^{1,p}(\Omega)$ such that

$$\int_\Omega |\nabla z|^p \, dx \le \frac{Np}{N-p} \int_\Omega F(z) dx - \frac{p}{N-p} \int_\Omega u(x - x_0, \nabla z) dx. \tag{8}$$

This circumstance allows us to prove that OCP (1)–(4) is consistent and has a nonempty set of optimal pairs.

ADAPTIVE GYROSCOPIC SYSTEMS: CONTROL SYNTHESIS

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The motion of a gyroscopic control object is described by the following system of equations

$$\dot{x} = (A_0 + \varepsilon A_1)x + Bu,$$
$$y = Cx, \tag{1}$$

where $x = [x_1,...,x_{2n}]^T$ — n is a measurable state vector, $u = [u_1,...,u_m]^T$ — m is a measurable vector of controls, $y = [y_1,...,y_l]^T$ — l is a measurable exit vector, ε is a small parameter; $A_0 \in \Re_{2n \times 2n}$, $A_0 = -A_0^T$ — is a skew-symmetric non-degenerate matrix, $A_1 \in \Re_{2n \times 2n}$ - is a perturbation matrix, $B \in \Re_{2n \times m}$ — is a matrix under control, $C \in \Re_{l \times 2n}$ — is a matrix of observations. The matrix elements A_0, , B and C are all or partly uncertain.

The study is devoted to the construction of a regulator for a gyroscopic system (1). The proposed approach is implemented by solving the problem of identification of continuous systems by the method of quasi-linearization [1] and the method of control construction for almost conservative dynamical systems [2]. The gyroscopic system has a special shape, which makes it possible to obtain significant simplifications in the construction of the regulator. The authors succeeded in analyzing the control law and identifying the coefficients unknown to the matrix.

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MODELING AND PROGNOSTICATION SOME ASPECTS OF THE ACTIVITY OF THE REGIONS OF UKRAINE

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The State Statistics Service of Ukraine (Gosstat) is a specially authorized central executive organization in the field of statistics whose activities are directed and coordinated by the Cabinet of Ministers of Ukraine through the Minister of Economic Development and Trade and which implements state policy in the field of statistics, regularly publishes statistics of various aspects of the activity of regions of Ukraine. It is useful to use this data to increase the efficiency of a particular activity. In this paper, it was decided to create and test a software product for predicting some aspects of Ukraine's regions based on available data. To achieve this goal, it is planned to use a model based on a cellular automaton with a certain modification. To use cellular automata require that the backside you initial ground state of cells as well as cells transition rules from one state to others second. At each iteration (step) using transition rules and the state of neighboring cells is determined new state of each cell. Usually, the transition rules are the same for all cells and apply directly to the entire grid. It is planned to modify the rules so as to take into account the specifics of each activity in the regions of Ukraine, which means that the rules for the cells will be different. The identification of the rules will be based on the genetic algorithm (GA) of the rules identification. GA work is based on the principles of natural selection and inheritance. Advantages of GA over other methods of optimization is in the parallel processing of the set of alternative solutions. It is also very important that the GA enables one to set the initial parameters randomly. For this work, this will be applied as follows: the initial rules are based on known data, then with the help of the genetic algorithm these rules will be combined in phrasal steps, which will allow to derive the most correctly formulated rule for one or another aspect of the activity of the regions of Ukraine. As a result, we will receive a program that will carry out a prognosis for data on one or more steps forward, which will allow the relevant organizations to adjust their activities according to prognosis.

GLOBAL OPTIMIZATION IN ACTION

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Many problems in economy, finance, projection, planning, computer graphics, management, scheduling and information are difficult computational systems. They can be transformed to optimization problems in finite-dimensional space. Such problems contain many of local minima and belong to NP-difficult class of the computational complexity. It is necessary to develop new methods of global optimization for the solution of these problems.

In this paper we propose method of exact quadratic regularization (EQR) for deterministic global optimization. The method EQR includes only local prime-dual interior point method of optimization and of a dichotomy method.

We consider the problem

$$\min\{f_0(x) \mid f_i(x) \le 0, i = 1,...,m, x \in E^n\}, \tag{1}$$

where all functions $f_i(x)$ are twice differentiable, x is a vector in n-dimensional Euclidean space E^n. Let the solution of the problem (1) exists and x^* is a point of global minimum of the problem (1). The problem (1) is transformed to the following

$$\max\{\|z\|^2 \mid f_0(x) + s + (r-1)\|z\|^2 \le$$
$$\le d, f_i(x) + r\|z\|^2 \le d, i = 1,...,m, z \in E^{n+1}\}, \tag{2}$$

where $z = (x, x_{n+1})$, $s \ge \|x^*\|^2 - f_0(x^*)$. The value $r > 0$ exists so that all constraints of the problem (2) are convex. It is necessary to find the minimum value d^* for which $r\|z^*\|^2 = d^*$ where z^* — is solution of the problem (2). We find such value d by a dichotomy method.

Let

$$S = \{z \mid f_0(x) + s + (r-1)\|z\|^2 \le$$
$$\le d, f_i(x) + r\|z\|^2 \le d, i = 1,...,m, z \in E^{n+1},$$

if S is a rectangular parallelepiped or a polyhedron inscribed in a sphere then in this case solution of the problem (2) is the trivial. We find the solution of the problem (2) simply also for other convex sets.

We have found the solutions in more than 300 test problems of global optimization and have received the best solutions (see for example: http://www.gamsworld.org/global/globallib. htm).). The method EQR can be used for search of the solutions in discrete and large sparse of the problems. The comparative numerical experiments have shown that this method is very efficient and promising.

MATHEMATICAL MODEL OF DIFFERENT TYPE BIN PACKING

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We consider the NP-complete problem of different type bins packing, namely the problem presented on ESICUP – Renault Container Loading Challenge (2015). The objective of the problem is to pack a given set of items into set of different type bins under the series of conditions. The packing quality criterion is a vector of four objectives ordered lexicographically. Actually that means that the multicriteria optimization problem is reduced to single-objective one. To find the approximate solution to the optimization problem there was made decomposition of the problem into two basic parts. The first part is forming of feasible stacks set. The second stage is the problem of packing stacks into bins, which is a variant of the problem of a flat rectangular cutting with an unlimited set of different type pieces. The second stage includes packing optimization within each bin, which is also a variant of the problem of a flat rectangular cutting. In the second part hybrid game and evolutionary-fragmented model for optimum search was used. The first player proposes a sequence of bin types, which is described by an integer vector. The second player provides permutation of stacks. Stacks are being packed tightly into bins by the rule Top-Left. All conditions of the problem except of two of them are fulfilled on the first stage. The two remaining conditions can be estimated only when solution is constructed. Thence we introduced zeroth criterion, which is penalties for violation of these constraints. The player`s task is to achieve the minimization with given criteria. Finding of the optimal solution for two players is performed by means of the evolutionary algorithms. Such game is applied several times with different parameters. The best result is considered to be a near-optimal solution of the problem.

SIMULATION OF SHEAR DEFORMATION IN GRANULAR MASSIF

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The dynamic behavior of granular media has many features that distinguish them from the behavior of solids, liquids and gases. At present, there are no any universal mathematical models fully describing the dynamical processes in granular media. The main obstacle is that granular media are discrete complex systems with long-range correlations. In this case to model the dynamics of granular flows it is suitable to use the discrete elements method. The well-known advantage of this method consists in the ability to describe the dynamics of each elements of structure in detail.

In this report, we present a simulation of the shear of a granular massif composed of angular grains, namely cubes. For this purpose, we developed the computer code CuBluck based on the discrete elements method. The interaction of cubes incorporates the elastic interaction defining via the mutual penetration and friction including both static and kinetic one. For the description of rotational motion we apply the quaternion technique. Equations of motion are solved by the Beeman's algorithm.

The shear simulation was performed for the massif of 3000 cubes at a constant rate of deformation. In simulation, the total kinetic, elastic, rotational and dissipating energies are derived. The spectra for all types of energy obey the power dependencies with the exponents close to 2. The type of these spectra testifies that these temporal dependencies do not contain any characteristic frequencies. The temporal relation for total force, with which cubes act on the upper wall of box, has the similar spectrum but exponent equals 1.4. This is an indication that there are long time correlations in this time series. Besides temporal long-range correlations, the granular system possesses the spatial long-range correlations. This follows from the character of distribution functions for the forces acting between structural elements.

OPTIMAL DESIGN OF ELECTRIC ENGINES

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The scientific and technological progress in various industries causes the growth of the demand for electric machines. The development of new technological processes for the production of these objects opens up wide opportunities for increasing labor productivity and efficiency of production activity. The production of electric machines is characterized by a variety of designs, increased requirements for reliability and technical level, technological design, increased level of specialization and cooperation production.

A software product that allows designing one-phase asynchronous motor with different technical constraints was created. The following optimization methods were used to solve the problem of nonlinear programming: the method of penalty functions, the modified method of Lagrange multipliers, one of the methods of zero order — the method of complexes, as well as the method of permissible directions.

Optimally engineered the engines, each of which had its technical limitations, it was established that the methods of penalty functions and permissible directions are unstable in calculations. The efficiency of using the complex method and the modified Lagrange multiplier method for optimal design of electric motors was demonstrated.

STRONG ANTISIPATION IN MODELS OF BRAIN PHENOMENA

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Problems of consciousness – the brain – thinking is key in modern science. Despite all the efforts, the problem does not yet have a final solution yet. So far, a lot of concepts have been proposed, and in different sciences completely different, sometimes contradictory. The diversity of approaches indicates that before the final understanding of the processes in the brain is still far away and therefore, perhaps important aspects or factors may not be considered yet, or factors may be important for solving the general problem of brain functioning.

In this report, we present a discussion of the possible role of the strong-anticipatory property, which was introduced by D. Dubois, and is to take into account in the models of future (unknown) values of variables in system modeling. Under certain conditions, such models generate multi-valued solutions (this is called hyperincursion).

Since one of the main classes of models for processes in the brain are artificial neural networks, we discuss possible interpretations of solutions of neural network models with strong anticipation. The problems of information storage and processing, connection with other concepts, especially with quantum mechanical, image recognition, the problem of freedom of choice, brain activity, etc. are discussed. Psychological phenomena and mental illnesses (for example, schizophrenia) are discussed.

THREE NEW TASKS IN RESEARCH OF ARTIFICIAL LIFE

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A relatively new branch of research, the so-called artificial life models [Langton, Epstein, Burtcev, Bert-2017, Zavertaniy & Makarenko] appeared at the junction of biology, the theory of automata and cellular automata of information technologies from the beginning of the 1990s. This branch emerged from the need to find relatively simple basic models for the study of biological systems taking into account spatial aspects, the evolution of competing teams of active agents, the emergence of social groups and social norms. The results of the research turned out to be rather interesting and new, and the set of problems studied in this approach is becoming wider and wider. In this article, we propose three such new tasks, which are suitable for the application of artificial life.

1. Modeling the game of football with the help of the concept of artificial life.

2. Modeling the functioning of science as a large command structure.

3. Modeling of traffic processes taking into account strong anticipation.

TO SYSTEMIC ANALYSIS OF EDUCATION AND EDUCATIONAL PROCESSES

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To date, education has typically evolved within the traditional (classical) direction and forms inherent to it. But in today's society, societies are in continuously changing states, with the pace of change all the time accelerating. Therefore, the role of education and the timely acquisition of knowledge and the possibility of generating new knowledge is constantly changing. Of course, the progress in the use of information technologies, as well as the achievement of other sciences (cybernetics, computer science, statistics, etc.) in distance education is recognized first of all. At the same time, successes are mainly observed in the application of information technology to local tasks (corporate, individual training courses, improvement of education systems, etc.).

However, it is believed that from the point of view of system analysis, synergetic, global modeling of social procesess, and in the field of classroom education, the need for significant changes, rethinking the essence and forms of education in society has matured. The report provides some suggestions and suggestions in the field of education, both locally and globally.

Thus, the suggestions are given for improving the typical (first-to-first) educational process in higher educational activities. Separately, the relationship between science and society is discussed. General questions of the theory of science, knowledge and their description are also discussed.

COMPARATIVE ANALYSIS OF NONLINEAR DYNAMICS IN INVESTMENT MARKETS

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Investment markets are complex dynamic systems. Influence of objective economic conditions and subjective decisions of market participants predetermine the nonlinear character of the prices dynamics in the market, crisis phenomena and, as a result, a high degree of unpredictability of the dynamics. The emergence of a large number of investment instruments raises the question of understanding the underlying processes occurring in the market, and the purpose of taking a correct and well-founded decision makes it necessary to compare the effectiveness of various investment instruments.

There are various paradigms for analyzing the dynamics of financial markets [1]: linear (Efficient market hypothesis, EMH) and nonlinear (Fractal market hypothesis, FMH; Coherent market hypothesis, CMH).

The purpose of this work is a comparative analysis of the dynamics of prices and their profitability in the world investment markets, development of recommendations on the benefits of investing on different planning horizons. In this research three segments of the investment market were selected: market of precious metals (gold market), Forex (currency pair EUR / USD) and financial market of crypto-currency (Bitcoin).

For the comparative analysis, an indicators system for assessing the characteristics of the dynamics was formed. This system is based on the results of both the methodology of statistical research and the methods of discrete nonlinear dynamics [2].

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CATEGORY OF LAME NONLINEAR EQUATIONS

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In order to construct the Category of Lame nonlinear equations, we recall the concept of differential invariants in the spirit of S. Lie. Following Vessiot who was the first to study differential conditions that could be satisfied by geometric objects while most of the modern authors only give definitions, we built a differential invariant of order q as a function that is invariant under the category action.

Since the work of Lie it is known that a fundamental set of differential invariants of order $q+1$ must contain the formal derivatives of the differential invariants of a fundamental set of order q. This implies the existence of a generating fundamental set of differential invariants for the constructing the Category of Lame nonlinear equations.

STUDYING INTERACTIONS: FROM PEDESTRIAN DYNAMICS TO COLLABORATIVE GAMES IN IOT CONTEXT

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TOOLS/APPROACH: ARTIFICIAL INTELLIGENCE AND DATA ANALYTICS

Focus on: Collaborative patterns – those generated by interactions due to/forced by a collaborative shared task/goal

Goal: studying, in a comparative way, different forms of interactions that may occur due to

Spatial sharing: e.g. pedestrian dynamics context

Goals: e.g. collaborative planning

Micro-meso-macro dynamics in pedestrian dynamics context in giocoso context

INTERACTIONS IN SYSTEMS OF PEDESTRIANS (CROWDS AS COMPLEX SYSTEMS)

What is a pedestrian *system*?

Which are suitable interactions occurring within these systems?

Due to spatial constraints

Due to goal sharing

Due to emotional individual dynamics

Due to emotional relationships (e.g. dyads, "families")

…

Micro: pedestrian, groups, micro-interactions, individual behaviors, features, …

Macro: "mass flow rate", egress ratio, … all other pedestrian dynamics performance indicators

Meso: **uniform lanes spontaneously can emerge in corridor-like geometries with pedestrians bi-directional movement**

(https://youtu.be/J4J__lOOV2E)

CONSIDERATION OF A NEW STRUCTURE
IN THE UNIVERSUM OF MATHEMATICS

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People always were curious how to describe the changing scope of mathematics and mathematical modeling in a given period of time as well as whether exists a holistic approach which would allow to look at mathematics as an integral structure allowing to see analogies not only among theorems but also among theories. This paper is about categorical aspect of those issues.

The category theory is a generalization of mathematical theories treated as a suite of sets and functions between these sets on the first level of abstraction, on the second – families of sets and mappings and on the third – appropriate for categories – objects and morphisms. Thus, it can be seen that the *concept of a set* occurs in the *universum of mathematics* as a *multi-category*, *at least based on three types of multi-objects: set, family and object*. What is more, on the example of a family (set of sets) and objects, we see that mathematics is often interpreted from the view point of the first hierarchy, and it is obvious that reference to the lowest level is at least unsatisfactory if we ignore the paradoxes associated with occurrence of so called "own" sets. In addition, it is clear that the hierarchies of multi-objects and cardinal numbers are unbounded.

In this situation, the article proposes to consider the structure of mathematics by formalizing the intuition related to Poisson's $[\cdots]$ and Moyal's $\{\!\!\{\cdots\}\!\!\}$ brackets and reducing the original relation of belonging to the set $\in$ as the concept of denotation of the primary parenthesis $\{\cdots\}$ of the *multi-object generation* (in the particular case of the *set*).

LEARNING OF HIGHER-ORDER CORRELATIONS IMPROVES CAPACITY OF AN ASSOCIATION MEMORY

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New findings from neuroscience suggest new ways of improving association memory models. It is recognized that neuron computation is extended by dendritic computation due to its nonlinear summation. Each dendrite works as a coincidence detector for higher-order correlations and neuron works as multiple coincidences detector. This biological results formalized into new hetero association model that uses advantages of sparse coding and learning of coincident activation of input neurons. Theoretical investigation shows that this operation equivalent to extending dimension of input vector from N to C_N^k where k is an order of correlation. Higher dimension enables to reduce error and to increase memory capacity. The most important finding that for a sparsely active neuron population tracking coincidence even for a small number of neurons k tremendously improves memory capacity due to the combinatorial expansion of dimension. System with a good association memory is an important and necessary step to create cognitive agents and supports the trend to organize data in the linked form.

KOLMOGOROV CONSISTENCY THEOREM
FOR MULTIPLE PROBABILITIES

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We provide necessary and sufficient conditions for consistency of weak* closed sets of finite-dimensional distributions. Specifically, suppose T and Y are nonempty sets, F is an algebra on Y. For each $n \in N$ and finite sequence $t_1, \dots t_n \in T$, let $V_{t_1, \dots t_n}$ be a weak closed set of finitely additive probability measures on (Y^n, F^n). Given that these sets of measures satisfy two consistency conditions, we show that there exist a collection of mappings $X_t : \Omega \to Y$ ($t \in T$) on a measurable space (Ω, A) and a weak closed set P of finitely additive probabilities on (Ω, A) such that the following condition is satisfied for all $n \in N$ and $t_1, \dots t_n \in T$. For any $p \in P$ there is $v \in V_{t_1, \dots t_n}$ such that

$$v(F) = p([X_{t_1}, \dots, X_{t_n}] \in F)$$

for all $F \in F^n$ and vice verse. Moreover, if each set $V_{t1, \dots, tn}$ consists of σ-additive probabilities on R^n, then we can restrict P to σ-additive measures. This extends to the multiple probabilities setting the classic Kolmogorov consistency theorem, in which every set $V_{t1, \dots, tn}$ and the set P are singletons. For the proof see [1].

This implies that if finite-dimensional distributions are not uniquely determined, we still can define random variables on a probability space (Ω, A, p). However, in this case the probability p is determined up to a set P. In other words, a consistent collection of weak-∗ closed sets of finite-dimensional distributions define a non-stochastic random process. One might use this notion to model social and economic processes that are not statistically stable [2, 3].

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ON PRACTICAL INTERNAL STABILIZATION OF DIFFERENTIAL INCLUSIONS VIA LYAPUNOV FUNCTION

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We consider differential inclusion

$$\frac{dx}{dt} \in F(x,t) + G(t)u(x,t), \tag{1}$$

where $(x,t) \in D$, $D \subset \mathbb{R}^{n+1}$ is a bounded domain, a set-valued mapping $F: D \to conv(\mathbb{R}^n)$ is measurable in t, upper semicontinuous in x, $F(0,t) = 0$, $(0,t) \in D$ and integrably bounded on D, $G(t)$ is integrable $n \times m$-matrix, $u(x,t)$ is an m- dimensional control function, $u(0,t) = 0$. We assume that $u(x,t)$ is integrably bounded on D, continuous with respect to variable x being measurable with respect to t.

A multifunction $\Phi: [t_0, T] \to comp(\mathbb{R}^n)$ prescribes phase constraints, the graph of the mapping Φ belongs to D, $0 \in int\Phi(t)$, $t \in [t_0, T]$, $G_0 \subset \Phi(t_0)$. Let there exists a continuously differentiable function $V: D \to \mathbb{R}^1$ such that $\Phi(t) = \{x \in \mathbb{R}^n : V(x,t) \leq 1\}$, $t \in [t_0, T]$, and $V(0,t) = 0$, $grad_x V(0,t) = 0$ on $[t_0, T]$. The maximum set of internal practical stability of the zero solution of (1) at $u(x,t) = 0$ does not contain G_0. The problem of $\{G_0, \Phi(t), t_0, T\}$ — internal stabilization for differential inclusion (1) consists is to find the admissible control function $u(x,t)$ such that the zero solution to (1) is $\{G_0, \Phi(t), t_0, T\}$ — internally stable.

Theorem 1. Given $W(x,t)$ is a continuous nonnegative function on D and

$$\left| W(x,t) + \frac{\partial V(x,t)}{\partial t} + c(F(x,t), grad_x V(x,t)) \right| \leq$$

$$C \| G^*(t) grad_x V(x,t) \|^2,$$

$C > 0$. The control function

$$u(x,t) = \begin{cases} (k(x,t)I + P)G^*(t)grad_x V(x,t), & \text{if } G^*(t)grad_x V(x,t) \neq 0, \\ 0, & \text{if } G^*(t)grad_x V(x,t) = 0 \end{cases}$$

solves the problem of $\{G_0, \Phi(t), t_0, T\}$ – internal stabilization for differential inclusion (1). Here $P = -P^*$ is an arbitrary $m \times m$ - matrix,

$$k(x,t) = -\frac{W(x,t) + \frac{\partial V(x,t)}{\partial t} + c(F(x,t), grad_x V(x,t))}{\|G^*(t) grad_x V(x,t)\|^2}.$$

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PRODUCT PATTERNS OF ATLAS SOLUTIONS FRAMEWORK AND EXAMPLES OF THEIR USAGE

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Many years of practice of creating atlas systems at the national level made it possible to formalize the requirements and to create the Atlas Solutions Framework AtlasSF1.0+, which is a system of verified in practice, interconnected, repetitive solutions to the most common problems that arise when solving problems of obtaining, storing, processing, interpreting and visualization of large atlas data in the creations of atlas systems.

Creating a modern atlas system (product) can only be provided with a properly organized process. The duality of the 'product-process' simplified can be formulated as follows: a product can not be created without process, as well as the process of creating products (atlas systems) does not make sense without the product created by him.

The most important part of AtlasSF1.0+ is the product example solutions, or patterns of such elements of any Atlas as a contents tree, cartographic component, base and thematic maps, etc. Examples of solutions for the user interface, search functions, non-cartographic content and background information related to geographic entities (in the form of documents, tables, graphs, multimedia), implementation of the working space of the atlas are important for electronic interactive representation. The established relations between the patterns determine and support the architecture of the atlas information product.

In general, AtlasSF1.0+ product package consists of eight patterns and an architectural framework: 1) ptnAtUserInterface – pattern of the user interface of the atlas; 2) ptnAtTreeSolution – contents/solutions tree; 3) ptnAtMapComponent – pattern of the cartographic component of the atlas; 4) ptnAtThematicMap – pattern of thematic map of the atlas; 5) ptnAtDocTemplates – pattern of atlas document templates (document, photographs, graphics, etc.); 6) ptnAtBaseMap – pattern of the base map of the atlas; 7) ptnAtSearch – atlas search pattern; 8) ptnAtWorkSpace – pattern of the working space of the atlas (representation); 9) frmAtArchitecture – the framework of the atlas architecture, which unites all the above-mentioned patterns.

The idea to use without the developer predetermined and implemented patterns/templates makes it possible to build new atlases with the least cost of effort and with the highest quality.

COMPRESSIVE SENSING AND DEEP LEARNING

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Classical paradigm of analog signal acquisition is two stage process — sampling with further compression. This approach requires high quality measurements during sampling stage, but most of that information we throw away during following compression. Compressive sensing (CS) is an approach to signal acquisition which join both stages of classical approach at one. CS has become vibrant research are a due robust theoretical foundation [1] and wide range of applications.

CS approach allows signal reconstruction exceeding Nyquist limits under the next criteria: the signal is sparse in a transform domain, the signal is sampled incoherently in the transform domain, the signal is reconstructed using convex optimization with a sparsity promoting L1 norm reconstruction.

Unexpectedly big variety of signals (e.g. NMR, MRI) are sparse after choosing of proper transform domain e.g. wavelet, Fourier or DCT. The second point and the third point are related. The signal is sampled incoherently in the transform domain such that aliasing propagates as noise, which is then iteratively filtered using convex optimization. Convex optimization in CS has a data consistency term and regularization term. Early work hinting at CS leveraged assumptions about sparsity and used an L1 regularization term to express this. Combination of CS and Deep Learning (DL) approaches allows to receive state of the art results in certain tasks [2]. Usage of Bayesian framework with CS problem, especially with utilizing hierarchical models [3], also looks promising.

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DIFFEOMORPHISM-ASSOCIATED BOUNDARY VALUE PROBLEM ON A RIEMANNIAN MANIFOLD

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We consider L_2 version with respect to measure of Laplace operator construct in the context of diffeomorphism between (infinite-dimensional) Riemannian manifolds. It is proved that in the case when gradient closure, boundary restriction operator and divergence with respect to measure are correctly defined on a Riemannian manifold, the respective operators are correctly defined on a diffeomorphic Riemannian manifold too.

Let G_1 be an area in a Riemannian manifold M_1, $S_1 \overset{\Delta}{=} \partial G_1$, μ_1 — a positive normed Borel measure on M_1, n_1 is a strictly transversal to S_1 vector field, $\Phi_t^{n_1}$ — n_1 vector field flow.

Let us consider following boundary value problem:

$$\operatorname{div}_{G_1}(k \cdot \overline{\mathbf{grad}}_{G_1} u) - a \cdot u = f, \tag{1}$$

$$\gamma_1(u) = \varphi, \tag{2}$$

where $f \in L_2(G_1)$; $k \in C^1(G_1)$; $a \in C(G_1)$; $k(x) \geq \delta > 0$; $a(x) \geq \alpha > 0$; $\varphi \in \operatorname{Im}\gamma_1$, $\gamma_1 : D(\overline{\mathbf{grad}}_{G_1}) \to L_2(S_1) = L_2(S_1, \tau_1)$ is a boundary trace operator: $\gamma_1(u) = u|_{S_1}$ for $u \in C_1(\overline{G_1})$; surface measure τ_1 is defined as follows:

$$\int_{S_1} f \, d\tau_1 = \frac{d}{dt}\bigg|_{t=0} \int_{\Phi_t^{n_1} G_1} f \, d\mu_1.$$

Let M_2 be a diffeomorphic to M_1 Riemannian manifold, $F : M_1 \to M_2$ is a *bounded* diffeomorphism (there exists such $K > 0$, that for all $p \in M_1$ и $q \in M_2$ following inequalities hold: $\|F'(p)\| \leq K$ and $\|(F^{-1})'(q)\| \leq K$); $n_2(\cdot) = F'(F^{-1}(\cdot))n_1(F^{-1}(\cdot))$, $\mu_2(A) = \mu_1(F^{-1}(A))$, $G_2 = F(G_1)$, $S_2 = \partial G_2 = F(S_1)$.

Theorem. Function $u = u_2$ is a solution of following (F-*associated*) boundary value problem: $\operatorname{div}_{G_2}((k \circ F^{-1})F'(F^{-1}(\cdot))(F'(F^{-1}(\cdot)))^* \overline{\mathbf{grad}}_{G_2} u) - (a \circ F^{-1}) \times u = f \circ F^{-1}$, $\gamma_2(u) = \varphi \circ F^{-1}$ if and only if $u = u_1 = u_2 \circ F$ is a solution to Dirichlet problem (1)–(2).

ELEMENTS OF SYSTEMIC THINKING

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Synergistic resonance training, a polylogue instead of a monologue — a reaction to the challenges of the information age, the development of the ability to self-education and system thinking (ST) by the influence of the impulses of system information (I) (the thesis interpretation of concepts system analysis (SA)):

• Components of SA — philosophy of the SA; modeling of processes and systems; applied SA. The idea of SA is to analyze the problem «as a whole». The essence of SA is a simple explanation of a complex one. The main objective of SA is forecast as a decrease in the uncertainty of trends in development, growth, decline, crisis phenomena.

• Thinking is a contextual interpretation of reality. ST — creative nonlinear strategic orderly thinking, the ability to combine intuitive, logical and imaginative thinking, to identify connections and draw conclusions, create models of thinking, choose a goal. Intuition finds, logic paves the way to the goal. Imagery is a metaphorical interpretation. Man thinks in ideas — the product of experience. The idea is the pattern of connections between facts, events, people, systems. Content and form — category ST. I — the intuitive concept of content; forms I (texts, tables, formulas, knowledge) are transformed; the amount of I is measured (similarly to mass, energy, time).

• Systematics — a pattern of natural and cultural phenomena. System (S) — structure (purposeful organization of links) and behavior (dynamic form of adaptation to the surrounding). Connections — the implementation of the functions of elements, S and surrounding. The goal (an understandable, attractive and achievable future) is determined by the cultural paradigm S. The ideal goal is independence from the surrounding; be a subject, not an object. The goal (the order parameter) and the functions determine the structure and behavior. The behavior is complex (oscillations, exacerbation, disruption of adaptation, chaotization), the structure is cumbersome. Human behavior is the most difficult. The essence of the living S is conflict. Value conflicts are not overcome — coexistence and compromise are needed. Strategy S is the idea and the way to achieve the goal. Survival strategy S — enhancing the exploitation of the surrounding as a source of limited resources. Openness S — the interaction of S with the surrounding through the space-time, material-energy, information, mental connections — the subject and point of view of the SA, the basis of ST.

• Our unstable, unpredictable, indefinite life on *the boundaries* of the space of the *Earth-Cosmos*, *the past-future* time, I *the known-unknown*, the systemic *order-chaos, the good-evil* cultures — the situation of bifurcation (unstable balancing of connections) and the choice of the future (assessment, acceptance and realization of equiprobable solutions). The uncertainty of fate is the source of hope and chance.

DATA MINING AND KNOWLEDGE DISCOVERY METHODOLOGY IN CYBER SECURITY

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Data mining and knowledge discovery methodology (DMKD) aims to extract useful information and discover some hidden patterns from huge amount of databases, which statistical approaches cannot discover. It is a multidisciplinary field of research includes: machine learning, data science, artificial intelligence, statistics, and knowledge engineering. DMKD is supported by a host that captures the character of data in several different ways. Researchers are investigating the use of DMKD in both national security (e.g. detecting the bad guys) and in cyber security (e.g. intrusion detection and auditing).

This paper presents the application of DMKD paradigm in cyber security problems. The paper discusses the following topics; (a) profiling networks traffic using clustering, (b) tracing viruses to the perpetrators using link analysis, (c) detecting unusual behaviors and patterns using anomaly detection techniques, (d) grouping various cyber-attacks and then use the profiles to detect an attack when it occurs using classification, and (e) determining future attacks using prediction models.

INFORMATION SYSTEM FOR THE CITY WATER SUPPLY

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The report considers the initial stage of building an information system for a municipal water utility. The basic information environment is described. The main cartographic layers and thematic layers are shown. An example of the use of unified corporate resources is exemplified by the example of an address space server.

- The results are presented:
- Integration with other subsystems.
- Connections of real devices to the information network.
- Data preparation for the solution of problems of network development, and hydraulic calculation.
- Examples of reports.

DESCRIPTIVE THEORY OF THE DETERMINISTIC CHAOS

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Descriptive theory of sets is a classical section of mathematics, which arose at the beginning of the last century. The talk proposes the basis of the descriptive theory of chaos.

We consider dynamical systems on a compact X, generated by a continuous map $f : X \to X$, mainly in the case of when X is an interval $I \subset R$.

The asymptotic behavior of every trajectory is usually determined through the so-called ω-limit set, or, more simply, **the attractor** of this trajectory. The set of all trajectories attracted by the same attractor is called **the basin of this attractor**.

Dynamical system if its topological entropy is positive:

1) has a lot of different attractors of trajectories, namely, the continuum of attractors;

2) basins of most attractors have a very complex structure, namely, they are sets of the 3rd class in the terminology of the descriptive theory of sets;

3) basins of different attractors are very intertwined and they can not be separated from each other by open or closed sets, but only by sets of the 2nd class of complexity, and

4) in the space of all closed subsets of the state space (with the Hausdorff metric), the set of all attractors is an attractor net (network) whose cells are formed by Cantor sets whose points are themselves attractors.

Most of the results presented in the talk were obtained and published in the 60th of the last century, but even now, it seems, they are little known, although all of them were translated into English at the same time.

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QUALITATIVE ANALYSIS OF POLYNOMIAL SOLUTIONS
TO THE MODELS FOR MUTUALLY PENETRATED CONTINUA

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Natural materials at the nonequilibrium conditions of loading can manifest the peculiarities of their internal structure. In particular, the hidden degrees of freedom can be excited and influence on the resulting response. To describe these phenomena in mathematical models [1], the concept of mutually penetrating continua is applied and leads to the following model

$$u_{tt} = \sigma_x - m\, w_{tt}\,,\; w_{tt} + \omega^2(w-u) = 0\,,\; \sigma = e_1 u_x + e_2(u_x)^2 + e_3(u_x)^3\,, \quad (1)$$

where u is the displacement of carrying medium of the density ρ, w is the displacement of inclusions oscillating with natural frequency ω and forming the continuum with the density $m\rho$. According to the previous studies [1, 2, 3], model (1) possesses complicated travelling wave solutions, but here we are interested in the properties of polynomial solutions of the following form [4] $u = a_0 + x a_1 + x^2 a_2$, $w = b_0 + x b_1 + x^2 b_2$, where the coefficients $a_i = a_i(t)$ and $b_i = b_i(t)$ are the functions of time only. Inserting this ansatz into (1) and equating the coefficient at the proper monomials, among the resulting equations we can

extract the closed system: $-24 a_2{}^3 e_3 + \dfrac{d^2 a_2}{dt^2} + m \dfrac{d^2 b_2}{dt^2} = 0$, $\dfrac{d^2 b_2}{dt^2} + \omega^2(b_2 - a_2) = 0$.

This system has the Hamiltonian $H = \dfrac{1}{2} p_1{}^2 + \dfrac{1}{2} p_2{}^2 + \dfrac{1}{2} m\omega^2 \left(\dfrac{1}{\sqrt{m}} x - y \right)^2 -$

$-6 e_3 y^4$, where $\{x, p_1; y, p_2\} = \{X, Z; a_2, Y\}$, $b_2 = \dfrac{1}{\sqrt{m}} X$, $\dfrac{db_2}{dt} = \dfrac{1}{\sqrt{m}} Z$,

$\dfrac{da_2}{dt} = Y$. Constructing the Poincare sections at the different values of energy $H = const$, the regular and chaotic regimes are discovered. The existence of chaotic modes can be caused by the formation of stochastic layers in a vicinity of separatrices and testifies about the non-integrability of dynamical system.

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ON THE UNIQUENESS OF MINIMISERS
OF GINZBURG-LANDAU FUNCTIONALS

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We provide necessary and sufficient conditions for the uniqueness of minimisers of the Ginzburg-Landau functional funder a suitable convexity assumption on the potential and for boundary data that is non-negative in a fixed direction. Furthermore, we show that, when minimisers are not unique, the set of minimisers is generated from any of its elements using appropriate orthogonal transformations. We also prove corresponding results for harmonic maps.

If you are interested you can find out more about my research here:

https://www.researchgate.net/ profile/Valeriy_Slastikov

https://scholar.google.co.uk/ citations?user=xx2qkLUAAAAJ& hl=en

MODELS OF BIPOLAR CHOICE OF A REFLEXIVE PERSON WITH HIGH-ORDER REFLECTION

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The founder of the mathematical theory of reflection V. Lefebvre proposed and investigated models of bipolar choice for a subject with first and second rank reflexion, both for Boolean variables and for continuous ones [1, 2]. He also indicated a method for constructing models of arbitrary rank by iterating the first-order reflection equation, but there are no corresponding formulas in known publications. The report presents such formulas as a disjunctive form (for the Boolean model), and in the form of multilinear arithmetic expressions (for the probability model). The case of third-order reflection, including the emerging 4 models of choice, has been separately investigated, the solutions of the corresponding choice equations have been constructed and analyzed. A special role of third-order reflection in people's lives is described. Structural connections of the models of reflection at different levels are indicated, and the features of model reduction are described. A new interpretation of the first four reflexive variables, the corresponding choice equations and their solutions is proposed.

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COMPARISON THEOREM
FOR NEUTRAL STOCHASTIC DIFFERENTIAL EQUATIONS OF REACTION-DIFFUSION TYPE IN HILBERT SPACE $L_2(\mathbb{R}^d)$

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We have proved a comparison theorem for so-called mild solutions u_1 and u_2 to the following Cauchy problems for stochastic integro-differential equations with delay

$$d\left(u_i(t,x) + \int_{\mathbb{R}^d} b_i(t,x,u_i(t-r,\xi),\xi)d\xi\right) = \left(\sum_{i=1}^{d}\frac{\partial^2 u_i(t,x)}{\partial x_i^2} + f_i(t,u_i(t-r,x),x)\right)dt +$$

$$+\sigma(t,x)dW(t,x), \ 0 < t \leq T, \ x \in \mathbb{R}^d, \ r > 0, \ i \in \{1,2\},$$

$$u_i(t,x) = \phi_i(t,x), \ -r \leq t \leq 0, \ x \in \mathbb{R}^d, \ r > 0, \ i \in \{1,2\},$$

where W is $L_2(\mathbb{R}^d)$-valued Wiener process. According to our result, if $f_1 \geq f_2$, then $u_1 \geq u_2$ with probability one.
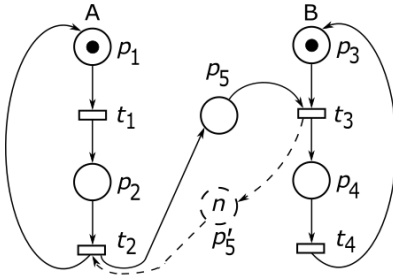
ON REGULAR EXPRESSIONS FOR PRODUCER/CONSUMER PETRI NET LANGUAGES WITH BOUNDED BUFFER

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Petri nets, introduced by C.A. Petri, are used in modeling, analysis and design of various systems, particularly ones with nondeterministic and asynchronous behaviour, parallelism (concurrency) features and conflicts [1]. The producer/consumer problem was proposed by Dijkstra (1968) as one of the synchronization problems, the versions with the unbounded buffer and the bounded buffer are described in the figure.

We consider the L-type Petri net language for the producer/consumer prob-

lem with the bounded buffer of size n. Namely, we associate symbols a_1, a_2, a_3, a_4 to transitions t_1, t_2, t_3, t_4 respectively and set the final marking equal to the initial marking μ_0. These formal languages in cases of $n = 1,2$ are shown [2] to be regular, corresponding regular expressions are presented. The following result is discussed: these languages for arbitrary n are also regular, corresponding regular expressions can be written in the recursive form. The star height (see [3] for more details) of mentioned regular expressions is calculated, thus the upper bound for the star height of Petri net language is obtained.

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STRATEGIC SUSTAINABLE ECONOMIC DEVELOPMENT FOR A COUNTRY AND AN ORGANIZATION: A COMPLEX SOCIETAL PROBLEM

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Finding a strategy for reaching a more sustainable economic development for an organization or an country is a complex societal problem. Complex societal problems belong to the field of Methodology of Societal Complexity. Complex societal problems should be handled based on the scientific ideas of the field of Methodology of Societal Complexity. In case of an organization the stakeholders should agree on a sustainable approach and in case of a country there should be a political basis to create a strategy for a more sustainable economic development. Seen from the view of the producer a more sustainable development is often more expensive than sustainable development. Seen from the view of the people a sustainable development is better for well-being and health. Finding out whether there is a possibility and a willingness for reaching a more strategic sustainable economic development is not an easy task to do. In a democratic setting this should be carefully explored with the use of the Compram methodology (DeTombe 1994; 2015).

Using the Compram methodology the contemporary situation and the future desired goals have to be analyzed, and it should be determined whether there is enough support to develop a more sustainable strategy in the organization or in a country. Therefore we have to know what is the nature of sustainable development, what is needed to reach sustainable development (knowledge), how to reach sustainable development (the strategy and the power), and how to implement the strategic plan based on mutual agreement.

This process can be explored by using the Compram methodology. The Compram methodology is developed to analyze, define, guide and evaluate the process of policy making on complex societal problems. The Compram Methodology starts with defining the problem based on cause-effect models (system dynamic models) built by experts of different disciplines related to the problem (knowledge), and then the same problem can be defined by the actors involved in the problem (power) and including the emotion the problem provokes. Based on the comparisons of these models of the problem the actors and experts discuss possibilities for interventions. By using the guidelines of the Compram Methodology

one can find causes of the complex problem and give directions for strategic changes towards a more sustainable economic development.

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PROBLEMS OF CLASSIFICATION AND NONLINEARITY

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The problem of resolution the nonlinear systems of equation may be represented as procedure of reduction from nonlinear to linear problem. This result may be represented as:

General Sato theorem [1]. Any nonlinear system of nonlinear integral-differential equations, that represents correctly problem of mathematical physics, may be reduced to system of linear algebraic equations. Moreover groups of monodromy of these two systems are coincided.

Presently we'll go to classifications. The problem of reduction may be expanded on classification. A classification may be used on various stages of resolution the proper problems. So, this concept was used for the creation two basic concepts of Relaxed Optics: phenomenological energy-kinetic and electromagnetic (based on Pointing tensor series) classifications of processes the light-matter interaction [2]. For more general sense for the using the classification we must use polymetric analysis (classification of knowledge by step of its complexity) [1, 3]. It allows to receive the more general representation of reduction: from more complex to more simple systems in both directions [1, 3].

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EXISTENCE OF PERIODIC SOLUTIONS FOR A DIFFERENTIAL EQUATION MODELLING OPTICAL CONVEYOR BELTS

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The dynamic of particles in an axial optical conveyor belt can be modeled by the differential equation:

$$z' = \frac{\partial V(t,z)}{\partial z}, \tag{1}$$

where

$$V(t,z) = F_0 f(z) \cos\left(kz - \frac{bt}{2}\right)^2, \quad F_0, k, b > 0. \tag{2}$$

We prove the existence of periodic solutions for the nonautonomous equation (1) in the following particular cases:

- Lorentzian axial region strength: $f(z) = \dfrac{1}{1+(z/z_0)^2}$, $z_0 > 0$.

- Gaussian axial region strength $f(z) = \exp\left(-2\dfrac{z^2}{z_0^2}\right)$, $z_0 > 0$.

INFORMATION REDUCTION IN A REVERBERATORY NEURONAL NETWORK THROUGH CONVERGENCE TO COMPLEX OSCILLATORY FIRING PATTERNS

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In the inferior temporal cortex (IT), some neurons are selective to objects based on their complex form. Response of those neurons does not depend on the size of the object the neuron is tuned to. Also, it is invariant with respect to view angle, location in the scene, presence of distractors. We offer here a possible physical mechanism of the invariance observed. For this purpose, we perform numerical simulation of spiking neural network. The network is initially stimulated with different stimuli from a definite set and then goes freely. For each stimulus, in the course of free evolution, activity either dies out completely or the network converges to a periodic trajectory demonstrating a complex pattern of spatio-temporal activity. After applying each stimulus from the set, 102 different periodic end-states are found. The conclusion is made, after analyzing the trajectories, that neuronal firing is the necessary prerequisite for merging different trajectories into a single one, which eventually transforms into a periodic regime. Observed phenomena of self-organization in the time domain are discussed as a possible model for processes taking place during perception in the IT. The repetitive firing in the periodic regimes could underpin memory formation.

STATISTICS OF NEURONS WITH DELAYED FEEDBACK

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Biological neural networks in the brain are reverberating and neurons in them exchange with electrical impulses (spikes). Due to axonal and synaptic delayes, the interneuronal communication is delayed. There are experimental evidences that activity of bilogical neurons is random. We study the statistics of interspike intervals (ISI) for the simplest possible case of such a network a single neuron with delayed feedback. We put a question: how the presence of the delayed feedback affects the statistics?

To answer to this question, we consider several classes of neuronal models with delayed feedback, namely, excitatory neurons with delayed feedback and neurons with fast inhibitory feedback, which are fed with Poisson stream of impulses. We have derived general relations which allow calculating exactly the probability density function (pdf) $p(t)$ of output ISI of a neuron with feedback based on known pdf $p^0(t)$ for the same neuron without feedback, and on the properties of the feedback line. The course of $p(t)$ in considered cases has a pronounced peculiarity, which makes it impossible to approximate $p(t)$ by Poisson or other simple stochastic process. Also, it is shown that output statistics of a neuron with delayed feedback is non-Markov.

TOWARDS THE PROOF OF STABILITY OF SOLITON-LIKE SOLUTIONS TO A NONLOCAL HYDRODYNAMIC MODEL

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It is shown in [1] that for the specific values of the parameters the soliton-like travelling wave solutions of the hydrodynamic-type system

$$u_1 + \partial_x \frac{1}{v+2}(\beta + \sigma \cdot \partial_x^2)\rho^{v+2} = 0, \ \rho_t + \rho^2 u_x = 0 \qquad (1)$$

are spectrally stable [2]. Recently it was realized that transformation $\rho = \eta^{-1}$, $u = \frac{1}{v+2}(\beta + \sigma \cdot \partial_x^2)w$, which is invertible when $\beta \sigma < 0$, leads to the the Hamiltonian system

$$\partial_t \begin{pmatrix} w \\ \eta \end{pmatrix} = \partial_x \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \delta H,$$

where

$$H = \int \left\{ \frac{1}{2(v+2)} [\beta w^2 - \sigma w_x^2] + \frac{1}{v+1} \left[\frac{1}{\eta^{(v+1)}} - \frac{1}{\eta_\infty^{(v+1)}} \right] \right\} dx$$

$$\eta_\infty = \lim_{|x| \to \infty} \eta(t, x)$$

The analysis of the stability of solution-like solutions to (1) reduces to the study of the spectrum of the operator

$$L = \partial_x \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \delta^2 (H + sQ), \ Q = \int w(x)(\eta(x) - \eta_\infty) dx$$

Solution is considered to be stable if $\sigma(L)$ has empty intersection with the right half-plane $\mathbf{C}^+$. It is shown that the operator L has no more than one eigenvalue in the right half-plane $\mathbf{C}^+$, and if such a value λ_0 does exist, then it lies on $\mathbf{R}^+$. Studies enabling to confirm or exclude the existence of $\lambda_0 > 0$ are based on the analysis of the behavior of the Evans function $D(\lambda)$ [2] at zero and its asymptotics on $+\infty$, [3].

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AS SYSTEM-DYNAMICS APPROACH TO IDENTIFY THE FACTORS INFLUENCING THE QUALITY OF PRIMARY EDUCATION IN DEVELOPING COUNTRIES

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The system dynamics approach is a holistic way of solving problems in real-time scenarios. This is a powerful methodology and computer simulation modeling technique for framing, analyzing, and discussing complex issues and problems. System dynamics modeling and simulation is often the background of a systemic thinking approach and has become a management and organizational development paradigm. In this paper, we present our experiences and thoughts on developing system thinking models to understand the important factors such as Facilities (includes infrastructure), Local and national political stability, Family migration from rural to urban localities, and socio-economic status of the families on the quality of primary education system in developing nations. This paper provides a high level view on the factors which need to be addressed for providing sustainable education experience to children living in developing nations. In this presentation, we discuss the situations in India, making an application of our method on data from the state of Gujarat, in Turkey and in Indonesia.

NECESSARY EXTREMUM CONDITIONS FOR DIFFERENTIAL INCLUSIONS WITH MEMORY AND FUNCTIONAL VIABILITY

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An optimization problem with a constraint in a form of differential inclusion with memory which is a multivalued variant of a functional differential equation is studied. Such problems arise when studying systems with prehistory. Among them are planning problems in economics, evolutionary problems in biology, control theory problems where the right-hand side of the system is a set of possible velocities of the system depending upon the past history represented by some function and upon control from a set of controls. The result is necessary extremum conditions for the problem at the fixed time interval on the minimum of a functional specified at the right end, with constraints at the left end of the trajectory of differential inclusion with aftereffect.

Functional viability means viability constrains which also depend upon the history of the evolution of the state of the system, or even, when the constraints act not only on the state of the system, but on its past evolution. The techniques devised for the usual viability problems for differential inclusions adapt to functional viability problems for differential inclusions with memory.

Differential inclusion with memory describes the link between the velocity $\dot{x}(t)$ and the history $T(t)x$ up to time t through a set-valued map: $\dot{x}(t) \in a(T(t)x)$ for almost $t \in [0, +\infty)$, where $T(t)x(\tau) = x(t + \tau)$, $\tau \in (-\infty, 0]$.

The initial condition is $T(0)x = \varphi$, the viability constraints are $T(t)x \in K$, $t \in [0, +\infty)$, φ — given function, K — given closed subset of state evolutions.

SPACE WEATHER PREDICTION MODELS: COMPARATIVE ANALYSIS AND NUMERICAL RESULTS

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Space Research Institute of NASU-SSAU is now using forecast models that substantially improves predictions of space weather impacts on satellite devices. Better forecasts offer additional protection for people and the technology-based infrastructure we use daily. Explosions in the sun's outer atmosphere – tracked and forecast by SRI scientists – can cause geomagnetic and solar radiation storms at Earth that can impede the operation of electrical power grids, interfere with the normal function of Global Positioning Systems and temporarily hamper radio and satellite telecommunications. Grid and satellite operators and airlines can take protective measures when stormy conditions are forecast. This advanced model has strengthened forecasters' understanding of what happens between Earth and the sun following a solar disturbance. It will help power grid and communications technology managers know what to expect so they can protect infrastructure and the public.

This report also focuses on predictive and risk assessment methods which can be used to model hydroclimatic extremes. This report starts with the physical basis and a brief description of the system identification approach. Following that, several examples illustrate practical issues in temporal and spatiotemporal prediction, NARMAX and bilinear modeling. This report concerns improvement and new development of models based on data driven modeling, such as BILINEAR and NARMAX The following methods and models have been proposed: (a) dynamical-information approach to NARMAX system identification; (b) combination of NARMAX model and Lyapunov dimension; (c) guaranteed prediction; (d) robust models; (e) risk assessment in safety analysis. This **research was supported by** European project "Progress".

MODELING AND OPTIMIZATION CRYOGENIC-OPTICAL GRAVIMETER: PRINCIPLES, METHODS, AND APPLICATIONS

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This report focuses on the problem of designing and developing optical-cryogenic devices using new physical principles, mathematical methods, and new superconducting materials. The sensor element is based on new controlled magnetic levitation phenomenon, high-precision optical registration of mechanical coordinates of levitating body, and the robust signal processing tools. A controlled self-bearing probe dynamics is also analyzed. We have shown how to produce reliable YBCO thin films with controllable surfaces and physical properties and how to integrate them in a ring form into the optical-cryogenic gravimeter so as to reduce its size and render it convenient for future space applications. This report also focuses on modeling and optimization problems. This report starts with the physical basis and a brief description of the system identification approach. Following that, several examples illustrate practical issues in temporal and spatiotemporal prediction, NARMAX and bilinear modeling. This report concerns improvement and new development of models based on data driven modelling, such as BILINEAR and NARMAX The following methods and models have been proposed: (a) dynamical-information approach to NARMAX system identification; (b) combination of NARMAX model and Lyapunov dimension; (c) guaranteed prediction; (d) robust models; (e) risk assessment in safety analysis.

QUALITATIVE AND QUANTITATIVE ANALYSIS OF NONLINEAR SYSTEMS

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We present modern methods of analysis for nonlinear systems which may occur in fields such as physics, chemistry, biology, economics etc. We concentrate on the following topics, specific for such systems:

(a) constructive existence results and regularity theorems for all weak solutions;

(b) convergence results for solutions and their approximations;

(c) uniform global behavior of solutions in time;

(d) pointwise behavior of solutions for autonomous problems with possible gaps by the phase variables.

The general methodology for the investigation of dissipative dynamical systems with several applications including nonlinear parabolic equations of divergent form, nonlinear stochastic equations of parabolic type, unilateral problems, nonlinear PDEs on Riemannian manifolds with or without boundary, contact problems as well as particular examples is established. The presented results published in [1].

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COMPUTER AND NUMERICAL INVESTIGATION OF REGULAR AND CHAOTIC DYNAMICS OF ONE NON-LINEAR SYSTEM

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In this paper, the mathematical model of a nonlinear finance chaotic system showing the complicated regular and chaotic behavior is investigated. Based on Lyapunov function, definitions of globally exponentially attractive set and positive invariant are introduced. Theorems of the existence of the globally exponentially attractive set and positive invariant, of periodic solutions, of Poincare–Andronov–Hopf bifurcation existence and theorems in the field of control of attractors are formulated and proved. Controls of deterministic chaos which transform the system from the chaotic regime to the regular were found in the last theorem. It was also found controls for slave system in general form in which it was is fully synchronized with master system. Information technology and an automated multi-threaded system were offered and developed by the author for the numerical investigation of nonlinear dynamical systems given by differential equations of the first order. Based on a complex numerical investigation, the map of dynamic regimes was built for the first time depending on the bifurcation parameter. Bifurcating trees of the nonlinear system were also built. Using bifurcating trees all the main scenarios of the transition to deterministic chaos (Feigenbaum scenario, the scenario of Ruelle-Takens and Pomo-Mannevil scenario) were identified.

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