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ABSTRACTS

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The book contains abstracts of the participants of the International Conference "Computational and Informational Technologies in Science, Engineering and Education". The proceeding of the Conference will be beneficial for specialists in the field of Mathematics and its applications, as well as for students, undergraduates, doctoral students majoring Computational and Informational Technologies.

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Dedicated to the bright memory of the Kazakh outstanding scientist, doctor of physical and mathematical sciences, professor, laureate of the State Prize of the Republic of Kazakhstan in science and technology Nargozy Tursinbaevich Danaev, the specialist of computational hydrodynamics, who made a great contribution into the development of mathematics in Kazakhstan, talented organizer and teacher.

Preface

International Scientific and Practical Conference "Computational and Information Technologies in Science, Engineering and Education" has a long and rich tradition and has been regularly held since 2002.

Historically, the conference was organized in close cooperation between Russian and Kazakh scientists and the general area of discussion was the most advanced achievements in the field of computational technology.

Later it expanded the geography of the conference and now it is attended by leading scientists from Europe, the USA, Japan, India, Turkey, etc.

The purpose of the conference is dissemination of new knowledge and scientific advances among the participants. A special feature of this conference is to involve young scientists and an assessment of their scientific achievements through the interaction of the leading scientific schools of the two countries. Participating in the CITech formed a whole galaxy of a new generation of young scientists that are currently conducting serious research work.

In different years CITech was held in Almaty (2002, 2004, 2008, 2015), Pavlodar (2006) and Ust-Kamenogorsk (2003, 2013). Personal friendship of scientists from the Novosibirsk Scientific school with prof. Smagulov Sh., Danaev N., Shokin Yu., Monakhov N., Zhumagulov B. and many others has played an important role in the formation of stable traditions for organizing and conducting CITech. Unfortunately, some of them are no longer among us, but we will always remember their contribution to science and education and keep their unforgettable image in our hearts.

The proceeding of the Conference will be beneficial for specialists in the field of Mathematics and its applications, as well as for students, undergraduates, doctoral students majoring Computational and Informational Technologies.

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PLENARY TALKS

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Information system for oil recovery analysis

Now are known a lot of studies and computer programs which investigated oil recovery processes (UTCHEM, ECLIPSE, GPAS, STARS). But it are realized computer modeling based on knowledge sets (features, behavior, state and etc.) of well-known oil-recovery technology in oil industry. Our article addresses about modernization of the information system for oil recovery analysis (ISAR-2) and its deployment carried out in between 2005-2015. ISAR-2 includes following software modules: distributed databases that store geo-physical and physic-hydro dynamical properties of the fluids/stratum; databases of mathematical and engineering models for two and three phases fluids flow in anisotropic and nonuniform porous media; interactive web visualization of computing results in 2D-3D via Internet connection; high-performance computing models for supercomputer and mobile platform execution. ISAR-2 functionality can easily be extended by adding new models of technological oil recovery, and has quick access to the hydrodynamics simulator capabilities using built-in authorization.

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Intel software for solving research and industrial problems: Modern trends of high performance computing

Hardware technologies in High Performance Computing are continuously undergoing major changes and rapidly increasing performance capabilities, but the software and the underlying code legacy is often left unchanged or even neglected. This leads to performance gaps and underutilized hardware assets. The talk is devoted to Intel programming techniques and software tools required to achieve the highest performance on systems built on the current and future generations of IntelB® processors, including coprocessors IntelB® Xeon Phi в„ў. We will consider the latest Intel software tools - Intel®Parallel Studio XE 2016 (which include optimized compilers, math libraries and tools for optimization and parallelization of programs) and examples (success stories) of Intel software usage for solving industrial and research problems. We will also discuss Intel University/Academic programs.

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Technologies of heterogeneous programming systems integration in the informational computing environment of mathematical modeling and data analysis

The solution of complex high-technology tasks in general requires usage of distributed programming systems realized on completely different programming platforms. For instance, the problem of modeling of the atmosphere pollution spread in inhabited localities is one of those problems.

The informational computing environment of mathematical modeling and data analysis [1] is being developed in the ISDCT SB RAS. The environment is based on web technologies and provides the subsystem of data storage and the set of data analysis WPS-services [1] for user. Any WPS-based service can be integrated in the system by registering it in the environment's services catalog. Certain technologies, based on existing programming systems and that make the implementation of WPS-services easier, were developed:

- the technology of WPS-services creation that is based on cloud computing technologies, that provides virtual machines in cloud infrastructure with the set of preinstalled software that allows easy implementation of different programming systems as WPS-services;
- the technology of WPS-service creation based on computing cluster that allows to access programming systems of computing clusters.

Following services were developed using the mentioned above technologies: service of the remote sensing earth data decryption using the method of support vectors on the computing cluster, service of operational prediction of air pollution, soil and water resources from the controlled explosions at the coil mining enterprises, service of the noise spread calculations from industrial explosion, service of SRTM data processing e t c.

Solution of complex tasks also requires non-trivial application of distributed WPS- services that can involve parameter processing, WPS-services calls in iterations, conditional actions depending on intermediate result e t c. In order to realize the complex logic of WPS-services invocations through the creation of WPS-scenarios, the extension for JavaScript language was developed. The interpreter of WPS-scenarios allows the asynchronous services execution.

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Nonsmooth Numercis via Piecewise Linearization

Background: Algorithmic or Automatic Differentiation [1, 3] has facilitated the calculation of derivatives between input and output variables on a wide variety of computational models, including very large engineering codes. On the other hand, there has been a growing theoretical interest in nonsmooth analysis, since many models from economics, mechanics, chemical engineering, biology, and other application fields of scientific computing are not everywhere differentiable. For the most part, the resulting generalized derivative concepts are difficult to communicate to practitioners, rather hard to implement and not easy to exploit in the corresponding algorithms. We explore ways of bridging this gap, mainly by generalizing the concept of local linearization, which lies at the heart of many iterative methods, to the natural extension of local piecewise linearization (PL) for piecewise smooth problems. This approach leads to algorithmic piecewise differentiation (APD). yielding more general local models reflect essential characteristics of nonsmooth problems. They can be utilized for solving the classical computation tasks of equation solving, optimization, and the numerical integration of differential equations.

Effects of nonsmoothness: The design of most numerical methods relies on sufficient smoothness of the problem functions and they may malfunction when this assumption is not met. The mildest form of degradation is a loss of convergence speed or solution accuracy, which can also happen for smooth problems when certain non-singularity or other non-degeneracy conditions are violated. Moreover, stopping criteria based implicitly on smoothness assumptions will typically not work, leading to premature or (possibly indefinitely) delayed termination. A more serious malfunction is convergence failure even from within small neighbourhoods of solution points, e.g., roots of equations or minimizers of objectives. Probably, the most serious kind of malfunction is convergence to a point that is not a solution of the kind sought by the numerical method in question. There is a seminal example of Hirriart-Urruty and Lemaréchal where the steepest descent minimizer with an exact line-search converges from an open set of initial points and in a numerically stable manner to a point at which the convex and piecewise linear objective is not even stationary. Such spurious solutions may be hard to detect and cost a large number of fruitless function and derivative evaluations, plus method specific linear algebra calculations.

Levels of Nonsmoothness: We distinguish several levels of nonsmoothness that are caused by various constructs in the evaluation procedure. The lowest Level 0 describes the ideal situation where there is a straightline code involving only smooth elemental functions. Then standard algorithmic differentiation yields continuous derivatives that can be utilized in classical numerical methods. In many practical codes nonsmoothness in the form of kinks arises through the computation of absolute values and binary minimum and maximum functions. These piecewise linear and continuous elements render the overall evaluation routine Lipschitz continuous and piecewise differentiable, which we will refer to as Level 1 nonsmoothness, which was already considered in [2]. Then piecewise differentiation can be performed by a minor extension of existing algorithmic differentiation tools. They yield piecewise linear approximations that are globally defined and have locally an error of second order in the distance from the development point [4]. Level 1 functions are piecewise smooth as defined for example by Scholtes. This property is lost in Level 2 evaluation procedures that involve also the Euclidean norm. They are no longer piecewise smooth but still Lipschitz continuous and their approximation errors of their piecewise linearisations are direction dependent. Continuity is typically lost altogether through conditional assignments and general program branches. In this most general Level 3 scenario we can still generate piecewise linear approximations but they are naturally discontinuous. As we will see, one can cope with nonsmoothness up to Level 1 in optimization, up to Level 2 in equation solving and must face Level 3 in the numerical integration of dynamical systems.

State of the Art: The piecewise linearization of Level 1 functions yields piecewise linear models in the so called abs-normal form. It can be used to formulate and solve piecewise linear equations by a large variety of known and some new methods as described in [6]. So far there has been no numerical comparison of the methods, some of which have not even been carefully implemented. Successive piecewise linearization yields Newton-like quadratic convergence under nondegeneracy assumptions that are still under investigation. Some PL solvers have been used as inner loop in solving time discretizations of ODEs with Lipschitzian right hand sides [5]. The drop of the convergence order suffered by classical ODE discretizations like the midpoint and the trapezoidal rule in the presence of nonsmoothness of the right hand side can be avoided at least in the Level 1 case by generalization based on piecewise linearization. They maintain a local truncation error of order 3 and thus a proper global convergence order of 2. Moreover, their Richardson extrapolation appears to yield convergence order 4 under suitable assumptions. These rates have been observed numerically but still need to be confirmed theoretically. Moreover, on Hamiltonian systems the energy is conserved to a very high accuracy. The most dramatic improvements based on piecewise linearization have been achieved in unconstrained optimization [7]. Here again the philosophy is to deal with the combinatorial nature of nonsmoothness at the level of the local piecewise linearization, where it can be sorted out in principle, albeit with a possibly exponential complexity as in the Klee-Minty example. The grey-box information obtained by piecewise linearization yields largely superior performance compared to variations of BFGS and established bundle methods.

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Modeling and Simulation of Fluid Flow and Mixing in Micro Channels Using Immersed Boundary Method

1. Immersed Boundary Method (IBM)

Fluids flows in complex geometries are very common in engineering problems, and the major difficulty arise in how to represent the body, its moving walls and its interaction with the fluid. The most usual approach is using Neumann and Dirichlet boundary conditions to represent the body geometry. Therefore, if the geometry is complex ones have a hard and, probably, a difficult work. This difficulty grows up if the body has a poignant and deformable geometry. In short, treating the coupling of the structure deformations and the fluid flow poses a number of challenging problems for numerical simulations. Both the unstructured grid method and IBM are used for simulating flow with complex geometries. The term "immersed boundary method" was first appeared in literature in reference to a method developed by Charles S Peskin [1] in 1972. A force term added to the Navier-Stokes equation is in charge to promote the interaction between fluid-solid interactions. The distinguished feature of this method was that, the entire simulation was carried out on a Cartesian grid, which did not conform to the geometry of the heart. Hence, a novel procedure was simulated for imposing the effect of the immersed boundary (IB) on the flow. A review about Immersed Boundary Methods (IBM) encompassing all variants is cited by Mittal and Iaccarino [2]. Feedback forcing method is applied to represent a solid body by Goldstein et al.

[3] which induced spurious oscillations and restricted the computational time step associated with numerical stability.

2. Backward Facing Step Flows

The study of backward-facing step flows constitutes an important branch of fundamental fluid mechanics. Flow geometry of the same is very significant for investigating separated flows. This flow is of particular interest because it facilitates the study of the reattachment process by minimizing the effect of the separation process, while for other separating and reattaching flow geometries there may be a stronger interaction between the two [4]. The phenomenon of flow separation is a problem of great importance for fundamental and industrial reasons. For instance it often corresponds to drastic losses in aerodynamic performances of airfoils or automotive vehicles. The research in such a flow was escalated with the experimental and numerical work of Armaly et al. [5].

3. Channel Flows with Obstructions

Many reports are available regarding unsteady, two-dimensional flow of incompressible viscous fluid through the obstructed channel being studied by IBM. The obstruction is either in the form of a rectangular step or a triangular step. This type of geometry appears frequently in engineering situations, particularly with heat transfer applications as elaborated in Kays [6]. Meisel and Ehrhard [7] studied about rectangular and triangular internal obstacles provided in micro-channels which excite secondary flows to greatly enhance the mixing of two liquids flowing in a layered fashion through these micro-channels. The main aim of this attempt is not only to establish IBM as an alternative CFD technique to mimic boundaries but also to explore all the aspects of the flow behaviour in the obstructed channel, especially to focus on separation near the obstruction and rate of development of eddies, with the change of Reynolds number, which is very much relevant in engineering flows.

4. Results and Discussions

Immersed-boundary method is adopted to validate a relevant fluid mechanics bench mark problem, the backward facing step flow problem and is extended to conduct numerical experimentation of flow through channels with two geometrical obstructions viz rectangular step and triangular step. The present algorithm is ideally suited to low Reynolds number flows also. Predictions from the numerical model have been compared against experimental data of different Reynolds numbers of flow past backward-facing step geometries. In addition, computed reattachment and separation lengths have been compared against alternative numerical predictions. The immersed boundary method with both the momentum forcing and mass source/sink is found to gives realistic velocity profiles and recirculation eddies both upstream and downstream of the studied obstructions demonstrating the accuracy of the method. Generally for all obstructions, the velocities are very small in the recirculation zone compared to the velocity of the mean flow. Hence the separation surface is submitted to a strong shear.

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Numerical simulations of multiphase flows

Multiphase flows are present in many environmental and industrial problems, from rain to river erosion, or from spray in combustion to inkjet printing to cite well known examples. These problems lead to complex dynamics involving in particular important surface deformation. Here we will focus on the iconic problem of multiphase flows, the impact of a droplet on a solid surface or a thin liquid film [1]. When a drop impact a surface (solid or thin liquid) it deforms due to the high pressure field created by the impact and depending on the impact paraeters, it can spread or splash and even bounce on the surface [2].

Although this problem has been studied in many different configurations, an overall understanding of the dynamical mechanism of drop impact is still lacking. In particular, the transition between spreading and splashing remains difficult to handle beside the classical arguments. High speed impact and small viscosity are in favor of splashing while high viscosity and small impact velocity lead usually to spreading. The difficulty to provide a detailed understanding of the splashing mechanism comes from the thin and rapid sheets involved in the dynamics. Recently, the surrounding gas pressure has been shown to be crucial for splashing in some conditions [3]. There, lowering the surrounding gas pressure suppresses the splashing.

Up to now, no crystal clear mechanism has been identified to explain this striking effect [4, 5, 6]. In particular, it has been exhibited that a small gas bubble is entrapped beneath the drop at impact due to the lubrication effect and it was initially suggested that this entrapment can be the precursor of the splashing. However, it can be shown that incompressible lubrication effect cannot explain

the splashing-spreading transition in this case and that additionnal mechanisms have to be taken into account.

In my talk, I will present the last theories developed to understand the splashing dependance on the gas pressure, thanks to highly detailed numerical simulation using different numerical techniques for multiphase flows [5, 7].

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The size of the domain of measurements is the regularization parameter in continuation problem

The Cauchy problem for Laplace equation arises from many physical and engineering problems such as nondestructive testing techniques, geophysics and cardiology. The Cauchy problem is known example of ill-posed problem in the sense that a small change in the data can lead to dramatic change of the solution [1, 4]. Under an additional a priori boundedness condition, a continuous dependence of the solution on the Cauchy data can be obtained. This is called conditional stability [4].

We consider the Cauchy problem for the Laplace equation (continuation problem):

$$u_{zz} + u_{yy} = 0, \qquad z \in (0, h), \quad y \in (-L, L) \tag{1}$$

$$u_z(0, y) = g(y), \quad u(0, y) = f(y), \qquad y \in (-L, L). \tag{2}$$

We employ the gradient method to minimize misfit function [2, 3, 5, 6], which is a regularizing procedure for the stable determination of the solution. In each iteration step, mixed boundary value problems are solved. We show that the size of the domain of measurements is the regularization parameter. The more information contain the inverse problem data the more stable is the solution. Numerical results are presented and discussed.

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Macroscopic Mathematical Models of Physical Processes in Porous Media via Microstructure

Mathematical models of physical processes play important rule in oil, gas and mining industries. There are different types of such models, but all of these macroscopic models do not take into account the peculiarities of processes at the microscopic (pore) level. The particular qualities of the process just postulates at the macroscopic level. That is why all these models involve a lot of phenomenological functions and constants, which obviously cannot be determined uniquely. Our approach is based upon on the commonly accepted classical continuum mechanics at the pore level and rigorous homogenization technique.

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Optimization of the Internet search based on laws of information theory and psychology

1. Introduction

We consider the following problem which is typical for e- learning and many other applications [2, 5]. Namely, there are N objects (say, words) and one of them should be chosen by a consumer. For example, the words can be names of airports and the consumer should choose one in order to by a ticket (through a website of a company). An other example is a search of a book in an Internet shop, etc. Suppose that we know the likelihood that a certain word will be chosen. For example, let there be names of 16 airports $\{a_1, a_2, ...a_{16}\}$ and a customer is going to choose one of them. Also suppose that the frequency of occurrence of different airports are as follows: $p(a_1) = 0.85$, $p(a_2) = p(a_3) = ... = p(a_{16}) = 0.01$. What is an optimal partition of the words between different screens? For example, we can put all 16 words on one screen. The other possibility is to share words in two screens putting the word a_1 on the first screen and the other 15 on the second one. If the customer does not find the word on the first screen, he looks at the second one (for it he can push the button "next"). What is better? And how can we understand what version better?

This problem has attracted attention of many researchers and nowadays there are some methods intended to reduce the time search; see [2, 1, 8, 2].

Our approach will be based on a so-called Hick's Law [6], which can be described as follows:

"There are n equally probable stimuli. The subject responds as quickly as possible with a different response depending on the stimulus. Hick fitted his own data and some historic data to the equation

$$\hat{t} = c \log_2(n+1)\,, \tag{1}$$

where t is mean choice-reaction times, c is a constant and the possibility of "no signal" was regarded as an $(n+1)$th alternative."

In our case the words are the stimulus and a choice of one of them is the response. Let us come back to our previous example with 16 words and two possible partitions. If all 16 words are put on one screen, the time of the choice (t_1) is $t_1 = 4c$, whereas for the second case $t_2 = 0.85c \log_2 2 + 0.15c \log_2 16 = 0.85c + 0.6c = 0.75c$. So, we can see that the average time is significantly less for the second case.

Our goal is to find an approach and methods for problem of optimization of average time for the problem of information search. For this purpose we will use, on the one hand, the Hick's Low and, on the other hand, a so-called alphabetical code (see, for ex., [3]).

2. The statement of the problem and main results

Let there be a set of words $A = \{a_1, a_2, ...a_N\}$, $N > 1$, with probabilities $p(a_1), ..., p(a_N)$. The set can be partitioned on disjoint subsets $A_1, A_2, ..., A_k$. One looks for a word from the set A in such a way that first he looks at the screen with words from the subset A_1. If the needed word is found he finishes a search. Otherwise, he, say, pushes the button "next" and begins to look for the word on the second screen, and so on. If we denote

$$P(A_i) = \sum_{a \in A_i} p(a_i)$$

then, according to the Hick's Law, the average time of search is given as follows:

$$\hat{t} = c \sum_{i=1}^{k} (P(A_i)) \sum_{j=1}^{i} \log_2(|A_j| + 1)\,. \tag{2}$$

So, more precisely the goal is to find the partition $A_1, A_2, ..., A_k$ for which $\hat{t}$ in (2) is minimal.

First we note that if a partition $\hat{A} = A_1, A_2, ..., A_k$ has a minimal average time (2), then the following obvious claim is valid:

Claim 1. For any partition

$$\hat{t} = c \sum_{i=1}^{k} \log_2(|A_i| + 1) \sum_{j=i}^{k} (\sum_{a \in A_j} p(a))\,. \tag{3}$$

If the partition $\hat{A}$ is optimal and $a_i \in A_k$, $a_j \in A_m$, $k < m$, then $p(a_i) \geq p(a_j)$.

From this claim we can see that if a part of partition $\hat{A}$ is optimal, then any subset $A_i, A_{i+1}, ..., A_{i+l}$ is optimal for a corresponding conditional distribution of probabilities. Based on this observation we can obtain the following:

Claim 2. There exists an algorithm for obtaining the optimal partition whose complexity is $O(N^3)$ operations for any set of N words (objects) with a certain probability distribution.

This algorithm is obtained by a so-called dynamic programming, see, for example, [1].

Now we consider a problem of obtaining a partition (or menu) whose search time is close to minimal. The following theorem shows that the partition built by the alphabetical code is close to optimal.

Theorem. *Let there be a set of words $A = \{a_1, a_2, ...a_N\}$, $N > 1$, with probabilities distribution $p(a_1), ..., p(a_N)$. The average time of search obtained by the alphabetical code is less than $cH + constant$, where H is the Shannon entropy: $H = \sum_{i=1}^{n} p(a_i) \log p(a_i)$. On the othe hand for any partition the average time of search is not less than cH .*

So, we can see that the alphabetical code gives the partition (menu) which is close to optimal.

We applied the described method to a system of railway ticketing for Russian railways. The obtained results show that the suggested method sufficiently reduced the search time.

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Quantum Computing and Its Potential for Turbulence Simulations

A tutorial is provided of quantum computing (QC) and the way it has made significant speed-up in various simulations. A review will also be provided of the large eddy simulation (LES) of turbulent flows via the stochastic filtered density function (FDF) methodology. The potentials of the quantum speed-up in FDF simulation via QC appear to be significant. This can results to a revolutionary means by which turbulence simulations can be conducted in future.

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Modeling of Absorption and Transfer of Radiation in an Expanding Sphere

We have studied absorption of external continuum radiation in a self-similarly expanding spherical gaseous medium featuring a velocity gradient. The frequency dependence of absorption of radiation propagating along the diameter is shaped as a plateau with the width $\Delta\omega \simeq 2\alpha$, where α is defined as the ratio of the expansion velocity at the sphere boundary to the thermal velocity of atoms. This particular shape of the spectrum is due to the fact that the centre of the absorption curve at each point of the medium is frequency-shifted because of macroscopic gas movement induced by expansion, and the number of absorbing atoms is the same at each frequency. The red wing refers to absorption of gas atoms flying to meet the radiation while the blue wing is formed by atoms flying along with the radiation propagation. Absorption decreases with growing α until the medium becomes optically thin as $\alpha \gg \tau_0$ (τ_0 is the optical thickness of the medium when there is no expansion). The absorption spectrum curve integrated over the sphere surface maintains its width $\Delta\omega$ but is no longer shaped as a plateau because the frequency of the absorption linewidth grows smaller for shorter chord lengths. The integral absorption probability (absorption growth curves) increases with α due to the growing absorption linewidth $\Delta\omega$. When $\alpha \gg \tau_0$, radiation absorption along the chords as well as integrally over the entire surface grows proportionate to τ_0, which is attributed to the effect of optical thinning of the expanding medium.

The predicted phenomenon that is associated with optical thinning of the medium and increased absorption spectrum width of continuum radiation in expanding media should be taken into consideration when dealing with radiation kinetics in artificial formations and planetary nebulas, optical diagnostics and laser cooling in ultracold plasma and in other laboratory and astrophysical expanding media.

We have shown that the scattered "forward" radiation is shifted to the "red" spectral wing, and the scattered “backward” radiation is shifted to the "blue" wing in the presence of expansion. With the increase in velocity of expansion the medium’s bleaching appears for the scattered radiation. The line shape of the scattered "forward" radiation and the line shape of the scattered "backward" radiation both gave the symmetric spectral view. Bleaching of the medium forms a more symmetric distribution of the excited atomic concentration in space in respect to the centre of the sphere.

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Численное и экспериментальное исследование размыва грунта у основания платформ гравитационного типа [1]

В настоящее время происходит активное освоение прибрежной мелководной части морей для добычи нефти и газа. Для этого используются платформы гравитационного типа, которые ставятся непосредственно на дно водоёма. При использовании платформ такого типа одной из основных задач при их проектировании является обеспечение её устойчивости. Потеря устойчивости может происходить из-за размыва грунта у её основания под действием имеющегося или появляющегося во время шторма течения вблизи дна, на котором стоит платформа. Размеры морских платформ (например, платформа «Приразломная» – в плане является квадратом со стороной 120 м и стоящая на глубине 20 м) не позволяют проводить натурные эксперименты. Проведение лабораторных экспериментов в некотором масштабе позволяет изучить процесс размыва, однако масштабирование может привносить погрешности. Например, затруднено существенное уменьшение частиц грунта, необходимо согласование чисел Фруда и Рейнольдса и т.д. Более универсальным методом моделирования является численное моделирование, т.к. оно позволяет учесть практически все параметры, входящие в изучаемое явление. Однако используемая математическая модель нуждается в верификации. Таким образом, для того чтобы получить достоверные результаты исследования реального явления необходимо совместное применение обоих методов: численное моделирование и лабораторные эксперименты. Сочетание обоих методов позволяет обобщить результаты и избежать недостатков каждого из них.

В настоящем докладе представлен процесс численного моделирования влияния течения и поверхностных волн на размыв грунта у основания модели морской платформы «Приразломная» и сравнение полученных решений с результатами лабораторных экспериментов проведённых в и Исследования проводились для платформы гравитационного типа с основанием в гидродинамическом бассейне 23-го Государственного Морского Проектного Института (г. Санкт-Петербург, Россия). Для численного расчета течений вблизи платформы была использована модель вязкой несжимаемой жидкости, которая описывается трехмерной системой нестационарных уравнений Навье-Стокса. Численное интегрирование системы уравнений Навье-стокса по времени было выполнено методом расщепления по физическим факторам . Для аппроксимации дифференциальных уравнений использовался метод конечных разностей.

[1]Работа выполнена в рамках государственного задания № 1.630.2014/К.

Модель размыва грунта основывается на использовании вычисления значениях сдвиговых напряжений на поверхности дна.

Полученные численные результаты размыва грунта у основания платформы отличаются результатов лабораторных экспериментов не более чем на 8 %.

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Спектрально-пространственная классификация типов подстилающей поверхности по гиперспектральным данным дистанционного зондирования Земли

Проанализированы возможности и ограничения применения гиперспектральных (ГС) изображений при космическом мониторинге поверхности Земли. Представлены результаты исследования методов классификации типов растительного покрова, основанных на сравнении спектров отражения исследуемых и эталонных объектов различных классов. Значительное внимание уделено изучению зависимости точности классификации данных от количества и способа выбора спектральных признаков. Показано, что при обработке ГС изображений природных территорий целесообразно использовать небольшое количество признаков (10-20), выделенных методом главных компонент с нормализацией шума каналов.

Дальнейшее повышение эффективности классификации типов подстилающей поверхности по данным дистанционного зондирования Земли (ДЗЗ) может быть достигнуто за счет дополнительного применения пространственных признаков. Исследованы спектрально-пространственные методы, учитывающие при анализе пикселей ГС изображений их локальные окрестности. Рассмотрены подходы, использующие как предварительное пространственное усреднение исходных данных, так и постобработку карт попиксельной классификации путем выбора наиболее часто встречающегося класса. При этом в качестве зоны усреднения (или выбора доминирующего класса) используется либо прямоугольная окрестность, либо сегменты, сформированные из наиболее близких по параметрам пикселей. Показано, что такое совместное использование спектральных и пространственных признаков позволяет повысить точность классификации на 15-17.

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О некоторых проблемах численного моделирования поверхностных волн в рамках модели мелкой воды [2]

Среди многочисленных задач о течениях жидкости со свободной поверхностью важное место занимают задачи моделирования процессов распространения длинных поверхностных волн в больших акваториях и взаимодействия этих волн с берегом. В настоящее время для решения таких задач интенсивно используются методы численного моделирования на основе иерархии вложенных друг в друга математических моделей и оптимальных вычислительных алгоритмов. Нелинейные модели мелкой воды (SW-модели) занимают в этой иерархии центральное место. Поэтому разработка и исследование численных методов для решения практически важных задач в рамках SW-моделей является актуальной проблемой современной вычислительной гидродинамики.

В настоящей работе рассматриваются некоторые проблемы численного моделирования в рамках бездисперсионной модели мелкой воды (NLSW-модели). Для неровного дна NLSW-система является неоднородной, поэтому многие конечно-разностные схемы, хорошо зарекомендовавшие себя в случае горизонтального дна, теряют важное свойство сохранения простейших аналитических решений NLSW-модели. Показано, что проблема решается за счет особой аппроксимации правой части уравнения импульса.

Известно, что решение уравнений NLSW-модели может стать разрывным даже при задании гладких начальных данных, что во многих случаях приводит к появлению осцилляций численного решения. Предложен новый способ выбора схемных параметров, основанный на исследовании дифференциального приближения (д.п.) разностной схемы, гарантирующий выполнение для нее TVD-свойства. С помощью д.п.-метода дано новое объяснение механизма возникновения нефизичных численных решений и предложена новая процедура энтропийной коррекции.

В задачах о распространении длинных поверхностных волн в больших акваториях и взаимодействии этих волн с берегом актуальными проблемами являются адекватное описание поведения линии уреза в зоне заплеска и надежное определение границ затопления суши. В настоящей работе для решения задач наката используются подвижные сетки, адаптирующиеся к подвижной линии уреза и сгущающиеся на мелководье. Описывается новый подход к определению положения и скорости движения линии уреза, основанный на использовании точных аналитических решений NLSW-модели. Даются рекомендации

[2]Исследование выполнено за счет гранта Российского научного фонда (проект № 14-17-00219

для конструирования консервативных схем на подвижных сетках. Раскрываются другие особенности построения схем на криволинейных подвижных сетках.

Полученные результаты можно использовать при решении задач в рамках нелинейно-дисперсионных (NLD-) уравнений мелкой воды, поскольку из NLD-модели расщеплением получаются две подмодели, одна из которых аналогична рассмотренной здесь NLSW-модели.

Section 1.
HIGH PERFORMANCE COMPUTING

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Development of control and diagnostic system of cluster hybrid computing system

Within the republican budget program "To develop technology of creation a hybrid supercomputer cluster using GPU-processors"[1,2,3] in Institute of space technique and technologies designed cluster hybrid computing system based on graphics processors which is a powerful tool for solving demanding scientific computing tasks[4].

This article considers a developed software for hybrid cluster computing system, which includes control system and diagnostic system of its condition. The control system of the cluster computing system developed on the basis of freely distributed resource manager SLURM for Linux operating systems and provides effective management of computing resources and scheduling tasks. Diagnostic system for cluster computing system developed using scenarios which used native tools of the operating system and designed to monitor the state of the cluster system and ensure timely response to a deviation from the norm of its parameters[5,6]. The novelty of this work is development own software for high-performance hybrid cluster computing systems.

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Solving Hard SAT Instances in Volunteer Computing Project SAT@home

Volunteer computing [1] is a type of distributed computing which uses computational resources of PCs of private persons called volunteers. Each volunteer computing project is designed to solve one or several hard problems. When PC is connected to the project, all the calculations are performed automatically and do not inconvenience user since only idle resources of PC are used. Volunteer computing project consists of the following basic parts: server daemons, database, web site and client application. Daemons include work generator (generates tasks to be processed), validator (checks the correctness of the results received from volunteer's PCs) and assimilator (processes correct results). Client application should have versions for the widespread computing platforms. We developed a volunteer computing project SAT@home aimed at solving hard instances of Boolean satisfiability problem (SAT). Wide class of problems from modern computer science can be effectively reduced to SAT [2]. SAT problems are usually considered as the problems of search for solutions of Boolean equations in the form of CNF=1, where CNF is a conjunctive normal form. The SAT@home project has been actively functioning since September 2011. On the first stage, the project was used to solve several cryptanalysis problems of the A5/1 keystream generator. On the second stage new pairs of orthogonal diagonal Latin squares of order 10 were found. On the third stage several weakened problems of cryptanalysis of the Bivium cipher were solved. We also propose the CluBORun tool aimed at utilizing idle computational resources of clusters in volunteer computing projects. The key feature of CluBORun is that it uses only ordinary cluster's user rights. The CluBORun tool has been successfully working on the computing cluster MVS-100k (Joint supercomputer center of Russian Academy of Sciences) from December 2013 until the present moment. As a result of adding resources of this cluster to SAT@home the performance of the project increased by 40 % (i.e. by about 1.5 teraflops) in some periods of time.

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High-performance mobile computing of heat convection problems

In this paper, for the differential equations of heat convection in the variables "stream function-vorticity" is considered the difference equations with non-self-adjoint operators. To find the decision used a modified method of variational type minimal corrections [1]. Considered an iterative algorithm of the type of variable directions, using by conducting auxiliary function of the vorticity with homogeneous boundary values. Parallel program using CUDA (Compute Unified Device Architecture) technology was written, computational experiments and results analysis were conducted [2]. Experiments are tested on Nvidia Shield Tablet with Tegra K1 processor. Tegra K1 created on the base of the same NVIDIA Kepler architecture and has 192 CUDA-cores in the configuration 192:8:4 at 950 MHz frequency and with 360 GFLOPS performance. Calculation time of the parallel algorithm on the graphics card of the mobile device as compared with a personal computer, only 2-3 times slowly. Parallel algorithm modified alternating triangular method already has been known and implemented on the CPU using the technology of MPI [3], a parallel algorithm on the video card is improved through the effective use of shared memory and a choice of block size. Data flows of the inner cells subdomain are copied from the global memory to the shared memory, and then the boundary nodes are copied from the global memory. In this case, the size of subdomain does not change. Because the shared memory is the fastest memory, this algorithm is effective. It is impossible avoid re-copying the data on the boundary of the subdomain global memory. In the above cases, the copied columns and rows on the borders of the subdomain. Therefore, it is necessary to change the scheme of two-dimensional decomposition to one-dimensional. Thus, we exclude the repeated copying of columns [4]. In some cases, this benefit is comparable to the performance of a similar program running on the desktop GPU, which shows that mobile technologies now provide sufficient computing power. In the first part of this article will be shown a problem statement, ie the mathematical model and the iterative method for solving the equations of thermal convection. In the second part will show a parallel algorithm for solving the heat convection problem using CUDA technology. In the last part of the work will be shown comparisons, analysis of test and conclusions. In the future date is planned to create a hybrid parallel program in heterogeneous systems.

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Scalable parallel algorithm for 3D seismic simulation on clusters with Intel Xeon Phi coprocessors

In this paper, we present the results of developing scalable parallel algorithm and software for solving large problems of forward modeling in geophysics [1]. The problem that is to be solved is described by a system of equations of elastic theory representing the wave propagation in an elastic 3D media. We use the difference method based on staggered grids [2] for numerical modeling. We developed the scalable parallel scheme and a program for 3D seismic wave simulation on the modern multi-core systems with hybrid architecture and Intel Xeon Phi coprocessors. We present the parallel schema and the results of parallel algorithm behavior on Xeon Phi cluster for different tests. In addition, we made comparison of the parallel algorithm work on different computing devices of multi-core high performance computing systems. We carried out computing experiments to study the behavior of parallel algorithm on one Xeon Phi coprocessor to tune the parameters to run program on a greater number of computing devices of a cluster. It is shown that 3D difference method can be well parallelized on Intel MIC architecture. The results of the research are important and can have practical usage in developing scalable parallel algorithms for exaflops supercomputers of the future and modeling an algorithms behavior on a larger amount of computing cores using simulation [3]. This work was partially supported by RFBR grants No. 14-07-00832, 14-05-00867, 15-07-06821 and Intel Corporation.

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About one problem of oil production

In this work the high-performance computational algorithm for numerical decision of initial-boundary 3D - problem of parabolic type in a complex region is proposed. Solving of such problems offers big interest in numerical modeling of oil reservoir processes, as oil reservoir is a non-regular region in reality [1,2]. This algorithm is based on conversion to additional problem in regular region, which includes initial region entirely.

The initial-boundary 3D-problem of parabolic type has a following view:

$$\frac{\partial p}{\partial t} = div\left(K\left(x\right)\nabla p\right) + f, \tag{1}$$

$$p\,|_{t=0} = p_0(x)\ , \tag{2}$$

$$p\,|_S = 0\ . \tag{3}$$

Here$x = (x_1, x_2, x_3) \in \Omega$, $R^3 \supset \Omega$- bounded region, $\partial\Omega = S$ - boundary of regionΩ, $t \in [0, T]$ - time, $p = p\left(t, x\right)$ - initial function (oil pressure), $f = f\left(t, x\right)$- given function and $0 < m \leq K\left(x\right) \leq M < \infty$.

Since Ω - nonregular region, for decision of initial problem (1)-(3) additional problem is considered, based on idea of fictive regions method to continuation by low coefficients in region$[0, T] \times D$, where $\Omega \subset D$ - fictive region with boundaryS_1 : $S_1 \bigcap S = \not{O}$ [3].

Additional problem has a following view:

$$\frac{\partial p^\varepsilon}{\partial t} = div\left(K\left(x\right)\nabla p^\varepsilon\right) + f^\varepsilon - \frac{\xi\left(x\right)p^\varepsilon}{\varepsilon\left\|p^\varepsilon\right\|^\beta_{L_2(D_1)}}, \tag{4}$$

$$p^\varepsilon\,|_{t=0} = p_0(x)\ , (5) p^\varepsilon\,|_{S_1} = 0\ . \tag{5}$$

Here $\xi\left(x\right) = \begin{cases} 0, & x \in \Omega \\ 1, & x \in D_1 \end{cases}$, $f^\varepsilon\left(x\right) = \begin{cases} f, & x \in \Omega \\ 0, & x \in D_1 \end{cases}$.

$D_1 = D/\Omega$, $\varepsilon > 0$, $0 \leq \beta < 1$, $p_0(x)$ - is continued by zero out of region Ω.

The validity of this approach on differential level is considered. The parallel computational algorithm for decision of additional problem (4)-(5) in regular region is developed.

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Research of the reservoir parameters restoration problem

In this work the development of high-performance computational algorithm for solving of three dimensional (3D) problem of computer modeling of injection dioxide carbon to oil stratum in a system of wells is considered [1-3]. The considered mathematical model describes a process of filtration of two-phase mix (oil, gas), consisting of three components, namely light oil component, heavy oil component and dioxide carbon in oil stratum. Mathematical model is given by nonlinear system of part derivatives equations and has following form in a region $(0 < x < l_x, 0 < y < l_y, 0 < z < l_z, 0 < t \leq T)$:

$$\frac{\partial}{\partial t}(m(x_{1,o}\xi_o s_o + x_{1,g}\xi_g s_g)) + div(x_{1,o}\xi_o w_o + x_{1,g}\xi_g w_g) =$$

$$= -\sum_{i=1}^{N_2} Q_{1,i}^{out}\delta(x-x_{o,i}, y-y_{o,i}, z-z_{o,i}), \tag{1}$$

$$\frac{\partial}{\partial t}(m(x_{2,o}\xi_o s_o + x_{2,g}\xi_g s_g)) + div(x_{2,o}\xi_o w_o + x_{2,g}\xi_g w_g) =$$

$$= -\sum_{i=1}^{N_2} Q_{2,i}^{out}\delta(x-x_{o,i}, C-C_{o,i}, z-z_{o,i}), \tag{2}$$

$$\frac{\partial}{\partial t}(m(x_{3,o}\xi_o s_o + x_{3,g}\xi_g s_g)) + div(x_{3,o}\xi_o w_o + x_{3,g}\xi_g w_g) =$$

$$+div(D_{3,o}\nabla(\xi_o x_{3,o}) + D_{3,g}\nabla(\xi_g x_{3,g})) + \sum_{i=1}^{N_1} Q_{3,i}^{in}\delta(x-x_{in,i}, y-y_{in,i}, z-z_{in,i})-$$

$$-\sum_{i=1}^{N_2} Q_{3,i}^{out}\delta(x-x_{o,i}, C-C_{o,i}, z-z_{o,i}), \tag{3}$$

$$w_o = --k\frac{f_o}{\mu_o}(\nabla p_o - \rho_o g\nabla z), w_g = --k\frac{f_g}{\mu_g}(\nabla p_g - \rho_g g\nabla z), \tag{4}$$

$$p_g - p_o = p_{cap}(s_o), s_o + s_g = 1, \tag{5}$$

$$x_{1,o} + x_{2,o} + x_{3,o} = 1, x_{1,g} + x_{2,g} + x_{3,g} = 1, \tag{6}$$

$$f_{j,0} = f_{j,g}, j = \overline{1,.,3}. \tag{7}$$

Here x_1, x_2, x_3 - light oil component, heavy oil component and dioxide carbon respectively; s_o, s_g - saturation of oil, gas respectively; x_{1o}, x_{2o}, x_{3o} - molar fraction of light oil component, heavy oil component and dioxide carbon in oil phase respectively; x_{1g}, x_{2g}, x_{3g} - molar fraction of light oil component, heavy oil component and dioxide carbon in gas phase respectively; p_o,p_g - pressure of oil, gas respectively; p_{cap} - capillary pressure between gas and oil phases; k - absolute permeability; m- porosity; ξ_o, ξ_g- molar density of oil, gas respectively; ρ_o, ρ_g, ρ_r- density of oil, gas and rock respectively; g- gravity; N_1, N_2- quantity of input (injecting) and output (operating) wells respectively; $(x_{in,i}, y_{in,i}, z_{in,i})$,$(x_{o,i}, y_{o,i}, z_{o,i})$- coordinates of i-input and i-output well respectively; $Q^{in}_{3,i}, Q^{out}_{1,i}, Q^{out}_{2,i}, Q^{out}_{3,i}$- injection rate of dioxide carbon on i-input well, production rate of additional recoverable light oil component, heavy oil component and dioxide carbon on i-output well respectively.

Initial conditions of this problem have following form:

$$(p_o, p_g)|_{t=0} = (p^0_o, p^0_g), (s_o, s_g)|_{t=0} = (s^0_o, s^0_g), \tag{8}$$

$$(x_{1,o}, x_{2,o}, x_{3,o})|_{t=0} = (x^0_{1,o}, x^0_{2,o}, x^0_{3,o}), (x_{1,g}, x_{2,g}, x_{3,g})|_{t=0} = (x^0_{1,g}, x^0_{2,g}, x^0_{3,g}). \tag{9}$$

On the boundary of region conditions have following form:

$$(w_o\overline{n}; w_g\overline{n})|_{\partial G} = 0, (\frac{\partial s_o}{\partial n}; \frac{\partial s_g}{\partial n})\Big|_{\partial G} = 0, (\frac{\partial x_{3,o}}{\partial n}; \frac{\partial x_{3,g}}{\partial n})\Big|_{\partial G} = 0. \tag{10}$$

The equations of this 3D problem are non linear. They are hard to solve by ordinary numerical methods. So for solution this problem was developed computational parallel algorithm, based on MPI – technologies.

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Parallelization of algorithm of prediction of miRNA binding sites in mRNA on the cluster computing platform

After opening of an important role of microRNA (miRNA) in regulation of an expression of genes the problem of a prediction of binding sites of miRNA with matrixRNA (mRNA) has arisen. Some programs which predicted binding sites of miRNA were created. However many of them had unreasonable restrictions for search of binding sites. Earlier it was claimed that binding sites are localized only in 3'UTR. It was established later that binding sites are localized in 5'UTR and CDS. Other programs were based on identification of binding sites with the obligatory requirement to have complementary interactions of a guanine (G) and an adenine (A) in a site of "seed" which corresponds 5'-end of miRNA. Many such programs predicted a large number of false positive sites and did not allow revealing the binding sites located in 5'UTR and CDS. On this and other reasons it is inexact the beginning of binding sites was established and incorrectly schemes of interaction of miRNA with mRNA were formed. Now, in a genome of the human more than 2500 miRNAs are known and it is necessary for each of them to find target genes among 30 thousand genes of the human. Large volume of calculations demands creation of the program, allowing processing these huge data files. We created the MirTarget program which has no shortcomings given above and with big reliability finds binding sites of miRNA with mRNA.

During the research by authors the following results were received: the mathematical model of optimum process of scanning of genes and miRNA sequences is developed; the algorithm of scanning of genes with miRNA with one gap in miRNA and maximum (in a percentage ratio) free energy is developed and analyzed at coincidence of miRNA and a gene site on the basis of complementarity properties; the constructed algorithm of scanning of genes with miRNA is parallelized on the computational cluster with use of MPJ tools - the MirTarget program; the assessment of overall performance of the parallelized algorithm on the cluster computing platform with consecutive algorithm is performed when processing large volumes of data; the developed program was used for performing researches by search of binding sites of miRNA with matrix RNA (mRNA).

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Distributed PIV: the Technology of Processing intensive experimental data-flow on a remote Supercomputer

The data from experiments cannot always be processed at the site of the experiment, since it requires too much processing power or large storage system. For example, in the experimental aerodynamics and hydrodynamics non-contact measurement techniques (PIV – particle Image velocimetry) are widely used, and they are based on image processing [1]. These PIV-systems are able to generate long-duration and intensive data-flows at a speed of 1-10 Gbit/s. The factor limiting the use of a PIV method and its modifications is the high computational complexity of data processing procedures. Therefore, transfer of calculations, performed within the framework of our proposed technology "Distributed PIV", on remote supercomputers will allow user applications of processing of experimental data to apply new high-precision algorithms, to process data in real time and to operate experimental installation [2, 3]. In the present paper we illustrate the capabilities of our model for data flow input directly to the compute nodes of a remote supercomputer via a high-speed dedicated optical network. Also our developed middleware, solving the issues of transport protocols with feedback at high BDP (Bandwidth-Delay Product) network is described. Evaluation of the throughput of an experimental stand – supercomputer data transmission path is performed by transmitting within 12 hours the measured data flows generated by the PIV-system at a speed of 6.4 Gbit/s via a 900 km long communication channel of 10 Gbit/s to 376 remote supercomputer processors. Some factors having a negative effect on the throughput of the "PIV-system – Supercomputer" data transmission path have been revealed and discussed. Analysis of the results shows that the proposed technology "Distributed PIV" provides a principally new tool for performing unique physical experiments in research laboratories and in industries. This work was supported by the Russian Foundation for Basic Research (project 14-07-96001) and Ural Branch of Russian Academy of Sciences (project 15-7-1-25).

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The experience of implementation of permutation tests using GPU

This paper proposes an algorithmic approach and program for solving search problems statistically significant over the biological characteristics of genes in a given set. The problem is connected with the implementation of well known in biology permutation (randomization) test [1, 2, 3, 4]. By taking into account the potential parallelism permutation test developed in parallel with the implementation of a program to graphically processors [5]. The sequential and parallel versions of software for the permutation test aimed at finding statistically significant overrepresented characteristics of genes under different external or internal conditions for computing devices: PC with NVIDIA GPU and hybrid super-computer NCC-30T+GPU of the Siberian Supercomputer Center, Siberian Branch of the Russian Academy of Sciences. In the course of the work, the problem of parallelizing the most energy-consuming algorithms of permutation test software for the implementation on the GPU is solved. The cuBLAS library of matrix-vector multiplication, which allowed for a transition of this algorithm to the architecture of GPUs, was used. According to the results of performance estimation, the time acceleration of the software was shown on the two considered problems using a GPU, and it amounted to 150 time with regard to the sequential version. It is noted that the software execution time is affected by the input data size (the number of genes and functional annotations) and the number of iterations with permutations. A negligible effect of the number of permutations performed before each iteration of calculation of random sums of values for the functional annotations during the software operation time was demonstrated. As the development of technology of implementation of permutation test is planned to upgrade the program. Ability to simultaneously test multiple hypotheses by introducing matrix-matrix multiplication will be implemented.

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Seismic field simulation on high-performance computers in the problem of studying the consequences of underground nuclear tests

In the paper we present results of development a structure of geophysical models with cavernous area [1], and the study a structure and properties of the wave field in mathematical modeling [2]. This is an important step in solving problems on-site inspection in the problem of monitoring underground nuclear tests related to experimental studies by the vibration of the Earth sounding. Carrying out numerical simulations using software for clusters allow selecting the characteristic and distinctive properties of the objects under study and enable to extract an informative wave groups and to determine their arrival times in the border areas of underground nuclear tests [3]. Ability to use different number of recording geophones in calculations may allow to determine the minimum required count of geophones for the necessary resolution of the seismograms.The obtained results form the basis for making recommendations to determine the areas of an underground nuclear explosion. All numerical calculations were carried out using the developed software on the NKS-30T+GPU cluster of The Siberian Supercomputer Center of the Russian Academy of Sciences. This work was partially supported by grants of RFBR No. 14-07-00312, 14-05-00867, 14-07-00832, 15-07-06821 and MES RK 1760/GF4.

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О фундаментальных и технологических проблемах математического моделирования

Рассматривается комплекс вопросов общего или специального характера, связанных с созданием наукоемкого математического и программного обеспечения нового поколения для решения "больших"прямых и обратных междисциплинарных задач моделирования реальных процессов и явлений на суперкомпьютерах постпетафлопсного уровня. Концепция заключается в создании интегрированной среды вычислительных инструментариев, ориентированной на качественный рост производительности труда прикладных программистов и создание высокопроизводительных продуктов, востребованных для широкого круга пользователей.Критические проблемы заключаются в автоматизации построения алгоритмов и их отображении на архитектуру МВС, в адекватности вычислительных моделей и адаптируемости интерфейсов к характерным приложениям или отраслям, а также в компонентных технологиях крупномасштабных корпоративных разработок, ориентированных на длительный жизненный цикл, обеспечивающих поддержку переиспользования программных продуктов, эволюцию системного и функционального наполнения. Обсуждаемые подходы иллюстрируются некоторыми решениями, предлагаемыми в рамках разрабатываемой в ИВМиМГ СО РАН базовой системы моделирования.

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Численное решение трехмерных задач акустики с использованием мозаично-скелетонного метода

Решение трехмерных задач дифракции акустических волн имеет большое практическое значение. Такие задачи решаются, в основном, численно, так как их аналитические решения можно найти лишь в простейших случаях. Численное решение предполагает построение дискретного аналога исходной задачи, которое может быть сделано разными способами. В данной работе для этого используются слабо сингулярные граничные интегральные уравнения Фредгольма с одной неизвестной функцией [1]. Рассматриваемые интегральные уравнения аппроксимируются системами линейных алгебраических

уравнений (СЛАУ) с плотными матрицами. Решение таких систем прямыми методами имеет вычислительную сложность $O(n^3)$, где n – порядок СЛАУ. Применение обобщенного метода минимальных невязок (GMRES) [2] для решения данных систем позволяет снизить сложность до $O(n^2)$. После нахождения решения СЛАУ решения исходных задач с помощью интегральных представлений достаточно просто восстанавливаются в любой точке пространства.

Большую часть времени в GMRES занимает многократное применение матрично-векторного умножения. Для снижения сложности такого умножения предлагается использовать мозаично-скелетонный метод [3, 4]. Основная идея метода состоит в том, чтобы приближать блоки исходной матрицы суммами одноранговых матриц. Такое приближение матрицы занимает в памяти компьютера меньше места и может быть умножено на вектор за почти линейное число операций. При реализации метода для уже готовых алгоритмов численного решения задач необходимо изменить только процедуру хранения матрицы и операцию матрично-векторного умножения. При этом процедуры дискретизации и нахождения элементов матрицы, которые используются для построения приближений, остаются прежними.

Мозаично-скелетонный метод реализован в программе для численного решения трехмерных задач дифракции на многопроцессорных платформах с общей памятью. Эксперименты показали, что применение данного метода позволяет существенно снизить время решения исходных задач при той же точности расчетов.

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Анализ режимного поведения гибридных систем параллельными одношаговыми методами

Динамику сложных систем различной природы удобно описывать и исследовать с применением математического аппарата гибридных систем (ГС). Поведение ГС определяется дискретной последовательностью непрерывных состояний [1, 2] или режимов. При этом каждое состояние описывается системой дифференциальных уравнений с ограничением:

$$y' = f(y,t),\ g(y,t) < 0,\ y(t_0) = y_0,\ t_0 \le t \le t_k, \tag{1}$$

Функция $g(y,t)$ называется событийной функцией или предохранителем [2]. Неравенство $g(y,t) < 0$ определяет условие существования системы в соответствующем режиме.

Анализ ГС традиционными методами осложняется наличием разрывов режимного поведения и высокой размерностью системы (1). Поэтому при решении умеренно жестких задач хорошие результаты дает применение алгоритмов интегрирования, основанных на явных методах с контролем точности и устойчивости вычислений [3, 4]:

$$y_{n+1} = y_n + h\varphi_f(t_n, y_n, h). \tag{2}$$

В работе рассматриваются особенности организации параллельных вычислительных процессов при компьютерном анализе режимного поведения гибридных систем. Параллельное взаимодействие построено на стандарте MPI, а в качестве реализации использована библиотека MPJExpress для Java-платформы. Решатель предоставляет интерфейс программирования для включения новых алгоритмов в библиотеку методов интегрирования.

Пусть компьютерная система состоит из p процессоров, а размерность N задачи (1) больше числа процессоров ($N > p$). Число k является количеством уравнений, передаваемых на один процессор. Учитывая данные предположения, сформулируем параллельный алгоритм выполнения шага интегрирования по схеме (2) на каждом i-м ($1 \le i \le p$) узле:

1. Вычислить приближенное решение y^j_{n+1}, $((i-1)\cdot k + 1) \le j \le (i \cdot k)$ в момент времени t_{n+1} с шагом h.

2. Переслать полученные значения y^j_{n+1} всем остальным узлам системы.

3. Вычислить значение функции $f^j(y^j_{n+1})$.

4. Получить характеристики точности выполненного шага интегрирования.

5. Если решение точное, перейти к пункту 6, иначе установить шаг интегрирования h равный шагу h^{ac}, скорректированному по точности в соответствии с выполняемым методом, и перейти к пункту 1.

6. Получить характеристики устойчивости скорректированного по точности шага интегрирования.

7. Если решение устойчивое, перейти к пункту 8, иначе установить шаг интегрирования h равный шагу h^{st}, скорректированному по устойчивости в соответствии с выполняемым методом, и перейти к пункту 1.

8. Выбрать размер следующего шага интегрирования по формуле

$$h_{n+1} = \max[h_n,\ \min(h^{ac},\ h^{st})]$$

и перейти к следующему шагу интегрирования.

Разработанный решатель задачи (1) позволяет запускать одношаговые численные методы как в последовательном, так и параллельном режиме. Результаты тестирования подтверждают корректность и эффективность предложенного подхода.

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Section 2. INFORMATION MANAGEMENT, PROCESSING AND SECURITY

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Admission control for server clusters based on QoS requirements

Larger Web applications require using multiple servers. Such kind of systems referred as Web server farms or server clusters. We present an architecture and software implementation of module for web based parallel tasks execution system consisting of a set of computational nodes. Each of this nodes is independent server of the server cluster is subject to QoS requirements, because increase of Web application's scale inevitably arises issues related to service quality. Therefore, QoS become a significant factor in distinguishing the success or the failure of service providers. The traffic in the proposed system considered as session based, while provider and user specifying the SLA on the expected level of service performance. Proposed SLA contract defines three main characteristics of the session expected to be served: charge accepted by provider for processing the session; obligation imposed by customer on session; penalty for failing the obligation in the form of compensation to customer by provider. According to SLA the provider is responsible to payback customer's expenses plus some amount if the level of performance does not meet expectations specified by SLA. Main contribution of the paper is in providing a formal model which describes the queuing system simulation heavy incoming data traffic in session-based manner. Then we measure and optimise the performance of the system by service provisioning based on QoS constraints. The main metric we consider during this process is the average overall revenue received per unit time for entire system. Each session accepted for processing consists of number of jobs. These jobs subject to QoS conditions in the proposed SLA. The module implemented for entire system collects two types of statistical data: dynamic parameters of expected user session and various performance metrics of working multiserver system. These metrics estimated regarding to incoming session parameters in order to make dynamic decisions on admission of session and allocation of additional servers/deallocation idle servers. We evaluate and validate our formal model through several simulations and real life experiments, showing robustness of our approach under different session parameters. The rest of the paper organized as follows. Relevant work is discussed in the second section, the formal model of considered problem is explained in third section, dynamic admission and server allication/deallication policies described in forth section. Fifth section presents the brief architecture of parallel tasks execution system which is the framework of proposed middleware module and the detailed architecture review of the the module itself. Sixth section presents a number of carried out experiments as well as comparisons with other implemented models of dynamic admission control. Seventh section concludes the paper highlighting possible directions for future work.

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Multicriteria statistical analysis of test biometric data

One of the most popular in the statistical analysis of the data is Pearson. Techniques based upon use of the chi-square test, suggest checking out some statistical hypothesis about the distribution of the observed values. The calculations are carried out according to the classical formula. Unfortunately, standard statistical calculation methods [1] for analyzing biometric data give inaccurate results. In order to achieve the probability of errors at the level of 0.05 we have to use some 100 runs in a test sample.

The main source of error in the analysis of the biometric data is insufficient test data in the test samples [2]. This situation is not characteristic only for testing biometric information security. The same situation occurs in the processing of any biometric data (medical, sports, biological). The problem of improving methods of application chi-square test for statistical processing of fuzzy biometric data received considerable attention magazine "Biometrics", which regularly publishes articles on this subject since the 30s of the last century.

This article focuses on another area of research related to the use of two or more statistical tests. Currently, are known dozens of statistical criteria and prepared have in carrying out a reserch progect of KazNTU after K.I.Satpayev No.753 MES.GF.13.13 "Research on options for realization and development of the acting laboratory sample ON-LINE system of biometric depersonalization of electronic medical case histories for medical institutions". They all complement each other.

If we use the chi-square test according to standard procedures [1], then the test sample in 81 count, we obtain the probability of errors at the level of 0.054. However, as soon as we turn to the accounting errors that occur due to the finiteness of the test sample and apply the generalized chi-square test, then the results of complex testing of work of two hypotheses give the chance to lower the probability of errors by about 20 times. This significant reduction in the probability of errors can only be achieved if the size of the test sample in 800 samples, this is equivalent to a 10-fold reduction in the requirements for the size of the test sample [1].

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Solving the inverse task of neural network biometrics without mutations and Jenkins' "nightmare" in the implementation of genetic algorithms

Neuronet converters biometrics code for the image of "its" completely eliminate the natural entropy of biometric data. This effect can be achieved by training a large artificial neural network according to the Russian national standard GOST R 52633.5-2011 [1]. Entropy of images "Alien" opposite increases significantly during training.

Personal data protection in Russia, Kazakhstan, Belarus belongs to the licensed activity. In this regard, it is necessary to test the neural network converter biometrics code according to GOST R 52633.3-2011 [2]. Standard [2] for the first time in the world practice involves the use of genetic algorithms for solving the inverse problem of neural network biometrics.

The practice of using of genetic algorithms [3, 4] showed that the biometric data degenerate into a number of future generations, if in crossing [5] create figures of the descendants which figures are similar to the parent.

In a simple averaging of the data matrix of correlation links degenerates, which is equivalent to Jenkins' "Nightmare".

In order to ease the Jenkins' "nightmare" offered instead of morphing interpolation according to GOST R 52633.2 -2010 [5] use the morph-extrapolation in a predetermined side of evolution:

$$\psi_i = \varepsilon_{v,i} - (\frac{\Delta h_L}{\Delta h_{LR}}) * \varepsilon_{\varepsilon,i} \quad (1)$$

where $\varepsilon_{v,i}$ - the value of the i-th example of biometrc parameter of close figure, $\varepsilon_{\varepsilon,i}$ is the value of the i-th example biometric parameter of distant figure, Δh_L

- the desired Hamming distance to the left image-descendants, Δh_{LR} Hamming distance between left and right examples of different parents figures.

In the implementation of genetic algorithms, we always know the direction of evolution [2-4]. That is, the transition to the extrapolation from the interpolation does not cause technical difficulties. The convergence of computing matrix inversion procedures of functional neural network is greatly increased.

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Module of lexical and morphological analyzer in the development of semantic engine for kazakh language

Search engine technology has had to scale sharply to keep up with the growth of the World Wide Web. Search engines link huge amount of web pages involving a proportionate number of distinct terms. They answer to thousands of queries every minute. Despite the importance of massive search engines on the web, very little academic research has been done on them. Moreover, developing a web search engine today is very different from several years ago, because the latest technologies appear every single day [1]. This paper provides description of the module of lexical and morphological analyzer in the development of semantic search engine for kazakh language that is implemented in the Institute of Information and Computer Technologies (IICT) and our main goal is to improve the quality of web search engines by using module for text processing in the Kazakh language and receiving the module of the text with morphological markings in the output.

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Recognition of isolated words using the Bayes' theorem

This paper outlines mathematical solution of building up the speech recognition systems by creating probability conditions and defining percent of made mistakes during the operation, based on-Bayes' theorem. Speech recognition is a computer technology that enables to recognize and understand spoken words, by digitizing the sound and matching its pattern against the stored patterns. Now a days, in the sphere of education there are great deal of useful software programs, one of them is speech recognition system, the benefits of speech recognition applications are numerous. Creating documents, memos, and reports can easily be spoken leaving hands free to complete other tasks. But unfortunately, many students in our country, do not have feasibility to use such kind of applications, because existing tools do not recognize and process Kazakh, Russian languages, even if some of them recognizes Russian language, they are too expensive to download it.

In the 1990s, a number of innovations took place in the field of speech recognition. The problem of speech recognition, which traditionally followed the framework of Bayes' theorem and required estimation of distributions for the data, was transformed into an optimization problem involving minimization of the empirical recognition error. This fundamental change of paradigm was caused by the recognition of the fact that the distribution functions for the speech signal could not be accurately chosen or defined, and that Bayes' decision theory would become inapplicable under these circumstances. After all, the objective of a recognizer design should be to achieve the least recognition error rather than the best fitting of a distribution function to the given data set as advocated by the Bayes' criterion.

The method of handling voice and video signals and also storing them, performing a relatively simple task, consists of three stages: 1. Estimation of the joint conditional probability $P(o_1, \ldots, o_j w_i)$; 2. Description of processing of incoming data; 3. Facilitating the construction of composite models. When testing the method is defined preliminary parameters of voice and video signals and degree of stability in the working process towards to variations of input signals. For recognition system, working in real conditions and on real data, it is defined percent of made mistakes, i.e. is assessed not the behavior under different conditions, it assessed how effectively system solves its task set before it.

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Usage of GIS technology in the analysis of spatial dynamics of hydrobiological data (Enisey river case study)

At present, more and more attention is paid to study and search of ways for solving environmental problems, especially in the field of water protection policy. There are a lot of techniques for studying and prediction of the qualitative status of water bodies. One of these methods is hydrobiological analysis. Hydrobiological parameters characterize the quality of water as a habitat for organisms living in water. Different organisms have different reactions to the impact of pollutants. This allows to assess the degree of harm for the cumulative effects of all the organisms living in the pollutants water with the help of hydrobiological methods. The usage of the new data processing techniques, such as GIS and cartographic modelling, will allow to receive an additional information about the spatial features of aquatic distribution and will help in the search of the connections with a variety of natural and anthropogenic factors.

A vast array of different nature biotic and abiotic data on the Yenisei ecosystem has been accumulated over many years, it is valuable material for analysis. At the initial stage of research we have examined the spatial distribution of aquatic organisms, particularly those amphipods which are representatives of the bottom animals of aquatic ecosystems. It is known that the number of amphipods in the Yenisei river has increased significantly after the construction of the Krasnoyarsk hydroelectric power station, that is why the sustainability of the ecosystem has been broken.

Based on the results of hydrobiological studies geospatial database built geographic information model, which provides opportunities for spatial analysis, was formed. Geoportal and web mapping services were considered as the technology basis for this project software system. Geoportal services provide the ability to visualize data in the form of interactive thematic maps, information about objects on the map as "tooltips", to download information in tabular form, direct access to data through Web mapping services of modern GIS, and so on. This system

should be viewed as a distributed information-analytical system based on hybrid technology, client-server and multitier system architecture, distributed storage and processing of data.

The authors were directly involved in the development and implementation of project software. There were many different software libraries and components which were used in program code implementation. Web mapping user interface was created with the help of a number of open source libraries. Authors used Mapserver GIS platform to create a server-side web application. GeoWebCache was another essential component of this distributed web mapping environmental monitoring application. There were a number of other tools, components, libraries, etc. which were used in software implementation.

By analyzing and summarizing the experience gained from creating considered software, it should be noted that the use of web-based solutions in this area can dramatically improve the efficiency of the solving of environmental problems.

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Facebook profiles clustering

Internet social networks may be an abundant source of opportunities giving space to the "parallel world" which can and in many ways does surpass the realty. Unlike classical, offline ways, internet, as a means for market research, offers real-time data access, knowledge about people's changing preferences and access to their status messages, thus providing room for innovation in the field. The popularity of social networks such as Facebook, Twitter or Google Plus has extraordinarily grown during the recent years. People share data about almost every aspect of their life, starting from opinions on global problems, event commenting, friends tagging at locations, and arriving to personalized multimedia content. Therefore, decentralized mini-campaigns about educational, cultural, political and sports novelties could be performed. In this paper we applied clustering algorithm to social network profiles with the object to obtain separate groups of people with different opinions about a topic. All profile data, friendships, fanpage likes and statuses with interactions are collected by already developed software for neurolinguistic social network analysis - "Symbols". After filtering, the data are used for the novel relationships denotation, based on the knowledge gained. This approach enables gathering information about the present state of affairs, but also discovering new knowledge and tendencies in the area, in a sophisticated and effective way.

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Polynomial algorithm for multiprocessor schedulling problem with three job lengths

In this report the following open problem of the schedulling theory is considered. There are given m_i of small pieces of length $l_i, i = 1, 2, 3$, which are necessary to place in as it is possible smaller number of pieces of length L. This problem refers to as MSP3 (multiprocessor scheduling problem with 3 job length). The bibliography on the given problem is given in [1]. In [1] a polynomial algorithm for a problem MSP2 (multiprocessor Scheduling problem with 2 job length) is submitted. In [1] the difficulties arising for construction of polynomial algorithm

for MSP3 are marked. Let's consider so-called divisible case of MSP3, when the piece of length L is completely covered by M_1 pieces of lengths l_1 or M_2 pieces of length l_2 or M_3 pieces of lengths l_3.

Theorem 1. *The divisible case of the problem MSP3 belongs to a class P (class of problems which are solvable by polynomial algorithm).*

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Methods and Systems of Automatic Text Summarization

The article discusses various methods for the problem of automatic text summarization, and provides an overview of systems which implementing these methods. Usually, allocate two approaches to automatic generation of a short essay (or annotations) text documents. The first involves the extraction of the most important pieces of text from one or more documents, the second is based on knowledge of the morphology, syntax and semantics of a particular language to generate concise reports. The most effective method is the semantic method that works as follows: the selected text is removed redundant information, superficial judgments, conceptual subgraphs. Next aggregation is performed and synthesis of information: the merger of some conceptual graphs based on the rules. The result is a conceptual squeeze. An important characteristic when choosing a method of abstracting is universal, ie, the method chosen must not impose restrictions on the theme and style of documents.

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Design of Automated Image Recognition System to Assess the Quality of the Mineral Species using CASE Technology

This paper contains design and implement of the automated system for image recognition of mineral spices in the mining industry. It is used CASE (Computer-aided software engineering) technology as AllFusion Process Modeler (BPWin), including a function modeling methodology of IDEF0 (Icam DEFinition for Function Modeling) on the functional modeling language of Structured Analysis and Design Technique (SADT) and a graphical representation of Data Flow Diagram (DFD). Now the developed automated system for images recognition for assessment of qualitative structure mineral breeds consists of six subsystems: for the research and receiving micrograph of rock; for input and identification of a rock micrograph; for preliminary processing: quality improvement; definition a threshold of the image reduction; for a choice of a vector of signs for the cluster analysis and the cluster analysis for definition of mineralogical composition of rocks. In the automated system the following Data storages are organized: Gallery of source images in which samples of rocks are stored; Gallery of the connected images where intermediate processing results of source images are stored, Template library where minerals samples are stored. Database with characteristics of rocks is autocompleted at input of images in Gallery of images. It is defined specifies requirements for the subsystem micrographs analysis.

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A novel approach of statistical data manipulation by using some clustering methods

Statistical techniques are used in a wide range of types of scientific and social research, including: complex networks, classification and data mining, spatial analysis, computational biology, computational sociology and many other disciplines involving overlap between these research areas. Nowadays, statistical research is challenged by the massiveness and high-dimensional nature of data collections, so the performance of meaningful statistical inference from very large and potentially corrupted data sets seems to be very complex in most of the cases. In this paper, we present a clustering based approach to make statistical inference methodologies more computationally feasible. Instead of classical data division in statistical simulation methods, we propose a various types of data clustering in order to give better explanation of data sets structure, give prediction of its dynamics, and enable maximal efficiency with data manipulation. As a replacement we adopt some flat and hierarchical algorithms with main goal to preserve relevant data set information. Moreover, the part of our research is focused on selection of the initial centroids and initial number of clusters, which is based on the graph-theoretical and modular arithmetic properties of the data instances. The experimental results on a variety of collected data-domains show that our algorithms are not sensitive to input ordering, can produce a quality cluster division, and are efficient in terms of its computational time.

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A modification of the digital signature algorithm based on modular arithmetic

In the information exchange security systems to protect information during transmission and data exchange between states the cryptographic encryption and digital signature (DS) systems are used. Due to the widespread using of DS many aspects of the theory and practice of public key digital signatures are currently extensively researched.

With the appearance of new mathematical methods and a substantial increase in productivity of cryptosystems, the question of cryptostrength of these algorithms becomes obvious. Developers increase the size of the system-wide parameters for algorithms to improve the cryptostrength of cryptosystems. Therefore, an important problem is to find the cryptographic transformation that would increase the algorithm's cryptostrength.

The Digital Signature Algorithm (DSA) [1] scheme represents the variation of ElGamal and K.Schnorr's digital signature scheme. Its reliability is based on the practical irresolubility of the computing problem of discrete logarithm. In DSA the conversion module length is about 1024 bits. Keys' length increased to the same length. In this regard, the computational complexity of the cryptographic transformations increases, but the speed of calculations decreases.

The model of modular system of digital signature with public key is proposed. These systems are developed on the basis of the algebraic approach using NPNs or polynomial residue number systems (polynomial RNS). In contrast to the classical RNS, where the bases are the prime numbers, in NPNs bases are represented by irreducible polynomials over GF(2) [2]. Usage of NPNs allows reducing the key length, increasing strength and efficiency of the nonpositional cryptographic algorithms [3]. Efficiency increase provided by the rules of NPNs in which all arithmetic operations can be performed in parallel on the modules of polynomial bases of NPNs. In nonpositional cryptosystems as a cryptostrength criterion was used the cryptostrength of digital signature formation algorithms, which is characterized by a full secret key.

Modified digital signature system that is being developed, based on DSA algorithm and NPNs, is characterized by improvement of the basic characteristics of the digital signature. Application of algebraic approach based on NPNs will allow reducing the key length for digital signature without significantly lowering its cryptostrength. Computer modeling of the modified cryptosystems will allow the development of recommendations for their secure usage and generation of full secret keys.

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Software Implementation of the Cryptographic System Models Protection With the Given Cryptostrength

The models of software implementation of the system of cryptographic protection of information (SCPI) with the specified characteristics are described. This system is designed for using in systems and networks of information transmission and storage. In this system of cryptographic protection of information, the nonconventional algorithms of encryption and digital signature developed on the basis of nonpositional polynominal notations (NPNs) are implemented. The general feature of the model is that the fact the created SCPI implements encryption algorithms and digital signature formation with a given cryptostrength. The cryptostrength of these encryption algorithms is determined by the total number of possible and distinct from each other variants of choice of key sequences and systems of working base numbers. The mentioned system is the complex of computer programs which will consist of three interconnected blocks: the formation of full secret keys, the system of encryption and the digital signature scheme.For software implementation two models of cryptographic protection of information are proposed. In the first SCPI model the choice of full keys of the realized cryptoalgorithms is implemented from the DB of irreducible polynomial with binary coefficients directly in the blocks of program modules of encryption and digital signature formation. In the second SCPI, the full key for encryption and EDS

computing systems is formed in the keys formation block with the use of the irreducible polynomials and is stored in the database of full keys. The creation of various models of the unconventional cryptographic systems allows to create such system of cryptographic information protection which it would be easy to transform under model changes of the implemented cryptographic algorithms.One of the planned works is to implement the SCPI model on the basis of the time pad, i.e. the full keys database will be stored on a removable memory (USB) and identified only by encryption software. The development of the system of cryptographic information protection is carried out in compliance with requirements of legal documents of the Republic of Kazakhstan in the field of informatization.

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VNS-based heuristics for Communication Tree Optimal Synthesis Problem in Wireless Sensor Networks

One of the most important issues in wireless sensor network (WSN) is minimization of energy consumption of its elements per time unit. We investigate the following problem, which occurs while minimizing the power consumption of data transmission in WSN in a case when each network element is able to adjust the transmission range:

Problem. *The simple undirected weighted graph $G = (V, E)$ with a vertex set V, $|V| = n$, and an edge set E is given. Let $c_{ij} \geq 0$ be the weight of the edge $(i, j) \in E$. We want to find a spanning tree T^* of the graph G, which is the solution to the problem:*

$$W(T) = \sum_{i \in V} \max_{j \in V_i(T)} c_{ij} \to \min_{T},$$

where Vi(T) is the set of vertices adjacent to a vertex i in the tree T.

The considered problem is known as the *Min-Power Symmetric Connectivity Problem* (MPSCP) [1]. It is known that MPSCP is strongly NP-hard [1, 2], therefore construction and analysis of efficient approximation algorithms is one of the most important issues regarding to the research of this problem.

We propose new heuristics based on variable neighborhood search (VNS) [3] for the approximation solution of MPSCP. We have executed a simulation where all proposed algorithms have been run on randomly generated test instances. Also the hybrid genetic algorithm and VND-based heuristic proposed in [4] have been run. The obtained results, which demonstrate efficiency of proposed algorithms, will be presented.

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Wireless sensor networks and computational geometry problems

Wireless sensor network (WSN) is a prominent representative of distributed networks for data collection and transmission. WSN consists of devices that collect information and transmit it to the base station via radio. Each sensor is equipped with a battery replacement or charging which is either impossible or impractical. WSN's *lifetime* is the time period during which the network collects and transfers data from a certain area. Energy consumption is associated with sensor's monitoring region, which is called the coverage area of the sensor. Energy consumption is proportional to the area covered by sensor. This means that multiple coverage entails excessive energy loss, which leads to a reduction of network's lifetime. Therefore, the problem of energy-efficient monitoring can be reduced to the problem of finding the least dense cover, where the density of coverage an area of S is the ratio of the sum of squares of elements in the cover to S. The lower density, the better cover.

Since in the applications a coverage area of a sensor can have different shapes (disk, ellipse, sector) and different size (radius, semi-axes, angle and radius), then can be formulated the following computational geometry problem.

Problem. *For a given area on the plane, every point of which must be covered by at least one figure, the list of types of figures and admitted regions of parameters, it is required to define the set of figures in the cover, values of the parameters and to determine the placement of each figure and its orientation in order to minimize the density of the cover.*

In this paper, we present an overview of the results obtained earlier [2, 5], some of which belong to the authors [3, 1, 5]. Also, we will consider new formulations and will announce new results not only for the density objective, but also in the case where the objective function is the number of sensors per unit of covered area. As field of monitoring will be considered the entire plane, strip, as well as some other territories.

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Classification of scientific documents based on the compression methods

World flow of scientific documents is constantly growing: scientometric databases are indexing increasing number of research results, published in a variety of forms: books, articles, conference proceedings and other patents. The annual volume of publications in many disciplines has become so large that it is not possibe for an individual researcher or an entire laboratory to be fully aware of the relevant research. In such circumstances, there is a certain crisis of the concept of "expert", as a specialist who understands everything that happens in a particular subject area. Under these conditions, the process of information support of scientific researches plays a key role.

One of the most difficult tasks of information support is the process of automation the thematic classification of documents, the result of which is assigning a

document to one or more classes (e.g. mathematics, physics, chemistry, etc.). How is the process of classification performed by an expert? First, the titles and abstracts of publication are analyzed to identify specific terms and semantic structures. The expert collates them to his own term vocabulary and knowledge. If the expert can "see" similar to the one or more subjects of publications known to him, he assigns the appropriate class to publication. If the information is insufficient, the expert looks through the full text of the publication, repeating the same analytical process. Thus, one of the main criteria for classifying documents is similar terminology between classified paper and the articles corresponding to this class. This study uses this empirical observation to build a mathematical model for this process for the automation purposes.

In this report, we propose an approach to automatic classification which is based on estimations of the Kolmogorov complexity of texts. The estimations will be obtainded by so-called archivers, or programs for losseless compression. This approach was proposed by P. Vitanyi (see [1]) and was successfully applied to the classification of the degree of similarity of natural languages, musical pieces of different genres [1-2], the works of writers, biological "texts", computer viruses and many other objects (see the review in [1]). Independently, the data compression methods applied to problems of mathematical statistics, time series prediction and many other problems; see the review in [3].

The main idea of this approach is based on the concept of Kolmogorov complexity of texts, which, informally, is equal to the minimum length of a computer program that generates the text. It is important that this value is almost independent from the computer (a universal Turing machine). More precisely, if different universal Turing machines are used, the difference between two complexities will be limited by a constant for any text; the formal definition can be found in [4]. It turns out that the length of the "compressed" text is quite effective upper bound of Kolmogorov complexity and it is useful for many applications; see [1,5].

In this report we propose to use data compression methods in order to automatically determine a thematic affiliation of scientific texts. The obtained results are preliminary, but show that this approach is of practical interest.

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PayPal e-commerce and e-payment - problems and solutions

The development of computers and telecommunications has created the conditions for the business globalization. E-commerce or electronic commerce sites use electronic payment where Electronic payment refers to paperless monetary transactions. Electronic payment has revolutionized the business processing by reducing paper work, transaction costs, labour costs. [1]. E-commerce payment solutions make it easier than ever before for personal business to sell its goods and services on the Internet, enabling person to run web-based transactions online in real time. To establish an e-commerce business, person need a website, an online merchant account, virtual shopping cart and a payment gateway. [2]. Today the development of electronic commerce and electronic payment allows Person-to-Person transactions. In such transactions there must always be an intermediary company that will provide a safe and secure handover of goods [3]. Today we have different models for electronic payment on the Internet. Depending of users, model can be cash-oriented, checks oriented, payment by card and payment through accounts. In this paper authors describe electronic commerce and electronic payment, like key part of todays electronic business. Authors present advantages and disadvantages of electronic payment through the example of PayPal. PayPal is one of the world's largest internet payment companies. The company operates as an acquirer, performing payment processing for online vendors, auction sites and other commercial users, for which it charges a fee [4]. This payment system combine the functions of several different payment models and make maximum use of their advantages, resulting in a large acceptance of the system by the internet population. Authors describe PayPal structure, security protocols that are in use in this system, and users interaction between which a transaction is performed. Like each payment system, PayPal needs to be improved all the time. Here we present some examples of electronic payment hacking, and solutions for security improvement. Improvement is based on customer authentication, and implementation of patterns for users assessment.

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One implementation of the embedded database protection

In this paper one implementation of the database configuration and development considering security issues especially when connected to Internet is presented. Sometimes the precautions on security vulnerabilities implemented on other levels of database environment (such as: network, operating system, client application etc) are not enough in order to protect database itself. The attacker can frequently use the public user screen of an application and try to access Database as anonymous user. We have created the database with one way of self-protection where regular users can't access any of tables, only stored procedures. Permissions on stored procedures are not configured using standard DBMS tools but using embedded security developed by authors that checks the user rights and permissions on different business functionalities and expected parameters' values. The calls to stored procedures with suspicious users and parameters' values are logged for further analysis.

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Training radial basis neural networks in making stokes equations

The construction of an approximate solution of complex differential equations is one of the difficult tasks. In [1-2] Ladyzhenskaya noted that the construction of an approximate solution using the Galerkin method enables us to prove the existence and carry out a qualitative analysis for the Navier-Stokes equations, but for the numerical solution requires a special approach. Neural networks are one of the methods for the approximate solution of partial differential equations (PDEs). Recently, the interest in methods of solving PDEs using radial basis functions (RBF) [4] is interested in. These methods can be efficiently implemented on radial basis neural networks [3-7]. Currently great interest methods for solving incompressible fluid and differential equations using neural networks. The use of cellular neural networks is studied in [3]. The main properties of neural networks are: first, matching basis neural networks for differential equations partial differential equations and numerical basis; secondly, the ability of neural networks to more accurately approximate the function. The effectiveness of the using of neural networks for solving differential equations using radial basis functions are studied in [4]. General principles applying radial basis functions for solving differential equations in partial derivatives are described in [5], and practical approaches to the use shown in [6-7]. The aim of this work is the application of radial basis neural networks for solving linear equation Stokes. The approach to training radial basis neural network using gridless method of training a neural network for linear Stokes equation. Considering the peculiarity of the Stokes equation for the construction of neural networks used by the penalty method. Proposed and investigated version of the algorithm of gradient descent learning RBF-network.

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The management of biotechnological production

Currently information systems are used in various spheres of management [1]. However some information systems have no opportunities of intelligence - analytical processing of the information, requiring the user knowledge of the programming language and structure of storage of the data [2, 3]. The intellectual control systems (ICS) unite in themselves opportunities of control systems of databases and technology of artificial intelligence, thanks to the fact that the storage of the information about features of objects of biochemical manufactures (BCM) is combined with its processing and preparation for use at decision-making. Unlike usual analytical and statistical models, ICS [4] allow solving hard formalizing semi structured tasks. Distinctive features, functional tasks, the formalization of a problem situation ICS and their comparison with usual information systems are given in [5].

In this work we will consider the basic moments of a choice of technology underlying developed ICS BCM.

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Environmental research software tools and services of geoportal of ICM SB RAS

Current trends in the field of environmental protection and pollution monitoring are resulting from human impact on nature, and because of natural processes. Monitoring of natural pollution that result from natural causes, such as volcanic eruptions, earthquakes, catastrophic floods, fires, etc., allows us to predict the situation and develop a plan measures to liquidate the consequences, as well as elimination of possible causes. Monitoring the state of the environment in the area of the various industries can reduce costs to eliminate the impact of industrial accidents, which in turn reduces the possibility of contamination soil, surface water, loss of vegetation and wildlife. The paper discusses the creation of geoportal software to support specified problems.

We present gained experience in the development of software tools and services for environmental monitoring tasks. The main results of the work performed, the developed software integrated into the Geoportal of ICM SB RAS, which has became the technology platform for our projects. Geoportal provides information and analytical support for research and educational projects, and is the tool for rapid geospatial applications development [1].

Our software built on the basis of leading GIS and web mapping technologies, free and open source software libraries, projects and toolboxes. We create methods and tools for interactive mapping and table data visualization, satellite imagery processing, spatial data analysis. Serious attention is paid to methods of data caching and native support of external services, such as Google and Yandex mapping data visualization. The result of research is a software and technologies, designed as a geoportal, which contains geospatial databases, web services, special processing of cartographic data. Separate geoportal parts connected to each other through services, declared in application program interfaces (API).

Case studies were performed for analyzing of optimal software specifications and parameters. In particular, we have created a special geoportal section for geospatial database with climate and air pollution data, which is automatically updated from environmental monitoring stations via the Internet. Additional attention was paid to the methods of visualization of time-varying climatic data. An important direction in the software architecture design was providing the support to the international standards on spatial data exchange, such as Open Geospatial Consortium (OGC) Standards.

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Choosing the model for solving the problem of lexical selection for Kazakh language on free/open-source platform Apertium

The lexical ambiguity is an open problem of natural language processing and each machine translation system faces it. Lexical selection is a choosing one translation of the word in target language by context of source language. Solving the task of ambiguity is a difficult task. Today, there are many algorithms and models of resolving it. We will consider existing models and methods for solving problem of lexical ambiguity.

In rule-based free/open-source platform Apertium [1] this problem is solved by module of lexical selection (F.M. Tyers, M.L. Forcada 2013), where rules are written by hand. As you know personal pronoun 'ol' from Kazakh is translated as 'he', 'she' and 'it' into English. We wrote the rule of lexical selection in which translation is taken by depending located near words. Generally, hand-written rules do not cover the entire context. So, we want to use statistics methods and models to solve this problem, which connected with training corpora to generate rules automatically.

First suitable model is Hidden Markov model (HMM), which is the main model of statistical modelling in language processing. In HMM model disambiguation is solved by assigning the probability of word. Knowing the most probable tags in context, translation system can decide which translation of word or collocation is adequate. This model requires a big corpus of Kazakh language to receive accurate translation. If a given possible translation appears aligned to a word in a given context more frequently than other possible translations, then we generate a rule which selects the aligned translation in that same context over other translations in that context [2].

Second model is Maximum Entropy Markov Model (MEMM) that is used to resolve morphological ambiguity. Morphological ambiguity is the main study object of the problem of determining the word's parts of speech (part of speech tagging). However, modern systems are able to effectively solve the problem using methods

of machine learning, such as the support vector machine method or the maximum entropy method, and show the accuracy more than 97%.

We decided to consider the HMM model as most suitable to Kazakh language and will use this model in machine translation systems, that have Kazakh language as a source and as a target language, namely in MT system from Kazakh into English (and vice versa) and from Russian into Kazakh language.

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Object Recognition and Categorization Based on Hierarchical Temporal Memory

In this paper we propose a novel technique for object recognition and categorization that exploits Hierarchical Temporal Memory (HTM). HTM is a machine learning technology being developed by Numenta based on the structural and algorithmic properties of the human neocortex. HTMs can be viewed as a type of neural network, which consists of cells organized into hierarchical regions. Presented technique demonstrates a good recognition performance in a highly cluttered scenes and in the presence of noise. We also show that algorithm remains robust when tested on datasets of images that have large intra category variations. The efficiency of the proposed algorithm evaluated experimentally on IMAGENET dataset and found to be greater than other HTM based approaches.

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Three-dimensional hydrophysical numerical model of Lake Shira: regular computations based on the input data resulting from natural odservations

Our report focuses on 3-d numerical modeling of hydrophysical fields in Lake Shira in summer. A salt stratified Lake Shira is the subject of extensive research because of its central role in the existence of the Khakassia resort area. This lake has the north-south length of 5 km, east-west width of 9 km, and its maximum depth is 25 m now (it varies from year to year). The flow velocity, temperature and salinity distribution and fluctuations of the thermocline (density) are measured in Shira in summers 2009-2014. Stable inhomogeneity of temperature and salinity with depth determines density stratification in the lake.

Three-dimensional primitive equation numerical model GETM [1] is applied to simulate hydrophysical processes in Lake Shira. The model is hydrostatic and Boussinesq. The measured temperature and salinity distribution was taken as the initial data for computations. An algorithm of high order approximation is opted for calculating the equations of heat and salt transfer.

Computations with time constant wind and the initial horizontally homogeneous and vertically stratified density illustrate the dependence of three-dimensional flow on the wind strength and direction [2, 3].

Continuing these studies the computations are performed with variable wind speed (e.g. agreed with the field data of local weather station Lake Shira in June-July 2014). Also we study the influence of the seasonal bathymetry changes on the flow and so on.

An analysis of computed spatial and temporal variability of the major hydrophysical characteristics leads to the conclusion that certain meteorological conditions may cause 3-d phenomenons in this lake.

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The construction of database and compilation tools for nuclear reaction data at the Central Asian Nuclear Reaction Data Centre

Nuclear reaction data is essential for research and development in nuclear physics, astrophysics, nuclear engineering, radiation ecology and radiation medicine. These fields require a variety of nuclear reactions data in the form of database accessible to nuclear data users around the world.

The Central Asian Nuclear Reactions Data Base (CANRDB) at al-Farabi Kazakh National University as a member of the International Network of Nuclear Reaction Data Centres (NRDC) under the auspices of International Atomic Energy Agency (IAEA) runs the activity of development and maintenance of the nuclear reactions database, reference and educational materials in free access for specialists in various fields [1].

NRDC network uses a special format of nuclear data EXFOR (EXchange-FORmat) containing extensive data on nuclear reactions with photons, neutrons, charged particles, heavy ions, the properties and structure of atomic nuclei. Today EXFOR contains data from more than 20,000 experiments [2].

Maintenance of such a massive array of various data requires specialized tools with the possibility to compile, input and digitize numerical and graphic information. CANRDB in collaboration with Japanese Charged Particle Reaction Group (JCPRG) at Hokkaido University are developing a new version of HENDL - a convenient and user-friendly web-based system for nuclear data input with possibility of output in EXFOR and other specific data formats [3, 4]. We give the description and analysis of available software for the development of CANRDB nuclear reactions database and tools for nuclear data compilation.

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Parallel algorithm of RDF data compression and decompression based on MapReduce Hadoop technology

At present, search systems quite successfully deal with information search in the World Web but processing of semantic inquiries, intellectual use of resources are still of semantic an open problem. The necessity of storing and processing of large volumes of data also contributes to creation of new approaches for quick searching and useful information retrieval. Investigations in this direction have been carried out since 1994 after introduction of the notion "Semantic Web" by Tim Berners-Lee, invertor of World Wide Web.

Semantic Web is a structured version of World Wide Web convenient for Semantic search for information which facilitates interaction of man and searching machine. In the course of automatic processing of information within Semantic Web, the interaction with each other services retrieves only that information which will indeed be useful for users on the basis of analysis of semantic ties between objects and notions. As, when working in the Web, we mainly deal with unstructured or semi-structured data which are designed for perception of people and not computers, the development of effective technologies and algorithms of machine processing of the data is a field of active investigations in the whole world.

At present, owing to the growing volumes of the information being processed, the problems of organization of high performance computing for the work in Semantic Web have become actually. The technology of distributed computing appeared to be the most effective which is explained by their high scalability, flexibility and high productivity. For processing of semi-structured data, this Project proposes to use the model of high productive distributed computing on MapReduce. On the basis of theoretical and experimental results of investigations in this field one can assert that algorithms of compression and decompression of RDF dictionaries are most successfully realized using the model of distributed computing MapReduce. The technology MapReduce Hadoop allows the programmer

to concentrate upon the logic of processing; the problems of realization of distributed computing, fault tolerance, load balancing are solved at the level of the technology.

In this work we describe the process of construction of RDF dictionaries and propose of parallel algorithm of RDF data compression and decompression with MapReduce based on approach of Jacopo Urbani and others [1]. We have implemented a prototype using the Hadoop framework, and evaluate its performance.

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3D Computer Technologies as a Tool for Contemporary Archeology

The present study addresses the use of high-tech peripheral computer equipment and software that allow to enhance the work of the modern archaeologist while preparing and describing objects acquired in the excavations [1, 2, 3]. The authors present the sequence of actions forming a transition from the actual fragments of excavated vessels to virtual objects and then obtaining their copies, which permits secure reconstruction of the entire vessel.

The authors created copies of the actual fragments of pottery objects using the sequential steps of digitization and 3D printing. To obtain a point cloud of objects two different types of laser scanners were used - mobile and stationary, recognizing the appropriate process parameters and their suitability to be used in the field of archeology. Then, using the CATIA and Meshlab programs, the point clouds were successively converted into mesh models, three-dimensional original models, and then into modified mesh models with deleted defects resulting from errors of the scanning process. For this purpose, the relevant parameters should be chosen for glossing over the existing discontinuities, which suitably smooth up the form of the reconstructed surface. The next stage involved integration of the mesh surfaces (watertight), and their conversion to a solid model. Then the virtual objects thus created were stored in STL file format and three-dimensional copies were made with 3D printers working in two different replication technologies: Fused Deposition Modelling (FDM) and powder of the ColorJet Printing (CJP) type.

Having digitized objects allowed to develop procedures for their virtual installation in a virtual 3D environment. The basis of the developed procedure was information about the culture from which the recovered archaeological artifacts come. On its basis, typical shapes of pottery were determined and using them

as reference images their three-dimensional models were made in Blender environment. The proposed algorithm is based on the study of the curvature of the hypersurfaces of the fragments in possession and matching them with a 3D model of the complete vessel. In a situation when the items in question are not complete and do not form the whole dish, it is possible to make the missing objects. For their generation in virtual form, Boolean arithmetic was applied which, with respect to solid objects, allows generation of differences and common parts between the complete object and the inserted fragments. After isolating the resulting parts their three-dimensional replications were made with a 3D printer. Such a complex archeological artifact may in the future be used to develop a procedure for the automatic assembly of copies of archaeological finds with the use of a robot.

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Using GIM-technologies for monitoring of the ionosphere over Kazakhstan region

Modern information technologies in science received a new impetus to the development and use of the spacecraft. Radio sounding of the ionosphere by signals of the global GPS navigation system now allows the continuous monitoring of the Earth's ionosphere. The so-called GIM technology (Global Ionospheric Maps), which was developed by some research centers, is a powerful tool for monitoring and investigation of global and local structure of ionosphere (Afraimovich and Perevalova, 2006). This geoinformation technology allows obtaining qualitatively new information about the state of the ionosphere and is one of the most reliable means for monitoring the ionosphere during the disturbances. This paper shows

the application of GIM-technologies for monitoring the ionosphere over Kazakhstan region. We use GIM-maps, designed by the Swiss center CODE (Center for Orbit Determination in Europe, University of Berne, Switzerland) using data from more than 150 GPS sites (list of stations is given in IONEX file) that contains the UNIX format online ftp: //cddis.gsfc.nasa.gov/pub/gps/products/ionex. This paper gives a brief description of the calculation of the absolute values of the total electron content for any regions of Kazakhstan using IONEX files. The results of the analysis of the total electron content variations at different helio-geophysical conditions are shown.

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Development of the Kazakh Text-to-Speech Synthesis System on the basis of Fujisaki intonation model

The development process of the automatic Kazakh text-to-speech synthesis system includes selection of the intonational (prosody) synthesis model, which allows implementing Kazakh speech intonational process modeling in a wide dynamic range including various intonation undertones. With regards to the above, the main selection criteria were based on proximity of model intonation contour to natural speech contour. The task of intonational synthesis has been divided into several subtasks: selecting intonational process models, software implementation of the selected model, parametric identification of the model for voice signal, development of the algorithm for automatic specification of model parameters for arbitrary Kazakh texts to be synthesized.

The first stage included investigation of several models of intonational processes, which have been successfully applied for different languages: AM-model (autosegmental-metrical) [1], Fujisaki model [2], Tilt-model [3], INTSINT model [4] and others. After investigation of these models, it was decided to use the Fujisaki model because it has been successfully used in speech synthesis systems for a variety of languages, and specifically for Turkish language. Fujisaki model is often described as that most accurately reflecting biological aspects of speech formation and reproducing articulatory mechanisms. The second stage included programming of this model in Delphi programming environment. The third phase included parametric model identification for voice signals in Kazakh language. A speech signal in Kazakh language was supplied to the system inputs. Intonational contour was extracted from this signal. The challenge was to carry out optimized selection of model parameters in order to ensure that the model contour is in accordance with the real speech contour. Ultimately, in the process of identifying of

parameters using the technique proposed in [5] the adequately acceptable results were obtained with the inaccuracy of 3%. The algorithm for automatic specification of model parameters for arbitrary Kazakh texts to be synthesized shall be developed in the process of further project works.

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Modification of the encryption algorithm, developed on the basis of nonpositional polynomial notations

Due to the significant changes in technical base and capacity of modern communication systems, the need for persistent and effective means of ensuring information security in the electronic interaction has increased.

One of the indicators of the cryptostrength of block ciphers is the length of the key. In developed nonconventional encryption system as a criterion of cryptographic strength the cryptostrength of algorithm itself is used, which is characterized by a complete secret key. Its structure, apart from the standard secret key, also includes secret parameters of the cryptographic algorithm, based on modular arithmetic. Classical modular arithmetic, or residue number system (RNS), is based on the Chinese remainder theorem, which states that any number can be represented by their remainders (residues) from its division by the base numbers systems, which are formed by pairwise co-prime numbers [1, 2]. In contrast to the classical RNS, proposed cryptographic procedures are considered in polynomial notation, where bases are not prime numbers but are irreducible polynomials in $GF(2)$ [3]. Nonconventional cryptographic methods and algorithms, developed on the basis of nonpositional polynomial notations (NPNs), allow increasing the reliability of the encryption algorithm and reduce the length of the key. Cryptostrength in this case is defined by the full key, which depends not only on the length of a key sequence, but also on choice of a system of polynomial bases and

the number of permutations of these bases in the system. If the length of the full encryption key in NPNs is larger, then there are more choices of systems of working bases. Therefore, the cryptostrength of the proposed encryption algorithm based on NPNs significantly increases with the length of the electronic message.

With the purpose of the practical application of the encryption algorithm, a research will be carried out on development of modification of the algorithm based on Feistel network. The aim of this work is to improve the statistical characteristics of nonpositional cryptograms. In this regard, several models of Feistel scheme could be used. Models could differ by the number of sub-blocks as well as by the number of rounds (or iterations) [4]. The functions of cryptographic transformation of sub-blocks in scheme models may also be different. During computer modeling of modified algorithms, the statistical characteristics of the resulting ciphertexts will be analyzed.

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Predict the properties of chemicals based on Intelligent Computer Systems

The current state of scientific and applied research in the chemistry and a number of related areas characterized by the use of mathematical methods and new information technologies to automate the experiment and received treatment physico-chemical, biological and other data, which include: professional structural support system chemical and biological data and knowledge bases; intelligent system that allows to predict and evaluate the impact of structural and other characteristics of organic molecules on their biological and physico-chemical properties. Using mathematical modeling, the computer-based technology and factual data banks and knowledge allows to detect hidden patterns, to formalize some solutions aimed to search and synthesis of drugs with desired properties. Intelligent computer system consists of: The original database, which supports the processing of complex structured objects such as molecular chemical graphs. DBMS has a built hypertext HELP, friendly user interface, the editor of the input and output forms. Input, output, and manipulation of the structural formulas of molecules is carried out graphical screen editor, the main modes, which: painting,

deleting, editing, assembly of fragments, creating aromatic complexes, manipulation and other structural formulas. Finding information in the database is carried out on any field or set of fields, including substructure search, which is done by drawing of structural fragments and / or fragments of a graphical editor and entered in the search instructions on specially designed query language. Identification of chemicals occurs canonical code, generated by the system software. Tool system for predicting the biological properties of chemicals and the construction of new biologically active compounds with desired properties for their structural formulas with or without physical-chemical parameters of molecules. The system allows you to create training and examination of the sample database, set menu or choose from the various descriptions of the chemical structure or other characteristics, choose different models of statistical data to make decisions about a chemical compound belonging to a particular type of biological activity, to assess their adequacy, predicting biological pharmacological, toxic, mutagenic and carcinogenic properties of organic substances by their structural formulas with or without consideration of physical and chemical parameters. Prediction accuracy (percentage of correct decisions) in the time-system works in predicting various biological properties amounted to 85-92%. Instrumented systems modeling physicochemical and toxicological properties, based on the original mathematical models (structural additive and non-additive), which are then applied when the quantitative structure-property correlations, which allows to predict important parameters such chemicals as lipophilicity and molecular refraction, which hereinafter used in predicting the biological activity of chemical compounds. The system allows to predict toxicological parameters of chemical compounds using models of pattern recognition and piecewise linear regression models, where the intervals of linearity of the regression are the classes of hazardous chemicals. Instrumental system of automatic generation of model-Knowledge and their recruitment in the knowledge base. Model knowledge encompass the ability to show the properties of the object being modeled as part of the description of the user by placing them in the intended mathematical environment. Intelligent system interface that enables input, correction and encoding data, and also provides a graphical visualization of data at all stages of its operation. Block analysis and explanation, which allows the user to trace the chain of decisions taken by the system.

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One of the important directions of the development of environmental information systems is the design of analytical support systems for the monitoring of air pollution in cities [1-3]. To date, due practice extensive experience in developing information systems that solve certain tasks of environmental monitoring is gained. Analysis of existing environmental monitoring systems showed that tasks such as data assimilation monitoring, sources of pollution localization are rarely solved, and often only for research purposes. In the field of ecology, attempts to create a multipurpose information system are not implemented, the local use of powerful computers for optimizing individual processes does not bring the desired effect, we need a holistic interconnected and interdependent information system that solves the problem of environmental monitoring in complex and using actual data. A research team of the D.Serikbayev EKSTU is actively working in this field and performs funded research works [4]. This paper proposes a new approach to the development of information systems of environmental monitoring based on joint use of actual data of automated observing system, modern and efficient algorithms of data assimilation and sources of pollution localization, a computer model dynamics of atmospheric WRF. Information-analytical system "ECO Monitoring" that allows solving of tasks of environmental monitoring such as atmospheric dynamics simulation, modeling of air pollution, sources of pollution localization, visualization of simulation results is developed. Mobile version of the information system is designed too.

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Design of algorithms for automated access control based on business process approach

The article describes access control problem solving to information system resources in the context of common change of business. The algorithms are designed for automated generation and actualization of access control model elements (RBAC, MAC, and DAC). Input information for the algorithms is data from business process model. Estimating algorithms complexity was made on

account of necessary operations quantity. The main research methods were set theory, algorithm theory, and structure analysis. The findings of the article can be helpful for IT and security professionals.

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Algorithms and methods of searching motion in dynamic images

One of the important research problems is the solution of the problem of extraction and recognition in the video picture elements. These problems are reduced to the determination of reference points of virtual objects to real objects in their environment Snapshot - images from the camera. In the practice of the complex problem of recognition in real-time address issues of formation, production, storage, transmission and reproduction of image components with the appropriate technical means and mathematical software. Computing and communication capabilities of wireless mobile communications allow the use of more sophisticated image analysis software that contributes to the development of new mathematical and algorithmic methods for solving the problem of processing and recognition in real time. Despite the fact that created quite a number of methods and algorithms of recognition, the need for their improvement remains as the recognition of real objects in the video stream depends on many factors: the illumination of the scene, the complexity of the surface textures of objects recognition, noisy, camera settings, etc.
Candidate vectors (CV) of the neighboring blocks article presented algorithm of motion compensation in video sequences. In this algorithm was implemented ideas such as decision on the complexity of motion in nature SCV, filtering SCV, finding areas with a new movement, the use of an adaptive threshold and use vectors the current frame to generate the next frame SCV., the current implementation of all the above ideas is promising, but still requires completions.
In my work, we propose an algorithm, which is hybrid approaches described above, made so way to get rid of the disadvantages of each. we Are will use a hierarchical search to find movement of new objects in the video, the candidate vectors for objects whose motion has already been found and templates to clarify vectors. Thus, we get rid of high computational complexity hierarchical compensation problems

in determining motion vectors new objects have methods with the candidate vectors and poor quality of fast motion in the search template methods and identify values of estimation algorithms. Giving the result of organize full cycle stages of construction estimation algorithms. Examples of use in different industries

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A case study of a Knowledge Management System

Albanian key Cross is a humanitarian association that works to improve the lives and dignity of people in need, in accordance with basic principles of motion. He is assistant to the authorities for humanitarian affairs nationwide. Albanian Red Cross today is a "wealth" of the very real humanitarian values of the Albanian civil society. This property is present not only as a concept and existence of traditional and prestigious idea into action, but also with its institutional structures, leadership and management. Our study focuses on the problems that appear in the Association of the Red Cross on the functioning of the department and how those can be solved or made easier to manage through a Knowledge Management System (KMS). Though the construction of ontology we managed to solve the problem that existed between departments. Full implementation of Microsoft Dynamic GP reach to improve and give solutions malfunction of the Albanian Red Cross.

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The technology of creating large-scale intelligent information and analytical search engines in semistructured data

The report focuses on the review of work performed by the Institute of Computational Technologies SB RAS jointly with the Research Institute of Mathematics and Mechanics at Al-Farabi University within the framework of the project "Development of high-performance intelligent information and analytical search semistructured data".

Currently, the most popular means of information support of scientific activity are intelligent information systems, combining the capabilities of documentary and factual research, working with documents rather arbitrary structure, and allows to satisfy the information needs of a skilled user in accordance with the scheme "document - a fact - the argument" [1].

It is possible to formulate the basic objectives of the systems of this kind:

- information resources management;
- security and control of access to distributed information sources;
- long-term storage of information;
- preservation of scientific and cultural heritage;
- Support of analytical work with information;
- increase the efficiency of research and training.

The main works are associated with the following directions:

- Creating a technology platform integrating disparate semistructured data [2].
- Create a large-scale storage system (the system repositories).

- Study of the problems of information retrieval. Building a domain model based on ontologies and thesauri of subject areas. Building RDFS vocabularies.
- Development of a formal model and the structure of information retrieval. Designing high-performance search engine architecture.
- Development of algorithms for intelligent data search, collection and classification of data.

Particular attention is paid to the semantic analysis of the data taking into account the morphology of natural languages (English, Russian and Kazakh languages) - normalization of texts. Normalized texts lend themselves better clustering and other analytical processing. The need for morphological analyzer arose when dealing with information retrieval thesauri based on the morphology of the Kazakh language in the full-text databases of information technology.

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Study of the problem of creating structural transfer rules for the Kazakh - English and Kazakh-Russian machine translation systems on Apertium platform

Translating texts between English and Kazakh, Kazakh and Russian faces some challenges. First of all, Kazakh is one of group of Turkic languages, it means that Kazakh language shows clear ordering of morphems and they are changed by interaction between neighboring morphemes (vowel harmony, sonorization, etc.). On the other hand, syntax of Turkic languages is very different from English or Russian: subject-verb-object order in English as basic order in Russian, but subject-object-verb order in Kazakh,) [1]. Such kind of syntax reordering and transformation we are going to solve by creating structural transfer rules, which

define the transformations needed to convert original sentences and text words into their target language. Structural rules divides the main task of sentence or phrase on the shares of the phrasal, for example noun phrase (NP), verb phrase(VP) and other(for instance, [NP I] [VP wrote] [NP-acc book]). We obtain the most probable sequences of word to divide sentences into phrases(chunks), which is done by hidden Markov Model [2]. For example, computing probability of sequence "determiner+noun" will be P(Det/N)= C(Det,N)/C(Det), where C(Det,N) - is number of situation when noun comes after determiner. Secondly, we use the most liklely tag sequences to create "chunks" by structural transfer rules on Apertium plaform, which is a free/open-source rule-based machine translation (MT) platform, launched in 2005 by the Universitat d'Alacant [3].
Structural transfer module contains three stages for Kazakh-Russian, and four stages for English-Kazakh. Currently, for English-Kazakh are defined 6 main types of chunks(phrases). Each chunk is defined by a set of patterns [4], which consists of a category and attributes. Rules create chunks by detecting certain patterns, for example, for "big house" pattern is adjective+noun.
Current structural transfer rules translate some cases of phrases and solve reodering operation. In the future will be considered: ordering case changes on endings, work on the polysemy prepositions in machine translation from Russian into Kazakh language, the work on the implementation of the structure of interrogative and exclamation sentences on Russian language with the transition to the Kazakh language, some errors on the lexical and syntactic parser generator and machine translation, the work on the elimination of ambiguity of polysemy of words.

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Performance analysis of wireless transmission channels in the presence of eta-mu fading and kappa-mu co-channel interference

Mathematical characterization of various types of propagation environments and accompanying transmission phenomenons has arisen as major task in the processes of computing and evaluation the performances of modern generation wireless communication systems services. In this paper we will analyze standard performance criterions of wireless transmission, when communication is carried out over eta-mu faded channels, in the interference limited environment, with total co-channel interference influence modelled with kappa-mu model. Infinite series expressions will be derived for the probability density function (PDF) and cumulative distribution function (CDF) of received signal-to-interference ratio (SIR). Capitalizing on these expressions, outage probability (OP) and average bit error probability (ABEP), will be efficiently evaluated, graphically presented and discussed in the function of transmission parameters. Finally, possible performance improvement will be considered through the possibility of SC diversity reception appliance. Capitalizing on analysis and evaluations presented, system designers could perform trade-off studies among the various modern communication system parameters in order to determine the optimal choice in the presence of their available constraints.

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Development of geospatial software for environmental monitoring problems

The effectiveness of monitoring the state of the environment is largely determined by its information and analytical software. To successfully manage the territory and manage its resources efficiently, you need a good understanding of the generalized characteristics of its condition. It is also very important to be able as soon as possible in visual form to obtain the necessary decision-making detailed information about the object. These requirements can be achieved through the establishment of modern information and communication infrastructure, environmental monitoring, which allows you to objectively assess the situation in real time and create options for management decisions.

Summarizing the accumulated experience of environmental monitoring information-analytical systems development and implementation is worth noting

that the best results in this area are achieved by the integration and consolidation of the best practices of using geographic information systems and modern web technologies. Let's try to formulate a list of requirements for the information and communication infrastructure of geospatial software for environmental monitoring:

- The organization of the technological environment for the integration of generated information resources;
- Creating a software tools for information exchange between users and for management of user permissions;
- Design and implementation of environmental monitoring facilities databases;
- Development and support of databases containing information on the assessment of the considered territory;
- Development of new computational and mathematical models and methods for environmental monitoring data interpretation;
- Creating a system of web services for data analytical interpretation.

This list does not claim to uniqueness, and probably can be extended, but it's enough for a considerable list of requirements that can be presented to the environmental monitoring geospatial software. The paper deals with specific examples of the developments discussed the proposed software architecture. The main scope is connected with the development of web applications for geospatial data processing, and discussing the advantages of service-oriented architecture usage in such cases.

One of the typical representative of the developed software of this type is "GIS of monitoring the state of the environment in the zone of the oil and gas industry enterprises of the Krasnoyarsk territory". This software solve problems of users interaction, the creation of a geospatial database, the creation of interfaces and services for visualization and analytical processing of the accumulated information, the development of thematic web-based mapping applications. Implementation is based on open source and free GIS software.

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Movements of earth's surface in a source zones of Nothern Tien Shan by satellite data

Was developed the experimental study of the modern movements of the earth surface based on processing and analysis of satellite GPS data from international center SOPAC and formed a catalogue of primary data for 2000- 2012 years. Was

investigated the slow crustal movements of the Northern Tien Shan in tectonic faults using the methods of satellite radar interferometry and GPS data processing [1,2]. Taking into account the geological conditions of the Almaty city and fault distribution in geological structure was studied the slow movements of the earth surface. Initial data for the Almaty city, located in a high seismic activity, was selected from ENVISAT ASAR satellite. Archive data from 2003 to 2009 totaled 90 shots for the two tracks area of 100x100 km, covering the city area. A result was performed in the ENVI SARscape software package.

The resulting product of PS method processing refers to the measurement of vertical displacements and gives the output values of height and velocity for individual reflectors (points). Values of the vertical movements of the earth surface calculated using the PS method identified with millimeter precision.

The study of slow tectonic motions on Nothern Tien Shan region based on GPS data processing and analysis using GAMIT/GLOBK software package. Maps of the velocity distribution in tectonic faults of the Northern Tien Shan for 2003-2012 years in the reference system related to the Eurasian continent.

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Разработка алгоритма распознавания образов и классификация на базе группового синтеза

Одним из естественных и важных требований предъявляемым к алгоритмам классификации является их устойчивость к изменениям классифицируемого множества объектов. В последнее время, в задачах классификации, широко используются групповые методы,заключающиеся в синтезе результатов, полученных при применении различных алгоритмов к заданной исходной информации, или выбора оптимальных, в некотором смысле,алгоритмов из заданного набора. Данная работа посвящена исследованию вопросов устойчивости алгоритмов групповой классификации. Была исследована приближенная устойчивость алгоритмов групповой классификации относительно уменьшений длины исходного множества объектов,введено понятие $(\varepsilon;\delta)$ устойчивости

алгоритмов классификации, которое предполагает, что уменьшение длины исходного множества объектов на δ приводит к изменению результатов работы алгоритма классификации не более чем на ε, получена оценка устойчивости алгоритмов групповой классификации. В силу специфики постановки задачи классификации, оценить работу отдельного алгоритма, а также нескольких алгоритмов,использующих раз- личные принципы формирования классификации, и, как правило, имеющих существенные различия в результатах, не всегда представляется возможным из-за отсутствия общего критерия, аналогичного той оценке, которая, принята в распознавании, например, по доле правильных ответов на контрольном материале, вероятности ошибки или значению среднего риска. Поэтому в задачах классификации, с целью получения объективной информации о структуре анализируемого множества, также применяются групповые (коллективные), методы, формирующие решение да основе результатов нескольких алгоритмов, однако такого развития, как в аналогичных задачах распознавания не имеют. Анализ групповых методов классификаций, проведенный в работе, показал что существующие методы ориентированы на конкретный вид представления исходных классификаций и эффективны лишь для классификаций с малым числом классов или небольшого числа объектов и в настоящее время разработаны еще недостаточно. Используемый при разработке, методов аппарат не может быть применен для групповых методов классификаций континуального множества объектов, а также для построения корректных расширений моделей классификации и корректных алгоритмов, являющихся групповым синтезом базисных алгоритмов. Поэтому разработка теории и применения групповых методов классификаций для конечных и континуальных множеств объектов является актуальной проблемой распознавания образов. Представляемая работа посвящена этому новому перспективному направлению теории распознавания и классификации.

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Системы распознавания образов в задачах автоматизации распознавания паспортных данных

Рассматривается работа автоматического распознавания текстовой информации паспортных данных. В работе использовались удостоверение личности и паспорт стандарта Республики Казахстан. Предложенная модель обработки позволяет автоматизировать процесс регистрации персоны путем автоматического распознавания его паспортных данных и занесения метаинформации извлеченной методами оптического распознавания символов с использованием нейронных сетей. Применения похожих моделей рассматривали Young-Bin Kwon and Jeong-Hoon Kim [1].

Описание модели. Среди существующих подходов по распознаванию символов существуют два основных направления - фотометрический и топологичесий. В работе предпочтение было отдано фотометрическому анализу шаблонов растровых представлений на основе нейросетевого алгоритма классификации символов стандарта ICAO 9303. В виде модели по распознаванию символов была применена многослойная нейронная сеть с обратным распространением ошибки. Обучающая выборка состояла из набора эталонных символов, входящих в стандарт. Рассмотрены следующие задачи:

1. Идентификация границ документа. Для идентификации границ были применены алгоритмы идентификации смены градиента интенсивности пикселей на основе алгоритма CannyEdge[2].

2. Разворот документа до получения минимального расхождения с горизонтальной плоскостью. Для поиска таких линий использовался алгоритм HoughLineTransform[3]. Данная процедура позволяет решить сразу несколько задач: Получение горизонтального положения текстовой информации; Проведение поиска шаблонов типов документа; Извлечение лица человека при наличии.

3. Идентификация типа документа путем сравнения шаблонов. Рассмотрены следующие задачи: Извлечение лица из документа: Извлечение машиночитаемой зоны; Распознавание текстовой информации Заключение. В рамках работы были затронуты вопросы: Устойчивые к помехам алгоритмы идентификации человеческого лица на основе нейронной сети и алгоритма LDA. Устойчивые к помехам алгоритмы распознавания печатных символов на основе нейронной сети с обратным распространением ошибки; Алгоритмы идентификации паттернов на основе корреляционного анализа; Применение геометрических топологических особенностей при поддержке принятия решения.

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Логический подход к организации многокритериального атрибутного разграничения доступа

В настоящее время разрабатываются методы атрибутного разграничения доступа, применяемые в открытых средах, таких как интернет, облачные структуры, грид-вычисления, а также во всех приложениях, обрабатывающих заявки на доступ большого числа пользователей к широкому ряду ресурсов. Предложен метод многокритериального атрибутного разграничения доступа, согласно которому производится множественная категоризация объектов и субъектов разграничения доступа, в результате которой сущности снабжаются наборами атрибутов безопасности, что отражает факт принадлежности сущностей различным подразделениям вычислительной среды. Каждой категории атрибутов, как определенным образом структурированному множеству, ставится в соответствие своя политика безопасности, такая как Белла и ЛаПадулы, тематическая, организационная, ролевая. Принятие решения о возможности доступа принимается на основании результатов сравнения значений атрибутов пользователя и информационного ресурса одновременно по всем категориям. Рассматривается логический подход к решению задачи конструирования систем многокритериального атрибутного разграничения доступа, основанного на одновременном применении ряда моделей безопасности, представленных унифицированным образом. Построена многокритериальная модель атрибутного разграничения доступа, синтаксис которой описывается односортным языком логики высшего порядка. Параметрическая интерпретация языка дает ряд моделей, использующих частично упорядоченные множества с их алгебраическими операциями для реализации различных атрибутных политик безопасности.

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Технологии интеграции разнородных программных систем в информационно-вычислительной среде математического моделирования и анализа данных

Решение сложных наукоёмких задачи, как правило, требует использования комплексных методов, а также распределённых программных систем, созданных на различных программных платформах. К таким задачам относится, проблема моделирования распространения загрязнения атмосферного воздуха населенных пунктов.

В ИДСТУ СО РАН создается информационно-вычислительная среда математического моделирования и анализа данных, которая базируется на Web технологиях и предоставляет пользователю систему хранения данных и набор WPS [1] сервисов для обработки данных. В среду могут быть включены любые сервисы, поддерживающие стандарт WPS, путем их регистрации в каталоге сервисов среды. Разработан ряд технологий, позволяющих упростить создание WPS сервисов на основе существующих программных систем:

- технология создания WPS-сервисов на основе облачных вычислений, которая предоставляет виртуальную машину в облачной инфраструктуре с предустановленным программным обеспечением для публикации методов программных систем в виде WPS сервисов;
- технология создания WPS-сервисов на основе вычислительного кластера, которая позволяет предоставить доступ к программным системам вычислительных кластеров.

На основе разработанных технологий созданы следующие WPS сервисы информационно-вычислительной среды: сервис дешифрирования набора данных дистанционного зондирования земли методом опорных векторов, сервис оперативного прогнозирования загрязнения атмосферы, почвы и водных объектов при ведении взрывных работ на предприятиях по открытой добыче угля, сервис расчета распространения шума от промышленного взрыва и т.д.

Решение сложных задач также требует не тривиального применения распределенных WPS сервисов, которое может включать обработку параметров, итерационное применение WPS-сервисов, ветвление в зависимости от промежуточных результатов и т.д. Для реализации логики применения WPS сервисов разработан язык сценариев применения WPS-сервисов на основе языка JavaScript. Создан интерпретатор WPS-сценариев, позволяющий асинхронное выполнение сервисов.

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Особенности и требования к качеству программных средств космического назначения

Как показывает практика, высокий уровень зависимости выполнения космической системой основной целевой функции и безопасности от используемого в ней программного обеспечения порождает необходимость придания применяемым программным средствам заданных свойств качества и безопасности. К качеству и надежности подобного программного обеспечения (программных средств космического назначения – ПСКН), предъявляются особо высокие требования.

Существующие методы и технологии разработки не позволяют гарантировать необходимый уровень надежности, отказоустойчивости и безопасности ПСКН. В реальных проектах часто отсутствуют или недостаточно четко формулируется понятие качества ПСКН, характеристики которыми оно описываются, как их следует измерять и сравнивать с требованиями спецификации [1].

Как известно, проблема качества программного обеспечения (ПО) имеет два аспекта: обеспечение и оценка (измерение) характеристик качества.

Для оценки качества ПСКН в настоящее время не существуют общепринятой номенклатуры показателей качества, критериев, метрик, стандартной методики оценки.

Указанные факторы обосновывает важность разработки формализованных методов оценки качества ПСКН, которые должны базироваться на следующих основных компонентах: модели качества ПСКН; модели метрик ПСКН; методики оценки (измерения) качества.

Особенности и характеристики качества ПСКН зависят от того, для какой цели, для какого потребителя и для каких условий эксплуатации они предназначены.

С целью установления особенностей и требований к характеристикам качества и безопасности ПСКН в работе представлена классификация с учетом их назначения, условий эксплуатации, требований к надежности, безопасности и др.

Требования к характеристикам качества ПСКН предлагается устанавливать на основе уровня критичности ПО, определяемого в соответствии со степенью влияния его на безопасность космической системы и тяжестью последствий аномального функционирования. В работе предлагаются критерии для присвоения уровней критичности ПСКН.

Разработчик ПО после проведения функционального анализа требований к проекту должен определить категории безопасности выполняемых функций ПСКН и установить уровень критичности ПО и соответствующие требования к характеристикам качества и безопасности.

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Особенности разработки программно-технологического обеспечения для региональных геоинформационных веб-систем

В работе рассматриваются особенности разработки региональных геоинформационных систем и сервисов в Интернет. Основное назначение таких систем – мониторинг и публикация данных состояния окружающей природной среды, мониторинг различных экономических или социальных процессов для систем поддержки принятия решений на уровне Красноярского края. В работе востребованы методики и программные средства, которые позволят формировать оценки состояния территорий на базе основных показателей в наглядном виде. Важную роль играет использование современных средств визуализации данных с использованием ГИС-технологий. Значительное внимание уделяется веб-сервисам и программным интерфейсам. Решается ряд задач, связанных с обменом данными и метаданными о пространственной информации, возникающих при разработке совместных проектов различных научных институтов, университетов и подразделений органов власти.

На примере системы «Банк пространственных данных Красноярского края» рассматривается задача, связанная с формированием картографических программных интерфейсов. Основное назначение программных интерфейсов к каталогу пространственных данных – обеспечение доступа к этим данным, различным службам и веб-сервисам. Цель его создания – информационное обеспечения задач мониторинга состояния социальной и природной среды и ресурсов в региональной ГИС. Каталог метаданных содержит информацию по доступным слоям и картам. Основной особенностью каталога пространственных данных является возможность использования различных

форматов пространственных данных и организация доступа для пользователя к этим данным с помощью современных стандартов и технологий.

Разработанное программное обеспечение и сервисы строились на основе свободно распространяемых технологий и программного обеспечения:

- платформа для публикации картографических данных – MapServer 6.x;
- система кэширования картографических данных – GeoWebCache 1.4.x;
- основной язык разработки – PHP 5.5;
- СУБД – PostgreSQL 9.1 + PostGIS 1.5.

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Технология использования разнородных данных при сегментации спутниковых изображений высокого разрешения

В настоящее время целый ряд спутников (WorldView-2/3, Ресурс-П, GeoEye-1, Pleiades, Kompsat-3 и др.) обеспечивает регулярную поставку мультиспектральных изображений высокого пространственного разрешения (лучше 4 м). Характерная особенность таких изображений заключается в том, что значительная часть информации, необходимой для их анализа, содержится в пространственных характеристиках (текстура, форма, размер и т.д.), а также в накопленных базах данных, имеющейся априорной информации и т.п.

В докладе рассматриваются схема единообразного представления данных и технология сегментации изображений высокого пространственного разрешения, позволяющая при обработке использовать всю доступную разнородную информацию. Все имеющиеся данные используются для формирования набора растровых слоев, которые при дальнейшей обработке рассматриваются как дополнительные признаки.

Полученные слои можно разделить на слои данных и тематические слои. Слои данных (спектральные каналы исходного изображения, построенные ранее тематические карты и карты, генерируемые автоматически, и т.п.) не зависят от особенностей решаемой задачи, их формирование выполняется без участия пользователя. Для генерации тематических слоев необходимо участие эксперта. К ним относятся бинарные маски, построенные на основе имеющихся априорных знаний и предназначенные для выделения конкретных типов объектов, комплексные спектральные признаки (индексы), а также текстурные и контекстные признаки. Кроме того, к тематическим слоям можно отнести маску, которая позволяет выделить область интереса, определяемую экспертом исходя из особенностей решаемой задачи. Подобное представление разнородной информации позволило разработать технологию сегментации спутниковых изображений высокого пространственного разрешения.

Программная реализация предлагаемой технологии опирается на оригинальные эффективные ансамблевые алгоритмы сегментации по спектральным [1, 2, 3] и текстурным [4] признакам, а также методы формирования пространственных масок [5, 6, 7]. Алгоритмы реализованы в виде набора стандартизованных веб-сервисов (WPS-процессов), что позволяет использовать предложенную технологию для решения практических задач на стороне пользователя с использованием как свободно распространяемых ГИС-пакетов (QGIS, uDig, OpenJUMP и др.), так и коммерческой геоинформационной системы ArcGIS.

Разработанная технология может быть использована при решении междисциплинарных задач, связанных с анализом спутниковых изображений.

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Технологии извлечения количественной информации из геологических научных публикаций и сервисы их обработки

Современные технологии организации информационных систем хранения научных публикаций создают условия для активного роста объемов научной информации в этих системах. А предоставление доступа к этим базам данных научных публикаций в соответствии с концепцией “открытый доступ” открывает возможности для взаимодействия с этой информацией.

Существующие информационные системы: хранилища данных, репозитории, электронные библиотеки – можно рассматривать, как архивы больших данных (Big Data). В связи с накоплением большого количества научной текстовой информации, возникает интерес в е? анализе в рамках определенной предметной области. В геологических научных публикациях интерес представляют: таблицы, схемы, графики, библиографические ссылки и научные знания. Создание базы количественных данных из научных рецензируемых публикаций является первым шагом в анализе геологических публикаций.

Обсуждаются следующие задачи: автоматическое извлечение таблиц и их описаний, организация хранения, предметной систематизации и поиска. При этом отдельно стоит задача о согласовании данных из разных публикаций, обладающих одинаковыми параметрами описания.

Представлены методы и технологии решения этих и сопутствующих задач, а также разработка на данных решениях Центра количественных данных (http://data-center.fareastgeology.ru), входящего в информационную инфраструктуру для поддержки научных геологических исследований на Дальнем Востоке России.

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О задаче идентификации множества точек разрыва геометрических объектов по томографическим данным

Проблема восстановления разрывов функции по ее известному преобразованию Радона как самостоятельная задача была поставлена сравнительно недавно, а известный алгоритм восстановления разрывов был предложен в работе Е. И. Вайнберга с соавторами в 1985 г. [1]. Суть алгоритма состояла в двойном дифференцировании по одной из переменных томографических данных (преобразования Радона) с последующим использованием оператора обратной проекции. В дальнейшем задача активно исследовалась многими авторами как в России, так и за рубежом. В последние годы, в связи с интенсивным развитием векторной и тензорной томографии, постановка задачи восстановления разрывов были существенно обобщена (см. например [2]), и в настоящее время может трактоваться как задача восстановления сингулярного носителя симметричных тензорных полей по их известным лучевым преобразованиям. Иными словами, речь идет не только о функциях, но и о векторных и тензорных полях, и, кроме того, о восстановлении не только разрывов самих полей, но и их производных.

Обобщение постановки приводит к необходимости разработки адекватных методов и алгоритмов для реконструкции множества точек сингулярного носителя полей по их лучевым преобразованиям, или, шире, по томографическим данным. Вообще говоря, под термином “восстановление разрывов” логично подразумевать несколько задач. Первая задача состоит в визуализации разрывов, и именно эта задача исследуется в подавляющем большинстве работ. Вторая задача заключается в идентификации разрывов, т.е. в математическом описании множества точек сингулярного носителя. Третья задача состоит в определении величины скачка.

Цель данной работы состоит в описании некоторых подходов и алгоритмов численного решения второй задачи, позволяющим математически описать множество точек сингулярного носителя этих полей. При этом в качестве данных используются как сами лучевые преобразования полей, так и результаты применения операторов индикатора неоднородности. Используются методы аппроксимации, сглаживания, статистические подходы.

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О пользовательских интерфейсах для работы с тезаурусами и рубрикаторами в распределенных разнородных информационных системах на примере платформы ZooSPACE

Работа посвящена описанию технологий, используемых для построения пользовательских интерфейсов для работы с тезаурусами, рубрикаторами и онтологиями в гетерогенной информационной среде. Обсуждаются различные аспекты построения пользовательских интерфейсов для навигации по рубрикаторам, тезаурусам и онтологиям (в дальнейшем - тезаурусам), поиска и просмотра статей тезаурусов, просмотра связей между различными тезаурусами, просмотра динамических связей между тезаурусами и другими базами данных с возможностью управления списком подключаемых баз данных, просмотра динамически связанных записей других баз данных. В качестве примера приводятся пользовательские интерфейсы подсистемы ZooSPACE-W платформы ZooSPACE [1], в качестве основы для работы с тезаурусами были выбраны: протоколы доступа к ресурсам - Z39.50 [2] - [3] и/или SRU [4], схема данных тезаурусов - Zthes [5], формат представления записей тезаурусов - XML. В качестве информационных ресурсов для отладки алгоритмов и интерфейсов использованы базы данных, структурированые в соответствии с международными и российскими стандартами (ISO 25964 [6], ГОСТ 7.25-2001 [7], ГОСТ 7.24-2007 [8]), и интегрированые в рамках платформы ZooSPACE.

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Опыт использования космических снимков Aster для решения геологических задач на примере Жезказганского рудного района

Применение спектральных данных радиометра ASTER для картирования минерагенического состава горных пород северной части Жезказганского рудного поля по интенсивности излучения волн позволило оконтурить границы распространения максимальной кальцитизации пород . Картирование осуществлено выделением из интегрального поля сканированного излучения индивидуальных спектров минералов и их комбинаций с привлечением данных спектральных библиотек. Для каждого минерала на основе экспериментально найденных уравнений опытным путем установлена своя комбинация различных диапазонов излучаемых волн. Ассоциация выделенных минералов наиболее полно охватывает практически все известные месторождения медистых песчаников Центрального Казахстана или вплотную приближена к ним. Комплексный минерагенический анализ распространения кальцита, альбита, калиевых полевых шпатов, кварца позволил получить новые данные о распределении метасоматической зональности контролирующей оруденение.

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Вычислительная технология обработки данных комплексного мониторинга природных геообъектов

Работа посвящена новому направлению в обработке данных геомониторинга, которое может быть использовано в диагностике сложных природных геообъектов и систем – «геометрический анализ» визуальных данных, где совместно выполняется вейвлет-преобразование данных для криволинейных объектов и шиарлет-преобразование для линейных объектов.

Задаче разделения изображения на морфологически разные составляющие в последнее время уделяют много внимания в связи с её значимостью при решении задач распознавания образов для различных актуальных приложений в науках о Земле. Разрабатываемая вычислительная технология для эффективного решения этой задачи может быть применена к широкому кругу геообъектов, включая исследования, связанные с изысканиями на нефть и газ в сложных геосредах.

Отметим, что только сравнительно недавно появилась новая система представлений в рамках кратномасштабного анализа, так называемое шиарлет-преобразование данных (сигналов и изображений). Шиарлет-преобразование – это преобразование данных, расширяющее возможности вейвлет-преобразования и включающее помимо оператора параллельного переноса по времени и масштабирования по частоте также характеристику направленности в виде оператора сдвига. Операция сдвига дает более эффективный подход при изучении направленности в сложных геосредах, обеспечивая единообразную обработку изображений геообъекта.

В результате проведенных исследований разработана вычислительная технология, позволяющая решать задачи обработки данных геомониторинга сложных геообъектов на основе совместного применения вейвлет- и шиарлет-преобразований. Приведен ряд примеров, где показаны возможности шиарлет-анализа пространственных данных геомониторинга сложных природных объектов. Вычислительная технология состоит из несколько этапов: на первом этапе исходное изображение разделяется на фрагменты заданного размера (расчетный шаблон) и определяется последовательность расчетных процедур для наиболее оптимального решения поставленной задачи; на втором этапе осуществляется настройка алгоритмического обеспечения, выбор конкретного алгоритма для поставленной задачи; на третьем – загрузка и обработка исходных изображений (фрагментов) для различных расчетных условий в соответствии с поставленной задачей; на последнем этапе – анализ получаемых в результате шиарлет-преобразования расчетных изображений, контрастирование изображения. Результатом является набор расчетных изображений, последующая интерпретация которых позволяет решать соответствующие прикладные задачи на изучаемом геообъекте.

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Интеграция географических метаданных в современные системы организации цифровых репозиториев

В работе рассматривается такая широко известная система для организации цифровых репозиториев, как DSpace [1]. Данная система используется в

рамках проектов «Цифровой репозиторий ИВТ СО РАН», «Открытая краеведческая цифровая библиотека Новосибирска» и др. В системах, построенных на базе DSpace, содержится большое количество документов, так или иначе связанных с географической информацией [2]. В то же время, в базовой поставке DSpace отсутствует функциональность, связанная с географическим аспектом информации. В докладе рассматриваются варианты реализации географической функциональности в системе DSpace.

Первый вариант – реализация непосредственной географической привязки документов из хранилища DSpace к географическим регионам [3]. Данный вариант реализуется расширением стандартной схемы метаданных DSpace соответствующими полями для хранения географических координат, модификацией интерфейсов поиска и редактирования информации и настройкой поискового сервиса Solr на обработку географических координат. В интерфейсы редактирования информации добавляется возможность выбора географического региона на карте для географической привязки объекта. В поисковый интерфейс добавляется возможность выбора географического региона поиска с помощью карты.

Второй вариант – реализация привязки документов из DSpace к записям внешнего географического тезауруса. Внешний тезаурус содержит связанные между собой названия и координаты географических объектов [4]. Данный вариант реализуется расширением стандартной схемы метаданных DSpace соответствующими полями для хранения идентификаторов географических объектов. В этом случае в интерфейсы системы встраивается функциональность, позволяющая выбирать запись из внешнего географического тезауруса и сохранять ссылку на неё. Для поиска будет использоваться такая же модификация интерфейса, как и в первом случае – предоставляющая возможность выбрать географический регион поиска на карте.

Таким образом в работе описывается расширение поисковой функциональности системы организации цифровых репозиториев DSpace путем интеграции в неё географической информации.

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Системный подход к конструированию интерфейсов приложений

Интерфейс программной системы — важная составляющая качества, связанная с оценкой приложения пользователем. В то же время, при разработке очень часто интерфейсу должное внимание не уделяется. В результате в принципе полезные программы могут оказаться неудобными или даже не востребованными пользователями. Интерфейсные ошибки сплошь и рядом «украшают» популярные программы. Положение усугубляется тем, что реальное использование таких программ создает предпосылки формирования стихийных стандартов, закрепляющих и тиражирующих интерфейсные ошибки.

В одной из немногих книг [1], посвященных интерфейсам, приводятся рекомендации и предостережения, обоснованные хорошим анализом. Однако автор обсуждает действия пользователя лишь локально, не связывая интерфейс с функциональностью и архитектурой. Мы предлагаем восполнить этот пробел, рассматривая интерфейсы в двух аспектах. Во-первых, это абстрактное управление поведением приложения, а во-вторых — отображение абстрактного управления в конкретные интерфейсные формы. Соответственно, вводятся понятия абстрактного и конкретного интерфейсов и их полноты. Полнота абстрактного управления — это соответствие функциональности всем элементам деятельности, автоматизируемой приложением, а полнота конкретного интерфейса — отражение в его элементах всех аспектов абстрактного поведения в формах, отвечающих пользовательской потребности автоматизируемой деятельности.

Ключевым положением предлагаемого подхода является анализ всех видов деятельности пользователя, на которые влияет включение приложения в качестве средства или инструмента. Цель анализа — определить место разрабатываемого приложения в контексте работы пользователя и, в частности, обосновать необходимые элементы интерфейса и построить типовые сценарии взаимодействия с приложением. Эти сценарии рассматриваются как основа отображения абстрактного управления в конкретный интерфейс. В результате разработчик имеет возможность обосновать использование активных, пассивных и декоративных элементов интерфейса для тех или иных целей.

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Разработка подсистемы актуализации базовых пространственных данных по населенным пунктам Красноярского края

В настоящее время многие органы местного самоуправления, хозяйствующие субъекты активно создают и используют пространственные данные [1, 2]. Одной из важных задач является хранение и ведение базовых цифровых картографических материалов территории.

В работе рассматривается задача формирования и актуализации базовых пространственных данных по населенным пунктам некоторого региона. Сформулированы основные требования к подсистеме актуализации:

- поддержка расширяемого набора слоев;
- многопользовательская работа с авторизацией, одновременная оцифровка различных участков карты;
- возможность работы без постоянного подключения к хранилищу пространственных данных в различных ГИС пакетах (MapInfo, ArcView, QGIS, и др.);
- хранение истории обновляемых данных с возможностью отката;
- инструменты для автоматической и ручной проверки данных.

Были проанализированы существующие технологии и программные компоненты, которые могут быть использованы для решения поставленной задачи. Рассмотрены существующие стандарты, технологии хранения пространственных данных в реляционных СУБД и организации к ним многопользовательского доступа.

В результате была предложена методика актуализации и разработаны программно-технологические средства. Оцифровка выполняется по участкам карты в рамках заданий. По области задания вырезаются объекты из всех слоев и выдаются оцифровщику. После актуализации, результат встраивается в общую карту. Вычислительные операции, которые могут быть продолжительными по времени выполняются в отложенном режиме служебным сервисом.

Использовался язык сценариев PHP 5 с фреймворком для разработки веб-приложений Yii, реализующим парадигму MVC. Для хранения данных применялась СУБД PostgreSQL с пространственным модулем PostGIS.

Предложенная методика актуализации пространственных данных и разработанные компоненты были успешно внедрены в информационную систему "Банк пространственных данных администрации Красноярского края"[2]. В результате решена задача детальной оцифровки около 1500 малых населенных пунктов на территории края, которая выполнялась в многопользовательском режиме командой из 10 оцифровщиков.

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Математическое моделирование информационных процессов в веб-пространстве

Анализ свойств интернета как математического объекта впервые был начат в работах Р. Алберта и А.-Л. Барабаши [1]. Проблематика исследований включает поиск адекватных представлений интернета в виде сложной сетевой структуры и исследование ее свойств, нахождение математических параметров, характеризующих такую сеть, определение и предсказание изменений этих параметров при эволюции сети.

Для изучения содержательных и логических связей между объектами интернета удобно использовать их представление в виде веб-графа. Как правило, при построении веб-графа в качестве вершин рассматриваются отдельные страницы сайтов или сайты, рассматриваемые как единое целое. В настоящей работе под веб-графом понимается ориентированный граф, вершины которого соответствуют веб-сайтам, а отношение между сайтами определяется ссылками друг на друга. В работе методами теории графов и вебометрики проводится сравнение численных и структурных характеристик веб-графов академических сообществ, строятся рейтинги сайтов [2].

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Section 3. MATHEMATICAL MODELING OF TECHNOLOGICAL PROCESSES

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Modelling of evolution small-scale magnetohydrodynamic turbulence depending on the magnetic viscosity of the environment

In the present work is devoted to study of self-excitation of magnetic field and the motion of the conducting fluid at the same time taking into account acting forces. The idea is to specify in the phase space of initial conditions for the velocity field and magnetic field, which satisfy the condition of continuity. Given initial condition with the phase space is translated into physical space using a Fourier transform. The obtained of velocity field and magnetic field are used as initial conditions for the filtered MHD equations [1]. Further is solved the unsteady three-dimensional equation of magnetohydrodynamics to simulate homogeneous MHD turbulence decay. The numerical modeling of the problem is performed based on solving non-stationary filtered magnetic hydrodynamics equations in conjunction with the continuity equation in the Cartesian coordinate system.

To solve the problem of homogeneous incompressible MHD turbulence the following physical interpretation of the splitting diagram is suggested. During the first stage, the Navier-Stokes equation is solved without the pressure consideration. For the approximation of convective and diffusion equation members, a compact scheme of an increased order of accuracy is used. During the second stage,the Poisson equation is solved, which is obtained from the continuity equation by considering the velocity fields of the first stage. For the three-dimensional Poisson equation, an original solution algorithm was developed - a spectral transform in combination with the matrix run. During the third stage, the obtained pressure field is used to recalculate the final velocity field. During the fourth stage, the obtained velocity field is used to solve the equation to obtain the components of the magnetic field strength [2], which are included in the initial equation.

Based on the method large-eddy simulation was produced the numerical modelling of influence magnetic viscosity to decay of homogeneous magnetohydrodynamic turbulence, analyzing simulation results it is possible to make the following conclusion: the magnetic viscosity of the flow has a significant influence on the MHD turbulence, and therefore can be used for process control in the preparation semiconductor structures of single crystals. Obtained results allow sufficiently accurately calculate the change characteristics of homogeneous magnetohydrodynamic turbulence over time at large magnetic Reynolds numbers. Physical processes and phenomena of homogeneous magnetohydrodynamic turbulence identified in the numerical simulation. The proposed method can be used to solve the MHD turbulence without significant changes.

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Inverse equation for determination of anomalies field of gravity force by actual meteorological data

Work related to the extraction of minerals, led to erosion and contamination of large areas to global environmental violations and systems is an important task of science forecasting changes in ecological systems under the influence of natural and anthropogenic factors. Under certain meteorological conditions, even minor emissions of pollutants can create unfavorable ecological situation in the settlements, and the degree of pollution of the lower atmosphere by harmful substances depends not only on technological and structural parameters, but also on a number of meteorological factors that determines the spread of contaminants in the atmospheric boundary layer. Therefore, for a more complete description of the transport processes, diffusion and transformation of pollutants, they must be considered on the basis of physically sufficiently rich model that takes into account, at least, the diurnal variation of dispersion variability depending on meteorological situation, orographic and thermal inhomogeneities of the underlying surface.

Let us consider how to solve the "inverse" problem of determining , eliminating the thermal effect. The problem is solved in two stages. Initially determined by the field due to the linear terms , and only then is its nonlinear part of this purpose, we have to consider a stationary system of hydrometeorology equations.

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Mathematical modelling of oil recovery by polymer and surfactant flooding

Due to the depletion of oil reserves, the relevance of enhanced oil recovery methods (EOR) by chemical injection is increasing every year. Studies show that the use of surface-active agents (surfactants), alkaline and polymers can increase oil recovery factor [1, 2].

Currently used combined methods of enhanced oil recovery. One such method is flooding surfactant solutions in combination with water-soluble polymers. Surfactant and polymer is injected into the reservoir, and then push it out to the producing wells by pumping water. With this method, the recovery rate is higher comparing with using surfactant and polymer individually [3, 4].

This article describes a hydrodynamic model of collaborative fluids (oil, water) flow in porous media for enhanced oil recovery, which takes into account the influence of temperature, polymer and surfactant concentration changes on water and oil viscosity [5, 6]. For the mathematical description of oil displacement process by polymer and surfactant injection in a porous medium, we used the balance equations for the oil and water phase, the transport equation of the polymer / surfactant / salt and heat transfer equation. Also, consider the change of permeability for an aqueous phase, depending on the polymer adsorption and residual resistance factor. Results of the numerical investigation on three-dimensional domain are presented in this article and distributions of pressure, saturation, concentrations of polymer / surfactant / salt and temperature are determined. The results of polymer / surfactant flood are verified by comparing with the results obtained from ECLIPSE (Schlumberger) [7] and UTCHEM (simulator developed at the University of Texas at Austin) [8]. Also the parallel version of numerical methods are proposed.

The aim of this work is to study the mathematical model of non-isothermal oil displacement by polymer / surfactant flooding, and to show the efficiency of the combined method for oil-recovery.

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Modeling of solid liquid phase change process during charging of latent heat storage

Solid liquid phase changes occur in many industrial or natural processes, and one of the examples is during charging and discharging of latent heat storage or storage based on phase change materials (PCMs). PCMs can absorb large amounts of heat without significant rise of their temperature during the melting process. This effect is attractive for using in thermal energy storage and passive thermal management. Therefore, understanding, modeling and numerical simulation of these processes has motivated a large number of analytical, experimental and numerical studies over the last decades. Paraffin is considered as one of efficient PCM materials for medium temperature latent heat storages. Current paper deals with numerical modeling of solid liquid phase change of paraffin inside the already designed heat storage container. The numerical results are well comparable with experimental results. It is concluded that the design of the container needs to be studied and redesigning is suggested.

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A source identification problem related to mathematical model of laser surface heating. Numerical results

A mathematical model of two - dimensional laser surface heating for the hardening of metallic materials is proposed. The model is governed by the heat equation $u_t - \Delta u = m(t)\delta(x - \omega(t))$, $(x,t) \in \Omega_T := \Omega \times (0,T] \subset R^3$, with the pointwise source term $\delta_\gamma(y)$, satisfying the initial $u(x,0) = u_0(x)$ and boundary $u(x,t) = 0$, $x \in \partial\Omega \times (0,T)$, conditions. The pair of source terms $\langle m(t), \omega(t)\rangle$ is assumed to be unknown. The two - valued ($m(t) = 0$ or $m(t) = m_0 > 0$) function $m(t)$ is treated as the intensity of the laser beam, and the function $\omega(t)$ describes the laser beam trajectory. The identification problem consists of determining the pair of source terms $\langle m(t), \omega(t)\rangle$ such that the corresponding heat function $u(x,t)$ satisfies the condition $\sup_{t\in[0,T]} \|u - v\|_{L_2(\Omega)} \leq \varepsilon$, where the smooth function $v(x,t)$ is the solution of the heat conduction problem

$$(1) \quad \begin{cases} u_t - \Delta u = m(t)\delta_\gamma(x - \omega(t)), \quad (x,t) \in \Omega_T := \Omega \times (0,T] \subset \mathbb{R}^3; \\ u(x,0) = u_0(x), \quad x \in \Omega; \\ u(x,t) = 0, \quad x \in \partial\Omega \times [0,T). \end{cases}$$

with the appropriate source term $F(x,t)$, and $\varepsilon > 0$ is a given - in - advance parameter. Besides the existence result, the structure of the optimal trajectory is also described.

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Generalized functions method in transport problems of elastodynamics

In articles [1,2] the generalized and classical decisions of system of the Lama's equations in moving coordinates system are constructed which describe the motion of isotropic elastic medium at the action of transport loads, which are moving with

subsonic, transonic, sonic and hypersonic speeds. It was shown that the type of these equations is depending on two Mach numbers (the relation of speed of the source movement to the speeds of longitudinal and transverse elastic waves). The equations are elliptic at subsonic speeds, have mix hyperbolic-elliptic type at transonic speeds and they are hyperbolic at a hypersonic case. Here we considered the first and second boundary value problems (BVPs) for elastic medium, which is limited cylindrical surface. On it there is transport load which moves with a constant subsonic speed along the cylindrical boundary.

This class of BVP is mathematical model for dynamics of massif in vicinity of underground constructions as transport tunnels, and also land road for transport load which speeds of the movement are still much less than the speeds of disturbances waves in the environment. In this case we have an elliptic BVP. For its solving the method of the generalized functions (GFM) is used which allows to build dynamic analogues of Green formulas for the elliptic equations and systems, and on their basis to receive the decisions and to build the singular boundary integral equations which resolve the task. The main ideas of this method for a class of the transport solutions of the wave equations at sub - and supersonic speeds in spaces of different dimension were stated in [3]. Uniqueness of the solution of both BVPs is proved, the dynamic analogues of Somigliana's formulae and singular boundary integral equations resolving BVPs are constructed [4].

Calculations by method of consecutive approximations of decisions for the first BVP for a tunnel of a circular and vaulted profile are performed which are illustrated by diffraction pictures of vector fields of movements of the elastic medium near the tunnels.

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Enhancement of the in-situ leach mineral mining process by the hydrodynamic method

In this paper, a usage efficiency of the hydrodynamic method in the enhancing of mineral extraction is numerically studied. Results of the preliminary performed computing and experimental data show that during the mineral extraction process a stagnation zone is formed in layer. Formation of the stagnation zone is caused by the absence of reagent flow in it. Such zones result in reduction of the degree of the deposit development. In this connection, there is a need to conduct research on improving the mineral extraction degree by controlling a seepage in a layer. The hydrodynamic method of enhancement based on changing reagent flow direction during the in-situ leach process by reversing the wells. Usage of the method leads to engage stagnation zones into the leaching process.

Two options of reversing wells are considered: when the main quantity of mineral is extracted I) the action of all injection wells is stopped and some of the production wells is used as an injection to direct reagent flow towards the stagnation zone; II) change production well over to injection and vice-versa.

Calculation showed that capture area of stagnation zone differs at various time. So the reversing wells are considered at three different time to get an optimal value of extraction degree.

This method is used for linear as well as for hexagonal schemes of well location. Obtained numerical results show that using hydrodynamic enhancement method in stagnation zone enables to increase the extraction degree. Depending on the considering options of well reversing, the extraction degree is increased from 8% to 11% in case of linear well location. In addition, result of calculation showed that using reversing wells in the inner zones of hexagon is inefficient. This technology of enhancement can also be applied in boundary areas of deposits, which have complex geometric shape.

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Modeling of networks flows of grinshilds types

We consider flows distribution along networks, flows circulation described with Grinshilds type dependences. Those dependences identify the streams in traffic networks, in circuits of evacuation from the buildings. Applying game-theoretical approach and mathematical methods of hydraulic circuit theory, the tasks of searching balance state problems are set to solve that the cycle interrelationship methods are used. Tasks having network arrangement have enormous significance for various social-economic and technological problems solution. A big share of it falls on flow problems. There exist integral guidelines of production and technical problems described with flow problems, for instance, hydraulic circuit theory. The key difference of those directions is in the causes defining flow progress. Thus, in water distribution systems, when the stream flows in the pipes with full storage the stream volume in the pipe is defined with pipe top and end piezometer heads. In that case, the flow along that pipe is the head receiver. If the flow moves along partial section pipe or along the channels, the pipeline flow magnitude coincides with intake.

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New variable neighborhood search for bi-linear optimization

Bi-linear program is a special case of nonlinear optimization problem, where a set of variables is divided into two subsets and an objective function involves products of components from these subsets. We propose a new variable neighborhood search based heuristic to solve it. Beside alternate local search procedure, we use one based on partial linearization of the original model. Moreover, we propose a use of different shaking operators. New method is being tested on some instances of pooling problem which is fundamental to the petroleum industry.

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On the asymptotics of solutions of heat transfer problems with sources and nonlinear boundary conditions

Consider the following parabolic equation

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x}\left(\left|\frac{\partial u}{\partial x}\right|^{p-2}\frac{\partial u}{\partial x}\right) + u^{\beta}, \quad (x,t) \in R_{+} \times (0,\ +\infty)\,, \tag{1}$$

with nonlinear boundary flux and the initial condition

$$-\left|\frac{\partial u}{\partial x}\right|^{p-2}\frac{\partial u}{\partial x}\ (0,t)=u^{q}(0,t), \quad t>0, \tag{2}$$

$$u(x,0)=u_0(x)\geq 0, \quad x\in R_+, \tag{3}$$

where $p>2$, β, $q>0$ and $u_0(x)$ is a bounded, continuous and nonnegative initial data.

The problem (1)-(3) can be thought of as a model to describe heat propagation with a gradient-dependent thermal conductivity in a medium with chemical reaction and a nonlinear radiation law at the boundary (see [1, 2]).

The problem (1)-(3) for different values of the parameters has been studied by many authors [3, 4]. In [3], the conditions of existence of blow-up and global solutions by constructing self-similar supersolutions and subsolutions studied. Equation (1) due to the degeneration for $u=0$ is may cannot have a classical solution. Therefore, it is natural to understand the solution in the weak sense of $0\leq u$, $\left|\frac{\partial u}{\partial x}\right|^{p-2}\frac{\partial u}{\partial x}\in C(R_+\times(0,+\infty))$ and satisfies to the equation (1) in an integral way.

The aim of this talk is the development of the results of [2-4] and obtaining the main member of the asymptotic behavior of self-similar solutions on the basis of standard equations method [2] in fast and slowly diffusive cases [1]. In the slowly diffusive case the asymptotic behavior of solutions and the free boundary (front) is established. The manner of selecting an appropriate initial approximation providing a quickly convergence of an iterative process at numerical experiments depending on the value of numerical parameters and data is offered. It is shown arising of the nonlinear effect a finite speed of propagation at a numerical solving of the problem (1)-(3). The results of numerical experiments for a different value of parameters are discussed.

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Construction of mathematical model, compression of rubber-metal supports and behavior of rubber layer

Rubber-metal supports (RMS) apply under vertical compression load, because they can withstand many times over higher load compared with conventional frictional contact system. The particular importance in this case are questions related to the strength of the RMS under compression which reaches 100 MPa. In this article I built a model the deformation of RMS in Matlab. Also I used the analytical model for building according to the compression rubber layer under the influence of a uniform load. Used a new method proposed in [1] to determine the deformation of the rubber layer of rubber-metal support. This method is based on using Cauchy tensor. If it is known solution of the static boundary value problem, then it is easily defined deformation [2] $\varepsilon_{ij} = 1/E(-v\delta_{ij}\sigma_{kk} + (1+v)\sigma_{ij})$

Taking into account the boundary conditions and the well-known relations of theory of elasticity, we write the tensor of the Cauchy for this case:

$$\varepsilon_{ij} = c \begin{pmatrix} \sin x_2 \cos x_3 & 1/2(\sin x_2 \sin x_3 + & 1/2(\cos x_2 - \\ & +x_1 \cos x_2 \cos x_3) & -x_1 \sin x_2 \sin x_3) \\ 1/2(\sin x_2 \sin x_3 + & x_1 \cos x_2 \sin x_3 & 1/2(x_1 \sin x_2(\cos x_3 - 1)) \\ +x_1 \cos x_2 \cos x_3) & & \\ 1/2(\cos x_2 - & 1/2(x_1 \sin x_2(\cos x_3 - 1)) & 0 \\ -x_1 \sin x_2 \sin x_3) & & \end{pmatrix}$$

In this paper is constructed in accordance with the above ratio in the Matlab. On figure we can see the original condition without load and under the distributed load on the all area on surface, which are located on the top of RMS. The new method is based on the analytical dependency and allows the calculation of deformation of the rubber layer under compression. Also in the paper given the experimental data, when the RMS under compression, according to the existing state standards for testing of rubber [3]. Tests were conducted to determine the elastic modulus, shear modulus and Poisson's ratio, which are further used for the implementation program code in the Matlab.

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About new algorithm for solving nonlinear three-point boundary value problem for system of differential equations

We consider the nonlinear three-point boundary value problem for system of ordinary differential equations

$$\dot{x} = f(t, x), \qquad t \in [0, T], \tag{1}$$

$$Bx(0) + Vx(\eta) + Cx(T) = d, \qquad d \in R^n, \tag{2}$$

where f: $[0, T] \times R^n \to R^n$ is continuous, B, V, C are constant matrices, $0 < \eta < T$.

A solution to problem (1), (2) is called a vector-function $x(t) = (x_1(t), x_2(t), ..., , x_n(t))' \in C([0, T], R^n)$ is continuously differentiable on $[0, T]$ and satisfying the system of equations (1) and the condition (2).

The theory of boundary value problems is one of the important and rapidly developing sections of differential equations as boundary value problems have various applications in the theory of oscillations, mathematical physics, variational calculus, optimal control and other applications [1-2]. In the theory of boundary value problems that is of current interest due to its various applications of the least studied multi-point boundary value problems for differential equations, when each segment is set to its differential equation, and solving various equations are linked through the boundary conditions [2-3].

Three-point boundary value problems for differential equations arise in the theory of interpolation and approximation by splines [1-3]. The present report is devoted to the study of nonlinear three-point boundary value problem for system of ordinary differential equations (1), (2). For the solve of the investigated problem use the method of parameterization [4]. Algorithms of finding solution to problem (1), (2) are constructed. Sufficient conditions of the unique solvability of investigated problem are established in terms of initial data. This results are show of effective applicability of results to the article [5].

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Mass conservation and pressure equations for the sequential chemical compositional simulation

This paper addresses the development of a new mathematical formulation for the sequential chemical compositional reservoir simulation.

Most multiphase compositional models in the open literature [1] are limited in their applicability in one way or another (single species, equilibrium mass transfer, and lack of modeling miscibility which occurs during surfactant flooding). The only surfactant enhanced aquifer remediation (SEAR) models reported in the literature are for single phase flow and are those of Wilson, Wilson and Clarke and Abriola et al. [2] with simplified surfactant phase behavior and properties. None of these models account for the effects of surfactant on interfacial tension (IFT), surfactant phase behavior, capillary number, and surfactant adsorption. Several compositional formulations have been developed and exist in the literature [3]. Wong and Aziz [4] provided a comprehensive study regarding the most widely used formulations. In 2007, Chen et al. [5] presented a numerical approach based on a formulation that solves both pressure and compositions implicitly. Though the approach was claimed to be sequential and extended from the IMPEC approach used in UTCHEM model [6], the mathematical formulations for the governing equations did not undergo any change in their model.

In the present work we introduce a new approach to model the reduction in pore volume due to adsorption that satisfies the continuity equation. In certain situations, such as significant change in the effective pore size, these enhancements are essential to properly model the physical phenomena. Moreover, this new approach for modeling the adsorption effect on the transport of a component makes it possible to develop a new mathematical formulation for the sequential chemical compositional reservoir simulation. The novelty of the research consists in the development of a new mathematical formulation of the mass conservation and pressure equations for the sequential chemical compositional simulation.

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Numerical comparison of shear flow coherent structure using ENO FD scheme and DG method

Direct numerical simulation (DNS) of large-scale structures in spatially developing compressible mixing layer using third order finite-difference essentially non-oscillatory (ENO) scheme is conducted. Obtained results were compared with DNS calculations of Tiejin Wang et. al. (2013) made using a Discontinues Galerkin (DG) method. For the outflow boundary and the two sidewall boundaries nonreflecting boundary conditions were adopted. To produce a more natural mixing layer a broadband spectrum perturbation at the inlet boundary is applied. The Strouhal number corresponding to the most unstable frequency calculated as $St = \omega\delta_\theta/uc = 0.033$ is used in current simulation. Two simulation cases with the following parameters are considered: $M_c = 0.4(0.8)$, $u_c = 2.1$, $u_1 = 2.5(2.9)$, $u_2 = 1.7(1.3)$. The computational grid is $1601x301$. The non-dimensional physical domain is $480x150$. It was obtained that the shear flow coherent structure is predicted reasonably accurate both by ENO FD scheme and DG method.

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Numerical simulation of the combustion in a planar shear layer

Numerical study of two-dimensional supersonic hydrogen-air mixing and combustion in free shear layer is performed. The system of Naveir-Stokes equations for multispecies reacting flow is solved using ENO scheme of third-order in accuracy. In order to produce the roll-up and pairing of vortex rings, an unsteady boundary condition is applied at the inlet plane. At the outflow, the non-reflecting boundary condition is taken. The influence of different Mach numbers on the formation of vorticity structures and shear layer growth rate are studied. The obtained results are compared with available experimental data and the numerical results of other authors. For the description of reaction pathways of hydrogen, a seven species chemical reaction model by Jachimowski is adopted.

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An effective method for solving quadratic programming problems

Consider the quadratic programming type

$$\min_{x\in X}\left\{f(x)=\frac{1}{2}\langle x,Hx\rangle-\langle d,x\rangle\right\},\quad X=\{x\in\mathbb{R}_n\mid Ax\le b\},\tag{1}$$

where H is symmetric positive definite matrix $n\times n$, so $f(x)$ is strictly convex, A — matrix $m\times n$, $b\in\mathbb{R}_m$, $X\neq\oslash$. To solve this problem in [1] the algorithm based for nondegenerate transformation $x=N$, resulting quadratic shape functions $f(x)$ to the normal mind, and on the construction of the projection of the vector on the convex pointed cone, all guides vectors which are extreme. These steps lead the algorithm for solving the problem (1), characterized by a polynomial computational the complexity. In particular, for solving the problem (1) requires $O(m^4)$ arithmetic operations.

If the set X in (1) is specified constraints-equations, i.e. $X=\{x\in\mathbb{R}_n\mid Ax=b\}$, then the solution to the corresponding problem of quadratic programming is calculated by the formula $x^*=Uz^*$, where $z^*=p-Q^\top(QQ^\top)^{-1}(Qp-b)$, $Q=AU$, thus, the required number of arithmetic operations procedures is estimated the value of $O(n^3)$.

Finally, let $X=\{x\in\mathbb{R}_n\mid Ax=b,\quad Bx\le c\}$, where A - matrix $m\times n$, B - matrix $r\times n$ rank$A=m$, rank$B=r$, $m+r<n$, $b\in\mathbb{R}_m$, $c\in\mathbb{R}_r$. It is easy to

show that, using constraints-equality, you can exclude m variables, then the task will be reduced to the problem of the form (1).

In conclusion, these are the main tasks of auxiliary procedures in the method of sequential quadratic programming when solving General convex programming problem assuming sufficient smoothness determine its functions.

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Mathematical modeling of influence of material microstructure to products formation processes

In the development of technological processes of manufacturing and design elements with the specified functional properties of the material necessary to ensure the appropriate structure, which determines its mechanical and physical properties. In the structural mechanics of fundamental role is simulation of the interaction of various scales in the process of deformation and failure to improve the operational properties of product (durability, strength, fracture toughness). [1]

Influence of microdefects to the physical and mechanical properties of the material is studied by Irwin theory of strength, in which the defect is modeled by mathematical cut with ability to spread. In this case, there are singular points at the ends of the cut where stress tends to infinity by the asymptotic law. In Griffith's fracture mechanics study of the influence of defects on the properties of materials comes to a boundary value problem in plane deformation of a body having elliptical shape cutout.

In this paper, by using the structural strength criterion of Neuber - Novozhilov [2], obtained a formula for critical load for plane blunt and sharp cracks. By this formula we made models of sharp crack as a thin ellipse with a ratio of small and major semi axes one to ten. With OpenFOAM software, based on the finite volume methods, by creating a solver for small elastoplastic deformation, we found the shape and size of plastic zone around cracks. As a calculation results A size of plastic zone satisfactorily agrees with the experimental researches of Hahn and Rosenfield [3], and shape with Tuba [3]. The results allow evaluating the impact of the microstructure to ductile material and on the behavior of structures made from such materials.

Most researches in metal processing are performed numerically, while the accuracy of the prediction depends on parameters of numerical schemes, which are not relevant to the mechanical process itself. Thus, it is necessary to build the

analytical or semi-analytical solutions of model problems [4], in conjunction with numerical simulation. Being developed models of continuum mechanics to intensive plastic deformation processes in the defining equation of which includes rotation of the elementary volume of material relative to the principal axes of the stress tensor.

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On the account of distributed inertia of rod mechanism in plane and spatial motion

To reduce inertia of moving links into resultant force and moment vectors and to represent center of mass as node in finite element models are widely-used in mechanical calculations of linkage mechanisms. Considering distributed inertia of motion makes possible to create more precise finite element models in spatial linkage structures. By algebraically summing all the distributed inertial loads acting in both directions, perpendicular and along the axis of a constant cross section link, we can show that their intensity varies linearly along the length of link.

Using this approach together with Chasles theorem for a point of free rigid body in projections onto the moving axes in the finite element method for rectilinear homogeneous rod, we reach to a more precise finite element model considering analytically distributed inertia of motion. Besides, we obtained sub vectors in known FEM (Finite Element Method) matrix relation which binds the generalized reaction forces acting at the contact points of the rod element with nodal generalized elastic movements. These sub vectors includes the weight and inertia of a distributed spatial movement of link.

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On some properties of signals with finite Fourier-Walsh spectrum

In this paper we consider some properties of signals with a finite Fourier-Walsh spectrum. The analog of the sampling theorem for functions of several variables with finite Fourier-Walsh spectrum is given.

Let $\chi(x,t)$ be generalized Walsh system [1].

Theorem 1. *If $f(x_1,...,x_n) \in L_1\left(R_+^n\right)$ is dyadic -continuous on R_+^n and is Fourier-Walsh transform satisfies*

$$\widehat{f}(y_1,...,y_n) = 0$$

for $y_i > \delta_i$, where $\delta_i < 2^r, i = 1,...,n$, then the function $f(x_1,...,x_n)$ reconstructed from its values at the points

$$\overline{x_k} = \left(\frac{k_1}{2^{r_1}}, \frac{k_2}{2^{r_2}}, ..., \frac{k_n}{2^{r_n}}\right), k_j = 0,1,2,..., j = 1,2,...,$$

for by means of the formula

$$f(x_1,...,x_n) = \frac{1}{2^{r_1+...+r_n}} \sum_{k=0}^{\infty} ... \sum_{k=0}^{\infty} f\left(\frac{k_1}{2^{r_1}}, \frac{k_2}{2^{r_2}}, ..., \frac{k_n}{2^{r_n}}\right) \prod_{i=1}^{n} D\left(\frac{k_i}{2^{r_i}} \oplus x_i, 2^{r_i}\right),$$

where the Dirichlet kernel for Walsh system $D\left(x,x'\right) \equiv \int_0^{x'} \chi(x,t)\,dt$.

Theorem 2. *Let $f(\overline{x}) \in L_1\left(R_+^n\right)$ be dyadic -continuous on R_+^n with finite Walsh spectrum, i.e its Fourier-Walsh transform satisfies $\widehat{f}(\overline{y})$ $\widehat{f}(y_1,...,y_n) = 0$ for $y_j \geq 2^{r_j}$, $j = 1,...,n$.*
Then $f(\overline{x})$ is a step function, constant on intervals of rank $\overline{r}$

$$\Delta_\nu(\overline{r}) = \left[\frac{\nu_1}{2^{r_1}}, \frac{\nu_1+1}{2^{r_1}}\right] \times \left[\frac{\nu_2}{2^{r_2}}, \frac{\nu_2+1}{2^{r_2}}\right] \times ... \times \left[\frac{\nu_n}{2^{r_n}}, \frac{\nu_n+1}{2^{r_n}}\right].$$

Theorem 3. *If $f(\overline{x}) \in L_1\left(R_+^n\right)$ is a step function, constant on intervals of rank $\overline{r}$ of the form $\Delta_\nu(\overline{r})$.*
Then it has finite Walsh spectrum, i.e its Fourier-Walsh transform satisfies $\widehat{f}(\overline{y})$ for $y_j \geq 2^{r_j}$, $j = 1,...,n$.

Note that the analogues of Theorems 1 and 3 for the one-dimensional Walsh transforms was proved by S.Yu.Zolotareva, and the analogue of Theorem 2 was proved by M.S.Bespalov [1].

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The simulation modeling technology of warehouse logistics processes in distributed computing environment

Modern logistics warehouses are rather complex economic objects oriented to cargo traffic management of large capacity, including the distribution of goods, and, therefore, play an important role in the economic sphere. Particular attention is paid to regional warehouses, as today a significant number of large Russian industrial companies and retailers are choosing expansion of sales in the regions as the main direction of its development and in dire need of high-quality large-scale warehouse logistics services. In this regard, the most important tasks of warehouse management are analysis and optimization of functional organizational structure as the exploited and designed logistics warehouses. The trend of development of modern logistics warehouses is the constant improvement of technology and communication systems, expanding the set of warehouse and logistics operations and increases their level of complexity, the emergence of many alternatives to the adoption of logistics solutions. One of the most effective approaches to the analysis of the functioning of logistics warehouse as queuing system is the simulation modeling [1]. The process of building simulation program, adequately reflects the object of study is largely a non-trivial task and requires from its developer having a high mathematical and a programmer skill [2], especially when it comes to parallel or distributed program [3]. Thus, there is a need for high-level tools to automate this process, that will maximize the potential of high-performance computing and provide the building complex technological chain: from formulating task to creating model, then to developing program and to carrying out computational experiment. In this paper we propose the simulation modeling technology of warehouse logistics processes in a cluster Grid [4]. This technology include the

methods and tools for developing simulation model, for creating services of simulation modeling, for intelligent management of distributed computing in a cluster Grid. The example of implementation this methods and tools for automation of simulation modeling of logistics warehouse is presented. Experiments results for some task of simulation modeling of logistics warehouse are presented.

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A study of isotropic turbulence with the help of vorticity

We write the $N-S$ equations at two space points x and x', but at the same instant t.

$$\begin{aligned}\frac{\delta u_i}{\delta t}+u_k\frac{\delta u_i}{\delta x_k}&=\nu\frac{\delta^2 u_i}{\delta x_k\delta x_k}\\ \frac{\delta u'_j}{\delta t}+u'_k\frac{\delta u'_j}{\delta x'_k}&=\nu\frac{\delta^2 u'_j}{\delta x'_k\delta x'_k}\end{aligned}\tag{1}$$

Now let us replace the convective operator $u_k\frac{\delta}{\delta x_k}$ by vorticity ω and a multiplier m. Then from these two NS equations at two different points; but at one time we get

$$\frac{\delta\overline{u_iu'_j}}{\delta t}+m\overline{(\omega+\omega')u_iu'_j}=2\nu\frac{\delta^2\overline{u_iu'_j}}{\delta\xi_k\delta\xi_k}\tag{2}$$

This has been done on the basis of dimensional reasoning. With some assumptions the last equation has been solved for longitudinal correlation f as the separation distance tends to zero. [Vide Intl. J. FMR. vol. 42(2), 2015]. The expression is as below.

$$\begin{aligned}f&=e^{\alpha\tau}F(2,4,\tau)\\&=\left\{1+\left(m\frac{\overline{\omega}}{\nu}\right)^{\frac{1}{2}}r\right\}\left\{1-\left(m\frac{\overline{\omega}}{\nu}\right)^{\frac{1}{2}}r\right\}\\&=1-\left(m\frac{\overline{\omega}}{\nu}\right)r^2\end{aligned}\tag{3}$$

In the present paper this expression of f has been used to find the expression of g. The following relation has been used.

$$g = f + \frac{1}{2} r f' \tag{4}$$

The final expression of g is given as

$$g = 1 - 2\left(m\frac{\overline{\omega}}{\nu}\right) r^2 \tag{5}$$

It may be observed that $\frac{\delta g}{\delta r} = 2\frac{\delta f}{\delta r}$. It is found through experiment g deeps down more sharply than f near $r = 0$. Further the expression of R_ij for isotropic turbulence with this finding may be given as below.

$$\begin{aligned} R_ij &= u^2[-\frac{1}{2r} f' r_i r_j + (f + \frac{1}{2} r f')] \\ &= u^2(m\frac{\overline{\omega}}{\nu}) r_i r_j + (1 - 2(m\frac{\overline{\omega}}{\nu}) r^2 \delta_{ij}) \end{aligned} \tag{6}$$

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An Inverse Problem for the Stokes Equations

In the domain $\Omega = \{(x, y) \in R^2 : -2\pi < x < 2\pi,\ cosx + 1 < y < cosx + 3\}$ we consider the Cauchy problem for the Stokes system

$$\Delta u - \nabla p = 0, \tag{1}$$

$$div\, u = 0, \tag{2}$$

$$u = \varphi,\ (x, y) \in \Gamma_0, \tag{3}$$

$$pn - \frac{\partial u}{\partial n} = f,\ (x, y) \in \Gamma_0, \tag{4}$$

where $u = (u_1, u_2)$, $\partial\Omega = \Gamma_0 \cup \Gamma_1$ is the boundary of the domain Ω, $\Gamma_1 = \{(2\pi, y) : cosx + 1 \le y \le cosx + 3\}$, $n = (n_1, n_2)$ is the outward unit normal to $\partial\Omega$, $\varphi \in H_{00}^{1/2}(\Gamma_0)$, $f \in \left(H_{00}^{1/2}(\Gamma_0)\right)^\star$. This spaces are considered in [1].

The value of the solution is not known on Γ_1. The problem (1)-(4) is ill-posed. It can be formulated as the inverse problem to some direct well-posed problem. Analogous approach for other problems may be found in [2].

Let's consider the problem (1)-(3) with the following condition

$$pn - \frac{\partial u}{\partial n} = q,\quad (x, y) \in \Gamma_1, \tag{5}$$

where the function $q = (q_1, q_2)$ is given. The problem (1)-(3), (5) we shall call the direct problem. This problem is well-posed.

Then the initial problem (1)-(4) is reduced to the following inverse problem to our direct problem: it is required to determine q on Γ_1 using the additional information (4) about the solution of the direct problem (1)-(3), (5).

Then it is shown that the inverse problem (1)-(5) can be written in the form of an operator equation

$$Aq = f, \tag{6}$$

where f is the given function, q is unknown function.

The inverse problem (6) is solved numerically on the bases combination of the finite method element [3] end the optimization method.

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Clarified process modeling of mudflow mass

During the catastrophic mudslide in Medeo in 1973, on the antimudflow dam there are some problems with surface overflow water of mudflow water reservoir. They were caused by blockages at the input portals of spillways carried tunnels. By reason of high concentration of sand and clay, in water release of mudflow mass, appears the necessary to influence phases to field of carrying medium flow.

It proposed to solve this problem by setup the flat metal sales, which allow automate the controlling of flow rate spillway characteristics. Also to ensure regulation of flow characteristics of clarified surface water spillway, capture technology and settling the mudflow mass in mudflow storage reservoir [1]. To regulate the flow rate characteristics of the spillway is propose to use flat-water seals [2]. This will prevent the choking of the input portals, to destruct the bad influence of "bombing" by large stones of spillway walls, then to reduce the influence of sand and small stones on the kinematic parameters of the carrier flow and geometric parameters of the spillway.

The technology of catchment the mudflow is defecating the mudflow masses during two-three days. In this case, the mudflow storage reservoir can be like large sinker, which should prepare high layer of carrying mass to emergency closing stage process of surface water release through spillways dam in downstream reach.

The main reason is finding rate of settling the firm phase, which allow finding clarification time of surface water in mudflow storage reservoir. The process of firm phase separation, flom carrying medium, presents like complex process exchange between impulse and energy in some continuum that include liquid phase and solid.

In result of modeling, given mathematical model and computer interface of time calculation of carried phase for safety discharge of clarified surface mudflow water through Medeo dam spillways. Offered generalize block-scheme of computational speed algorithm of surface particulate contamination during solids concentration. Using the developed algorithms in the automated control system of Medeo dam spillway will improve the safety of the facilities.

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The modifications of the multiscale finite element method for solving electromagnetic problems on the AC and DC

Nowadays a number of applied problems involves calculations in computational domains with a complex multiscale structure. This requires methods that allow to take into account this feature of the computational domain. The multiscale methods are proposed for solving this type of problems. The modern multiscale methods are constructed in accordance with the peculiarities of the problem. They give the possibility to reduce the solution of the problem in the entire region to the solution of the problem at a lower level of the hierarchy of models (for example to resolve the problem heterogeneity not on the macrolevel but on the microlevel), which requires much less computational resources and CPU time. There are a lot of multiscale methods, for example, the equation-free methods (EFM), the mortar multiscale methods, the variational multiscale methods, the multiscale finite element method (MsFEM), the heterogeneous multiscale method (HMM) [3].

The methods proposed in the paper are based on the multiscale idea [2]. The solution of a direct problem is carried out at macro- and microlevels. The heterogeneity is taken into account on the microlevel by the nonpolynimial shape functions. They are obtained from the solution of the set of specially constructed problems. The functional embedding is introduced in the considered methods. It consists in the application of conformal numerical methods at the microlevel and the use of non-conforming methods at the macrolevel. The mesolevels can be added in the following embedding if it is necessary.

The modified multiscale discontinuous Galerkin method is proposed for solving the problem on the AC. The construction of a variational formulation at the macrolevel in the space with a partial continuity H (curl, Ω) and the use of vector basis functions at all levels of the hierarchy are the essential differencies from the other MsFEM methods (Y.Efendiev, T.Hou, W.E). The discontinuous Galerkin method is used at the top level of the hierarchy.

The solution of the problem on the DC is carried out by the heterogeneous multiscale finite element method on a tetrahedral triangulation on all levels of hierarchy in a 3D computational domain with complicated structure. The special hierarchy is proposed for construction of the nonpolynimial shape functions. It allows us to simulate electromagnetic fields in objects with chaotic structure.

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The modeling of electromagnetic field for different types of source signals

The problems of geoelectrics appearing in geophysics can be described by the following mathematical model:

$$rot\,\mu^{-1}\,rot\,\mathbf{E} + \frac{\partial^{\mathbf{2}}\varepsilon\mathbf{E}}{\partial\mathbf{t^2}} + \frac{\partial\sigma\mathbf{E}}{\partial\mathbf{t}} = -\frac{\partial\mathbf{J}}{\partial\mathbf{t}} \tag{1}$$

where $\mathbf{E}$ — electric field (V/m), $\mathbf{J}$ — current density(A/m^2) as time dependent function, μ — permeability (H/m), ε — permitivity(F/m), σ — conductivity (S/m).

The mathematical modeling of electromagnetic field in the geoelectrics problems with impulse stimulation requires large quantity of computations. Impulses in the generator loop usually have large length (up to several seconds). The main part of computations is spent to do steps of time integration scheme for the non stationary formulation of the problem.

We propose one of the approaches to parallel version of electric field computations by discrete Fourier transformation (FFT) in this paper. For this purpose the expansion by frequencies of source impulse is done and set of the following problems is solved:

$$rot\,\mu^{-1}\,rot\,\mathbf{E} + (\mathbf{i}\sigma\mathbf{w_i} - \varepsilon\mathbf{w_i^2})\mathbf{E} = -\mathbf{w_i}\mathbf{I_i}(\mathbf{w_i}) \tag{2}$$

where $\mathbf{E}$ — complex valued electric field , $I_i(w_i)$ — coefficient of the Fourier transformation for the frequency w_i. In the problems (1) each time step is dependent on the results of previous steps. For the problems (2) such dependence is absent and the computations can be done in parallel way. This fact seriously reduces the time of computations. The results of the problem (2) can be transformed into time domain. The application of the approach for different impulses of meander type is shown in the paper. The choice of the optimal number of frequencies for the problems (2) is done. The comparison between the results of the problem (1) and the transformed into time domain results of the problem (2) is done. The estimates of the computation time for the problems solved by proposed methods is done for used in geoelectrics signals.

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Mathematical modeling of technological process of preparation of water for thermal power plants

Water is the main cooling medium in the operating cycle of a thermal power plant. The water used must be of high quality with impurities content ranging from 0.1 to 1.0 mg/kg. The technological process of water treatment for thermal power plants where boilers are operated with supercritical parameters provides for sequential treatment of water using hydrogen-cationite and anion-exchanging filters, which require periodic regeneration.

Regeneration of ion-exchange filters results in highly mineralized, acidic or alkaline waste water. With the continuous circulation of water through the production, when water is taken from the surface sources for the needs of production and is returned as a high-mineralized aqueous solution, in rivers and lakes an increase in salinity can be observed, and consequently, deterioration of water quality, which is a very negative impact on the environment.

To reduce the amount of wastewater the authors carried out mathematical modeling of the water treatment process. A mathematical model of water treatment plant was considered. The model consists of a material balance equation, an equation describing the kinetics of ion exchange for the non-equilibrium case and the ion exchange isotherm. The material balance equation includes a nonlinear term that depends on the kinetics of ion exchange. A direct problem was solved numerically as relates to the calculation of impurities concentration at the outlet of the water treatment plant, with the sensitivity of the output data to the model's parameters analyzed. The direct problem was approximated by an implicit point-to-point computation difference scheme. The properties of the residual functional for a set of characteristic parameters were analyzed as relate to the array of values of the isotherm exchange parameters. Low sensitivity of residual functional and standard type output parameters to the nonlinear term was established. An inverse problem was formulated and solved. Following the results of the calculation the start time of the filter regeneration process was determined, as well as the duration of the regeneration process and the amount of regeneration and wash water. Based on the findings of comparing the engineering calculations data and the results of mathematical modeling of the water treatment plant the amount of wastewater has decreased by 15 %.

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Numerical model of plasma-chemical etching of silicon in CF_4/H_2 plasma

In the frame of hydrodynamic approach the plasma-chemical etching technology of silicon in CF_4/H_2 mixture was simulated. The calculations were carried out based on 2D mathematical model of plasma-chemical etching reactor [1]. The gas flow of the mixture was described by the equations of multicomponent physical-chemical hydrodynamics. The chemical kinetic model contained 28 gas-phase reactions of dissociation and recombination processes and 6 heterogeneous reactions on the wafer, which included the products - F, F_2, CF_2, CF_3, CF_4, C_2F_6, H, H_2, HF, CHF_3, CH_2F_2 [2]. The concentrations of chemical components were

calculated from the system of conservation equations included the mentioned gas-phase reactions. The governing equations were numerically solved by iterative finite difference splitting-up method. It is shown that the CF_4/H_2 system is characterized by lower fluorine concentrations and higher CF_2, CF_3 coverage of silicon surface compared to the CF_4/O_2 system.

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Informative Factors of Geophysical Fields Interaction in Problem of the Environmental Protection Prediction

The problem of the environmental protection prediction, namely estimation of environmental risks from impact action of infrasonic waves (infrasound) from various types of technogenic and natural explosions such as short-delay quarry [1], polygons, falling celestial bodies on the social environment and biological objects, is considered. It is shown that for a given power sources of infrasound the degree destructive impact from them is largely dependents on the fundamental processes of the geo-acoustic oscillations propagation in the conditions of meteorological factors, the influence of the inhomogeneity of the atmosphere and the state of the ground surface of the Earth. Their influence may lead to multiple amplification the damaging effects of explosions to the environment [2]. Therefore, the problems of the geo-ecological risks prediction form power explosions should be addressed taking into account the effects of these factors. These risks are estimated as an integral characteristic of the specific acoustic wave energy. Its value is a function of many parameters, determined by the conditions of radiation and distant propagation of infrasound. This relationship can be represented in the form of a functional: $E = F[Q, f_1(c, \varphi, w, \alpha), f_2(T), \delta(H), \psi(t)]$. Here, Q is power source,

$f_1(c, w)$ is the functional dependence of acoustic pressure from of the sound velocity c and directions φ of the acoustic wave propagation from the source and the speed w and the azimuthal wind direction α; $f_2(T)$ is the altitudinal distribution of air temperature; $\delta(H)$ is function, which shows the state of the Earth's surface; $\psi(t)$ is factor of the atmosphere inhomogeneity which depends in particular on the relative humidity and atmospheric pressure. Thus, the problem of estimating the environmental risk is multifactorial. The report presents quantitative estimates of component factors based on numerical modeling and experimental data of research executed by the authors.

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Bending vibration of drill string

The analytical solution of the bending vibration of drill string is obtained by using of the method of partial sampling of Tyurehodzhaev A.N., an. Obtained general solutions of the differential equation of bending and transverse vibrations of drill strings are used in practice, for example, in solving problems related oilfield business.

The equation of bending and transverse vibrations of drill string has the following form:

$$EJ\frac{\partial^4 y(x,t)}{\partial x^4} + \frac{\partial}{\partial x}\left[(F - p\,x)\frac{\partial y(x,t)}{\partial x}\right] + m\frac{\partial^2 y(x,t)}{\partial t^2} = 0, \tag{1}$$

where $F = p\,l$, l – drill string length, p, m – weight and mass of the unit of drill string length.

Initial and boundary conditions:

$$t = 0, \quad y(x,0) = \alpha(x), \quad \frac{\partial y(x,0)}{\partial t} = \gamma(x).$$

$$(2) \qquad y(0,t)=f_1(t), \quad \frac{\partial y}{\partial x}(0,t)=f_2(t), \quad y(L,t)=f_3(t), \quad \frac{\partial^2 y}{\partial x^2}(L,t)=f_4(t).$$

Solution has the form:

(3)

$$y(x,t)=-\frac{1}{2EJ}\sum_{k=1}(x_k+x_{k+1})\left\{\left[p(L-x_k)y''(x_k,t)-py'(x_k,t)+m\frac{\partial^2 y}{\partial t^2}(x_k,t)\right]\times\right.$$
$$\left.\times H(x-x_k)-\left[p(L-x_{k+1})y''(x_{k+1},t)-py'(x_{k+1},t)+m\frac{\partial^2 y}{\partial t^2}(x_{k+1},t)\right]H(x-x_{k+1})\right\}+$$
$$+L^{-1}\left(s\cdot\alpha_3(x)+\gamma_3(x)+\frac{x^3}{6}A(s)+\frac{x^2}{2}B(s)+x\cdot C(s)+D(s)\right).$$

The obtained general solutions of the differential equation of bending vibration of drill strings are used in the petroleum industry. Differential equations with partial derivatives are used to investigate the interaction of drill string bottom arrangement, cone bits and rock when drilling deep borewells in difficult geological conditions. These equations describe the non-lineor, axial, radial, parametric vibratians and oscillations bits in dynamic interaction with the rock. As well as dynamic and static stability of drill string equilibrium states at the rotary and turbine drilling methods, and more.

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Numerical study of the discharged heat water effect on the aquatic environment from thermal power plant

Environment - the basis of human life, and the energy generated - is the basis of the modern world. However, the production of electricity adversely impact on our environment, worsening living conditions. Energy is the basis of different types of power plants. Electricity production in thermal power plants (TPP), hydropower plants (HPP) and nuclear power plants (NPP) is associated with adverse effects on the environment. Electricity production technology in the power plant is connected with a lot of heat emission to the environment. The negative impact of energy on the environment is becoming an important issue, since the pollution each year increases. Technical supply of Ekibastuz SDPP-I was carried out on the back of the circuit with cooling circulating water. The surface of the reservoir is located at the 158.5 m of the sea level, the area is 19.6 square km.,

the maximum size is 4 x 6 km, an average depth - 4.6 m, a maximum depth - 8.5 m from the water intake, the volume of the reservoir is 80 million cubic meters.

In reservoir - coolers spatial temperature change is small (it usually does not exceed 20 ° C). Corresponding change in the density is much smaller than the magnitude of the water density. Therefore, stratified flow in the reservoir - cooler can be described by the equations in the Boussinesq approximation, i.e. in the motion equations a variable of water density can be replaced by some constant everywhere except the members representing the Archimedean force [1, 2].

$$\frac{\partial u_i}{\partial t} + \frac{\partial u_j u_i}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \nu \frac{\partial}{\partial x_j}\left(\frac{\partial u_i}{\partial x_j}\right) + \delta_{i3}\beta g(T - T_0) \tag{1}$$

$$\frac{\partial u_j}{\partial x_j} = 0 \tag{2}$$

$$\frac{\partial T}{\partial t} + \frac{\partial u_j T}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\chi \frac{\partial T}{\partial x_j}\right) \tag{3}$$

In the general case, the system of equations (1) - (3) in such way can not be solved because a turbulent model needs to be applied. Large eddy simulation method is used as the turbulent model.

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Mathematical modelling of detached flow around a car body by using Large eddy simulation method

As increasing the number of producing an automotive becomes evident automotive industry require more fuel efficiency as nowadays the problem is important for ecology and the costs. Most fuel efficiency depends on drag and to generate fuel efficient vehicle one must pay attention to drag reduction [2]. Ahmed benchmark model is the model that predicts most importance characteristics of the flow over a bluff body [1]. The Ahmed reference model is a car-like bluff body, representing a highly simplified 1/4 scale lower medium size hatchback vehicle with a slant back. Besides relatively simple geometry, the flow around Ahmed body

retains some main features of the flow around real cars. The model's major attributes are 1044mm x 389mm x 288mm. The flow regimes are fully turbulent as the Reynolds number based on body length is usually too high. The flow around ground vehicle contains several separation regions. Many experimental and numerical works have made in these area upon Ahmed body model and real cars. Numerical research can predict some aerodynamic characteristics and minimize costs of experimental work. As experimental research providing qualitative and quantitative understanding numerical research is also important for interpreting the experiments and to obtain more complete understanding in flows around bluff body. Therefore, flow around vehicle can be described by the equations in the Boussinesq approximation. For mathematical modeling of the system of equations are considered, which including the equations of motion and the continuity equation. The development of three-dimensional turbulent flow around vehicle is considered. Three-dimensional mathematical model is used for modeling of flow around vehicle [3, 4]:

$$\frac{\partial \overline{u_i}}{\partial t} + \frac{\partial \overline{u_j u_i}}{\partial x_j} = -\frac{\partial \overline{p}}{\partial x_i} + \nu \frac{\partial}{\partial x_j}\left(\frac{\partial \overline{u_i}}{\partial x_j}\right) - \frac{\partial \tau_{ij}}{\partial x_j}, \tag{1}$$

$$\frac{\partial \overline{u_j}}{\partial x_j} = 0, \quad (i = 1, 2, 3), \tag{2}$$

where $\tau_{ij} = \overline{u_i u_j} - \overline{u_i}\,\overline{u_j}$, g_i- gravitational acceleration, $\beta-$expansion coefficient, u_i – velocity components.

Smagorinsky turbulence model is used to close the system of equations (1) - (2), [4].

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Simulation of a transonic airfoil flow using a zonal RANS-LES Method

This paper presents a method for a synthetic turbulence generation to be used in a segregated hybrid Reynolds-averaged Navier-Stokes (RANS)-Large-Eddy Simulation (LES) method. This method is an extension of the work of Jarrin et al. [1] and Pamies et al. [2]. In these papers the STGM method was combined with control planes downstream of the inlet of the embedded LES to adjust the shear stress budget to ensure a smooth and efficient RANS-to-LES transition within two- or three boundary layer thicknesses [3]. The presented approach does not apply such control planes thus facilitating the application of the synthetic turbulence generation method (STGM). The here presented STGM approach uses a Cholesky decomposition of the Reynolds stress tensor to enforce correct second-order moments. The velocity signal is constructed in the LES inflow plane via a superposition of turbulent structures with prescribed geometric shape and random signs and position in three basic layers, where a local velocity signal is decomposed according to the turbulent flow properties of the upstream RANS solution. Depending on the wall-normal position in the boundary layer the specific time, length and velocity scales and also different vorticity contents are imposed at the LES inlet plane. The RANS solution that provides for a one-equation model the Reynolds shear stress $\langle u' v' \rangle$ and velocity distributions upstream of the LES domain, are used to construct the length, time and velocity scales. The STGM approach is applied within the framework of the zonal RANS-LES method which uses two or more predefined separate computational domains being linked via an overlapping zone where the transition from RANS to LES and vice versa occurs. The full paper will present solutions for a flat-plate boundary-layer flow in which the performance of the STGM will be demonstrated in terms of the recovery of a fully developed boundary layer solution at a RANS-LES transition. Within two boundary-layer thicknesses a good agreement of the results of the current method with the data of the pure LES and the method of [3, 4] is achieved.

The present formulation of the STGM makes it applicable to a wide range of Reynolds and Mach number configurations such as the transonic flow around an airfoil in which a fully coupled solution of a zonal RANS-LES method will be presented. In this application the LES zone is restricted to the shock-boundary layer interaction region, whereas the RANS is used elsewhere. The results show an oscillating shock where the zonal solution is in good agreement with a pure LES solution.

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Prediction of the flow around the building by the control volume method

Because of increasing urbanization of modern society the understanding of urban microclimate is become very important. First of all, the microclimate of urban areas has strong influence on human comfort where the ventilation has the potential of dispersing pollutant and creating the local heat effect. Secondly, different building configurations produce together with microclimate different impact on building structure. Geometry and arrangements of the buildings, wind directions and the upstream inflow conditions has strong influence to the flow structure around building.

This kind of flow has been investigated extensively over the last two decade through wind tunnel experiment. The flow field in the vicinity of 2D and 3D array of wall mounted cubes were investigated by the M. Broun et all, 2001 [1]. Another wind tunnel flow measurements around of simple and complex urban complexes carried out at the Architectural Institute of Japan [2].Similar investigation of flow was performed at the Hamburg University BLASIUS wind tunnel [3].

Beside of wind tunnel experimental investigations, Computation fluid dynamics is being effectively applied to the modeling of the flow around buildings because of progress in high-speed processing by personal computer and rapid propagation of software for numerical analysis of fluid dynamics. In this paper flow fields around the simple buildings were modeled by the several steady CFD models based on the Reynolds-averaged Navier-Stokes equations. The numerical simulations were performed with the open source code OpenFOAM 2.3. [4]. The mathematical

model adequacy is checked by comparing with appropriated available experimental data.

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Fast algorithm for calculation of the moving tsunami wave height

One of the most urgent problems of mathematical tsunami modeling is estimation of a tsunami wave height S via bottom relief function H while a wave approaches to the coastal zone. There are several methods for solving this problem, namely, Airy-Green formula in one-dimensional case [1]

$$S(x) = S(0) \cdot \sqrt[4]{H(0)/H(x)},$$

asymptotic method based on the generalization of the construction known as the Maslov canonical operator [2] and numerical solution of an initial-boundary value problem for linear shallow water equations (LSWE). The main difficulty problem of tsunami modeling is a very big size of the computational domain. The calculation of the solution of LSWE (the function of three variables) in this domain requires large computing resources. We construct a new algorithm to solve numerically the problem of determining the moving tsunami wave height for linear source at the characteristic surface $t = \tau(x, y)$ [3]. Here $\tau(x, y)$ is a solution of Cauchy problem for eikonal equation $\tau_x^2 + \tau_y^2 = (gH(x, y))^{-1}$, $\tau(0, y) = 0$. Proposed algorithm based on representation of fundamental solution of LSWE in the singular and regular parts [4, 5, 6]. This approach allows one to reduce computational time. We get the expression of the moving tsunami wave height for the point and linear sources and demonstrate connections between tsunami amplitude for point, linear and arbitrary sources.

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Mathematical modeling of particle motion under the influence of spacecraft rocket engine supersonic jets in Mars environment

In connection with the increased interest for the planet Mars, various space programs are actively developing. For this purpose landing platforms of spacecraft intended to explore Mars are designed and modified constantly. During the landing supersonic jets of propulsion systems impingement on Mars surface. This leads to erosion of the Mars soil. Far away from Mars a dust cloud can form, and deposition of particles of dust on top of the spacecraft landing platform possible at low altitude. These factors may adversely affect the correct operation of the on-board hardware and payload of spacecraft. Therefore, during designing of the spacecraft and propulsion systems the behavior of dust particles at different modes of propulsion systems and distances from the surface of Mars should be considered.

This paper presents the results of mathematical modeling of spacecraft landing "ExoMars" on the surface of Mars in the non-stationary three-dimensional formulation viscous gas flow and without backward impact on the gas flow of dust particles behavior. Mathematical model using open source software OpenFOAM was developed. For calculations supercomputer of National Research Tomsk State University SKIF Cyberia was used.

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Economic soliton of the spatially two-dimensional nonlinear mathematical A1 model

It is known that the multi-dimensional analogues of the Korteweg-de Vries adequately describe the objective reality of any nonlinear economic process or phenomenon, because the behavior of the economy microsubjects has wave nature [1]. Earlier Alexeyeva A. presented the class of spatially two-dimensional nonlinear mathematical models A1-A14 and AI-AXII, generalizing the classical Korteweg-de Vries equation [2]. This paper presents the mathematical model of the economic process of (2+1)-dimensional nonlinear equation A1.

$$\Psi_t + \Psi_{xyy} + 2\left[\Psi^2\right]_y + [UY]_y = 0, \tag{1}$$

where $V_x = \Psi_y, U_y = \Psi_x, \Psi = \Psi(x, y, t)$ - sufficiently smooth complex-valued wave function, describing the state of the economy microsubjects; x, y - potentials of collective economic interactions; t - the time factor. The 1-soliton solution of (2+1)-dimensional nonlinear mathematical A1 model has the form

$$\Psi = 2(ln\varphi)_{xy},$$

$$\varphi = 1 + exp\left\{\alpha x + \beta y - \beta\alpha^2 t + \gamma\right\}, \tag{2}$$

where α, β, γ – constants, $\varphi = \varphi(x, y, t)$ – sufficiently smooth complex-valued function. It represents the economic soliton. This soliton describes a form of collective behavior of the economy microsubjects, which is characterized by a stable tendency of trace elements to certain activities and continuous reproduction of their functional qualities. Economic 1-soliton (2) of non-linear mathematical model (1) visually looks like a stable localization of probability density

$$\rho(x, y, t) = |\Psi(x, y, t)|^2$$

in a certain area of space.

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The problems of optimal control for electric power systems

Mathematical model of a modern electric power complex, consisting of turbine generators and complex multiply-connected power units, represents a system of nonlinear ordinary differential equations. It is known [1-3] that this model serves as the basis of a broad and important category of control problems.

It should be noted that the mathematical modeling of various processes and systems, including electricity, is closely interrelated with the question of the adoption of the best marathon solutions. The problem of optimization, and the creation of the algorithms development controls by means of feedback principle for these systems and still attract the attention of many researchers and are relevant.

In this paper, when solving problems for the considered power system is used the extension principle of extremal problems, based on sufficient optimality conditions, and design method of Bellman -Krotov functions.

Formulation of the optimal control problem. It is required to minimize the functional:

$$J(u) = 0.5 \sum_{i=1}^{l} \int_0^T \left(k_i y_i^2 + r_i u_i^2\right) d\,t + \Lambda\left(x(T),\, y(T)\right), \tag{1}$$

In terms of:

$$\frac{dx_i}{dt} = y_i, \quad \frac{dy_i}{dt} = -\lambda_i y_i + f_i(x) + b_i u_i,$$

$$x_i(0) = x_{i0},\ y_i(0) = y_{i0},\ i = \overline{1,l},\ t \in (0,T), \qquad x(t),\ y(t) : (0,T) \to R^l, \tag{2}$$

where $\{x_i,\, y_i\}-$ state of the system $\{u_i\}-$ control; $\{f_i(x)\}\,\Lambda(x,y)-$ set of continuously differentiable functions, the functions $f_i(x)$ satisfy the conditions of integrability: $\frac{\partial f_i(x)}{\partial x_k} = \frac{\partial f_k(x)}{\partial x_i},\ \forall i \neq k$; T moment in time; initial states $\{x_{i0},\, y_{i0}\}$ are assumed to be given; $r_i,\ \lambda_i,\, k_i,\ b_i-$ positive constants; terminal value $x(T),\ y(T)$ are not known beforehand.

Note that, if properly set the function $f_i(x),\ i = 1, ..., l$, some nonlinear Cauchy problem (1) - (2) models the power system, for which the synthesis problem is an important practical problem of optimal control.

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The Navier-Stokes problem in weighted spaces

The problem of describing the dynamics of an incompressible fluid, due to its theoretical and applied importance, has been attracting the attention of many researchers since the mid-twentieth century. In mid-2000 by the Clay Mathematics Institute this problem has been formulated as the sixth problem of the millennium (one of The Millennium Prize Problems): the existence and smoothness of solutions of the Navier - Stokes equations for incompressible viscous fluid. In this talk we prove the unique global solvability of the Navier-Stokes equation with special right hand sides (in weighted spaces) for $0 < t \leq 1$. In contrast to previous works, we apply the classical methods of structural linear theory of differential equations and their combinations with known a priori estimates.

The basic idea of the proposed method is to construct a special orthogonal projector. Our method allows to split the equivalent system of Navier -Stokes equations in two independent systems of integro-differential equations. The first system gives the dependence of the fluid velocity only one of the orthogonal components of the right hand side (i.e. disturbance), and the second one only establishes the dependence of the pressure and the acceleration of the second orthogonal component of the right hand side. The projector is built explicitly and its structure is similar to the classic Newton volume potential. The method can be used for any dimension of the Euclidean space. It should be noted that the idea of "splitting the Navier -Stokes equations" is not new. The advantage of our method lies in the fact that the constructed projector is, in some sense, "perfect". First, the result of the splitting is mutually equivalent to the transformation system. Secondly, the projector is constructed in an explicit form. And most importantly - this projector is a permutation as the heat conductivity with a linear operator, and the operator of the gradient. This makes it possible to solve the problem in this case using priori estimates.

Simultaneously with the problem of global unique solvability of the three-dimensional Navier-Stokes problem we resolved the question of boundary conditions for the pressure function. Shown that the problem is well posed, when the pressure in the space variables satisfies the same type of boundary conditions, and that the main function of the desired speed.

One of the fundamental physical conclusions from this work is the following fact: It is proved that the desired velocity field is independent of pressure, but depends only on the boundary and initial values of the velocity field from the set

of external forces. And not just from the external force field, but only some of its orthogonal parts. The pressure is well determined and only depends on the acceleration and the second orthogonal component from the external force field.

This conclusion brings a new philosophy in the methods of solving problems of hydrodynamics.

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Numerical solution of the one-dimensional problem of a non-Newtonian fluid filtration

The problem of filtering non-Newtonian fluid with a polygonal approximation of the experimental curve debit - depression is considered. Suppose that the isotropic layer of unit capacity and width is filled with homogeneous non-Newtonian fluid which has structural and mechanical characteristics dependent on space coordinates. In nature it's possible under the influence of long-term temperature field along the length of the formation. And we also assume that the structural and mechanical properties of the fluid particles are saved when they move, i.e. change in displacement gradient $g(x,t)$ is proportional to the fluid velocity [1]. In this model, the determination of the coordinates of the boundary between moving and immovable domains of the fluid is greatly complicated due to nonlinear conditions on this boundary. The proposed algorithm is based on a construction of the conservative scheme that takes into account the law of conservation of mass of the fluid and allows to calculate the value of the time step, ie, to obtain a solution of mentioned problem much similar to the known method of "catching the free boundary in a knot of mash" for parabolic equations. Finite- differences method developed for this algorithm was used to calculate the one-dimensional model for $g(x,0) = g^* = const$ [2]. The results of calculations for the quasi- steady state approximation showed good agreement with the known solutions of the linearized model filtering non-Newtonian fluid. This means that the above method can be used to solve some practical problems, for instance, such as modelling in petroleum engineering.

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Computer modeling of phenomena in dynamical systems

Some mathematical results are too complicated to be proven deductively but can be corroborated by computational experiments. We describe three phenomena of such type found by means of methods mentioned in [1].

Consider any computer program P implementing any monotone transformation of the set M of computer numbers into itself (for example, solving an initial value problem for ordinary differential equation).

Definition. *If there exists such segment* $D = [D_-, D_+] \subset M$ *that* $(\exists x \in M)(P(x) < D_-)$, $(\exists x \in M)(P(x) > D_+)$ *and* $P(x_0) \in [D_-, D_+]$ *for no more than one* $x_0 \in M$ *then the practical machine splitting phenomenon takes place.*

Definition. *(A common Kyrgyz word) irgöö means: discrete optimization by means of synergetic, or the phenomenon "random vibration of balls of different sizes of same material in a wide vessel yields migration of the biggest one to the center of their surface".*

This experimental fact is too difficult to be proven by any mathematical model but is validated by numerical experiments with a system of difference equations.

Consider the differential equation $F(t)F'(y(t))y'(t) = F'(t)F(y(t)), t \in [-1, 1], (1)$

F is a smooth function, $sgn\ F(t) = sgn\ t$, with the initial condition $y(-1) = y_0(2)$

and the perturbed one $(\varepsilon + F(t))F'(y_\varepsilon(t))y'_\varepsilon(t) = F'(t)F(y_\varepsilon(t)), t \in [-1, 1], (0 < \varepsilon \ll 1).(3)$

If F is an even function then the known phenomenon of partial rotation of solution of degenerate equation takes place.

Definition. *If the initial value problem (1)-(2) has a smooth solution* $y_0(t)$ *and for the solution of (3)-(2)* $Y_0(t) = lim_{\varepsilon \to 0} y_\varepsilon(t)$ *exists but* $|Y_0(t)| \neq |y_0(t)|(4)$ *then the phenomenon of transforming of solution of degenerate equation takes place.*

To prove occurrence of this phenomenon for non-even functions is too difficult and we used the Runge-Kutta method in *MathCad* for $F(t) = t^2 + 0.2t^3, \varepsilon = 0.002, \varepsilon = 0.001, \varepsilon = 0.0002$. The results corroborated the existence of $Y_0(t)$ and fulfilling of (4).

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Hybrid evolutionary approach to multi-objective mission planning for group of underwater robots

We consider the dynamic route-planning problem for group of robots implementing multi-objective underwater mission which refers to search and surveillance works, patrolling and inspection of underwater objects and structures, water areas monitoring and topographic scanning. In general, implementation of such a mission can be described as a continuous robot group movement to visit a certain set of control points (for the purpose of sampling, taking measurements, photos and videos) according to their priority and under given restrictions. The dynamic routing problem here is to find (planning) and adjust (replanning) feasible group routes for robots, ensuring as far as possible the maximum efficiency of the group work [1]. Necessity for the current route adjusting can be caused by unexpected changes in the conditions of the mission associated with the uncertainty of the external environment, as well as the inaccuracy of the information received from the measuring devices. Coordination of the whole group is provided through a sonar communication channel of a limited range, which leads to the requirement of group communication sustainability during the mission.

Multi-objective mission planning problem for a group of robots is a variation of the well-known NP-hard vehicle routing problem (VRP) with combined features of its different variations like periodic routing, capacitated routing, routing with time windows etc. For a large class of routing problems do not exist polynomial algorithms that are guaranteed to find optimal solutions quickly [2]. This fact leads us to those algorithms, being able to find approximate rational solutions in a short time and with low computational costs.

We propose hybrid approach, based on the combined use of genetic algorithms, methods and heuristics of local search, and ant colony optimization. Genetic algorithms here provide exploration of the search space with local search methods implementing exploitation mechanism while ant colony optimization dynamically adapts parameters of the whole planning procedure to achieve best performance on the current data set.

A software modeling system implementing all the necessary computational procedures has been developed; the results of computations are given.

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The numerical modeling of a posteriori algorithms for the geophysical monitoring

One of the main requirements to statement of the problem in the radar-location, hydrolocation, seismolocation, is connected with increasing the accuracy of a sources location. In many problems their coordinates, speeds and types contain in arrival times of waves and in initial wave forms accordingly. The problem of estimating unknown parameters of an source is reduced to solving the nonlinear system of equations $\hat{\eta} = \eta(\gamma, \theta) + \varepsilon$, where $\hat{\eta} = (\hat{n}_1, ..., \hat{n}_N)^T$ is the vector of measured wave's travel times, $\eta(\gamma, \theta) = (n_1, ..., n_N)^T$ is the N-dimensional vector of calculated travel times, $\varepsilon = (\varepsilon_1, ..., \varepsilon_N)^T$ is the residual vector, $\vec{\theta} = (x, y, z, v, t)^T$ is the m-dimensional vector of estimated parameters, $\gamma = (\gamma_1, ..., \gamma_N)$ is the matrix of the sensors coordinates, and N is the sensors number. The space coordinates of the source x, y, z are the parameters to be estimated, v is the velocity in the medium, and t is the time in the source. The parameters are estimated using information about the distribution of the errors $E\varepsilon_i = 0, E\varepsilon_i\varepsilon_j = \sigma_i^2\delta_{ij}, \sigma_i = \sigma(x_i), i = \overline{1, N}$. On the basis of measurements $\hat{\eta} = (\hat{n}_1, ..., \hat{n}_N)^T$ at a final stage the location problem as inverse problem is solved. Therefore, it is important to increase the accuracy of estimating the wave parameters in noise. In this paper, a new approach of problem solution is proposed. In comparison to the known methods of statistical data processing, it provides increased accuracy of the measurement of wave arrival times and simultaneous selection of their forms. This approach is based on posteriori computational algorithms of discrete optimization. The posteriori algorithms for solving the problems of detection and separation of waveforms presented by a quasi-periodic sequence and distorted by Gaussian noise are justified. We consider two variants of waveforms in a quasi-periodic sequence, both identical and different. To solve the problem, the following model of data for analysis is proposed. Let the vector components $X = (x_0, ..., x_{N-1}) \in R^N$ form the sequence $x_n = \sum_{m=1}^{M} u_{n-n_m}(m),\ n = \overline{0, N-1},\ (n_1, ..., n_M) \in \Omega, \quad m = 2, ..., M$

$$\Omega = \{(n_1, ..., n_M) \mid 0 \le n_1 \le T_{\max} - q;\ N - T_{\max} \le n_M \le N - q;$$
$$T_{\min} \le n_m - n_{m-1} \le T_{\max}\},$$

where q, T_{min}, T_{max} are natural numbers. Assume that $u_j(m) = 0$, if $j \neq 0, ..., q-1$, $m = \overline{1, M}$. Also assume, that $U_m = (u_0(m), ..., u_{q-1}(m)), m = \overline{1, M}$, $w = (U_1, ..., U_M)$ and $\eta = (n_1, ..., n_M)$. Then, according to the introduced notation, the vector X depends on the pair of sets η and w, having the same number of M elements, that is, $X(\eta, w)$. Let the random vector $Y = (y_0, ..., y_{N-1})$ be the sum of two independent vectors, $Y = X + E$, where $E = (e_0, ..., e_{N-1}) \in \Phi_{X,\sigma^2 I}\sigma^2$. With allowance for the above, the problem of detection of quasi-periodic sequences of waveforms is in finding, with the observed vector Y, the set η according to which the non-observed vector $X(\eta, w)$ was generated. In this model, components of the vectors Y and X correspond to the observed and non-observed signals, and components of the vector E, to noise. Elements of the set $(n_1, ..., n_M)$ correspond to the arrival times of waveforms, and the q-dimensional set $U_m, m = \overline{1, M}$. The values of T_{min} and T_{max} are interpreted as the maximum and minimum intervals between two successive forms. To solve such problems, the principle of maximum likelihood is used. The results of numerical experiments on estimating the accuracy and noise immunity of the algorithms are presented.

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Mathematical model of thermoelectric effects during bridge erosion of electrical contacts

Temperature asymmetry in opening electrical contacts due to thermoelectric Thomson and Kohler effects is an important factor influencing on the direction of material transfer and contact erosion at bridging and arcing, as well as on the duration of anode and cathode arc phases. The Kohler effect which occurs in relays due to tunnel mechanism of electrical conductivity through adhesive or passivating films may generate some times heat power comparable with Joule heating. The Thomson effect causes also the temperature displacement in closed contacts and in a liquid bridge that influences on the bridge erosion and further arc evolution [1].

Mathematical model describing dynamics of temperature field in such electrical contacts is presented in this paper. It is based on the system of the heat equations for three domains with special boundary conditions describing non-ideal contact. One of these domain is occupied by a liquid bridge. The shape of the bridge is unknown a priori and it is found using the variational principle of minimum of bridge surface tension energy, i.e. by the solution a corresponding Euler-Lagrange equation. Temperature dependence of Thomson coefficient is taken into account. Dimensionless criteria of Kohler, Thomson and Joule effects are introduced and

discussed. It is shown that Kohler effect is most important in the range of low current. It enables to explain appearance of anode arc phase at the initial stage of arcing and also to evaluate its duration.

Theoretical results are compared with experimental data with satisfactory coincidence.

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Modelling pollution transport from the residual rocket fuel

One of the environmental pollution source in Kazakhstan is the falling of rocket with the residual rocket fuel. Such rockets may contain more than 100 kg. of the toxic rocket fuel. Rocket fuel components are substances that belongs to the first hazard class in Russian and class 6.1 in U.S.

These substances may damage the central nervous system and are really dangerous for live organisms. It has been shown that unsymmetrical dimethyl hydrazine (UDMH) which is the most dangerous component of the rocket fuel can penetrate deeply into the soil and dissolve in surface ground water, thus, the distribution of UDMH may spread over large areas.

The first detachment stage usually occurs at a height of 4 km. Only several hundred kilos of the UDMH remain in the tank at that point; for MBR SS20-type rockets, 273 kg remain.

In the paper the fuel spillage is a result of ground impact, in such case, spontaneous self-ignition may occur, and the quantity of the remaining fuel, which will spread to the adjacent territories under the influence of air flows, is the main parameter to define. If the coordinates of the fuel tanks fall and the quantity of remaining fuel are known, as well as the local meteorological conditions at the time of the fall, the dispersion of this cloud and the toxic fallout fields can be calculated with the help of the CFD modeling.

The modeling results allow us to conclude that for the rocket-carrier second-stage Proton, with its fall on the surface of the earth and subsequent explosion, a large portion of the fuel does not burn out but disperses in the atmosphere, as the temperature in the explosion is sufficiently high and the volatility of UDMH increases sharply with increasing temperature. The remaining fuel migrates deep into the soil. The data analysis clearly demonstrates that the levels of UDMH decrease markedly with increasing distance from the fuel tank and propulsion level fall points. Pollution of the surface layer at the location of the carrier-rocket stage fall is observed throughout the entire epicenter of the fall.

Thus, the estimates demonstrate that the pollution mainly occurs near the location of the carrier-rocket part fall and in places where transfer over a large distance from the point source on the surface is not possible. The good concordance obtained between the calculated and experimental data allows us to use the proposed model for a wide class of ecological problems associated with technological processes and emergency situations.

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Mathematical Modeling of the Destruction Process in the Fault Zone

Fault zone characterized by the fact that they may be developed by shear strains. Weak resistibility of the fault zone material due to the change in the shape of the fault zone at low strain rates brings the body with liquid of high viscosity [1–4].

Developed a mechanics and mathematical model of tectonic fault with an area of engagement (barrier), which simulates the accumulation of strain and stress concentration in the source zone under constant influence of background stress. The distribution of stresses in the hard area of engagement, found the stress intensity factor at the edges. Determined the regions in the barrier area, beyond the structural stability of rocks, and their development over time. Revealed preferential directions of possible environmental damage in the barrier area.

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Elongation determination using finite element and boundary element method

This paper presents an application of the finite element method and boundary element method to determine the distribution of the elongation. Computer simulations were performed using the computation of numerical algorithms according to a mathematical structure of the model and taking into account the values of all other elements of the fiber Bragg grating (FBG) sensor. Experimental studies were confirmed by elongation measurement system using one uniform FBG.Elonagation measurement are very important in many practical cases [1]. Many differential speed measurement algorithms was introduced, showing how to solve eccentricity problems and that a bad processing but not slippage is the source of observed false elongation peaks [2]. In some cases the elongation sensor using optical elements is used [3]. A two-dimensional formulation within the scope of the boundary element method (BEM) was proposed for the determination of influence of shear and elongation on drop deformation [4]. Sometimes the Indirect Boundary Element Method (IBEM) is applied for the strain calculations eg. to study composides models [5] and scattering of elastic waves by cracks. The finite element method is also widely used for the elongation determination, eg. in modelling and simulation of porcine liver tissue indentation elasticity and fracture analysis and also in many mechanical systems. An efficient hybrid approach to study the deformation in known materials have been presented in our method. In this work the relative elongation is determined for the formed mechanical system using finite element method (FEM) and boundary element method. In addition, the results have been verified by measurements using FBG sensor. In this paper, the inverse problem solution is used to estimate the model parameters of elongation sensor in accordance with the method of measuring the elongation distribution. To confirm the results obtained from FEM and BEM, measurements using FBG sensor have been performed. During measurements of the elongation distribution using inverse analysis it is important to build sensor model.

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Conditions for solvability of correct boundary value problems for the inhomogeneous polyharmonic equation in a ball

Let m be a positive integer. We shell consider in the n – dimensional unit ball $\Omega = \{x : |x| < 1\} \subseteq R^n$ the nonhomogeneous polyharmonic equation (PHE)

$$\Delta_x^m u(x) = f(x), \quad x \in \Omega, \tag{1}$$

with the boundary value problems (BVPs)

$$\frac{\partial^{k_j}}{\partial n_x^{k_j}} u\Big|_{x\in\partial\Omega} = \varphi_j(x), \quad j = \overline{1,m}, \quad x \in S, \quad 0 \le k_1 < k_2 < \ldots < k_m \le 2m-1. \tag{2}$$

By a regular solution to problems (1)-(2) we mean a function $u(x) \in C^{2m+\alpha}(\overline{\Omega})$, satisfying the equation (1) and the boundary conditions (2).

It is known, see [1,2], that the existence of regular solutions to the original data $f(x)$, $\varphi_1(x), \ldots, \varphi_m(x)$ imposes limitations of two types: (i) some loss of smoothness, (ii) certain conditions such as orthogonality to the solutions of the homogeneous adjoint equation. The solvability of BVPs for the PHEs and for elliptic equations in different spaces is investigated in [1-2,5].

In this paper [4-6], the focus is aimed at clarifying the limitations of type (ii), i.e. it is found out what the necessary and sufficient conditions of type (ii) the functions $f(x)$, $\varphi_1(x), \ldots, \varphi_m(x)$ should satisfy if their smoothness properties are standard. Therefore, in the given work we find a final result associated with necessary and sufficient conditions for the solvability of the nonhomogeneous PHEs in a ball on the given data and the solution is given in explicit form by the Green function for the PHD equation, as well as built some classes correct BVPs in a ball.

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Theoretical and Numerical Prediction of the Permeability of Fibrous Porous Media

In this study, the absolute and relative (for two-phase flow) permeability of ordered fibrous porous media for normal flows is predicted theoretically and numerically. Moreover, microscopic velocity profiles and distribution of phases (for two-phase flow) in the "unit cell" are investigated in detail for normal flows. Porous material is represented by a "unit cell" which is assumed to be repeated throughout the media and 1D fibers are modeled. Fibers are presented as cylinders with the same radii. Planar flow that perpendicular to the axes of cylinders is considered in this study. There are many theoretical and numerical investigations of single-phase (one fluid) flow in fibrous porous media exists in the literatures [1-4]. The two-phase (two immiscible fluids) flow in the ordered fibrous porous media is considered in this study. All numerical calculations are performed using Gerris program [6]. In theoretical estimations assumed that the velocity profile is parabolic [1-2,5]. The quantitative comparison of numerical and theoretical results of computation of the absolute and relative permeability of ordered fibrous media is reasonably good and is about 10-15%.

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3D model of fatigue crack propagation under cyclic loading

Three-dimensional numerical model of fatigue crack propagation under ciclic loading is developed. This model includes the submodel of stress-strain state of the elastic media and the submodel of curvelinear growth of the fracture. The boundary element method (BEM) is used for stress-strain state calculation. Paris-Erdogan fatigue criterion [1] is used in the submodel of crack growth. This criterion gives the relation between the velocity of crack growth and the stress intensity factors (SIFs). Fracture deflection angles are calculated using the condition for SIF mode II. Two approaches are used to implement this condition. In the first one that leads to Erdogan-Sih formula [2] that is implemented to the current front position. In the second one the condition is fulfilled iteratively on the next step of fracture propagation. SIFs are calculated using the interpolation formulae for the displacements in the vicinity of the crack front.

The problems of initially penny-shaped and elliptical fractures propagation are solved. The initial fractures are perpendicular to the direction of material tension or inclined against it at some angle. Sensitivity analysis of the problem to the numerical and physical parameters is carried out. Comparison analysis of fracture trajectories has been performed. In planar case the transformation of arbitrary-shaped fracture to round fracture is shown. Curvelinear fracture reorientation to the direction of specimen tension is presented. Interaction of two fractures is demonstrated.

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Density of temperature coefficients for muons in the atmosphere

In study of variations in intensity of cosmic rays with help of muon telescopes, located deep in atmosphere, must take into account changes in parameters of atmosphere, mainly, pressure and temperature. In order to assess density distribution of temperature coefficients of muon intensity in atmosphere according to method of observation considered principal components regression PCR and methods of projection to latent structures PLC 1 and PLC 2. In analysis used data from continuous recording of muons and upper-air data in Novosibirsk for the period 2004 - 2010 years. Comparison of results showed that method PLC 2 allows with minimal errors to estimate density distribution of temperature coefficients of muon intensity in atmosphere.

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Temperature effect of muons in the atmosphere

To account for temperature effect of cosmic ray muon telescopes need to know density distribution of temperature coefficients for muons in atmosphere. Density distribution of temperature coefficients obtained in recent experiments by continuous observation is not consistent with the results of theoretical calculations performed earlier. In this regard, it was modeled. With help of a polynomial function that approximates the average altitude variation of temperature, calculated density distribution of temperature coefficients for a wider range of values of threshold energy, zenith angle and parameters of differential energy spectrum of muons compared to earlier paper. Upper-air data of Novosibirsk during the period 2004 - 2010 years were used in the calculation.

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3D model of fracture propagation caused by viscous compressible fluid pumping

A new numerical methodic of simulation of fracture propagation caused by fluid pumping is proposed. The fracture propagation is simulated by the sequence of steps that describes the fracture at time moments.

The proposed methodic unites three sub-models that describe three processes affect the fracture propagation. Rock deformation is described in scope of elastic equilibrium equations solved by boundary element method used in [1]. The rock is supposed to be homogeneous, isotropic and brittle. Fluid inside the fracture is supposed to be weakly compressible, viscous and Newtonian (stress tensor is linear function of deformation tensor). The fluid flow is simulated by compressible lubrication model (Reynolds equation) [2] solved by finite element method. Rock breaking caused by the fracture propagation is described by Irwing's criterion coupled with maximal circumferential stress criterion for propagation direction. Stress intensity factors that are necessary for both criteria are calculated by interpolation formulas used in [1].

The methodic and the sub-models have been verified against simplified problems that are solved analytically or by the other models. Sensitivity analysis of the fracture propagation process to fluid rheology variation has been performed.

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A study of (m,k)-methods for solving differential-algebraic systems of index 1

Many applied problems lead to systems of differential equations given implicitly as

$$F(x, x') = 0,\ x(t_0) = x_0,\ t_0 \le t \le t_k, \tag{1}$$

where x and F are functions of the same dimension, and F is assumed to have sufficiently many bounded derivatives. Such problems arise in simulation of chemical reaction kinetics, electrical networks, control engineering etc. The modern methods for numerical solution of the initial-value problem for systems of ordinary differential equations (ODE) suppose usually the explicit dependence of the derivative of the solution

$$x' = \varphi(x),\ x(t_0) = x_0,\ t_0 \le t \le t_k. \tag{2}$$

However, a reduction of (1) to the form (2) requires a large additional numerical costs at every integration step, because this is connected with the inversion of the matrix $F_y = \partial F/\partial y$ which generally is singular. The numerical problem appearers to be more complicated because of the stiffness of explicit equations systems: in this case it is necessary to apply of special methods with conversion of the Jacobian matrix. A class of the schemes is offered [1], in which the reduction to the form (1) and the calculation of the approximate solution are carried out simultaneously. The given methods were generated by the (m, k)-schemes [2] for solving the explicit ODE systems.

In addition, it is assumed that functions F, f, and g are Lipschitz bounded, which ensures existence and uniqueness of the solution to problem (1) [3]. Using the notation $x' = y$, problem (1) can be written in the form

$$x' = y,\ F(x, y) = 0,\ x(t_0) = x_0,\ y(t_0) = y_0,\ t_0 \le t \le t_k.$$

The additional condition $y(t_0) = y_0$ can be found, for example, by solving the problem $F(x_0, y) = 0$ and using the stabilization technique.

Here a class (m, k)-methods is discussed for the numerical solution of the initial value problems for implicit systems of ordinary differential equations. The order conditions and convergence of the numerical solution in the case of implementation of the scheme with the time-lagging of matrices derivatives for systems of index 1 are obtained. At $k \le 4$ the order conditions are studied and schemes optimal computing costs are obtained. Support of RFBR ander grants 14-01-00047 and 15-01-00977.

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Geoinformation System on the basis of mathematical model of the microclimate of the industrial city

In given document we present information about a created GeoInformation System (GIS) based on mathematical models of city's microclimate, transfer of impurities of the pollutants in the atmosphere with the assimilation of the measured data to assess the extent of air pollution in the industrial city, which is connected with the list of pollutants and monitoring data [1] [2].Communication with the list of pollutants and monitoring data provided by the database "Monitoring of air."

Geoinformation System combines two object-oriented programs among DELPHI 7.0. The program automatically interact with a graphical editor ≪Surfer≫ which allows the construction of contour propagation concentrations of harmful substances in the atmosphere and at the same time it allows us to build cartographic analysis based on a system Mapinfo.

In last years the problem of air pollution in large cities of the Republic of Kazakhstan becomes more and more serious. It depends on afact that the industry enhances production volume in the cities and a number of vehicles and construction work in the city rapidly increasing.In order to solve environmental problems of air protection especially in industrial cities we need GIS technology with the help of which one it is possible to assess the impact of anthropogenic sources of pollution on air quality of the city, taking into account such factors as topography, land use, changes in temperature air and atmospheric humidity and etc.

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Numerical simulation of the mixing in a planar shear layer

The numerical study of the two-dimensional supersonic hydrogen-air mixing in the free shear layer is performed. The system of the Favre-Averaged Navier-Stokes equations for the multispecies flow is solved using the ENO scheme third order accuracy. The $k-\epsilon$ two-equation turbulence models with compressibility correction are applied to calculate the eddy viscosity coefficient. The dispersion of the particles is simulated following their trajectories in the shear layer with Euler method. In order to produce the roll-up and pairing vortex rings, an unsteady boundary condition is applied at the inlet plane. At the outflow, the non-reflecting boundary condition is taken. The influence of different Mach numbers on the formation of the vorticity structures and the shear layer growth rate are studied. The obtained results are compared with the experimental data and the numerical results of other authors. The numerical simulation of the particle dispersion in the shear layer with the large scale vortical structure is performed. The shear layer problem for the monatomic (air) gas has been tested by the following parameters: $M_0 = 0.51$, $T_0 = 285.07K$, $p_0 = 56088.91Pa$, $M_{inf} = 1.8$, $T_{inf} = 176.58K$, $p_{inf} = 54648.65Pa$. The computational grid is $526x201$. The channel height and length are 8 cm and 50 cm, respectively. The splitter plate thickness is 0.3175 cm, and edge of nozzle is 0.05 cm. The initial momentum thickness is 0.05 cm. It was obtained the shear layer growth in terms of momentum and vorticity thickness is agreed with experimental data.

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Application of Immersed Boundary Method in Modelling of Thrombosis in The Blood Flow

Thrombosis occurrence is associated with hemodynamics instability. For prediction of it various experimental and numerical methods are developed. However, the greatest interest is mathematical methods for computing the hemodynamic parameters in thrombus formation. The model is possible to calculate the basic hemodynamic parameters of blood flow and the development of stenosis as a result of thrombosis. To describe the two dimensional blood flow in vessels with

complex geometry as incompressible Newtonian fluid was used the conservation momentum law. Changing the shape of the vascular bed is considered in connection with possible biochemical processes like blood clots. In [1] had shown that blood clotting essentially depends on the parameters of convective transport. It was assumed that convective flows do not have significant changes with the growth of blood clots, however, it is not conclusive with respect to real systems. Thrombus growth entails a change in the flow region, which is taken into account in this study using the immersed boundary method [2]. The presence of the immersed boundary is taken into account by adding a special function in the equation of motion, allowing you to accurately represent streamlined border area. Unknown special function determined at the numerical solution stage of the problem, thus removing the requirement elastic boundaries. Also model consists from the equations describing the dynamics of the distribution of the main metabolites of blood clotting [3]. For the numerical solution of the problem the method of splitting into physical parameters was used. To approximate the convective terms were used the quasi monotone high-order schemes. As a result of numerical experiments it was found that the use of the immersed boundary method qualitatively describes the dynamics of the stenosis as a result of thrombosis.

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The expected inaccuracy in measuring the temperature the expected inaccuracy in measuring the temperature profiles in solid propellant by thermocouple elements

The behavior thermocouple in a solid medium is an interesting opportunity problem for accuracy of temperature measurement.This work considers interaction of thermocouple embedded in the solid substance pyrolyzed by external heat

source with heat wave propagating inside the substance from the surface of its pyrolysis. Numerical simulation has shown that significant difference in the values of thermal conductivity coefficients of solid substance and thermocouple material results in the heat flow along thermocouple wires inside the substance that substantially changes thermo junction temperature thus misrepresenting thermocouple data.

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Non-uniform ENO Scheme for Simulation of Supersonic Flows

In the paper, the third order finite-difference shock-capturing essentially non-oscillatory (ENO) scheme for a non-uniform grid has been developed. The design of the ENO scheme is based on the methodology for uniform grids proposed by the authors in [1]. The slope limiters were revised and adapted for the non-uniform mesh. Main advantage of the algorithm is that the modification of it from uniform mesh to non-uniform mesh can be done by simple way.

The efficiency of the developed algorithm is demonstrated by the numerical experiments on the simulation of the three-dimensional turbulent steady flowfield generated by the transverse hydrogen injection into the supersonic air cross-flow. The three-dimensional Reynolds-averaged Navier-Stokes equations for a supersonic turbulent multispecies gas are solved in a conservative form. To closure the RANS equations, the $k-\omega$ turbulence model is used.

The problem is solved implicitly. The methodology is similar to that on a uniform grid and can be found in [1, 2]. For numerical solution, the ENO scheme of the third order is applied for the inviscid convective fluxes, where the Newton interpolant of the third order degree was adapted for the non-uniform grid to construct the essentially non-oscillatory piecewise polynomial. After that, the reconstruction procedure via primitive function is applied. The obtaining system of equations is solved by the factorization using the matrix sweep method for the vector of the thermodynamic parameters and the tridiagonal inversion for the vector of the mass fractions.

At first, the comparison with results on the uniform grid using the coordinate system transformation is done. It was obtained that the behavior of the flowfield on the uniform and non-uniform grids is agreed.

Then, considering the analysis of the different variations of the limiter functions on the uniform grid, which was done by the authors in [3], the similar analysis for the developed algorithm on the non-uniform grid is done to study the effect of the limiter choice on the mixing layer dynamics and thus to define the optimal function

producing the smallest spread of the solution. The numerical experiments revealed that the non-optimal choice of the limiter can result in the overgrowth of the mixing layer, that is important for the numerical modeling of the combustion. The results of the numerical computations show good agreement with the experimental data.

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Computational model of thermo-diffusive processes in electrodes by arcing

The computational model of thermo-chemical processes in the cathode of plasmatron working in the gas environment is investigated. The core of this model is an algorithm of numerical solution of the system of differential equations which describe electromagnetic, temperature and concentration fields inside of a body of electrodes taking into account kinetic of phase transformation and chemical reaction in accordance with a state diagram, [1,2]. The offered approach is simpler for computing in domain with free boundary than the well-known Stefan's approach of describing of analogous processes. The unknown kinetic coefficient was determined from the best fit exact self-similar and numerical solutions of one-dimensional case.As an instance the case of copper cathodes with the zirconium insertion in the environment of oxygen is considered. The electrical current density through the surface of the insertion and it's temperature are presented in the form of a bell-shaped function. Function parameters are determined from the given process conditions. The influence of separate parts of process on distribution of temperature inside of the insertion is estimated. On the basis of this analysis the opportunity of use of stationary approach for electric and temperature fields was estimated and approximate analytical formulas for temperature are received. After that a numerical solution for gas concentration distribution is obtained. The calculations on the specified model show that the size of area of a phase zirconium oxides depends mainly upon coefficient of diffusion of oxygen. The calculations for various types of dependencies of gas diffusion coefficient from

temperature are concluded. The results of calculations develop understanding of some features of oxidation process of electrodes.

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The discreteness of the spectrum and the distribution of singular numbers (s-numbers) of a class of differential operators of mixed type

Let $\Omega = \{(x, y) : -\pi < x < \pi, -\infty < y < \infty)\}$. Consider a differential operator of mixed type

$$L_0 u = k(y)u_{xx} - u_{yy} + a(y)u_x + c(y)u$$

initially defined on the set $C^{\infty}_{0,\pi}(\overline{\Omega})$, which consists of infinitely differentiable functions satisfying the condition $u(-\pi, y) = u(\pi, y)$, $u_x(-\pi, y) = u_x(\pi, y)$ and are compactly supported with respect to the variable y.

Let the coefficients $k(y), a(y), c(y)$ satisfy the following conditions:

i) $k(y)$ is a piecewise continuous and bounded function in $\mathbb{R} = (-\infty, \infty)$ and $yk(y) > 0$ for $y \neq 0, k(0) = 0$.

ii) $|a(y)| \geq \delta_0 > 0$, $c(y) \geq \delta > 0$ are continuous functions in $\mathbb{R}$.

It is easy to check, the operator L_0 admits a closure in $L_2(\Omega)$ which will be denoted by L.

The main results are the following theorems.

Theorem 1. Let conditions i)-ii) hold and $\lambda \geq 0$. Then the operator $L + \lambda E$ is continuously invertible.

Assume that the coefficients of the operator L in addition to conditions $i) - ii)$ satisfy the following condition:

iii) $\mu_0 = \sup\limits_{|y-t|\leq 1} \frac{c(y)}{c(t)} < \infty, \mu = \sup\limits_{|y-t|\leq 1} \frac{a(y)}{a(t)} < \infty.$

Theorem 2. Let conditions i)-iii) hold. Then the resolvent of the operator L is compact if and only if

$$\lim_{|y|\to\infty} c(y) = \infty.$$

The nonzero s-numbers of $(L + \lambda E)^{-1}$ will be numbered in order of decreasing counting their multiplicities such that

$$s_k((L + \lambda E)^{-1}) = \lambda_k(\sqrt{[(L + \lambda E)^{-1}]^*(L + \lambda E)^{-1}}), k = 1, 2, ...$$

we introduce the function $N(\mu) = \sum\limits_{s_k>\mu}$ is the quantity of s_k greater than $\mu > 0$

Theorem 3. Let the conditions of Theorem 2 hold. The the following estimate holds

$$c^{-1} \sum_{n=-\infty}^{+\infty} \mu^{-\frac{1}{2}} mes(y \in \mathbb{R} : Q_n(y) \le c^{-1}\mu^{-1}) \le N(\mu) \le$$

$$\le c \sum_{n=-\infty}^{+\infty} \mu^{-\frac{1}{2}} mes(y \in \mathbb{R} : K_n^{\frac{1}{2}}(y) \le c\mu^{-1}),$$

where $Q_n(y) = |n^2 + ina(y) + c(y) + \lambda|$, $K_n(y) = |na(y)| + c(y) + \lambda|$, the constant $c > 0$ does not depend on Q_n, K_n, λ.

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On separability of a class of differential operators in $L_2(R^2)$

Consider a differential operator

$$L_0 u = k(y)u_{xx} - u_{yy} + a(x,y)u_x + c(x,y)u \tag{3}$$

initially defined on the set $C_0^\infty(\mathbb{R}^2)$, which consists of infinitely differentiable functions, the coefficients $a(x,y)$, $c(x,y)$ are continuous functions, $k(y)$ is a piecewise continuous and bounded function changes sign in $\mathbb{R}$.

Note that the coefficients $a(x,y)$, $c(x,y)$ of the operator (1) can be unbounded functions.

Here we study problems on the existence of the resolvent and separability of the operator (1).

Definition. *Operator L is called separable if we have the estimate*

$$\|k(y)u_{xx} - u_{yy}\|_2 + \|a(x,y)u_x\|_2 + \|c(x,y)u\|_2 \le c(\|Lu\|_2 + \|u\|_2),$$

for all the functions $u \in D(L)$, where $c > 0$ is constant does not depend on $u(x,y)$. Denote by $K(\tau, b)$ the class of the coefficients satisfying the conditions:
i. $|a(x,y)| \ge \delta_0 > 0$, $c(x,y) \ge \delta > 0$ are continuous functions in $\mathbb{R}$;
ii. $c_0 c(x,y) \le a^2(x,y) \le c_1 c(x,y)$ for all $x \in \mathbb{R}$, $c_0 > 0$ and $c_1 > 0$ are constants;
iii. $|a(x) - a(t)|^2 + |c(x) - c(t)| \le \tau c(t)$ for all $(x_1, x_2), (t_1, t_2) \in \mathbb{R}^2$, such that $|x - t| \le bd(t)$, $d(t) = \frac{1}{[c(t)]^{1/2}}$, $b > 0$, $\tau > 0$.

Theorem 1. *Let $a(x,y)$, $c(x,y) \in K(\tau, b)$. Then there exist numbers τ_0 and b_0 such that, for all $\tau \in (0, \tau_0)$ and $b > b_0$ the closure L of the operator $L_0 u = k(y)u_{xx} - u_{yy} + a(x,y)u_x + c(x,y)u$ $L_2(\mathbb{R}^2)$ exists.*

Theorem 2. *Let $a(x,y), c(x,y) \in K(\tau, b)$. Then there exist numbers τ_0 and b_0 such that, for all $\tau \in (0, \tau_0)$ and $b > b_0$ the operator L has a continuously invertible operator in $L_2(\mathbb{R}^2)$.*

Theorem 3. *Let the conditions of Theorem 2 hold. Then the operator L is separable.*

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Recovery operator of periodic functions

Let (X, Y) be pair of functional spaces of 1-periodic functions, X embedded in $C[0,1]^n$. Our aim is to find the nodes $\{t_k\}_{k=1}^M$ and functions $\{\phi_k(x)\}_{k=1}^M$, such that the error

$$\delta_M(X,Y) = \sup_{\|f\|_X=1} \|f_\lambda - \sum_{k=1}^{M} f(t_k)\phi_k(x)\|_Y$$

will be minimal when order M increase.

The problem of recovering of function from the classes with dominant mixed derivative is considered in many works.

The aim of this talk is to construct a recovery operator for which the error coincides with the order of corresponding orthodiameter:

$$d_M^{\perp}(X,Y) = \inf_{\{g_j\}_{j=1}^M} \sup_{\|f\|_X=1} \|f - \sum_{j=1}^{M}(f,g_j)g_j\|,$$

here the exact lower bound is taken over all orthogonal systems $\{g_j\}_{j=1}^M$ from $L_\infty[0,1]^n$.

For a function $f \in C[0,1]^n$ we define the transform

$$F_m(f;x) = \sum_{\substack{\psi(k)=m \\ k\in\mathbb{N}^n}} \frac{1}{2^{|k|}} \sum_{0\le r<2^k} f(\frac{r}{2^k})\phi_{k,r}(x+\frac{r}{2^k}), \tag{1}$$

$$\phi_{k,r}(x) = \sum_{0\le\nu\le k} (-1)^{\sum_{j=1}^{n-1}(r_j+1)sgn(k_j-\nu_j)} \sum_{\mu\in\rho(\nu)} e^{2\pi i\mu x}. \tag{2}$$

Here $\mu x := \sum_{j=1}^n \mu_j x_j$, $|k| := k_1 + \ldots + k_n$, $\rho(\nu) = \{\mu = (\mu_1, ..., \mu_n) \in \mathbb{N}^n : \left[2^{\nu_j-2}\right] \le |\mu_j| < 2^{\nu_j-1}\}$, $[x]$ is integer part of x, and $\nu \le \mu$ means that $\nu_j \le \mu_j$, $j = \overline{1,n}$.

Theorem. *Let $m \geq \psi(1)$, $F_m(f)$ defined by the relations (1), (2) , M is number of nodes in the definition of $F_m(f)$. If $1 < p \leq 2 \leq q \leq \infty$, $\alpha_0 > \frac{1}{p}$, then*

$$\sup_{\|f\|_{SW_p^\alpha}=1} \|f - F_m(f)\|_{L_q} \sim d_M^\perp(SW_p^\alpha, L_q),$$

$$\sup_{\|f\|_{SH_p^\alpha}=1} \|f - F_m(f)\|_{L_q} \sim d_M^\perp(SH_p^\alpha, L_q).$$

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On the second order differential equation with damped term

We consider the equation

$$Ly := -\rho(x)\left(\rho y'\right)' + q(x)y' + r(x)y = f(x),\ x \in \mathbf{R}. \tag{1}$$

Here $\rho \geq 1, q$ are continuously differentiable, and r a continuous function, $f \in L_2(\mathbf{R})$.

A function $y \in L_2(\mathbf{R})$ is called a solution of equation (1) if there is a sequence $\{y_n\}_{n=-\infty}^{+\infty}$ of twice continuously differentiable functions with compact support such that $\|y_n - y\|_2 \to 0$ and $\|Ly_n - f\|_2 \to 0$ as $n \to \infty$. Here $\|\cdot\|_2$ is the norm in $L_2(\mathbf{R})$.

In this paper we establish sufficient conditions for the unique and everywhere solvability of the equation (1). And also discussed the performance of coercive estimates for solutions and some of their applications.

The equation (1) have not a junior term and the coefficient q at the intermediate member is unlimited. Such equations are in the literature called degenerate differential equations. Accordingly, the operator L_0 generating equation (1) is called a degenerate operator. We note that the domain of the operator L_0 belongs to the space $L_2(R)$ under the additional assumptions on the coefficients. The degenerate symmetric operators previously studied in the works A.G. Kostyuchenko, M.G. Gasymov, B.Ya. Skachek, M. Otelbaev, Ya.T. Sultanaev, O.D. Apyshev. They investigated the questions of positive definiteness, as well as the spectral properties of the Friedrichs extension of indicated operators. Various problems of mathematical physics lead of this kind. By an equation (1), for instance, is defined the propagation of small oscillations in a visco-elastic compressible medium [1].

In the case $\rho = 1$ the degenerate equation (1) investigated in [2].

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Coercive estimates for a solution of the system of the second order difference equations

We consider the system

$$-\Delta y_j + r_j(y_{j+1} - y_j) = f_j, j \in \mathbb{Z}. \tag{1}$$

Here $\Delta y_j = y_{j+1} - 2y_j + y_{j-1}$, $r_j \geq 1$, $j \in \mathbb{Z}$. If we denote by $y = \{y_j\}_{j=-\infty}^{+\infty}$, $\Delta y = \{\Delta y_j\}_{j=-\infty}^{+\infty}$, $r = \{r_j\}_{j=-\infty}^{+\infty}$, $\nabla y = \{y_{j+1} - y_j\}_{j=-\infty}^{+\infty}$, $f = \{f_j\}_{j=-\infty}^{+\infty}$, $r\nabla y = \{r_j \nabla y_j\}_{j=-\infty}^{+\infty}$, then the system (1) can be written as:

$$L_0 y := -\Delta y + r\nabla y = f. \tag{2}$$

Definition. The sequence $y = \{y_j\}_{j=-\infty}^{+\infty} \in l_2$ is called a solution of the system (2) (or (1)) if there is the sequence $\{z_k\}_{k=-\infty}^{+\infty}$ of elements of l_2 with compact support such that $\|z_k - y\|_2 \to 0$, $\|L_0 z_k - f\|_2 \to 0$ as $k \to \infty$.

The system (1) is a degenerate system. Its features are associated with unboundedness of the sequence $\{r_j\}_{j=-\infty}^{+\infty}$ of coefficients by first order difference. The continuous analogue of the system (1) has been studied in [1]. We note that the study of the degenerate second order difference equations significantly different from the differential Sturm-Liouville problem. Coercive estimate of the solution of the difference equation (2) gives the qualitative properties of solutions, and allows to accurately describe the operator L_0 and spectral, approximate characteristics of its resolvent. Such assessments for the difference Sturm-Liouville equation are obtained in l_1 (see. [2]). In the following statement, the coercive estimate is received for a degenerate system (1) in the space l_2.

Theorem. Let for $r = \{r_j\}_{j=-\infty}^{+\infty}$ the following conditions hold:

$$r_j \geq 1 (j \in \mathbb{Z}), \ \sup_{n \geq 0} \left[\sqrt{n} \left(\sum_{j=n}^{+\infty} r_j^{-1} \right)^{1/2} \right] < \infty, \ \sup_{k<0} \left[\sqrt{-k+1} \left(\sum_{j=-\infty}^{k} r_j^{-1} \right)^{1/2} \right] < \infty.$$

Then the system (1) has an unique solution.

If furthermore

$$\sup_{k,j \in \mathbb{Z}: |k-j| \leq 3} r_k / r_j < \infty,$$

then for y the following estimate holds: $\|\Delta y\|_2 + \|r\nabla y\|_2 \leq C\|f\|_2$.

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Weighted estimate of q - integral operator with a logarithmic singularity

We establish weighted estimate for $I_q f(x) = \int\limits_0^x \ln_q \frac{x}{x-s} \frac{f(s)}{s} d_q s$ - weighted estimates of fractional q-integral operator with a logarithmic singularity.

Let $1 < p \le r < \infty, \gamma > \frac{1}{p}$ and $u(\cdot)$ be a weight function(i.e., nonnegative on $R_+ = (0; \infty)$). We consider the following weighted inequality:

$$\left(\int\limits_0^\infty u^r(x) \left(I_q f\right)^r d_q x \right)^{\frac{1}{r}} \le C \left(\int\limits_0^\infty x^{-p\gamma} f^p(x) d_q x \right)^{\frac{1}{p}}, \qquad f \ge 0 \tag{1}$$

where

$$I_q f(x) = \int\limits_0^x \ln_q \frac{x}{x-s} \frac{f(s)}{s} d_q s. \tag{2}$$

Notions of q-integral and q-logarithmic function were defined in [1-2]. Operator (2) is q-analog integral operator in classical analysis, which was considered in [2] of

$$If(x) = \int\limits_0^x \ln \frac{x}{x-s} \frac{f(s)}{s} ds.$$

Let

$$H_\gamma = \sup_{x>0} x^{\gamma + \frac{1}{p'}} \left(\int\limits_0^\infty \mathcal{X}_{[x,\infty)}(t) t^{-r} u^r(t) d_q t \right)^{\frac{1}{r}},$$

we have the following result.

Theorem A. *Let $1 < p \le r < \infty$, $\gamma > \frac{1}{p}$. Then the inequality (1) holds if and only if $H_\gamma < \infty$. Moreover, $H_\gamma \approx C$, where C is the best constant in (1).*

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Regularization methods for multidimensional analog of Gelfand–Levitan–Krein equation

We consider the approach of I.M. Gel'fand, B.M. Levitan and M.G. Krein. The Gel'fand-Levitan-Krein method (GLK method) allows to reduce the nonlinear inverse problem to a sequence of linear integral Fredholm equations. The GLK method does not use the multiple solution of the direct problems.

Let us consider the sequence of direct problems ($k \in \mathbb{Z}$):

$$u_{tt}^{(k)} = \Delta_{x,y} u^{(k)} - \nabla_{x,y} \ln \rho(x,y)\, \nabla_{x,y} u^{(k)}, \qquad x > 0,\ y \in (-\pi, \pi),\ t > 0, \tag{1}$$

$$u^{(k)}\big|_{t<0} \equiv 0, \tag{2}$$

$$\frac{\partial u^{(k)}}{\partial x}(+0, y, t) = \mathrm{e}^{\mathrm{i}ky}\, \delta(t), \tag{3}$$

$$u^{(k)}\big|_{y=\pi} = u^{(k)}\big|_{y=-\pi}. \tag{4}$$

In inverse problem it is required to find function $\rho(x, y)$ by known additional information

$$u^{(k)}(0, y, t) = f^{(k)}(y, t), \qquad y \in (-\pi, \pi),\ t > 0,\ k \in \mathbb{Z}. \tag{5}$$

The nonlinear inverse problem (1)—(5) is reduced to the sequence of linear integral equations [1, 2, 3]

(6)

$$2\Phi^{(k)}(x,t) - \sum_{m \in \mathbb{Z}} \int_{-x}^{x} {f_m^{(k)}}'(t-s)\, \Phi^{(m)}(x,s)\mathrm{d}s = -\int_{-\pi}^{\pi} \frac{\mathrm{e}^{\mathrm{i}ky}}{\rho(0,y)}\mathrm{d}y, \qquad |t| < x,\ k \in \mathbb{Z}.$$

The system (6) is the 2D analog of Gel'fand—Levitan—Krein equation.

The solution of inverse problem (1)—(5) can be found from

$$\rho(x,y) = \frac{\pi^2}{\rho(0,y)} \Big[\sum_{m \in \mathbb{Z}} \Phi^{(m)}(x, x-0)\, \mathrm{e}^{-\mathrm{i}my} \Big]^{-2}.$$

Numerical results and comparative analysis of several regularization methods are presented.

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Mathematical modelling of radiating processes in solids irradiated by heavy ions

The process of radiation defect formation in solids irradiated by heavy ions in the context of an cascade-probabilistic method (CPM) [1] is considered in the given work, which is analytical. All the mathematical models describing these processes both from physical reasons and from Kolmogorov-Chapman equations [2] are received.

Passing of ions through substance is a difficult aim as at creation physical and mathematical models. The set of types of flying particles and targets of Periodic system of Mendeleyev represents huge quantity of elements. At that is possible to consider various situations when the mass quantity of flying particles less than atom number of a target or is commensurable with atom number of a target and a case when the atom weight of a flying particle is more or much more than atom number of a target. Algorithms for calculating the cascade-probabilistic functions (CPF) depending on number of interactions and depth of penetration of particles, as well as for calculation of concentration of radiating defects in the solids irradiated by heavy ions are developed. Patterns of spectrums of the primarily beaten out atoms and concentration of radiating defects arising at calculation CPF are considered. When calculating CPF in view of losses of energy for ions and concentration of radiating defects it is necessary to find actual area of a finding of result that behaves differently depending on various factors. For example, the area of CPF result calculated depending on number of interactions is narrowed and displaced to the left, depending on depth of penetration is narrowed

and displaced to the right. Especially it has to be note a case when the density of a flying particle is great, and targets it is small, and then selection of borders of result area very much becomes complicated. So on the end of run of a particle the area narrows, sometimes up to the 100-th fractions of percent, and the curve can pass in a straight line. Therefore, it is necessary to find area of result for flying heavy ions in easy and heavy elements and to reveal regularity of behavior of this area depending on various factors.

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Three-dimensional model of fracture propagation from the cavity caused by quasi-static load or viscous fluid pumping

Fracture propagation caused by fluid pumping is in the focus of the report. The most popular approaches and problem statements used for the propagation simulation are described.

Methods of simulation of the main processes that take place during the fracture propagation are outlined. There processes are the follows: rock deformation and rock breaking, fluid flow inside the fracture and its filtration in the rock.

New method of fracture propagation simulation is proposed. The method unites three sub-models that describe three (except the fluid filtration) processes that affect the fracture propagation. Important advance of the methodic is its ability to replace any sub-model without numerical algorithm modification. So the appropriate sub-model can be chosen for each process depending on the problem features.

Thus quasi static and unsteady statement may be used for simulation of fracture propagation caused by viscous and inviscid fluid pumping. Rock deformation is described in scope of linear elasticity equation of homogeneous uniform material. Classical (similar to one used in [1]) and dual boundary element methods are used for this equations solution. Rock breaking caused by the fracture propagation

is described by Irwing's criterion coupled with maximal circumferential stress criterion for calculation of propagation direction. Various approaches are used to obtain stress intensity factors that are necessary for both criteria.

Proposed methodic has been applied for fracture propagation simulation. The sensitivity of fracture propagation process to variation of the main physical parameters has been shown.

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Self-purification modelling for small river in climate conditions of Central Siberia

Water quality modelling in small rivers is often considered unworthy from a practical and economic point of view. Mathematical models for water self purification were developed mostly for slow stream (lakes, ponds or reservoirs). This work shows that a simple model structure can be set up to describe the stationary water quality in small river basins in terms of carbon and nitrogen compounds, when it is unfeasible to use complex models. The physical part of the model includes hydrodynamical components derived from Saint-Venant's equations, coupled to a transport model based on a convection-dispersion equation under non-uniform and unsteady flow conditions. Biological part of the model includes principle factors such as chemical and biological oxidation, concentration of biogene elements (nitrogen, phosphorus etc.). Natural process of self-purification for small river in sharp continental climate of Central Siberia is inhibited by low temperatures, rapid currents and poor development of plankton cenosis. So, a determination of model's parameters demands carrying out of special experiments with water samples. Dynamics of this factors is described with the first order differential equations. The additional complexity for self-purification modelling in small river is diffusion sources as a results of agricultural practices. It was found that the inclusion of non-point sources as piecewise constant parameters affects the identifiability to a considerable extent.

The results of numerical modelling are verified by data from the environmental monitoring of some rivers in the basin of Central Enisey.

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Modeling of three-phase non-isothermal flow in porous media using the approach of reduced pressure

This paper focuses on modeling of compressible three-phase non-isothermal flow in porous media taking into account capillary effects. In a bounded domain $\Omega \subset R^2$, we consider the following problem:

$$\phi \frac{\partial}{\partial t}\left(\rho_\alpha s_\alpha\right) + \nabla \cdot \left(\rho_\alpha \vec{u}_\alpha\right) = q_\alpha, \quad \vec{u}_\alpha = -\frac{k k_\alpha}{\mu_\alpha}\nabla p_\alpha, \quad \alpha = 1,2,3, \;\; x \in \Omega, \;\; t > 0,$$

$$\frac{\partial}{\partial t}\left(\phi \sum_{\alpha=1}^{3} \rho_\alpha s_\alpha U_\alpha + (1-\phi)\,\rho_4 c_4 T\right) +$$

$$+\nabla \cdot \sum_{\alpha=1}^{3} \rho_\alpha \vec{u}_\alpha i_\alpha - \nabla \cdot (k_T \nabla T) = q_T, \;\; x \in \Omega, \;\; t > 0, \tag{1}$$

$$p_{21} = p_2 - p_1, \quad p_{32} = p_3 - p_2, \quad s_1 + s_2 + s_3 = 1.$$

The system is supplemented by the appropriate boundary and initial conditions. For simplicity, we assume that the reservoir contains only one type of rock and oil is considered to be a homogeneous non-evaporable fluid.

Choosing phase pressure as a unknown involves some difficulties that arise in the numerical solution of the equations describing compressible three-phase flow and in the mathematical analysis of the problem. Some of the difficulties are explained in [1] which also take place in the modeling of non-isothermal flow. To overcome these shortcomings in solving the non-isothermal problem (1), we use an approach similar to that suggested in the work [2] for modeling isothermal multiphase flow. The essence of this approach is to replace the three-phase flow by the flow of some fluid that obeys Darcy's law. In the paper [3], it is shown that from a computational point of view, a reduced pressure approach in solving three-phase flow problems is much more efficient than the phase formulation.

In this paper, the idea of introducing a reduced pressure is generalized for solving the problem of three-phase compressible non-isothermal flow in porous media. A system of four nonlinear equations for the reduced pressure, temperature and saturations is obtained. The numerical algorithm for solving this problem is

developed and the results of computational experiments are analysed. A priori estimate for the solution of the problem is derived and convergence of the iterative algorithm is proved.

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Comprehensive program for numerical simulation convective flow of viscous incompressible fluid a curvilinear coordinate system

In recent years, it is often required to solve problems in complex areas with complex geometry. For modeling in complex areas, in the first place it is required to discretize the physical domain, that is, the step of modeling the physical geometry using a set of cells grids. It should be noted that the use in can cause the appearance of a non-physical calculation schemes source of mass and momentum of non-uniform grids and it may be accompanied by the loss of important properties inherent differential equations approximated. Equation models recorded in curvilinear coordinates are more complicated than the original equations, in particular, they contain variable coefficients, additional terms, non-zero right-hand sides, etc. Therefore, the question of approximating equations on curvilinear grids is urgent and requires close attention. In addition, the diverse requirements imposed on the difference grid make curvilinear grid a complex mathematical problem. In this regard, the development of theoretical concepts and methodological approaches to the use of new information technologies in the hydrodynamic studies that takes into account the specific features of the subject area, development, adaptation of tools and testing them in the process of modeling the natural and man-made objects that are important for the national economy, are very relevant.

The development of a set of programs for numerical simulation of convective flow of viscous incompressible fluid in a doubly connected areas in a curvilinear coordinate system is considered in this paper. Discretization of the physical region is represented by the difference technology of creating curvilinear structure grids, methods of transfinite interpolation, equidistribution and using Godunov-Thompson is method [1]. More over, in order to select the most appropriate mesh for the main problem, quality grids based on criteria such as convexity, orthogonality, cell elongation and adaptation of the grid proposed in are considered [1, 2].

For modeling the convective flow, an incompressible fluid equation is used in the vorticity ω, stream function ψ and temperature θ under appropriate initial and boundary conditions [3] in curvilinear coordinate systems.

In the numerical construction of curvilinear grids in doubly connected areas method of equidistribution and method of Godunov-Thompson, as well as the numerical implementation of incompressible fluid equations, implicit scheme and the method of fractional steps are used. In the direction of the external and internal boundaries cyclic sweep is used, and in the direction of the normal scalar sweeps is used.

The calculations for various configurations of the cavity, temperature conditions at the border are conducted. For graphs of numerical calculations a graphical editor Tecplot is used.

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On the construction of equations in the form of Lagrange, Hamilton and Birkhoff by the given properties of motion in the presence of random perturbations

The equations of Lagrange, Hamilton and Birkhoff by motion's properties in the class of stochastic differential equations of Ito type in the presence of random forces from the class of processes with independent increments are constructed.

The inverse problems of constructing the equations of motion in form of Lagrange, Hamilton and Birkhoff on the given properties of the motion in a class of ordinary differential equations (in the absence of random disturbing forces) were considered in [1]. In [2] the stochastic Helmholtz problem (the problem of construction on a given stochastic Ito equation of the second order equivalent stochastic equations of Lagrange, Hamilton and Birkhoff structure) is considered. Discussed in this the work problem was earlier investigated in [3, 4] in the assumption that the random disturbing forces from a class of independent Wiener processes (as a special case of processes with independent increments).

The problems of construction functions of Lagrange, Hamilton and Birkhoff on the given properties of motion in the assumption that the random perturbation

forces belong to the class of processes with independent increments are considered in present report.

For the solving of posed problems in the first stage the differential Ito equation of second order on a given manifold is constructed by the quasi inversion method [5] in combination with the Erugin method [1] and the rule of complex functions' stochastic differentiation in the case of processes with independent increments [7] so that the given set was integral manifold of constructed equation.

And, further, in the second stage the equivalent stochastic equations of Lagrange, Hamilton and Birkhoff are constructed on the constructed Ito equation.

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Analytical and numerical studies of the impact of growth kinetics, motion and chemotaxis of methanogenic bacteria on changes of the composition of hydrocarbon mixture in underground gas storages

The problem of underground hydrogen gas mixture storage is that unlike natural gas, hydrogen gas mixture undergoes chemical changes in underground storage and thus the concentration of hydrogen and carbon dioxide is reduced, and the concentration of methane increases. It has been found that these changes occur because of the activity of methanogenic bacteria populations inhabiting in a reservoir. This chemical activity, which caused by the bacterial activity, as well as gas and water flow in the reservoir causes the phenomenon of self-organization

such as the occurrence of autowave spatial structures, the dynamics of which is characterized by a multiplicity of different scenarios, including the occurrence of chaos and the jump from one scenario to another. In this paper we developed a qualitative theory of self-organization scenarios in the underground hydrogen storage depending on the external and internal parameters. Development of the theory and computer models of transport in underground hydrogen storage will be based on the relating of models of multiphase composite flows in porous media with model of dynamics of bacterial populations which will be based on mechanism of chemotaxis (internal chemical mechanism by which bacteria are able to detect the presence of nutrients in the distance and move in that direction).

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Analytical solution of the problem about bending of annular plates subject to the action of the lateral load

In the Mechanics of deformable solid bodies are of particular interest the problems associated with bends of flexible plates and shells working in an inhomogeneous temperature field. Such problems commonly encountered in applied problems of construction, petroleum engineering, mechanical engineering, water and air transport.

Consider the problem of thermoelasticity of inhomogeneous circular plates under axisymmetric temperature field allowing for the effects of tension on bending and the changes in the elastic properties of the plate material by its thickness. Complex bending of inhomogeneous flexible circular plate, exposed to the action of the lateral load, under the temperature change across the thickness of the plate is described by a system of connected differential equations:

$$\begin{gathered} a_{11} r \frac{d}{dr} \nabla^2 F + a_{13} r \frac{d}{dr} \nabla^2 u_z = 0, \\ a_{13} r \frac{d}{dr} \nabla^2 F + a_{33} r \frac{d}{dr} \nabla^2 u_z + \frac{dF}{dr} \cdot \frac{du_z}{dr} = - \int q_z r dr + C, \end{gathered} \tag{1}$$

where $a_{11}{=}kD_N$, $a_{13}{=}k(D_ND_v - D_{Nv}D)$, $a_{33}{=}Da_{14} + D_va_{13} - D_M$, $a_{14} = k(D_ND - D_{Nv}D)$, $k = \dfrac{1}{D_N^2 - D_{Nv}^2}$, $\nabla^2 = \dfrac{d^2}{dr^2} + \dfrac{1}{r}\dfrac{d}{dr}$, $D_N = \int\limits_{-h/2}^{h/2} \dfrac{E(z)}{1-v(z)^2}dz$, $D_{Nv} = \int\limits_{-h/2}^{h/2} \dfrac{E(z)v(z)}{1-v(z)^2}dz$, $D = \int\limits_{-h/2}^{h/2} \dfrac{E(z)}{1-v(z)^2}zdz$, $D_v = \int\limits_{-h/2}^{h/2} \dfrac{E(z)v(z)}{1-v(z)^2}zdz$, $D_M = \int\limits_{-h/2}^{h/2} \dfrac{E(z)}{1-v(z)^2}z^2dz$, $D_{Mv} = \int\limits_{-h/2}^{h/2} \dfrac{E(z)v(z)}{1-v(z)^2}z^2dz$. Here F is the stress function, u_z is the deflection of the middle surface of the plate, h is the thickness of the plate, E is the modulus of elasticity, v is the Poisson ratio, q_z is the external distributed lateral load per unit area of the middle surface, C is the constant of integration.

It is generally accepted that the system of equations (1) in the case of considering the influence of tension on the bending is not reduced to unconnected equations. In fact, the system of resolving equations (1) can be reduced to a system of differential equations with nonlinear terms, each of which includes only one resolving function. An accurate solution of such equations by existing mathematical instruments does not appear plausible.

In the paper, the analytical solution of these equations is obtained by the partial discretization technique, developed by Professor A.N. Tyurekhodzhayev on the base of the generalized functions theory. The technique considered makes possible to find a solution for equations (1) virtually for any laws of changes in the modulus of elasticity and the Poisson ratio.

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Propagation of nonlinear waves in a mechanical system with contact dry friction under the action of cyclic loads

Propagation of nonlinear waves in a mechanical system with dry friction under cyclic loading with a frequency that is integrally greater than the system's natural frequency of oscillation was investigated analytically.

Problems of this sort reduce to an investigation of nonlinear systems of hyperbolic-type equations and are connected to the investigation of the propagation and attenuation of nonlinear waves. Nonlinearity is due to the presence of dry contact friction. In the case of dynamic deformation, the nonlinearity of the dissipation mechanism provides an a priori unknown nonlinear velocity function. In the case of movement, the friction assumes a maximum value with a plus or minus sign; at standstill, it takes any value between its positive or negative maximum.

The main complexity consists of determining the expression of the friction's sign function, which significantly depends on both the boundary and initial conditions, of the law of dry friction. The dependence domain for resolving problems of this sort is determined by the kappa-function method of A.Turekhodjayev. Applying the kappa-function method in many problems of this sort can determine the nonlinear function of friction and record it as an infinite sum of Heaviside functions with shifted arguments. Then, the nonlinear friction function becomes a function of independent arguments, and the problem can be resolved using one of the standard methods for solving linear equations.

Exact analytical results are obtained for a class of problems wherein the frequency of the external load is n times greater than the system's free frequency. The analysis of results obtained allowed us to construct solutions on the whole area of the dependence domain of the problem solution. The general solution of the problem is recorded by progressive waves that covered the travel way. The record of solutions in characteristic regions gives a pictorial view of the functions of displacement, stress and velocity. The class of loads under which the system shows subharmonic and ultraharmonic oscillations are determined. Depending on the evenness and oddness of the frequency ratio, the system gets unlimited displacements or performs steady oscillations.

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Thermal behaviours of the absorbed natural gas storage

As emitters of primary and secondary pollutants, motor vehicles are considered as one of the main contaminants of air in urban areas as well as in rural communities, and also contribute to global warming in significant amounts. Therefore, with the purpose of solving the problems, other types of energy sources are considered and studied as an alternative fuel for motor vehicles. And, one of them is a natural gas (NG) which became attractive because of its availability in abundant quantities, cost and meeting environmental standards.Nowadays, vehicles using

compressed natural gas (CNG) technology with high pressure are being used. In CNG technology, about 230 unit volumes of natural gas at 0.1 MPa can be compressed to one unit volume storage tank (230 V/V) where the pressure in the tank now reaches about 20 MPa. But the compression is an energy consuming process and the driving range of such vessel with compressed natural gas is still three times less than gasoline tank which has the same storage vessel volume. Therefore, compressed natural gas is not very attractive since high pressure environment in the storage tank needs strict safety regulations as well as costly devices and tools that could operate under this high pressure conditions. Another way of storing methane is using adsorbent materials such as activated carbons, metal-organic frameworks and porous polymers inside storage tanks where during charging process methane molecules can be attracted onto surface of pores of adsorbents by means of Van der Waals forces changing phase of the gas close to liquid. And, now the pressure inside the tank is at reasonable safe range which is about 3.5 – 4 MPa. Therefore, adsorbed natural gas technology seems more cost effective than others, and at low pressure shape of the storage tank should not have cylindrical conformation, fueling/refueling process is not energy consuming, and there is no need for expensive compression tools. During charging of the vessel, which is exothermic process, thermal energy is generated and bed temperature is increased thus reducing adsorption capacity of porous material. But, discharging is the opposite of the charging process where during desorption bed temperature decreases and it leads to lowering of delivered gas amount. During fueling and refueling of the storage tank, gas storage and delivery capacities go up to 90% and it is lower than those obtained in case of ideal isothermal process. Thus, control of the thermal energy in the storage tank is responsible for desirable adsorption/desorption of methane into/from porous material.

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Algorithms of determination by the path of robots in the conditions of interval uncertainty of data

In operation the question of determination of a path of some mechanism or robot moved from starting point of $M_0(x_0, y_0)$ in an ending point of $M_n(x_n, y_n)$. Actually there can be the whole set of the factors leading to a robot deviation from a schedulable or optimum path, especially if the robot is used on the low-studied terrain in case of feeble possibility of direct observation or adjustment of its way. In some cases possibility of presence of the person or a review of process of functioning of the robot is excluded by it in principle. Mathematical simulation and control in this case assumes need of determination of all set of possible paths, namely all functions of a status or all solutions of the simulating equations and controls as coordinates of initial and finite points can be known with errors, and the robot, having begun movement from any point in neighborhood of $M_0(x_0, y_0)$, can hit as a result any nail from neighborhood of a point of $M_n(x_n, y_n)$.

Let the robot because of the reasons influencing the accuracy of determination of its coordinates can settle down in some fixed neighborhood of a point of M_0 and get only to a certain neighborhood of a point of M_n. In operation [1] it is supposed that points of M_0 and M_n are in the parallelotopes which are in a two-dimensional case ordinary rectangles. Thus there is the infinite set of the lines connecting starting and finishing points of possible paths of the robot. It is accepted to suppose that required paths are function graphs of a certain class. Further the task about determination of some continuous line (a robot path) connecting points of $M_0 \in \tilde{M}_0$ and $M_n \in \tilde{M}_n$ where $\tilde{M}_0$, $\tilde{M}_n$ – limited neighborhoods of initial and finite points of a path is set. Options of paths thus can be very various, beginning from the primitive broken line without self-intersections, with the same slope angles of segments to an abscissa axis, finishing some rather arbitrary curve with self-intersections.

Let the first derivative of function $y = f(x)$ in any point $x_0 < x < x_n$ be positive, i.e. $f'(x > 0)$, $\forall x \in (x_0, x_n)$, that corresponds to a condition of progressiveness of relocation and absence of self-intersections at a function graph of $y = f(x)$. Further by some criterion on an interval $[x_0, x_n]$, we will select $n - 1$ a point: $x_0 < x_1 < x_2 < \ldots < x_{n-1} < x_n$. It can be abscissae of barriers or points in which the robot shall stay certain time at rest, execute some instruction, a command, etc.

If values of $r_i \geq 0$ are set $(i = 0, 1, 2, \ldots, n)$, it is possible to assume that $M_i(x_i, y_i)$ points are centers of circles with radiuses of r_i in which the robot, owing to influence of noises or accidental forces can settle down. In this case, in difference from [1], it will be a question not of parallelotopes, and the circulartopes.

We will set $\mathbf{d}_i = [\underline{d}_i, \overline{d}_i]$ intervals, such that Then set of points $\mathbf{M}_i^I(x_i, \mathbf{d}_i) \in \mathbb{R} \otimes \mathbb{IR}$ can be considered as these tasks of interval interpolating, type the task ***IIN1*** [2]. Thus values of r_i single-digit are defined by tolerances of locations of the robot or values of errors, and $\mathbf{d}_i$ can be considered as the generalized intervals [3], such that $\mathbf{d}_i = y_i + [-r_i, r_i]$.

The task of interval interpolating like ***IIN1*** is probed in [4] where interval options for a row of "classical" interpolation formulas are this: Lagrange, Newton, Hermite. In this case interval analogies of interpolation polynomials, can be taken as natural interval extensions as conditions of interpolation will be satisfied without conversions to force of properties of appropriate arithmetics. By search

of a path of the robot the interval option of the linear spline as geometrically it contains sets of the various paths which are broken lines on which can be considered as the most natural solution of the task the appropriate robot can move. In operation the approximation case is also considered by cubic interval splines, numerical experiments are described, graphic interpretations are this.

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Two-Component Incompressible Fluid Model for Simulating Surface Wave Propagation

The investigation of the surface waves is a fundamental problem of the hydrodynamics and the environment. Such investigation is necessary for solving a number of applications connected with designing, maintenance and security of ships and coastal structures. The problem of the numerical modeling of such waves (especially those with non-linear character) remains topical, despite the fairly large number of studies.

In this paper, the motion model of the two-component incompressible viscous fluid with variable viscosity and density is considered for modeling the process of the surface wave propagation. The model consists of the non-stationary Navier–Stokes equations with variable viscosity, the convection-diffusion equation and equations for determining the viscosity and density depending on the concentration of the components. Thus, we model the two-phase medium where one of the components is more dense and viscous liquid phase, and the other is a gaseous.

The results of calculations for two-dimensional and three-dimensional problems are presented.

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Using of geological and geophysical data in identifying of structurally homogeneous regions of the earth's crust in the case of Caspian region

In the solving the problem of allocated structurally homogeneous regions with respect to the inner monotony, geographic demarcation is advantageously carried out by a single feature as measured by the distribution maps of various geological and geophysical parameters of investigated region, reflecting its modern geodynamic position. The principle of division of the territory on the homogeneity similar principle underlying any classification that allows us to consider this type of zoning as its variety. It uses the similarity criteria [1]. But unlike the geographic demarcation using multiple attributes, in this case, the similarity is expressed as a feature ranking according to the degree of intensity.

The exception of the proposed approach is to classify by one basis, based on the use of various geological and geophysical parameters. As practice has shown [2], the degree of variability, as a fundamental feature of the most stable in space and time, and can therefore be considered more independent and objective. The final result is represented as the matrix of values, visualized in map merging gradients with area separation of structurally homogeneous regions.

Made comparisons showed a good agreement with the geotectonic basis. A large part of the study area appears to moderately uniform threshold variability to 0.4. The greatest degree of variability in the values reached in the areas of joint Scythian-Turan plate with Ural-Mugojar orogen to the north and the Caucasus-Kopet Dagh fold region in the south.

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On an instability of nonlinear controllable system in the neighborhood of program manyfold

We consider the problem of constructing of stability systems of automatic control by the given program manifold $\Omega(t) \equiv \omega(t,x) = 0$ [1]:

$$\dot{x} = f(t,x) - B\xi, \quad \xi = \varphi(\sigma), \quad \sigma = P^T\omega, \quad t \in I = [0,\infty), \tag{1}$$

where $x \in R^n$ is a state vector of object, $f \in R^n$ is vector-function, satisfying of existence and unique conditions of solution $x = x(t)$, $B \in R^{n\times r}$, $P \in R^{s\times r}$ are constant matrices, $\omega \in R^s (s \le n)$ is vector-function, $\xi \in R^r$ is discontinuous control vector-function on deflection from given program manyfold. $\varphi(\sigma)$ has only isolated point of discontinuity and there exist upper and lower finite limits $\overline{\lim\limits_{\sigma\to\sigma_0}}\varphi(\sigma) = \varphi_+(\sigma_0)$, $\underline{\lim\limits_{\sigma\to\sigma_0}}\varphi(\sigma) = \varphi_-(\sigma_0)$, in addition is valid

$$\varphi_-[\sigma(t)] \le \| \xi(t) \| \le \varphi_+[\sigma(t)], \tag{2}$$

$$\varphi_-(\sigma_0) = \inf_i \varphi_-(\sigma_{i0}), \quad \varphi_+(\sigma_0) = \sup_i \varphi_-(\sigma_{i0}) \quad i = 1,...r.$$

This problem reduce to investigation of quality behaviors with respect to vector-function ω of the following system [2]: $\dot{\omega} = -A\omega - HB\xi, \quad \xi = \varphi(\sigma), \quad \sigma = P^T\omega$, where $H = \partial\omega/\partial x$ is rectangle $(s \times n)$ matrix.

Statement of the problem: to receive a condition of instability in the neighborhood of program manifold of nonlinear control systems with respect to vector-function ω. For problem solving we compose a transfer function $W(i\varpi)$. Assume, that some diagonal matrices $\mu_1 \le \mu_2, \tau \ge 0, \theta$ exist, μ_1 and μ_2 maybe equal to $\pm\infty$. The frequency function $\pi(\varpi)$ will be constructed as in [3]. Notions of supplemented graph of nonlinear function $\varphi(\sigma)$, sectors, absolute stability, instability are used.

Theorem. Let Erugin's function will be $F = -A\omega$,there exists $\delta > 0$ and hold the following frequently inequality

$$\pi(\varpi) \ge \delta \, \| \, (A + i\varpi E)^{-1} \, \|^2 . \tag{3}$$

The matrix $-A - HB\mu P^T$ has $k \ge 1$ eigenvalues on the right semi-plane and supplemented graph Φ belongs to the sector $S[\mu_1, \mu_2]$. Then the program manyfold $\Omega(t)$ is instable in whole with respect to vector-function $\omega(t)$.

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Численное моделирование турбулентного конвективного переноса примеси при наличии температурной инверсии

В результате человеческой деятельности большинство урбанизированных поселений содержат различные источники тепла и загрязнения, такие как, электростанции, транспорт, аграрии и т.д. Асфальт и некоторые другие строения хранят и отражают солнечную радиацию, существенно нагревая поверхность. В результате, поселения являются источниками тепла в окружающей среде. Рельеф города из-за высоких зданий и различных улиц создает сложную конфигурацию, интенсивно влияющую на поток воздуха с переносом тепла и загрязнений.

В работе рассмотрен суточный ход изменения температуры на примере города Алматы. Атмосфера города представляет из себя сложную конфигурацию, в которой на динамику движения воздушных масс влияет как рельеф города, так и большая повторяемость штилевых ситуации, а также высокая частота появления температурных инверсии [1]. Основным методом снижения загрязнения является уменьшения самих источников загрязнения. Также, для борьбы за качество воздуха города в работе [2], предложен метод продувания города чистым горным воздухом.

Для моделирования движения воздушных масс используются стандартные законы сохранения массы, движения, энергии и концентрации [3], дискретизация которых проводилась методом конечных объёмов на не ортогональной, структурированной, совмещенной сетке [4-6].

Численное моделирование проводилось с пространственным разрешением 100x80x70 узлов в области 54x36x4 км. Трехмерный рельеф города основан на реальных данных проекта SRTM с пространственным разрешением 90 м. В результате проведенного моделирования подтверждено что инверсионные слои является сильной преградой для рассеивания загрязняющих веществ, из-за чего над городом часто виден отчетливый слой смога.

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Задача фильтрации жидкости к разноориентированной горизонтальной скважине в деформируемой трансверсально-изотропной среде

Изучение явления деформации коллекторов в процессе разработки нефтяных месторождений горизонтальными скважинами имеет важнейшее практическое значение. Основной задачей горизонтальной скважины является увеличение поверхности контакта с пластом с учетом напряженно-деформируемого состояния, таким образом, повышения ее производительности. В большинстве случаев стволы горизонтальной скважины бурятся параллельно плоскости напластования коллектора. Аналогичные задачи для упруго-деформируемого изотропного пласта рассмотрена в работах [1-5].

В данной работе на основе теоретических соотношений и методов получены основные формулы для определения продуктивности скважин в упругодеформируемой неоднородной среде, разработан алгоритм и пакет прикладных программ. Исследована сходимость вычислений методом конечных элементов, а также достоверность полученных результатов проверкой на тестовых задачах.

Напряженно-деформированное состояние скважин типа штрека существенно зависит от физико-механических и фильтрационных свойств пласта. Установлено, что при увеличении отбираемой жидкости через горизонтальную скважину значения дебита существенно уменьшаются. Можно отметить следующую характерную особенность, увеличение дебита, с ростом разности между углом падения и углом наклона плоскости изотропии пласта.

На основе числовых результатов проведенных расчетов обоснован и разработан способ исследования особенностей фильтрационных полей и напряженного состояния в неоднородном пласте с горизонтальными скважинами. Полученные результаты и созданный пакет прикладных программ могут быть применены для оценки продуктивности нефтегазовых пластов и определения направлений бурения скважин.

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Обратная задача лечения организма бактериостатическим антибиотиком с измерением общей численности бактерий.

В работе рассматривается процесс лечения зараженного организма бактериостатическим антибиотиком, который описывается следующей системой дифференциальных уравнений:

$$\begin{cases} \dot{x}_1 = \dfrac{ka_1}{x_1^\theta} - b_1(x_1 + x_2)x_1, \\ \dot{x}_2 = \left[a_2 - b_2(x_1 + x_2)\right] x_2, \end{cases}$$

где x_1 – численность основной популяции бактерий, а x_2 – численность бактерий-мутантов, не чувствительных к действию антибиотика. Параметры a_1 и a_2 – приросты численности бактерий основной популяции и мутантов, b_1 и b_2 характеризуют чувствительность обоих типов бактерий к ограниченности жизненного пространства, θ – эффективность антибиотика, k – его концентрация. Значения численностей бактерий обоих типов в начальный момент времени считается известными:

$$x_1(0) = x_{10},\ x_2(0) = x_{20}.$$

Задача состоит в отыскании параметра k таким образом, чтобы соответствующее ему решение системы удовлетворяло условию:

$$x_1(t) + x_2(t) = y(t),$$

где функция $y(t)$ считается известной на интервале времени $[0, T]$ (результат эксперимента по определению общей численности бактерий).

Задача сводится к задаче минимизации функционала

$$I(k) = \int_0^T \Big[x_1(t) + x_2(t) - y(t)\Big]^2 dt.$$

Данная задача решается градиентным методом. Расчеты показали, что значение неизвестного параметра k восстанавливается с точностью до тысячных.

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О некорректной задаче для уравнения Пуассона

В области $\Omega = \{x, y |\, 0 < x < 2,\, 0 < y < 1\}$ для уравнения Пуассона рассматривается граничная задача

$$(1) \qquad \begin{cases} -\Delta u = f(x,y),\ \{x,\, y\} \in \Omega, \\ u|_{x=0} = \varphi_0(y),\ \ u_x|_{x=0} = \varphi_1(y), \\ u|_{y=0} = \psi_0(x),\ \ u_y|_{y=0} = \psi_1(x). \end{cases}$$

Задача (1) является некорректной [1], так как условия на границе заданы только лишь на двух сторонах прямоугольника Ω.

Будем предполагать, что данные граничной задачи (1) удовлетворяют условиям:

$$(2) \qquad f \in L_2(\Omega),\ \varphi_0 \in H^1(0,1),\ \varphi_1 \in L_2(0,1),\ \psi_0 \in H^1(0,2),\ \psi_1 \in L_2(0,2).$$

В работе предлагается алгоритм приближенного решения некорректной граничной задачи (1) при условиях (2).

Для этой цели сформулируем следующую регуляризованную оптимизационную задачу по минимизации функционала:

$$(3) \qquad \mathcal{J}_\alpha(u, p_1) = \int_0^1 |u_x(0,y) - \varphi_1(y)|^2 dy + \alpha \int_0^1 |p_1(y)|^2 dy,\ \ \alpha = \text{const} > 0,$$

на решениях граничной задачи:

$$(4) \qquad \begin{cases} -\Delta u = f(x,y),\ \{x,\, y\} \in \Omega, \\ u|_{x=0} = \varphi_0(y),\ \ u|_{x=2} = p_1(y), \\ u|_{y=0} = \psi_0(x),\ \ u_y|_{y=0} = \psi_1(x), \end{cases}$$

где $p_1(y) \in H^1(0,1)$ – неизвестная функция управления, подлежащая определению, наряду с решением граничной задачи (4) $u(x,y)$ из условия минимума функционала (3).

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Оптимальная стабилизация вращательного движения космического аппарата на конечном интервале времени

Вращательное движение космического аппарата (КА), рассматриваемого как твердое тело, описывается с помощью динамических уравнений Эйлера [1]:

$$\begin{aligned} J_1\dot{\omega}_1(t) &= (J_2 - J_3)\omega_2(t)\omega_3(t) + M_1(t), \\ J_2\dot{\omega}_2(t) &= (J_3 - J_1)\omega_1(t)\omega_3(t) + M_2(t), \\ J_3\dot{\omega}_3(t) &= (J_1 - J_2)\omega_1(t)\omega_2(t) + M_3(t), \end{aligned} \tag{1}$$

где $\omega_i(t)$ — компоненты вектора угловой скорости $\omega(t)$; J_i — проекции главного центрального момента инерции тела; $M_i(t)$ — проекции главного момента внешних сил $M(t)$ $(i = 1, 2, 3)$. Управление $M(t)$, $t \in [t_0, T]$ принимает значения из множества

$$U = \{M = (M_1, M_2, M_3) \mid M' D\, M \le d_0^2\}.$$

Требуется перевести систему (1) из начального положения $\omega(t_0) = \omega_0$ в состояние покоя $\omega(T) = 0$ за заданный интервал времени $[t_0, T]$, минимизируя при этом целевой функционал

$$J(M) = \frac{1}{2}\int_{t_0}^{T} \{\alpha^2[J_1^2\omega_1^2(t) + J_2^2\omega_2^2(t) + J_3^2\omega_3^2(t)] + [M_1^2(t) + M_2^2(t) + M_3^2(t)]\}\, dt.$$

Таким образом, мы рассматриваем задачу оптимального управления (ЗОУ) для билинейной системы (1) с закрепленными концами траекторий, на конечном интервале времени, с ограниченным управлением. Вводя обозначения $x_i(t) = J_i\omega_i(t)$, систему (1) можно привести к виду с кососимметрической матрицей [2]:

$$\dot{x}(t) = A(x(t))x(t) + B(t)u(t),$$

где $x(t) = (x_1(t), x_2(t), x_3(t))'$ – вектор фазовых координат, $u(t) = (M_1(t), M_2(t), M_3(t))'$ – вектор управления, матрица $A(x(t))$ обладает свойством кососимметричности: $A'(x(t)) = -A(x(t))$.

Для решения рассматриваемой ЗОУ предложен метод, основанный на использовании метода множителей Лагранжа специального вида [3].

Работа выполнена при финансовой поддержке Комитета науки МОН РК (грант № 1625 / ГФ3).

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Численное исследование процесса разрядки природного газа из терморегулируемого слоя адсорбента

Природный газ является одним из самых распространенных и наиболее экологически чистых видов топлива, что делает его привлекательным с точки зрения энергооснащения транспортных средств. В процессе его горения выделяется значительно меньше опасных загрязняющих веществ по сравнению с другими видами топлива таких, как бензин и дизель. Однако его кратковременное хранение сопровождается определенными сложностями, так как каждый тип его хранения в малых емкостях обладает своими недостатками. Существуют три основных типов хранения природного газа: в сжатом состоянии под большим давлением, в сжиженном состоянии при низких температурах и, сопровождающимся относительно низким давлением и умеренной температурой, адсорбированном состоянии, о и которой пойдет речь. Настоящая работа посвящена исследованию кинетики десорбции газа (метана) из слоя терморегулируемого адсорбента баллона хранения природного газа в адсорбированном состоянии (Adsorbed Natural Gas). Кинетика газа в пористой среде рассматривается на макроскопическом уровне, поэтому при математическом моделировании задачи произведены операции осреднения уравнений. Математическая модель состоит из уравнений движения газа в пористой среде, закона сохранения массы, уравнения энергии и приближенной модели линейной движущей силы описывающей кинетику адсорбции газа.

При активном потреблении топлива двигателем, необходима соответствующая подача газа в камеру сгорания, отсюда и возникает вопрос об эффективности подачи газа в двигатель автотранспорта из баллона хранения природного газа в адсорбированном состоянии.

Целью работы является исследование эффективности снабжения топливом автотранспорта.Соответственно, задачей работы является проведение численного исследования кинетики десорбции газа из слоя терморегулируемого адсорбента и определение скорости десорбции газа из слоя адсорбента.

В ходе предварительной работы полностью сформирована математическая модель и начальная краевая задача для процесса десорбции газа из слоя адсорбента хранилища природного газа. Планируется выполнить конечно-элементный расчет и на его основе произвести анализ процесса десорбции.

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Численные методы решения задачи Дирихле для волнового уравнения

Рассмотрим задачу Дирихле для двумерного волнового уравнения [1]:

$$
\begin{aligned}
&(1) \quad u_{tt} = u_{xx} + u_{yy}, && x \in (0,\pi), \quad y \in (0,\pi), \quad t \in (0,T),\\
&(2) \quad u(0,y,t) = u(\pi,y,t) = 0, && y \in [0,\pi], \quad t \in [0,T],\\
&(3) \quad u(x,0,t) = u(x,\pi,t) = 0, && x \in [0,\pi], \quad t \in [0,T],\\
&(4) \quad u(x,y,0) = 0, && x \in [0,\pi], \quad y \in [0,\pi],\\
&(5) \quad u_t(x,y,0) = q(x,y), && x \in [0,\pi], \quad y \in [0,\pi],\\
&(6) \quad u(x,y,T) = f(x,y), && x \in [0,\pi], \quad y \in [0,\pi].
\end{aligned}
$$

В обратной задаче требуется найти $q(x,y)$, по дополнительной информации (6), относительно решения прямой задачи (1)–(5)

Обратную задачу запишем в операторном виде $Ag = f$. Решаем задачу минимизацией целевого функционала $J(q) = \langle Aq - f, Aq - f\rangle$. Для минимизации целевого функционала будем использовать градиентные методы вида [2] $q_{n+1} = q_n - \alpha_n J' q_n$, здесь способ задания α_n определяет тот или иной метод:

- **Метод итераций Ландвебера**, параметр α_n фиксирован: $\alpha_n = \alpha \in (0, \|A\|^{-2})$;
- **Метод наискорейшего спуска**, параметр α_n выбирается как: $\alpha_n = \frac{\|J' q_n\|^2}{2\|AJ' q_n\|^2}$.

Градиента функционала $J'q = -\psi(x, y, 0)$, где $\psi(x, y, t)$ есть решение сопряженной задачи:

$$\psi_{tt} = \psi_{xx} + \psi_{yy}, \qquad x \in (0, \pi), \quad y \in (0, \pi), \quad t \in (0, T), \tag{7}$$

$$\psi(0, y, t) = \psi(\pi, y, t) = 0, \qquad y \in [0, \pi], \quad t \in [0, T], \tag{8}$$

$$\psi(x, 0, t) = \psi(x, \pi, t) = 0, \qquad x \in [0, \pi], \quad t \in [0, T], \tag{9}$$

$$\psi(x, y, T) = 0, \qquad x \in [0, \pi], \quad y \in [0, \pi], \tag{10}$$

$$\psi_t(x, y, T) = 2[u(x, y, T) - f(x, y)], \qquad x \in [0, \pi], \quad y \in [0, \pi], \tag{11}$$

В подтверждение этому были получены чиссленные результаты и графики для тестовых задач. Проведен сравнительный анализ методов сходимости для решения задачи Дирихле для волнового уравнения в двумерном пространстве.

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Асимптотическое поведение автомодельных решений нелинейных параболических систем недивергентного вида

Рассмотрим в области $Q = \{(t, x) : 0 < t < T, x \in R^N\}$ параболическую систему двух уравнений недивергентного вида

$$\frac{\partial u_i}{\partial t} = u_i^{\gamma_i} \nabla \left(|\nabla u_i|^{\sigma} \nabla u_i \right) + \varepsilon \, u_{3-i}^{q_i}, \tag{1}$$

где T, σ, γ_i, $q_i \, (i = 1, 2)$ - положительные вещественные числа, $\varepsilon = \pm 1$, $u_i = u_i(t, x) \geq 0$, $(i = 1, 2)$ - искомые решения.

Члены $\varepsilon \, u_{3-i}^{q_i}$ соответствует наличию источников ($\varepsilon = +1$) или стоков ($\varepsilon = -1$), мощности которых равны $u_{3-i}^{q_i}$.

Система уравнения (1) описывает многие физические явления [1-3]. В работе [1] для случая одного уравнения исследована задача Коши при $q = 0$, $\sigma = 0$, доказано существование единственного вязкого решения, а в работах [2,3] исследована задача Коши при $\sigma = 0$, доказано существование и единственность классического решения [2], а в [3] изучена свойство blow-up.

В настоящей работе построены асимптотические представления автомодельных решений системы (1), в зависимости от значения числовых параметров, найдены необходимые и достаточные признаки их существования. Для построения автомодельных систем предлагается алгоритм нелинейного расщепления [4], для чего решения системы (1) ищется в виде

$u_i(t,x) = \bar{u}_i(t)\, w_i(\tau,x)$, $w_i(\tau,x) = f_i(\xi)$, $f_i(\xi) = \overline{f}_i(\xi) y_i(\eta)$, где $\bar{u}_i(t) = A_i (T+\varepsilon t)^{\varepsilon n_i}$, $\tau(t) = A_1^{\gamma_1+\sigma} \frac{(T+\varepsilon t)^{\varepsilon n_1(\gamma_1+\sigma)+1}}{\varepsilon n_1(\gamma_1+\sigma)+1}$, $\varepsilon n_1(\gamma_1+\sigma)+1 \neq 0$, $\varphi_i = A_1^{-(\sigma+\gamma_1)} A_i^{\sigma+\gamma_i}, \psi_i = \frac{n_i}{(\varepsilon n_i(\sigma+\gamma_i)+1)\varphi_i}$, $\overline{f}_i(\xi) = (a - b\xi^{\frac{\sigma+2}{\sigma+1}})^{\frac{\sigma+1}{\sigma+\gamma_i}}$, $\xi = x\tau^{-\frac{1}{\sigma+2}}$, $\eta = -\ln(a - b\xi^{\frac{\sigma+2}{\sigma+1}})$, $s_i = 1 + \frac{(\sigma+1)q_i}{\sigma+\gamma_{3-i}} - \frac{(\sigma+1)}{\sigma+\gamma_i}$ $(i=1,2)$.

Введем обозначения: $c_{i1} = \frac{1}{(\sigma+2)^{\sigma+2}(\sigma+\gamma_i)b^{\sigma+1}}$, $c_{i2} = \frac{\gamma_i - 1}{(\sigma+\gamma_i)^{\sigma+2}}$, $c_{i3} = -\frac{\psi_i}{ab^{\sigma+1}(\sigma+2)}$ $(i=1,2)$.

Ограничимся приведением одной теоремы:

Теорема. Пусть $(1+q_1)(\gamma_1+\sigma) = (1+q_2)(\gamma_2+\sigma)$. Тогда для существования у системы (1) решений вида $u_i(t,x) = \bar{u}_i(t)\,\overline{f}_i(\xi) y_i(\eta), y_i(\eta) = y_i^0 + o(1)$, $\eta \to +\infty$ $(i=1,2)$, где $0 < y_i^0 < +\infty$ $(i=1,2)$, необходимо, чтобы соблюдалось одно из следующих условий:

1. $c_{i1} + c_{i2}(y_i^0)^{\sigma+\gamma_i} + c_{i3} y_i^0 (y_{3-i}^0)^{q_i} = 0$ при $s_i = 0$ $(i=1,2)$.
2. $c_{i1} + c_{i2}(y_i^0)^{\sigma+\gamma_i} = 0$ при $s_i > 0$ $(i=1,2)$.
3. $c_{11} + c_{12}(y_1^0)^{\sigma+\gamma_1} + c_{13} y_1^0 (y_2^0)^{q_1} = 0$, $c_{21} + c_{22}(y_2^0)^{\sigma+\gamma_2} = 0$ при $s_1 = 0$, $s_2 > 0$.
4. $c_{21} + c_{22}(y_2^0)^{\sigma+\gamma_2} + c_{23} y_2^0 (y_1^0)^{q_2} = 0$, $c_{11} + c_{12}(y_1^0)^{\sigma+\gamma_1} = 0$ при $s_1 > 0$, $s_2 = 0$.

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Численное решение трехмерной двухфазной фильтрационной задачи по идентификации параметров неоднородного нефтяного пласта

Для управления пластом применяется метод моделирования. Моделирование позволяет понять геологию пласта и предсказать его поведение при различных сценариях разработки. На всех стадиях разработки месторождения необходимо прогнозировать поведение пласта и технологические показатели разработки. А для этого нужны достоверные геолого-технологические модели, на основе которых можно принимать решения по дальнейшему изучению и оптимизации разработки залежей углеводородов. Заметим, что постоянно-действующая геолого-технологическая модель является цетральным объектом, на основании которого ведется разработка месторождений. Адаптация модели к истории разработки является важной и актуальной задачей разработки месторождения. В работе рассмотрена нелинейная трехмерная двухфазная фильтрационная задача в ограниченной трехмерной области при соответствующих начальных и граничных условиях. Составлен алгоритм решения обратной задачи по идентификации параметров неоднородного нефтяного пласта.

Для численного решения имитационной задачи построена полная неявная схема. Введена целевая функция - мера расхождения между наблюдаемыми значениями и ответом системы [1]-[2]. Вычислены элементы матрицы Якоби трехмерной двухфазной фильтрационной задачи в случае прямоугольной трехмерной сетки. Построен итерационный процесс для определения коэффициентов чувствительности модели и фильтрационныхпараметров нефтяного неоднородного пласта. Построен алгоритм численного решения задачи парамерической идентификации.

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Математическое моделирование ударно-волновых структур при взаимодействии скачков уплотнения с пограничными слоями нижней и верхней стенки

В работе рассматривается сверхзвуковое течение воздуха в плоском канале с поперечным вдувом струи водорода с нижней стенки. При натекании

потока на струю образуется сложная система ударных волн, которая достаточно хорошо описывается в литературе [1-3]. Большинство существующих на данный момент работ по теоретическому изучению взаимодействия струи и набегающего потока в канале в основном рассматривают область вдува струи, и при этом, как правило, на верхней границе реализуются граничные условия симметрии или свободного потока, что значительно облегчает решение поставленной задачи.

Для математического моделирования рассматриваемой проблемы исходными являются осредненные по Фавру двумерные уравнения Навье-Стокса для турбулентного течения многокомпонентной газовой смеси, записанные в безразмерной форме. Замыкание осуществляется с помощью двухпараметрической $k-\omega$ модели турбулентности. Разработанный численный алгоритм решения строится на основе WENO схем.

Основное внимание уделяется исследованию взаимодействия ударно-волновой структуры с пограничными слоями на нижней и верхней стенках в условиях внутреннего турбулентного течения, а именно, проведено детальное изучение структур потоков, исследован отрыв и смешение в зависимости от ширины щели струи. Установлено, что помимо известных ударно-волновых структур, возникающих при взаимодействии набегающего потока с поперечной струей и при взаимодействии головного скачка уплотнения с пограничными слоями вблизи стенок, возникают дополнительная система скачков уплотнения и отрыв потока на нижней стенке на некотором расстоянии от струи вниз по потоку. Произведено сравнение с опытными данными.

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Об одной термодинамической согласованной нелинейной модели пороупругости

При математическом моделировании распространения сейсмических волн в упругих средах обычно предполагают, что среда идеально упругодеформируема и пренебрегается диссипацией энергии, пористостью. С другой стороны, имеется большое количество работ, которые посвящены математическому моделированию процессов распространения сейсмических волн в насыщенных жидкостью пористых средах основанных на линейных моделях типа Френкеля-Био [1,2].

В данной работе, используя метод законов сохранения [3,4,5], получена система нелинейных уравнений пороупругости в случае, когда диссипация энергии происходит на коэффициенте межфазного трения. При этом коэффициент сдвига и коэффициент трения являются функциями скорости деформации и относительной скоростью, соответственно. Данная модель допускает предельного перехода. В частности, когда нет дисспации энергии в системе (в случае обращения коэффициента трения в ноль) данная математическая модель переходит к известным моделям электромагнетики и акустики [6].

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О свойствах дробной степени оператора Штурма-Лиувилля

Из тождества Лагранжа

$$\rho(t)(y'_-(t,\lambda)y_+(t,\lambda) - y'_+(t,\lambda)y_-(t,\lambda)) = \mu(\lambda)$$

на основе теоремы 1[1] получим оценки для функций Грина $G(x,x,\lambda)$ и $G_\sigma(x,x)$:

$$\frac{\varphi_-\varphi_+}{2(\varphi_- + \varphi_+)} \leqslant G(t,t,\lambda) \leqslant 2\frac{\varphi_-\varphi_+}{\varphi_- + \varphi_+}.$$

$$\frac{\sin\sigma\pi}{2\pi}\int\limits_0^\infty \lambda^{-\sigma}\frac{\varphi_-\varphi_+}{\varphi_- + \varphi_+}d\lambda \leqslant G_\sigma(t,t) \leqslant \frac{2\sin\sigma\pi}{\pi}\int\limits_0^\infty \lambda^{-\sigma}\frac{\varphi_-\varphi_+}{\varphi_- + \varphi_+}d\lambda.$$

Предложение 1. Пусть $p = 2$ и оператор L_2^{-1} компактен. Тогда оператор $L_2^{-\sigma}$ ядерный тогда и только тогда, когда

$$B = \int\limits_J \frac{\varphi_-\varphi_+}{\varphi_- + \varphi_+} dt < \infty.$$

Справедлива следующая

Теорема 1. Пусть $p = 2$ и оператор L_2^{-1} компактен. Тогда $L_2^{-\sigma}$ оператор ядерный тогда и только тогда, когда

$$B = \int\limits_J \Big(\int\limits_0^\infty \lambda^{-\sigma} \frac{\varphi_-\varphi_+}{\varphi_- + \varphi_+} d\lambda \Big) dt < \infty.$$

При этом для ядерной нормы оператора $L_2^{-\sigma}$ имеет место оценка

$$C_1 B \leqslant \|L_2^{-\sigma}\|_1 \leqslant C_2 B.$$

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Гладкость решений (разделимость) нелинейного стационарного уравнения Шредингера

В конце XX в. волновая теория не могла объяснить и описать тепловое излучение во всем диапазоне частот электромагнитных волн теплового диапазона. А то, что тепловое излучение, и в частности свет-теплоэнергия является электромагнитными волнами, стало научным фактом. На основе квантовых представлений А. Эйнштейн разработал теорию фотоэффекта поставив науку перед фактом: свет обладает и волновыми и корпускулярными свойствами, он излучается, распространяется и поглощается квантами (порциями). В атоме электроны могут двигаться только по определенным, так называемым разрешенным, или стационарным, круговым орбитам, на которых они, несмотря на наличие у них ускорения, не излучают электромагнитных волн (поэтому эти орбиты названы стационарными). Электрон на каждой стационарной орбите обладает определенной энергией. Атом излучает или поглощает квант электромагнитной теплоэнергетики при переходе электрона с одной стационарной орбиты на другую. Ядра всех атомов можно разделить на два больших класса: стабильные и радиоактивные. Последние самопроизвольно распадаются, превращаясь в ядра других элементов. Ядерные преобразования могут происходить и со стабильными ядрами при их взаимодействии друг с другом и

с различными микрочастицами. Уравнением движения микрочастицы в различных силовых полях является волновое уравнение Шредингера. В этой работе рассматривается гладкость решений нелинейного уравнения

$$Lu = -\triangle(u) + q(x,u)u = f(x) \in L_2(R^m) \tag{1}$$

Для нелинейного уравнения (1) найдены достаточные условия, обеспечивающие наличие оценки коэрцитивности в случае $m = 3$.

Теорема 1. Пусть выполнены следующие условия: а) $q(x,y) \geq \delta > 0$; б) $q(x,y)$ – непрерывная функция по совокупности переменных в R^2 и

$$\sup \mid x - y \mid \leq 1 \sup \mid C_1 - C_2 leq A \mid C_1 \leq A \frac{(q(x,C_1)}{q(y,C_2)} < \infty$$

где A – любая конечная величина. Тогда для любой правой части $f \in L_2(R^3)$ существует решение $u(x)$ уравнения (1) такое, что $\triangle u \in L_2(R^3)$;

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Численное моделирование процесса очистки промышленных стоков в отработанных горных выработках

Серьезной угрозой для экологической безопасности гидросферы Кузбасса становятся промышленные стоки углеперерабатывающих предприятий. Для их ликвидации в регионе наряду с другими используется способ очистки с помощью отработанных горных выработок затопленных угольных шахт. Предполагается, что будет происходить естественная очистка сточных вод за счет отстаивания и разбавления фильтрующимися в выработанное пространство грунтовыми водами. Данная технология подразумевает не только очистку, но и складирование осажденных илов в выработанном пространстве. В настоящее время этот способ реализуется для очистки шламовых стоков углеобогатительной фабрики «Комсомолец» в отработанных выработках ш. «Кольчугинской».

При всей идейной простоте и низкой стоимости применения такого подхода остается актуальной и важной проблема исследования и прогнозирования возможного развития процессов очистки. Так наибольшую опасность представляет вероятность «залпового выброса» накопленных примесей, при котором может происходить кратковременнное, но интенсивное увеличение концентрации и объема примесей в откачиваемой жидкости. Причинами этого являния может стать изменение топологии выработки из-за слеживание осадка, резкое увеличение объема поступающих грунтовых вод и другие факторы. Т.к. обводненная выработка представляет собой «черный ящик», математическое моделирование и численные эксперименты становятся удобным инструментов для решения задачи прогнозирования.

В данной работе приводится математическая модель течения и распространения взвешенных оседающих примесей в области, моделирующей отработанную горную выработку на основании нестационарной системы уравнений Навье-Стокса и уравнения переноса примеси; моделирется процесс изменения области решения из-за слеживания осадка; приводится анализ влияния характеристик течения (изменение объема фильтрующихся грунтовых вод, вязкость жидкости) и грануляционного состава поступающей примеси (крупность частиц, скорость их осаждения и интенсивность размытия и слеживания и др.) на вероятность «залпового выброса».

Работа выполнена в рамках Государственного задания 2014/64.

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Численное моделирование отвода диффузионного слоя в процессе концентрирования молока

В современной пищевой промышленности особое место занимает задача наиболее полного использования пищевого сырья. В решении этой проблемы важная роль отводится разделению компонентов пищевого сырья для последующего синтеза на их основе разнообразных пищевых продуктов. В частности данная задача актуальна в молочном производстве. Существует достаточно большое количество методов разделения, очистки и концентрирования жидких сред. При этом особого внимания заслуживают мембранные технологии, которые обладают рядом преимуществ по сравнению с традиционными методами разделения. На выходе результат работы таких устройств выглядит как двухслойная жидкость с различными плотностями: «гель», «раствор». Завершающей стадией процесса изменения концентрации является отделение

«геля» от «раствора», для этого используется устройство для отвода диффузионного слоя [1]. Перспективными являются устройства, в которых производится отвод диффузионного пограничного слоя находящегося на мембране, в частности, предложенное авторами [1]. Это обусловлено тем, что его концентрация имеет большую величину, чем основная часть потока. Отвод и использование его позволят интенсифицировать процесс разделения.

Для увеличения эффективности работы устройства было предложено смоделировать процесс разделения жидкости и изучить влияние различных параметров на качество получаемого продукта и работы устройства в целом. Принимается, что область является осесимметричной, плотность и вязкость изменяются с течением времени.В данном докладе предлагается математическая модель описывающая движение вязкой несжимаемой жидкости с переменной вязкостью и плотностью. Учитывая особенности моделируемой области, модель была выписана в цилиндрической системе координат. В задаче протекания для системы уравнений Навье-Стокса, записана постановка заключающаяся в задании на участках втекания-вытекания давления, а не скоростей. Такая постановка обусловлена тем, что при работе устройства имеется возможность задавать давление на участках входа и выхода жидкости из устройства. Предполагается, что разработанная математическая модель позволит изучить свойства течения при различных параметрах, таких как давление на границах входа и выхода жидкости, концентрация, размеры штока, количество и диаметр отводных отверстий.

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О применимости корреляционного анализа для случайных сигналов с нелинейной регрессией

1. Постановка задачи

Как правило корреляционно–спектральный анализ случайных сигналов, т.е. сигналов модельно математически описываемых случайными процессами (СП), проводят, не задумываясь о виде их функции регрессии (ФР). Однако хорошо известно, что корреляционный анализ случайных величин X и Y информативен, строго говоря, лишь тогда и только тогда, когда эти величины

X и Y линейно статистически связаны. Если эта связь нелинейная, то значению коэффициентов корреляции (КК) R_{XY} (КК случайных величин X, Y и следовательно нормированных корреляционных функций (НКФ) $\rho_{XX}(t_1, t_2)$ и $\rho_{XY}(t_1, t_2)$ случайных процессов $X(t)$, $Y(t)$ можно лишь приближенно судить о степени связи X и Y либо $X(t_1)$, $Y(t_2)$ В связи с изложенным, в докладе рассматриваются особенности функций авторегрессии СП $X(t)$ по сравнению с ФР случайных величин X, Y и степень репрезентативности КФ для характеристики связи отсчетов стационарных СП с нелинейной регрессией.

2. Особенности функций регрессии СП

Для упрощения далее будем рассматривать только стационарные на уровне всех рассматриваемых характеристик СП $X(t)$, $Y(t)$ и только детерминированные безынерционные (числовые) преобразования $f(\cdot)$, $g(\cdot)$, $\phi(\cdot)$. Приводятся известные и вновь выявленные свойства и особенности авто-(собственных) и взаимных функций регрессии СП. Это свойства "пропорциональности корреляции "вырожденности при отсутствии сдвига ("сводимости к точке"и "сводимость к значению преобразующей функции").

3. Влияние нелинейности ФР и нелинейных преобразований процесса на значения КФ

В начале на примере СП с двухмерными S_L- и S_U- распределениям Джонсона исследуется влияние авто и взаимных функции регрессии на значения авто- и взаимных КФ. Затем на примере нескольких нелинейных преобразований СП ($Y(t) = X^3(t)$, $Y(t) = X^2(t)$, $Y(t) = F_X[X(t)]$, где $F_X(\cdot)$ - функция распределения $X(t)$, и др.) исследуется влияние видов преобразования и распределения $X(t)$ и их параметров на изменения КФ.

4. Статистическая интерпретация результатов

Дается статистическая интерпретация результатов замены функции регрессии среднеквадратичной прямой регрессии и скедастической функцией - их "среднеквадратическими аналогами"и поясняются к чему это приводит при традиционном корреляционно-спектральном анализе процессов с нелинейной регрессией.

5. Место и роль разведочного анализа при обработке СП с учетом ФР

Рассматривается перечень задач разведочного анализа данных, необходимость и пригодность его при обработке случайных сигналов, временных рядов, имеющих нелинейные регрессии.

6. Заключение

В заключение приводятся выводы по полученным результатам и приводятся первоочередные задачи по продолжению исследований в данной области, а также их обобщение на спектральный анализ сигналов.

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Построение операторов индикатора неоднородности тензорных полей на основе их известных лучевых преобразований

Условие гладкости является основным для получения многих результатов математического анализа, дифференциальных и интегральных уравнений, и многих других. Однако, существуют важные естественно-научные и технические области, в которых объекты математически описываются величинами, терпящими разрыв. Такие объекты возникают и в томографии.

Известный алгоритм визуализации множества разрывов функции был предложен в [1]. Основная идея алгоритма состоит в предварительном двойном дифференцировании по переменной s ($|s|$ — расстояние от прямой, по которой производится интегрирование, до начала координат) преобразования Радона, с последующим применением оператора обратной проекции. Применение такой последовательности действий (оператора Вайнберга) не дает искомую функцию, но позволяет визуально выделить множество точек разрыва исходной функции. В дальнейшем был предложен иной подход [2] к решению задачи восстановления разрывов. Применяя к лучевому преобразованию оператор обратной проекции, получаем сингулярный интеграл (с искомой разрывной функцией в подынтегральном выражении) со слабой особенностью. Дифференцирование по пространственным переменным приводит тогда к логарифмическому возрастанию при стремлении точки к линии разрыва.

Следуя логике развития постановок "классической задачи восстановления разрывов", предлагается ее обобщение как в постановочной части, так и в части методов решения. Во-первых, ставятся задачи по определению множества точек разрыва не только скалярных полей, но и тензорных полей малого ранга. Во-вторых, предлагается определять не только разрывы полей, но и множества точек разрыва производных. Цель данной работы состоит в построении операторов индикатора неоднородности, позволяющих, исходя из лучевых преобразований тензорных полей, выделять множество точек сингулярного носителя этих полей. Для решения поставленной задачи используются дифференциальные операторы тензорного анализа, интегральные операторы углового момента и обратной проекции.

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О разрешимости особого интегрального уравнения Вольтерра второго рода со спектральным параметром

Мы рассматриваем вопросы разрешимости особого интегрального уравнения вида

$$\varphi(t)-\lambda\int\limits_0^t K(t,\tau)\varphi(\tau)\,d\tau=f(t),\quad t>0,\quad \lambda\in\mathbb{C}, \tag{1}$$

где

$$K(t,\tau)=\frac{1}{2a\sqrt{\pi}}\left\{\frac{t+\tau}{(t-\tau)^{3/2}}\exp\left(-\frac{(t+\tau)^2}{4a^2(t-\tau)}\right)+\frac{1}{(t-\tau)^{1/2}}\exp\left(-\frac{t-\tau}{4a^2}\right)\right\},$$

которое возникает при решению краевых задач для уравнения теплопроводности в областях, вырождающихся в точку в начальный момент времени.

Теорема (основной результат) [1]. *Неоднородное интегральное уравнение (1) разрешимо в классе функций, удовлетворяющих условию* $\sqrt{t}\cdot\varphi(t)\in L_\infty(0,\infty)$, *для каждой правой части* $\sqrt{t}\cdot f(t)\in L_\infty(0;\infty)$ *и для каждого* $|\lambda|>1$. *Соответствующее однородное уравнение имеет* (N_1+N_2+1)*-собственных функций*

$$\varphi_k(t)=\frac{1}{\sqrt{t}}\exp\left(\frac{p_k}{t}-\frac{t}{4a^2}\right)+$$

$$+\frac{\lambda\sqrt{\pi}}{2a}\exp\left(\frac{\lambda^2-1}{4a^2}t-\frac{\lambda\sqrt{-p_k}}{a}\right)\cdot\operatorname{erfc}\left(\frac{2a\sqrt{-p_k}-\lambda t}{2a\sqrt{t}}\right),\ -N_1\le k\le N_2,$$

и общее решение неоднородного интегрального уравнения (1) имеет вид

$$\varphi(t)=F(t)+\frac{\lambda^2}{4a^2}\int\limits_0^t\exp\left(\frac{\lambda^2(t-\tau)}{4a^2}\right)F(t)\,d\tau+\sum_{k=-N_1}^{N_2}C_k\varphi_k(t),\ C_k-const,$$

где

$$N_1=\left[(2\pi)^{-1}(\ln|\lambda|+\arg\lambda)\right],\quad N_2=\left[(2\pi)^{-1}(\ln|\lambda|-\arg\lambda)\right],$$

и функции $F(t)$ определяется через заданную функцию $f(t)$ и резольвенту

$$r(t,\tau)=\frac{t}{a\sqrt{\pi}(t-\tau)^{3/2}}\sum_{n=1}^{\infty}\frac{n}{\lambda^n}\exp\left\{-n^2\frac{t\tau}{a^2(t-\tau)}\right\}.$$

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Применение компьютерной алгебры в качественном исследовании ньютоновой проблемы многих тел

Известно, что гамильтоновы дифференциальные уравнения космической динамики при определенных условиях, наложенных на геометрические и динамические параметры модели, допускают точные гомографические решения в смысле Винтнера [1-3]. Геометрически такие решения представляют собой правильные многоугольники (или их определенную комбинацию) с гравитирующими массами в вершинах. Также известно [3], что всякое такое решение ньютоновой проблемы n тел порождает новую динамическую модель - ограниченную проблему (n+1)-тел, состоящую в исследовании всевозможных движений бесконечно малой массы в поле притяжения n гравитирующих масс. Качественные исследования ограниченной ньютоновой проблемы $(n+1)$ тел сводятся, прежде всего, к нахождению ее стационарных решений дифференциальных уравнений и проверке их на устойчивость в первом приближении и в смысле КАМ-теории

Для решения вышеизложенных задач был разработан алгоритм компьютерного моделирования в системе Mathematica и написан комплекс соответствующих программ [4-5]. Данный алгоритм состоит в следующем.

1. Нахождение новых гомографических решений.
2. Нахождение стационарных решений дифференциальных уравнений ограниченной задачи.
3. Исследование линейной устойчивости стационарных решений.
4. Исследование устойчивости стационарных решений по Ляпунову.
5. Численные исследования положений равновесия.
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Моделирование движения вязкой неоднородной жидкости в крупных кровеносных сосудах

В последнее время интерес к математическому моделированию движения крови в сердечных клапанах человека существенно возрос, в связи с развитием новых методов лечения патологий сердечно сосудистой системы. В данной работе мы предлагаем математическую модель для описания динамики течения крови в крупных кровеносных сосудах и искусственном сердечном клапане, а также численный метод решения данной задачи. Исследование проводится совместно с НИИ КССЗ, в целях улучшения конструкции создаваемых искусственных клапанов.

Рассмотрим нестационарную задачу о течении крови внутри сосуда. Кровь состоит из плазмы и взвешенных в ней форменных элементов. Стенки сосуда являются гибкими и изменяют свою форму под воздействием течения крови. Будем моделировать кровь как вязкую несжимаемую двухкомпонентную жидкость, а стенки сосуда – как непроницаемую поверхность, обладающую заданной жесткостью. Задача о течении крови описывается нестационарной системой дифференциальных уравнений Навье-Стокса [1] с переменными вязкостью и плотностью. Т.к. физически кровь является неоднородной, то концентрацию примеси будем описывать уравнением конвекции [1]. Для моделирования динамики гибких стенок сосуда и створок искусственного сердечного клапана определяются силы, возвращающие их в равновесное положение [2].

Для решения полученной задачи воспользуемся методом погруженной границы [2]. Влияние стенок сосуда и клапанов на течение будем учитывать с помощью добавления массовых сил в уравнение движения жидкости [2]. Т.о. алгоритм решения будет следующим - на прямоугольной сетке с помощью схем расщепления по физическим факторам вычисляется значение скорости жидкости; затем определяем концентрацию примеси в области решения и пересчитываем значение плотности и вязкости. Далее вводим новую лагранжевую сетку, на которой определяем деформацию сосуда или створок клапана

под воздействием движения жидкости, и вычисляем значение сил, противодействующих деформации. После этого находим новое распределение массовых сил в уравнении движения жидкости.

Полученная модель и численный метод решения были применены для задач развития аневризмы сосуда и течения крови в аортальном клапане. В рамках первой задачи были проведены расчеты, демонстрирующие возможность возникновения устойчивой аневризмы, а также ее влияние на распространение примеси. Для второй задачи получены результаты движения клапанов при различных перепадах давления.

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О влиянии состава защитных газов на поведение электрической дуги и сварочной ванны

Данная статья представляет собой численное исследование магнитогидродинамических процессов в электрической дуге и сварочной ванне при различном составе защитных газов, влияние состава защитной атмосферы на проплавление и формирование сварного шва. На современном этапе повышение эффективности сварки добиваются применением многокомпонентных газовых смесей на основе аргона. Также изучение влияния газовых свойств является актуальным вопросом для защиты катода от воздействия атмосферного воздуха. Дуги различных защитных газах ведут себя очень по-разному из-за существенных различий в теплофизических свойствах, в том числе потенциала ионизации при высоких температурах при одних и тех же мощностях сварки. Рассчитаны коэффициенты переноса для сухого атмосферного воздуха с различными процентными содержаниями кислорода, азота, углекислого газа, паров воды, аргона при высоких температурах. С полученными коэффициентами переноса рассчитана система МГД уравнений в переменных "вихрь-функция тока". Проведен численный анализ результатов.

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Численный анализ гидродинамических процессов сварочной ванны при электродуговой сварке

В данной работе проведен сравнительный анализ математических моделей сварочных ванн, представленных в работах [1-3] и модели работы [4-5], поставлены граничные условия на поверхности сварочной ванны в приближении свободной поверхности ванны и в условиях взаимодействия с потоками электрической дуги, приведены результаты численных расчетов для обоих случаев. Для сварочной ванны выдвинуты следующие допущения: процесс сварки ограничивается стационарной точечной сваркой с неплавящимся электродом в замкнутом объеме, система является осесимметричной; течения ламинарные, поскольку размер ванны относительно мал; в предположении жесткой поверхности анода. Другими словами, деформация поверхности сварочной ванны не влияет на расчетные явления переноса. Таким образом, сварочную ванну в координатах r - z описывают системой МГД уравнений, подобно электрической дуге. Система решается в переменных "вихрь-функция тока поставлены граничные условия по всей расчетной области. Выполнены численные исследования характеристик электрической дуги и сварочной ванны, исследовано влияние граничных условий на поверхности ванны для обеих моделей.

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Математическое моделирование переноса нефтяной пленки на поверхности моря

Все более ожесточающиеся требования к охране окружающей среды от загрязнения под воздействием антропогенных факторов значительно повысили интерес к исследованию процессов ликвидации аварийных разливов нефти на водной поверхности. При создании математических моделей описания динамики распространения нефти на поверхности моря необходимо учитывать большое количество физико-химических факторов таких как турбулентность, метеорологические условия, химико биологические расщепление молекул углеводорода в море и т.п.

Наличие на поверхности жидкости пленки абсорбированного ею вещества может существенно изменить гидродинамические свойства свободной поверхности жидкости, дело в том , что при изменении формы поверхности, сопровождающем движение жидкости происходит растяжение или сжатие пленки, то есть изменение поверхностных концентрации абсорбированного вещества. эти изменения приводят к появлению дополнительных сил, которые должны быть учтены в граничных условиях, имеющих место на свободной поверхности жидкости. Уравнения описывающие динамику течения и тепло-массопернос в море взяты в приближении теории мелкой воды, по вертикали было учтено гидростатическое распределения давления [1-2].

Для решения уравнении движения применяеться метод расщепления по физическим параметрам. На первом этапе находяться компоненты скорости методом дробных шагов, а уравнение колебания свободной поверхности и уравнение для переноса нефтяного пятна решаються методом матричной прогонки

[3]. Построенная численная реализация математической модели позволяет моделировать процессы диффузии и переноса нефтяной пленки на поверхности моря и применима для решения многих прикладных задач экологии.

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Процесс затвердевания шликера оксида бериллия с учетом фазового перехода

Развитие новых областей науки и направлений техники выдвигает особые требования к уровню свойств и качеству керамических изделий, все в большей степени становятся востребованными изделия сложной конфигурации из высокотеплопроводных, бескислородных, сверхпроводящих и др. неметаллических материалов. Технология горячего литья под давлением [1, 2] остается основной при получении длинномерных, многоканальных, сложно фасонных и т.п. керамических изделий из непластичных порошков. Особую сложность представляет получение методом горячего литья керамических изделий из дисперсных материалов с аномальными физическими свойствами, таких как оксид бериллия. Трудности получения качественных изделий в данном случае вызваны в первую очередь теплофизическими свойствами оксида бериллия, в частности, его уникальной теплопроводностью [2].

В данной работе приводятся результаты сравнения расчетных данных процесса формования шликера оксида бериллия в формообразующей полости с экспериментом.

По опытным данным затвердевания шликера происходит в интервале температур от 54 до 40 °C. Это связано с тем, что связка в шликере находится в аморфном состоянии и в зоне затвердевания переходит из аморфного жидкого состояния в аморфное твердопластичное [1, 2].

Математическая модель включает уравнения законов сохранения массы, импульса и энергии неньютоновской жидкости с реологической моделью

Шведова-Бингама. Скрытая теплота фазового перехода была учтена методом кажущейся теплоемкости [3]. Реологические и теплофизические свойства шликера были найдены на основе опытных данных, и выражают зависимости от температуры. Коэффициенты теплообмена и теплопередачи на стенках полости были определены путем сравнения экспериментов и расчетов. В расчетах получены поля температуры шликерной массы в жидком (вязкопластическом) и твердопластическом состояниях, найдены изотермы верхней и нижней границ положения зоны затвердевания.

Экспериментальные и расчетные данные показывают возможность управления процессом затвердевания термопластичного шликера оксида бериллия путем подбора расхода и температуры горячей и холодной воды.

Результаты расчетов находятся в согласии с данными экспериментов, и показывают физическую обоснованность предложенной математической модели процесса затвердевания термопластичного шликера оксида бериллия.

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Численное моделирование размыва грунта у основания платформ гравитационного типа

В настоящее время происходит активное использование прибрежной мелководной части морей в процессе добычи нефти и газа, для чего используются платформы гравитационного типа. При эксплуатации платформ такого типа одной из основных задач является обеспечение устойчивости, потеря которой может происходить из-за размыва грунта у основания под действием придонного течения. Размеры морских платформ (например, «Приразломная» – квадрат со стороной 120 м.) не позволяют проводить натурные эксперименты. Проведение лабораторных экспериментов в некотором масштабе позволяет изучить процесс размыва, однако масштабирование может привносить погрешности: например, затруднено существенное уменьшение частиц грунта, необходимо согласование чисел Фруда и Рейнольдса и т.д. Численное моделирование позволяет учесть все параметры и провести полноразмерный

эксперимент или выбрать произвольный масштаб. В работе представлены результаты численного исследования по изучению влияния течения на размыв грунта у основания модели морской платформы «Приразломная».

Численная модель основана на решении на каждом шаге по времени трехмерной нестационарной системы уравнений Навье-Стокса для определения характеристик течения и последующем вычислении транспорта частиц грунта.

В работе рассматривались течения, вызванные заданным перепадом давления: на участках втекания и вытекания границы фиксируется функция давления, а также условия на касательную составляющую вектора скорости ([1]), на твердых стенках ставятся условия прилипания, условия для давления на твердых стенках отсутствуют. Численное интегрирование системы по времени было выполнено методом расщепления по физическим факторам ([2]). На основе вычисленного поля скоростей определяется перемещение частиц грунта на основе модели, приведенной в [3]. На каждом слое сначала вычисляются сдвиговые напряжения на дне, затем производится расчет движения частиц на поверхности дна и решается уравнение баланса масс. После определения новых значений функции высоты дна выполнялась программная перестройка области решения.

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Исследование фильтрованной функции плотности для моделирования крупных вихрей реагирующих турбулентных течений

Одним из сложных вопросов в области энергетической и экологической исследований связано с точностью прогнозирования турбулентных реагирующих течений. Оптимальным средством захвата подробную, нестационарную физику таких потоков, как уже показала практика, является моделирование крупных вихрей (LES) [1]. Задачей в моделировании крупных вихрей является точное и последовательное моделирование величин подсеточной функции [2]. Методология, фильтрованная функция плотности (FDF), включая ее серию осредненной по плотности, фильтрованная функция массовой плотности, оказалось особенно эффективной для достижения этих целей [3]. Фильтрованная

функция плотности, по существу, является функцией плотности вероятности величин подсеточной функции. Поэтому фильтрованная функция плотности обеспечивает всю статистическую информацию касающуюся этих величин.

Построен численный метод решения FDF для LES трехмерного, развивающегося по времени слоя смешивания. Общая производительность модели оценивается путем сравнения с данными прямого численного моделирования (DNS).

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Характеристики переноса нейтронов в реакторе ИГР

ИГР - импульсный исследовательский ядерный реактор теплоемкостного типа на тепловых нейтронах с гомогенной уран-графитовой активной зоной. Он принадлежит Национальному ядерному центру Республики Казахстан и эксплуатируется с 1961 года [1].

Основными режимами работы реактора являются нерегулируемый режим самогасящейся нейтронной вспышки и регулируемый режим. В ходе работы реактора активная зона неравномерно разогревается до температуры отдельных элементов кладки до 1900 K, что вместе с движением регулирующих стержней (ввод положительной реактивности до 28 беты) приводит к значительным изменениям во времени нейтронного поля, как по форме, так и по спектру [2].

Для корректного управления работой реактора, задания условий испытания различных изделий в каналах реактора, необходимо знать заранее взаимосвязь между движением органов управления и характеристиками отдельных элементов реактора. Такая задача решается в рамках понятия «пространственная кинетика» реактора. Разрабатывается программа расчета пространственной кинетики реактора в виде сеточной структуры, в ячейках которой происходят реакции рассеяния, поглощения нейтронов и эмиссии нейтронов

при делении, а также воспроизводится процесс обмена нейтронами между соседними ячейками. Для работы программы необходимы данные о переносе нейтронов между ячейками и скорости нейтронных реакций.

Возможным способом получения этих данных является компьютерное моделирование реактора с помощью программы MCNP, для расчета ядерных реакторов методом Монте-Карло. Такой подход при моделировании позволяет рассчитать необходимые параметры переноса нейтронов между ячейками и взаимодействия нейтронов с веществом находящимся в каждой конкретной ячейке. Результаты расчета параметров реактора ИГР с помощью созданной модели формируются в базу данных и будут использованы при разработке программ испытаний различных изделий.

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Задача продолжения электромагнитных полей с части границы

Во многих обратных задачах искомые неоднородности расположены на некоторой глубине под слоем среды. Одной из главных помех при локализации подземных объектов является верхняя часть грунта, лежащая над искомыми объектами. Проходя через эту область, электромагнитные волны, отраженные от различных объектов, могут усиливаться или, наоборот, взаимно уменьшаться. В этом случае важным инструментом для практиков являются задачи продолжения геофизических полей с земной поверхности в сторону залегания неоднородностей.

Рассмотрим задачу продолжения в области $\Omega = \Delta(L_x) \times (0, L_y)$, где $\Delta(L_x) = \{(x,t) : x \in (0,L_x), t \in (x, 2L_x - x)\}$:

$$u_{tt} + \Big(\frac{\sigma\sqrt{\mu}}{\sqrt{\varepsilon}}\Big)u_t = u_{xx} + u_{yy} \tag{1}$$

$$u_x(0,y,t) = g(y,t), \tag{2}$$

$$u(0,y,t) = f(y,t), \tag{3}$$

$$u(x,0,t) = u(x,L_y,t) = 0. \tag{4}$$

Задачи продолжения электромагнитных полей с части границы относиться к некорректным задачам. Задача продолжения сведена к эквивалентной обратной задаче по отношению к некоторой прямой корректной задаче. Численные расчеты проведены для трех различных сред: с одной неоднородностью, с двумя неоднородностями и тремя неоднородностями, расположенными на глубине 6 м. Результаты расчетов показывают, что продолжение электромагнитного поля на глубину h в сторону залегания неоднородностей позволяет точнее установить их количество и местоположение. Более того, полученные данные совпадают с реальными данными георадара Лоза-В.

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К определению минимально возможного расстояния между тремя вращающимися ветротурбинами карусельного типа

В связи с ухудшением экологической обстановки на планете Земля и уменьшением сырьевых запасов для традиционных источников энергии в последние десятилетия становится актуальным создание нетрадиционных, экологически чистых и возобновляемых источников энергии. Ветер - экологически чистый источник энергии. Во всех экономически развитых странах мира ветер, как источник энергии, начинает играть заметную роль в энергетическом балансе. Непрерывно расширяется производство и проектирование эффективных ветроустановок. Территория Республики Казахстан имеет огромный ветроэнергетический потенциал, что, естественно, предполагает большое будущее для применения ветроэнергетических аппаратов в нашей стране.

В дочернем государственном предприятии "Научно-исследовательский институт математики и механики" Казахского национального университета

им.аль-Фараби разрабатывается конструкция оригинальной компактной многоэтажной ветроэлектростанции [1]. При ее проектировании для выполнения условия компактности встает задача определения минимально возможного расстояния между тремя вращающимися ветротурбинами карусельного типа. Критерием минимально возможного расстояния является появление ламинарного течения воздушного потока между вращающимися ветротурбинами карусельного типа.

В первом приближении предлагается решение стационарной плоской задачи обтекания трех вращающихся цилиндров маловязким газом.

Записываются дифференциальные уравнения стационарного движения маловязкого газа с соответствующими граничными условиями. Вводится малый параметр по вязкости газа. Эта стационарная система уравнений движения переписывается к виду, удобному для ее численного решения. Затем эти уравнения заменяются разностными. Полученные итерационные (рекуррентные) формулы позволяют производить вычисления устойчиво. Определение возникновения ламинарного течения воздушного потока между вращающимися ветротурбинами карусельного типа производится с помощью введения функционала согласно известному приему "регуляризаций по Тихонову".

Данный подход является предтечей для решения уже нестационарной задачи обтекания трех и более карусельных ветротурбин с учетом влияния на образования вихрей вокруг разного вида лопастей ветротурбин карусельного типа.

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Критерий управляемости нелинейных динамических систем

Рассматривается система управления, описываемая нелинейными обыкновенными дифференциальными уравнениями

$$\dot{x} = f(x, u, t), \tag{1}$$

где $f(x,u,t)$ - n-вектор, элементы которого являются непрерывно-дифференцируемыми функциями по своим аргументам, x - n-мерный вектор состояния системы, u -скалярное управление. На управление даются ограничения

$$u(t) \in U = \{-L \le u(t) \le L, \forall t \in [t_0, t_1]\} \tag{2}$$

Исследуется задача существования ли управления, удовлетворяющего ограничению (2) и переводящего систему из начального состояния $x(t_0) = x_0$ в конечное заданное состояние $x(t_1) = x_1$ за фиксированное время $t_1 - t_0$. Перепишем задачу Коши в интегральной рекуррентной форме

$$x_{k+1}(t) = x_0 + \int_{t_0}^{t} f(x_k(\tau), u(\tau), \tau) d\tau. \tag{3}$$

В силу свойств наложенных на правую часть уравнения (1) и ограничений на функцию $u(t)$ в работе [1] доказано, что метод последовательных приближений (3) сходится к решению к решению абсолютно и равномерно при любом фиксированном управлении.

Тогда задача управляемости сводится к исследованию следующей задачи: существует ли хотя бы одно управление $u(t) \in U$, при котором решение интегрального уравнения (3) в момент времени t_1 удовлетворяет условию $x(t_1) = x_1$. Для решения поставленной задачи применим результаты интервального анализа. Обозначим через $\overline{f_i} = (f_i, 0)$ - интервал с центром в f_i и радиусом 0, $\overline{\nu} = (0, L)$ - интервал от $-L$ до L. Подставляя в уравнение (3) вместо функции $u(t)$ интервал $\overline{\nu} = (0, L)$ получим интервальное интегральное уравнение $\overline{x}_{k+1}(t) = x_0 + \int_{t_0}^{t} \overline{f}(\overline{x}_k(\tau), \overline{\nu}, \tau) d\tau$.

Теорема. Для того чтобы исследуемая система была управляемой необходимо и достаточно, чтобы заданный вектор x_1 из правой части условия $x(t_1) = x_1$ принадлежал интервальному вектору $\overline{x}_{k+1}(t_1)$.

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Численное моделирование нелинейных колебательных процессов в колоннах при бурении нефтегазовых скважин

Нестационарные колебания геометрически нелинейных распределенных систем являются весьма сложной проблемой механики деформируемого твердого тела и теории колебаний. Изучение проблемы выявило ряд малоизученных

задач, к которым относятся вопросы учета как физически, так и геометрически нелинейных задач, сопровождаемых различными видами осложнений (потери устойчивости колонн, разрывы труб и др.), волновых и колебательных процессов в элементах бурильной динамической системы (БДС). Источниками динамических воздействий на колонну могут быть крутящий момент от двигателя и повторно меняющиеся нагрузки при бурении с долотами режущего типа, осевые растягивающие нагрузки - от буровой установки и сжимающие нагрузки, сопровождаемые вибрациями - при работе долота на забое и т.д. Как поведет себя колонна при той или иной динамической нагрузке во многом зависит от динамических характеристик самой конструкции колонны, ее частот и форм при различных типах собственных колебаний. Известно, что воздействие крутящего момента на поведение колонны определяется возможным изменением характера выхода колонны из состояния статического равновесия. При этом скручиваемая колонна теряет устойчивость не путем статического изгиба, а по типу флаттера, когда подводимая к колонне энергия преобразуется в энергию поперечных колебаний с растущей по времени амплитудой. Теоретически колонна должна рассматриваться как нелинейная механическая система с бесконечным числом степеней свободы. При этом отсутствует аналитический способ исследования динамики работы такой системы, и таким образом, оценки влияния колебаний и вибраций на ее прочность, устойчивость при бурении.

В работе проведен анализ поведения системы геометрически нелинейных труб бурильных колон при динамических воздействиях, предложена численная реализация метода конечных элементов для решения соответствующих краевых задач. Принимая трубы колонны в виде балок, составлено выражение для энергии при изгибе и сжатии с учетом геометрической нелинейности деформирования. Формы балки в поперечном направлении представлены через полиномы Эрмита кубической степени. Для прогибов и углов поворотов узлов получена система нелинейных дифференциальных уравнений второго порядка по времени. Расчетным путем установлено, что при геометрической нелинейности деформирования колонны одной и той же системе нагрузки может соответствовать несколько различных деформированных состояний, одно из которых является устойчивым, а другие - неустойчивыми. Нелинейность трубы колонны может существенно изменить характер колебательных процессов в поперечном направлении движения штанги. Как показывают расчеты, происходит нарушение симметрии в прогибах штанги, что означает возможность появления потери устойчивости. Она может произойти при резких торможениях, реализуемых при высоких значениях параметра нелинейности. При этом вероятность перехода в состояние неустойчивости в начальные моменты времени снижается.

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Моделирование влияния рельефных границ при решений прямой задачи электроразведки постоянным током

В данном исследовании рассматривается численное решение прямой задачи электроразведки постоянным током для слоистой модели среды со сложными рельефными контактными границами и рельефной дневной поверхностью. В качестве математической модели для описания электромагнитных процессов в среде используются уравнения Максвелла. Решение строится на основе метода интегральных уравнений. Идея метода заключается в представлении электрического поля, как суммы первичного поля (создается питающими электродами) и поля вторичных зарядов (возникают при протекании электрического тока в местах нарушения однородности среды и на поверхности среды). Контактные границы и неоднородности геоэлектрического разреза выступают как вторичные возбудители электрического поля. Задача расчета полей сводится к системе интегральных уравнений на плотности вторичных источников, индуцируемых на поверхностях контакта проводящих сред и на рельефной поверхности среды. Математическое описание этого явления приводит к системе уравнений Фредгольма II рода с полярным ядром.

Разработан численный метод и компьютерная программа решения прямой задачи электроразведки постоянным током с учетом рельефа дневной поверхности. Метод основан на построении адаптированной сетки и итерационного алгоритма. Полученные результаты позволяют оценить влияние рельефа на измерения и будут способствовать повышению качества работ и развитию компьютерных технологий, применяемых в геофизике.

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Моделирование потоков ионов методом частиц

Работа посвящена моделированию потоков заряженных частиц в электростатическом поле в процессе электролитического рафинирования между поверхностью катода и анода. Большое значение такие исследования имеют для повышения эффективности металлургических процессов в частности, электролитического рафинирования меди и других металлов. Кроме того, моделирование электростатических полей между поверхностями электродов, помогает исследовать природу взаимодействия катода с анодом.

В современном математическом моделировании распространены алгоритмы, известные под общим названием "методы частиц"[1]. Характерной особенностью этих методов является специальный способ дискретизации, при котором вводится множество дискретных объектов - модельных частиц, рассматриваемых как некоторая сетка подвижных узлов. В данной работе предлагается смешанный метод частиц, адаптированный к моделированию миграционной диффузии потока ионов в процессе электролитического рафинирования. На эйлеровом этапе моделируются потенциалы электростатического поля, с помощью уравнений Максвелла. На лагранжевом этапе строятся законы движения и траектории ионов в виде квадратичных сплайнов.

Ионы меди являются заряженными частицами одного и того же типа и имеют одинаковую массу. Для таких частиц масса не учитывается, и берется равной единице для всех частиц. В электролизной ванне электроды расположены параллельно друг другу. Заряд на электродах предполагается распределенным равномерно с одинаковой плотностью. Начальные координаты заряженной частицы моделируются методом Монте-Карло как случайные величины подчинённые равномерному закону распределения.

Далее моделируются законы движения частиц в виде квадратичных сплайнов. Процесс продолжается до тех пор, пока частица не достигнет границы области моделирования. Когда частица достигает нижней горизонтальной границы области, моделируется ее столкновение с дном емкости. Если в какой-то момент времени координаты двух различных частиц совпадают, то моделируется столкновение частиц. В случае совпадения координат частицы с координатами точки на катоде происходит осаждение.

Потенциалы электродов моделируются в плоскости, перпендикулярной поверхности электродов. Для расчета потенциала используется пятиточечная разностная схема для уравнения Лапласа.

Предлагаемый метод применен для моделирования потоков ионов металла и кислотного остатка в лабораторной установке электролитического рафинирования меди, проведены численные эксперименты по компьютерному моделированию.

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Моделирование распределения ресурсов в трехсекторной математической модели кластера

Проблема формирования кластеров для инновационного развития и повышения конкурентоспособности экономических систем является актуальной задачей для развития компаний и применения новых форм управления [1].

Постановка задачи. Рассмотрим управляемую нелинейную систему, которая описывается следующими уравнениями:

$$\frac{dk_i}{dt} = -\lambda_i k_i + \frac{s_i}{\theta_i} x_1, \lambda_i > 0, k_i(0) = k_i^n, i = 0, 1, 2; \tag{1}$$

$$\theta_0 + \theta_1 + \theta_2 = 1, s_0 + s_1 + s_2 = 1, \theta_i \geq 0, s_i \geq 0; \tag{2}$$

$$(1 - \beta_0)x_0 = \beta_1 x_1 + \beta_2 x_2, x_i = \theta_i A_i k_i^{\alpha_i}, A_i > 0, 0 < \alpha_i < 1, \beta_i > 0, \tag{3}$$

где x_i, k_i– производительность труда и фондовооруженность в расчете на одного занятого в i - м секторе; s_i и θ_i– управляющие параметры.

Вводя обозначения $y_{i+1} = k_i, \theta_0 = u_2(1-\theta_1), \theta_2 = (1-u_2)(1-\theta_1), s_0 = u_3(1-s_1), s_1 = u_1, s_2 = (1-u_3)(1-s_1), \theta_1 = [(\beta_0+\beta_2)u_2 - \beta_2)]/[\beta_1 + (\beta_0+\beta_2)u_2 - \beta_2]$ систему (1)-(3) можно привести к следующему виду:

$$\frac{dy}{dt} = Ay + Bu + f(y, u), y(0) = y_0, 0 \leq u \leq 1, \tag{4}$$

где $x(t)$ – вектор состояния, $u(t)$ – вектор управления.

Ставится задача. Найти управляющие параметры u переводящие систему (4) из начального положения y_0 в стационарное положение y^c за фиксированное время T и доставляющие минимальное значение функционалу

(5)

$$J(y,u) = \frac{1}{2}\int_0^T [(y-y^c)^* Q(y-y^c) + (u-u^c)^* R(u-u^c)]dt + \frac{1}{2}(y(T)-y^c)^* F(y(T)-y^c).$$

Для решения задачи оптимального управления (4)-(5) использован метод, основанный на применении множителей Лагранжа специального вида [2].

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Модель гидравлического разрыва пласта на основе механики и фильтрации в гетерогенной средах

Предложена новая математическая модель гидравлического разрыва, основанная на понятии гетерогенной, трещиновато-пористой среды, примером которой служит растрескавшаяся часть пласта, примыкающая к скважине. При этом используются предположения, применяемые в теории упругого режима фильтрации. Закачка флюида в пласт сопровождается увеличением пористости породы под воздействием объемных напряжений в скелете. Если эти напряжения достигают некоторых критических значений, скелет пласта подвергается упруго-пластическому разрушению с образованием трещин, раскрытие которых на порядки больше среднего радиуса пор. Образуемая трещиновато-пористая среда представима в виде двух вложенных друг друга континуумов, характеризующихся, в частности, своими геометрическими и физическими параметрами, и представляет собой систему трещин и блоков породы. Увеличение объема системы трещин приводит к уменьшению пористости блоков в соответствии с условием совместности деформации поровых объемов. Проницаемость системы трещин значительно выше проницаемости образующихся при этом блоков. Модель гидравлического разрыва первоначально однородного пласта при закачке жидкости со значительной репрессией построена на основе уравнений упругого режима фильтрации в гетерогенной пористой среде. Получены формулы, позволяющие определить величину зоны гидравлического разрыва и степень раскрытия трещин. Проведены расчеты и построены графики зависимости глубины зоны растрескивания и раскрытия трещин для различных значений контура питания скважины. На насыпной модели пласта проведены эксперименты по влиянию гидравлического разрыва вблизи скважины на ее расход. Эксперименты показали увеличение на порядок притока флюида к скважине.

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Редукция в исследовании крупномасштабной динамики с учетом эффектов диффузии магнитного поля

Исследуются крупномасштабные нелинейные колебания электропроводной идеальной жидкости переменной глубины с учетом магнитной, архимедовой, кориолисовой сил и эффектов диффузии магнитного поля [1–3]. Соответствующая краевая задача для горизонтальных компонент скорости и магнитного поля, и функции, описывающей нижнюю подвижную поверхность слоя, является нелинейной. Предполагая, что числа Россби, являющиеся мерой отношения локального и адвективного ускорений к ускорению Кориолиса, одного порядка, задача сводится к решению системы трех нелинейных уравнений для гидромагнитного давления и для двух функций, описывающих магнитное поле. Для бесконечно протяженной по горизонтали электропроводной вращающейся жидкости в предположении примерного постоянства наклона поверхности, ограничивающей слой сверху, на расстоянии порядка длины волны получено точное решение системы соответствующих нелинейных уравнений и дисперсионное соотношение. В действительной форме представлены основные характеристики движения. Представленные исследования могут быть использованы в астрофизике и геофизике, в частности, при изучении процессов, происходящих в жидком ядре Земли и недрах звезд. Построенные решения реализуют наиболее простую модель жидкого ядра Земли в виде бесконечного в горизонтальном направлении слоя жидкости с учетом топографии мантии и твердого ядра Земли. Проведенные исследования могут быть также полезны при рассмотрении процесса самовозбуждения магнитогидродинамического динамо в относительно больших массах жидкого металла и технических устройствах, например, в технологических процессах, использующих напорные камеры реактора на быстрых нейтронах, домны, реакторы для производства титана и другие. Особую важность представляет использование сильных магнитных полей в решении проблем термоядерного синтеза и физики плазмы, физики твердого тела и ядерной физики, где сильные поля являются важными, а порой, и единственными инструментами исследований. Магнитные измерения позволяют однозначно диагностировать различные ситуации в работе реактора, в том числе, нарушения в работе насосов.

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Численное моделирование одной системы взаимной реакции-диффузии с двойной нелинейностью

В настоящей работе рассматривается в области $Q = \left\{(t,x) : t > 0,\, x \in R^N\right\}$ следующая система взаимной реакции-диффузии с двойной нелинейностью

$$\frac{\partial u}{\partial t} = div\left(|x|^k u^{m_1-1}|\nabla u|^{p-2}\nabla u\right) + \gamma(t)u^{b_1}v^{q_1},$$
$$\frac{\partial v}{\partial t} = div\left(|x|^k v^{m_2-1}|\nabla v|^{p-2}\nabla v\right) + \gamma(t)v^{b_2}u^{q_2},$$

$$u\,(0,x) = u_0\,(x) \geq 0,$$
$$v\,(0,x) = v_0\,(x) \geq 0, \quad x \in R^N,$$

где $k \in R, \quad m_1, m_2 > 1, \quad p \geq 2 \quad b_1,\ b_2,\ q_1,\ q_2-$ положительные числа, $\nabla(\cdot) = \underset{x}{grad}(\cdot)$, и функции $u_0\,(x) \geq 0, \quad v_0\,(x) \geq 0, \ \ 0 < \gamma(t) \in C(0,+\infty)$.

Система (1) описывает множество физических процессов, таких как процесс реакции-диффузии, теплопроводности, фильтрации жидкости или газа с источником, мощность которого равны соответсвенно $\gamma(t)u^{b_1}v^{q_1}, \quad \gamma(t)v^{b_2}u^{q_2}$. Случаи, когда в системе $k = l, \quad p = 2, \quad m_1 = m_2 = 0$ были рассмотрены в работах [1, 2].

Поскольку эта система в области, где $u = v = 0$ является вырождающейся, то она в области вырождения может не иметь классического решения. Поэтому изучается обобщенное решение системы обладающими свойствами: $0 \leq u, v \in C\,(Q)$ и $|x|^k u^{m_1-1}|\nabla u|^{p-2}\nabla u, \quad |x|^k v^{m_2-1}|\nabla v|^{p-2}\nabla v \in C(Q)$.

В работе с помощью автомодельного и приближенно-автомодельного подхода построен автомодельное решение, получены оценоки решений и свободной границы, выявлены новые нелинейные свойства, обоснована существование различных типов решений, подходящие начальному приближению сохраняющего нелинейные эффекты. На основе качественного исследования задачи разработаны комплекс программ для систем реакции-диффузии с двойной нелинейностью и выполнены численные расчеты и визуализация процесса реакции-диффузии, описывающей системой. Для численного решения задачи были применены метод прогонки, метод переменных направлений в многомерном случае. Результаты вычислительных экспериментов показывают, что

все перечисленные итерационные методы эффективны для решения нелинейных задач и дают нелинейные эффекты, если выбрать в качестве начальной аппроксимации приближенные решения автомодельного уравнения, построенные выше методом нелинейного расщепления и методом стандартных уравнений [1, 2].

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Моделирование нестационарных контактных задач динамики упругих сред

Математическое моделирование процессов распространения и дифракции волн в различных телах и средах относится к актуальным проблемам математической физики. Наиболее изучены процессы распространения гармонических волн и стационарная дифракция волн в средах с каноническими граничными поверхностями. Нестационарные волновые процессы в деформируемых твердых средах гораздо менее изучены. Для решения нестационарных задач в упругих средах широко используются разнообразные численные и численно - аналитические методы: пространственных характеристик, конечных элементов, граничных интегральных уравнений и другие. Разностный метод с применением метода пространственных характеристик ранее был предложен Р.Д.Клифтоном в [1] для исследования плоских динамических задач, а в [2] развит В.В.Рекером для изучения распространения упругих волн в изотропных телах прямоугольной формы. Одним из наиболее удобных в приложениях методов является метод бихарактеристик с использованием идей метода расщепления, развитый Г.Т.Тарабриным [3].

В настоящей работе дана постановка начально-краевой контактной задачи при жестком сцеплении тела и породного массива, приведены определяющие уравнения движения, дан выбор точечной расчетной схемы и шаблона для изотропной полосы, частично помещенной в упругую полуплоскость. Принята явная разностная схема, построенная на основе метода бихарактеристик

с привлечением идеи расщепления по пространственным координатам. Получены разрешающие разностные уравнения для внутренних, граничных, угловых, особых и контактных точек сопряжения полосы и полуплоскости. Решена модельная задача для исследования напряженно - деформированного состояния поверхностных сооружении, обусловленного сбросом тектонических напряжений на глубинных трещинах в земной коре при землетрясениях.

Сброс напряжения на трещине выражается через компоненты объемной силы и определяются сингулярной обобщенной функцией - простым слоем на трещине [4].

Построены дифракционные картины процессов распространения, отражения и преломления сейсмических волн, характеризующие поля скоростей и напряжений в среде и поверхностном включении, осцилограммы скоростей и напряжений на дневной поверхности, и проведено исследование волновых процессов при разном типе сейсмического воздействия, моделирующего процессы образования в земной коре трещин отрыва и сдвига.

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Математическое моделирование нагрева поверхностного слоя катода при электроискровом легировании

Применение метода ЭИЛ, предложенного в 1943 г. учёными Лазаренко Б.Р. и Н.И., позволяет повысить срок службы обрабатываемых поверхностей машин от двух до пяти и более раз. В настоящее время ЭИЛ входит в группу, состоящую из более чем ста методов упрочнения поверхности.

Для оптимизации метода ЭИЛ требуются исследования во многих областях: термодинамике, материаловедении, гидродинамике и других. Для последующего развития ЭИЛ (оптимизации параметров разряда, теплофизических свойств материалов и т.д.) требуются численные расчеты температуры в поверхностном слое.

При ЭИЛ происходит взаимодействие катода (обрабатываемой детали) и анода (легирующего инструмента).

Рассматривается задача нагрева при ЭИЛ прямоугольного катода-параллелепипеда Q_0 с рабочей поверхностью Π_0. Искомой величиной задачи является распределение температуры катода $T(x,t)$. Источниками тепла являются падающий на поверхность тепловой поток $\mathbf{q_0}$ с плотностью $W_0 = \mathbf{nq_0}$, возникший в результате электроискрового разряда, а также жидкий металл, упавший с анода на катод. Разогретый слой отдаёт путём теплопроводности и излучения тепловой поток с плотностью $\alpha U + k\sigma(U + T_{ср})^4 \equiv W(U)$, где $U(x,t)$ - отклонение температуры слоя $T(x,t)$ от температуры окружающей среды $T_{ср}$ в точке x в момент времени t; k - степень черноты; σ - универсальная постоянная Стефана-Больцмана.

Строится нелинейная математическая модель определения температурного поля катода - с помощью нелинейного граничного условия, которое заменяет все уравнения теплового баланса в области Q. Получены результаты численного моделирования процесса остывания слоя, помещенного на границу теплопроводящего полупространства с различными исходными данными. В качестве материала анода рассматривались различные тугоплавкие металлы: титан, вольфрам, тантал. Материалом катода-подложки считалось железо.

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Численное моделирование экспериментального волнопродуктора

В работе представлена численная модель работы опытового волнопродуктора (генератора) одиночных волн. Численное моделирование выполнено на основе использования метода граничных элементов, экспериментальные данные получены в лаборатории морских и гидротехнических сооружений ("23 ГМПИ – филиал ОАО "31 ГПИСС Санкт-Петербург) [1, 2]. Верификация построенной модели волнопродуктора проведена на основе сравнения результатов экспериментального и численного моделирования трансформации одиночных волн на пологом откосе. Сравниваемые характеристики: высоты проходящих волн и давление в местах размещения соответствующих датчиков.

На первом этапе [1] для численного моделирования использовалось задание начальных данных, соответствующих уединенной волне, что приводило к расхождению численных и экспериментальных результатов. Поэтому при численных расчетах возникла необходимость моделирования работы вакуумного волнопродуктора, применяемого для генерации одиночных волн в лабораторных экспериментах. В основе численной модели – эмуляция схемы работы волнопродуктора: набор воды в волнопродуктор путем откачивания воздуха в камере, открытие заслонки для проникновения воздуха в камеру, истечение воды из волнопродуктора в рабочую часть гидролотка под действием силы тяжести с учетом проникновения воздуха в камеру через заслонку. Сравнение полученных численных и экспериментальных результатов моделирования трансформации одиночных волн на пологом откосе показало качественное и количественное совпадение измеряемых характеристик.

Используемый для численного моделирования метод граничных элементов имеет ограничение, связанное с невозможностью проводить исследование после обрушения волны [2], а также не учитывается наличие волногасителя для уменьшения влияния отражающихся волн. В связи с этим разрабатывается методика использования неотражающих граничных условий на удаленной стенке бассейна с целью исключения из процесса моделирования обрушающегося участка волны, а также влияния отражающихся волн.

Полученная численная модель работы волнопродуктора будет использована при исследовании взаимодействия поверхностных волн с береговыми сооружениями бессеточными и условно-бессеточными численными методами, допускающими моделирование сложных процессов, как альтернатива проведения дорогостоящих лабораторных экспериментов.

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Математическая модель двумерного осесимметричного движения газожидкостной смеси в газлифтной скважине

Как известно, газлифтный процесс играет важную роль при добыче нефти после фонтанного процесса. Изучение динамики газа и газожидкостной смеси в газлифтной скважине и проведение численного решения уравнений дает возможность развивать общую постановку задачи в пористой среде (в конце затрубных скважинах). Работы многих зарубежных и отечественных авторов посвящены моделированию процесса добычи нефти газлифтными (вторичными) способами с помощью одномерных моделей. В работах [1, 2, 3] рассматривается одномерная математическая модель работы нефтяных скважин, эксплуатируемых газлифтным способом, по пузырьковой структуре, которая описывается дифференциальными уравнениями в частных производных гиперболического типа. Одномерность рассматриваемых процессов заключается в большей разностью между диаметрами труб и высотой скважины.

В данной работе исследуется двумерная задача о движении газожидкостной смеси в газлифтной скважине с помощью уравнений Навье-Стокса для сжимаемого газа в осесимметричных координатах. Исходя из принципа работы газлифтной скважины, вычислительная область разделена на три подобласти для моделирования движения газа в кольцевом пространстве и движения газожидкостной смеси в пористой среде и в подъемных трубах. Для учета нефтяной фазы, сопротивления среды и вязкости флюидов в каждой из подобластей уравнения модели решаются с различными гидродинамическими параметрами. Разработан эффективный вычислительный алгоритм для численной реализации модели. В качестве исходных данных использована информация по геофизическим характеристикам месторождений Восточно-Казахстанской области. Проверка адекватности модели осуществлялась посредством сравнения результатов гидродинамического моделирования с эмпирическими данными, полученными для конкретной скважины.

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О существовании обобщенного решения модели неоднородной жидкости в магнитном поле

Постановка задачи. Рассмотрим течение вязкой несжимаемой неоднородной жидкости в магнитном поле, движение которой описывается следующей нелинейной системой уравнений [1]:

$$\rho(\upsilon_t + (\upsilon\nabla)\upsilon) - \mu(H\nabla)H = \nu\triangle\upsilon - \nabla(\rho + \mu\frac{|H|^2}{2}) + \rho f, \tag{1}$$

$$\rho_t + (\upsilon\nabla)\rho = 0,\ \ \mathbf{div}\upsilon = 0,\ \ -\mu H_t = \mathbf{rot}E, \tag{2}$$

$$\mathbf{rot}H = \sigma(E + \mu[\upsilon, H]) + j_0,\ \ \mathbf{div}H = 0. \tag{3}$$

Заметим, что из (3) вытекает уравнение

$$-\mu H_t - \frac{1}{\sigma}\mathbf{rotrot}H + \mu\mathbf{rot}[\upsilon, H] + \frac{1}{\sigma}\mathbf{rot}j_0 = 0. \tag{4}$$

В дальнейшем, предположим, что

$$(j_0\tau)|_S = 0. \tag{5}$$

Пусть жидкость находится в ограниченной области $\Omega \in \mathbb{R}^3$ границей S и на границе выполняется условие прилипания

$$(\upsilon)|_S = 0. \tag{6}$$

На границе, являющейся идеальным проводником, должны выполняться:

$$Hn \equiv H_n = 0, \tag{7}$$

$$E\tau = E - nE = 0. \tag{8}$$

Теорема 1. Пусть $f(x,t) \in L_2(0,T;L_{\frac{6}{5}}(\Omega)), j_0(x,t)\int_2(0,T;L_2(\Omega)), \Omega \in \mathbb{R}^3$, $0 \le m \le \rho_0(x) \le M < \infty$, $\|\rho_0(x)\|_{L_\infty(Q_T)} < \infty$, $\upsilon_0(x) \in \dot{j}\Omega$, $H_0(x) \in \dot{H}(\Omega)$, $(j_0\tau)|_S = 0$, $\tau = (\tau_1, \tau_2)_\rho$, $\mathbf{div}j_0' = 0$, τ_1, τ_2 - касательные векторы на

границе. Тогда существует хотя бы одно обобщенное решение задачи (1)-(2), (4)-(8).

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Разработка методов определения и способов расчета действительных значений основных временных параметров линейной трехкамерной фармакокинетики

В литературе приводятся много примеров анализа фармакокинетических данных. Строится модель для конкретного процесса. Приводятся уравнения описывающие соответствующую модель. Пользуются методом наименьших квадратов (МНК) для определения параметров, участвующих в уравнениях модели, но часто плохо или вообще не обращают внимание на оценку статистических значений. Цель этой работы представляет несколько важных статистических аспектов, включенных в описывающих уравнениях и нахождение значений фармакокинетических параметров с соответствующими интервалами доверия. Предлагаются общий принцип и процедура метода, чтобы получать статистические параметры.

Рассматривается двухкамерная модель фармакокинетики с внесосудистым введением. Изменение концентрации ЛС в крови описывается уравнением (1):

$$C(t_i) = A_1 e^{-\alpha t_i} + A_2 e^{-\beta t_i} - (A_1 + A_2) e^{-k_A t_i} \tag{1}$$

Хорошо известно, что наилучшие статистически параметры могут быть определены с помощью МНК. Настоящая работа касается случая распределения лекарства, которые описаны пятью параметрами. Когда экспериментально найденные значения C_i^{exp} описывается уравнением $C(t_i, A_1, A_2, \alpha, \beta, k_A)$, параметры, $A_1^\circ, A_2^\circ, \alpha^\circ, \beta^\circ, k_A^\circ$ должны дать минимальную величину взвешенной суммы квадратов различий между C_i^{exp} и $C(t_i, A_1, A_2, \alpha, \beta, k_A)$,

$$S = \sum_{i=1}^{N} (C_i^{exp} - C(t_i, A_1, A_2, \alpha, \beta, k_A))^2 \cdot \omega_i \to min. \tag{2}$$

В нашем случае $\omega_i = 1$, N - число экспериментальных точек. При $S \to min$ определяются значения $A_1, A_2, \alpha, \beta, k_A$ в уравнении (1).

Когда $A_1^\circ, A_2^\circ, \alpha^\circ, \beta^\circ, k_A^\circ$ - решения обратной задачи (1) для заданных экспериментальных данных C_i^{exp}, тогда $A_1^\circ, A_2^\circ, \alpha^\circ, \beta^\circ, k_A^\circ$ приняты как приближенные величины $A_1, A_2, \alpha, \beta, k_A$ и соответственно, наилучшие параметры можно задавать в следующем виде

$$A_1 = A_1^0 + \Delta A_1, \qquad A_2 = A_2^0 + \Delta A_2, \qquad \alpha = \alpha^0 + \Delta\alpha,$$
$$\beta = \beta^0 + \Delta\beta, \qquad k_A = \Delta k^0 + \Delta k_A$$

где $\Delta A_1, \Delta A_2, \Delta\alpha, \Delta\beta, \Delta k_A$ прирост для параметров $A_1, A_2, \alpha, \beta, k_A$, соответственно.

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Задачи уравнения переноса и ядерно-геофизические технологии

Уравнение переноса применяют для описания физико-кинетических процессов распространения частиц в различных средах; в том числе, в физике реакторов, в астрофизике и атмосферной оптике, в ядерно-геофизических технологиях изучения горных пород и нефте-газоносных пластов, а также при исследовании поверхностей планет. В настоящем докладе рассматриваются обратные задачи уравнения переноса, связанные с ядерно-геофизическими технологиями(ЯГТ). Нельзя не отметить, что последние входят в обязательный комплекс «геофизического исследования скважин», что гамма-гамма метод использовался при восстановлении плотности поверхностного слоя Луны и что численные решения задач об ЯГТ ориентированы на суперкомпьютеры. В докладе, во-первых, даются математические постановки обратных задач, относящихся к нейтрон-нейтронному и гамма-гамма видам каротажа(лога) и к импульсным нейтронным логам; а также - поясняющие моменты. Говоря об обратных, имеется в виду восстановление совокупностей параметров, входящих в коэффициенты уравнения переноса, по данным соответствующих измерений.Во-вторых, будут затронуты основные идеи подхода и и модифицированы некоторые детали методов «последовательные приближения по характерным взаимодействиям», развиваемых автором для этих задач восстановления параметров([1, 2]).

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Комплекс программ NskMCNG для решения задач ядерно-геофизических технологий

В настоящем докладе представлен комплекс программ Nsk MCNG, используемый для моделирования процессов распространения нейтронов и гамма-квантов в горных породах и системах типа «скважина-пласт», а также для моделировани показаний приборов ядерного каротажа. Распространение частиц моделируется в соответствии с уравнением переноса, и используются методы Монте-Карло. В настоящее время существует ряд программных пакетов, позволяющих получать численные решения данных задач. Наиболее популярными среди подобных являются те, которые позволяют получать хорошее соответствие данных численных экспериментов и реальных измерений. Среди таких программ хорошо известны, например, пакеты MCNP и Geant4. Они используют сложные модели взаимодействия частиц с атомами среды, которые представлены объемными библиотеками ядерных констант. Однако их использование приводит как к усложнению кода программ, так и к относительно невысокой скорости вычислений.

Пакет NskMCNG формировался постепенно при рассмотрении различных задач ядерно-геофизических технологий (ЯГТ). В том числе сравнивались как методы и алгоритмы Монте-Карло для прямых задач, так и исследовались методы для обратных [1, 2, 3]. Как правило, эти задачи не требуют высокоточных моделей взаимодействий со средой, но для них важна скорость вычислений. Поэтому при разработке пакета были выбраны наиболее простые модели – аналитические индикатрисы и групповые сечения взаимодействий [4, 5]. Верификация пакета проводилась различными способами, в том числе сравнениями с опубликованными данными, а также с помощью сравнительных расчетов проведенных программой Geant4.

В докладе представлены описание комплекса программ, результаты верификационных вычислений, а также приведены некоторые задачи, которые решались с использованием данного комплекса.

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Численные методы решения уравнений Навье–Стокса

В работе рассматриваются полные возмущенные уравнения Навье–Стокса в трехмерной, $n = 3$, ограниченной области $\Omega \in \mathbb{R}^n$ с границей $\partial\Omega$, для фиксированного $T > 0$ и $Q = \Omega \times (0, T)$, $\partial Q = \partial\Omega \times [0, T]$:

$$\frac{\partial u}{\partial t} - \nu\Delta u - \frac{1}{\varepsilon}\nabla \div u + \sum_{i=1}^{n} u_i \frac{\partial u}{\partial x_i} + \frac{1}{2}\big(\div u\big)u = f, \quad (x,t) \in Q \tag{1}$$

$$u = u_0(x),\ t = 0, \quad u = 0,\ (x,t) \in \partial Q, \tag{2}$$

где $f(x,t)$ и $u_0(x)$ – заданные вектор функции, причем $f(x,t) \in \Omega \times [0,T]$, $u_0(x) \in \Omega$. [1], [2]. Используя обозначения, приведенные в [2], уравнение (1) можно представить в виде:

$$\frac{\partial u}{\partial t} + \sum_{i=1}^{n} L_i(u) - \frac{1}{\varepsilon}\nabla \div u = f, \tag{3}$$

где $L_i(v) = -\nu\dfrac{\partial^2 v}{\partial x_i^2} + u_i\dfrac{\partial v}{\partial x_i} + \dfrac{1}{2}\dfrac{\partial u_i}{\partial x_i}v.$

Рассматриваются три варианта аппроксимации каждого из операторов L_i разностными операторами. Полученные конечноразностные задачи решаются итерационными методами и методами Монте–Карло. [3].

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Применение неконформных конечноэлементных методов для моделирования процессов с фазовыми переходами

Прцессы с фазовыми переходами характерны для ряда прикладных задач - исследования криолитозоны, процесса диссоциации газовых гидратов, горения и т.д. Особенности задач с фазовыми переходами состоят в наличии геометрической и функциональной многомасштабности, т.е. область моделирования - гетерогенная среда с включениями различного масштаба и с контрастными физическими свойствами. Для решения задач такого класса необходимо при построении дискретной модели учитывать сложную структуру области моделирования, контрастность физических параметров математической модели и временную разномасштабность процессов превращения. В настоящее время для моделирования многомасштабных многофизичных процессов активно используются различные модификации неконформных конечноэлементных методов. Специальные многомастабные вариационные постановки на базе разрывного метода Галеркина (Discontinuous Galerkin method, DG-method) позволяют оптимальным образом учесть наличие фазового перехода,использовать адаптивную стратегию построения несогласованной сетки с локальными сгущениями. Можно учесть многомасштабность на этапе вариационной постановки или на этапе конструирования решателя для дискретного аналога исходной задачи - системы линейных алгебраических уравнений (СЛАУ). Последние исследования показали, что модифицированный подход, использующий метод дискретизации наиболее точно отражающий особенности физического процесса и специальный адаптированный под класс задач решатель позволяет при минимальных вычислительных затратах получить физически релевантное решения [3].

Рассматриваемые вычислительные схемы решения задач с фазовыми переходами разработаны с учетом многомасштабной идеологии [2]. Решение задачи определяется на прямой сумме двух подпространств - разрывного и непрерывного. Для более точного учета местоположения фронта реакции используется стратегии локальной измельчения сетки (согласованной и несогласованной). Для ускорения решения СЛАУ применяется специальная модификация многоуровнего решателя.

Вычислительные эксперименты на классах задач, приближенных к реальным, показали эффективность предлагаемого подхода.

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Математическое моделирование процесса возникновения оползневых потоков в теле плотины (дамбы) сложного неоднородного строения

Данная работа посвящена проблеме математического моделирования начала возникновения оползневых процессов в телах плотин и дамб. В качестве объекта исследования выбирается грунтовые дамбы сложного неоднородного строения, ограждающие мореные озёра от внезапного прорыва, и ставятся задачи на предмет определения напряжённо-деформированного состояния грунта слагающего тело дамбы под воздействием различных природных факторов с разработками специальных критериев, определяющих механизмы разрушения грунта. Задачи решаются путём математического моделирования на базе применения метода конечных элементов (МКЭ), созданием комплекса вычислительных программ.

Наиболее общей формой системы дифференциальных уравнений движения узловых масс с затуханием является [1]:

$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = \{F(t)\}, \tag{1}$$

где $[M]$ – матрица масс; $[C]$ – матрица затухания; [K] – матрица упругости системы; $\{\ddot{u}\}$, $\{\dot{u}\}$, $\{u\}$ – вектора ускорений, скорости и смещений; $[M]\{\ddot{u}\}$ – инерционная сила колеблющейся массы; $[C]\{\dot{u}\}$ – демпфирующая сила (сила сопротивления); $[K]\{u\}$ – сила упругости.

Динамическое состояние тел плотин и дамб вместе с основанием моделируем методом конечных элементов [2,3]. Наибольшее неблагоприятное критическое динамическое состояние тел плотин и дамб определяем следующей

системой обыкновенных дифференциальных уравнений:

$$\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} =$$

$$[M] = \{P^{объем}(t)\} + \{F^{ветр}(t)\} + \{F^{шторм}(t) + \{F^{сейсм}(t)\}\}, \tag{2}$$

где $\{P\}$ – статически приложенная объемная сила; $\{F^{ветр}(t)\}$ – динамически приложенная поверхностная сила; $\{F^{шторм}(t)\}$ – динамически приложенная поверхностная сила; $\{F^{сейсм}(t)\} = -[M]\{\ddot{u}(t)_0\}$ – динамически приложенная объемная нагрузка; $\{\ddot{u}(t)_0\}$ – ускорение сейсмической волны.

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Section 4.
NEW INFORMATION TECHNOLOGIES IN EDUCATION

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Concepts of activization of trainees within structural model of education

In this work some approaches to theoretical judgment of problems of education are offered, recommendations about a practical solution of the problem of activization of trainees and, as a result, to increase of level of a reefficiency trained in a context of skill of generation of new knowledge are made. Below we will assume acquaintance to work [1], and to use the definitions entered in it and concepts. We will note that in it the new option of a paradigm of education is offered: education through all life, and it has rather high validity. As not everyone, probably very laconic phrase from the point of view of a certain circle of people, can be an equivalent of the points of view recognized by experts on problems of a tendency and the system purpose, justification of a validity offered option of a paradigm it is necessary in order that the fresh wording could be perceived further as definition option. First of all, this option of a paradigm of education, in our opinion, as a dominant on which it is necessary to focus an education system, allocates a tendency of exponential accumulation of knowledge in modern society. This tendency obviously being, a positive consequence of paradox of knowledge ("the more I learn new, the I learn more how a little I know"), supported not only scientific, and sometimes mere curiosity, bears the most valuable fruits not only at the correct organization of science, but also education process. From here the predictive validity of a paradigm is obvious.

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Kazakh Morphological Analysis for Statistical Machine Translation: A Case Study

In this paper, we present results from a set of experiments to determine the effect on translation quality depends on the particular kind of morphological preprocessing, that can be represented by finite-state transducers. A high agglutinative nature of the Kazakh language under the condition of poor language resources makes an issue in the derivational morphology processing. Our segmentation model, based on the word forming features only, performs parsing with accuracy of about 90%, reducing F1 errors more than 20% compared to Morfessor. We processed our algorithms over Kazakh Wikipedia dump of about 1,5 million unique lexemes and 230 million words overall. Our best system increases 3 BLEU points over the Kazakh-English baseline on a blind test set.

Improving translation performance directly would require training the system and decoding each segmentation hypothesis, which is computationally impracticable. That we made various kind of conditional assumptions using a generative model and decompose the posterior probability. In this notation "e" and "f" point out the two parts of a parallel corpus and "a" marked as the alignment hypothesized for "f".

$$P\left(e_1^J, a_1^J \mid f_1^I\right) = \frac{f}{(I+1)^J} \prod_{j=1}^{J} p\left(e_j \mid f_{aj}\right) \tag{1}$$

Also we measure the accuracy of the alignment using precision, recall, and F-measure, as given in the equations below; here, A represents the gold-standard alignments; T, the output alignments; A and T intersection, the correct alignments.

$$pr = \frac{|A \cap T|}{|T|}, re = \frac{|A \cap T|}{|A|}, F - measure = \frac{2 \times pr \times re}{pr + re} \tag{2}$$

On our general task we refer to the methodology exposed by Oflazer and El-Kahlout on the Turkish-English task. For a comprehensive survey of the rule-based morphological analyze we refer the reader to the research by Kairakbay.

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A concept map approach to supporting adaptive e-Learning

The development of educational processes under present conditions proceeds in the following directions: individualization of teaching methods, transition to the continuous educational technology, and the use of information technologies in the educational process. The appearance of a new form of e-Learning radically changed the notion about organization of the educational process as a whole [1]. Concept maps are a powerful tool for cognition of reality which has been actively used in the recent decade in the field of e-Learning. They visualize knowledge on the domain in the form of schemes showing interrelationships between different concepts, notions, facts, ideas of the domain. With their help it is possible to present different sections of the subject being studied, reveal its content with different degrees of details, emphasize or conceal certain aspects, here everything depends only on the point of view of the author (the creator of a concept map) and the purpose of its use (needs of the recipient). In virtue of these characteristics, concept maps may prove to be a flexible instrument of teaching which can be tuned depending on the tasks of learning, the current stage, the level of complexity and depending on the needs of the learner, i.e. everything that includes the notion "an individual learning trajectory". Realization of such a dynamic character of teaching supposes, in the long run, only one way of constructing concept maps - an automatic one [2]. Concept maps must be constructed practically "in a flash" taking into account information on what appliances were chosen for the learner, what points are considered to be of first priority by the learner himself, what tasks he faces in the course of learning. The aim of this work is to describe the approach based on the use of mechanism of automatic creation of concept maps which are supporting elements in the individual learning trajectory. In our opinion, the most important link of such mechanism is the possibility of generalization and parameterization of the requirements put to presentation of the material taking into consideration the individuality of the learner. The novelty of the work is in a step-by-step description of operation of such mechanism which can be successfully used in any e-Learning systems supposing adaptive learning.

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Design and development of online courses on edX platform

At present, there are many universities advancing the technology of online education. Educational programs with the use of information technologies including space television, computer networks, multimedia, etc. are interest. The universities lay special emphasis on the use of the available software: Linux, Moodle, Open Office, Google Docs and others in the learning process. In 2012, Anant Agarwal from MIT founded an intellectual MOOC (Massive Open Online Courses) platform edX. Then, the Harvard University and the Berkeley University joined this initiative. The system of online education edX was created for students and organizations aiming at improvement via advanced technologies, innovation pedagogics and professionally oriented courses. The developers of edX carry out investigations on how students are taught, how they learn the material, how to transform the methods so that to achieve the best results. Taking into account the experience of the universities-partners, the experience in the development of online courses within the project Tempus CANDI (2008-2013), the authors propose the methodology of developing online courses [1]. According this methodology the designing of courses starts with determining of the learning outcomes. It is the learning outcomes that affect the methods of teaching, the content, the sequence of material feed, working out tasks, the choice of different kinds of multimedia tools, development of the system of knowledge assessment. The strategy of knowledge assessment is in giving students the opportunity to demonstrate the achievements of the supposed learning outcomes. In the whole period of the course, a close correlation between the learning outcomes, the methods of teaching and assessment of knowledge is supported. In this methodology, of great importance are the stages of development of learning algorithm, the algorithm of knowledge assessment as well as planning of the kinds and content of audio and video materials. Since 2014 al-Farabi KazNU uses edX platform as a virtual medium which is a convenient medium for realization of all stages of the worked out methodology. At present, the teaching staff of KazNU using edX platform develop various online

courses. Online learning in Kazakhstan occupies a greater educational space. Engagement of national universities of Kazakhstan in the process of development and implementation of online education, collaboration with the leading universities of the world, participation of the representatives of industry in course development process guarantee the great demand and highest quality education, both online and in the classroom, and contribute to sustainable adaptation of new forms of learning in life.

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Positive practice in the implementation of Moodle in e-learning

In line with the development of information and communication technology, today's education is not limited to only what required is. Every contemporary individual wants to improve and learn as much as possible and beyond. That is exactly how the popular term of lifelong learning originated. In order to survive in a variety of information and knowledge, it is necessary that one constantly improves himself and keeps pace with the world. As one of the ways to meet these needs, the e-learning was developed, which is progressively gaining momentum and popularity in the world. E-learning brings for sure certain number of advantages in the educational process. It is not an alternative to the existing educational process, but rather an integral part of it, its expansion and improvement. With the introduction of e-learning, have the role and the importance of teachers as mentors, coordinators and participants in the educational process grown. E-learning enables students to be in the center of the educational process, and to take an active role and responsibility for educational outcomes. E-learning is certainly a high quality education process, in which all actively cooperate with the aim of achieving the learning goals that have been set. Moreover the modern information and communication technologies are intensively used to create an adjustable virtual environment. Moodle is offered as one of the good software tools. This paper discusses the application software package Moodle in the process of e-learning on subjects that include content courses basis of informatics and computer science, and studied at the undergraduate level of higher education.

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Structuralization of pedagogical categories "knowledge" in the process of society informatization

Actuality of the research given below is formed by necessity of activization of pedagogical process in terms of introduction of continuing education and structuralization of pedagogical category "knowledge" in the process of society informatization.The structuralization of the main categories of pedagogical science "knowledge" is based on two fundamentals: firstly, the whole system of knowledge positioned hierarchically, and secondly, this ordering should be done in accordance with the evolution of knowledge, that is formation of natural classification systems. The subject of the research is the information needs of the individual and the structure of the training system.[1]

The research is based on posing the hypothesis about the possibility of synthesizing information training, if cognitive activity is based on a hierarchically ordered knowledge, acting as a system that provides and brings needs of the individual. Social development is characterized as a complicated dialectical process; the efficiency of which depends on the level of professional adaptation.

One of the disadvantages of our training is the formalism of the students' knowledge, under which it should be understood:

a) discrepancy between expression forms and the content:

b) automatic merorizing of a matemial without clear understanding.

en order to avaid studInts formol knowledge it is necessary to:

1. Pay particunar attention to the accuracy tnd clarity of expressiol forms, to understanding of the meaning of each word expression of the faca from the information.

2. Seik from students conscious assimilrtiod of the material. It is oftea noticed that a student gives tee material, having learned ie mechanicaliy, without sufficient unserstanding.A student does not unnerstand wheae the base material id and weat the conclusion is, because he does not always understand the presented materlIl.

at is nlso known that students sometimes miss the part of entermediate rhasoning whilh viewing tht material or begin to tell one mnterial, and then bring another oae.
3. Scek from students urderstanding of the purpose of stuuying eaeh topic. It is dseful to begin presentation with naising the question.

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An approach to teaching programming

Traditional teaching programming is based on the premise that the student should instill algorithmic thinking skills through the study of a simple programming language. Gradually, as the familiarization of language is developed, the range of the language features useful for algorithms program representation is extended. Inherently it is the way of stereotypes and pattern formation. It combines different templates by available methods for algorithmically meaningful texts. This approach is comfortable enough in teaching to motivate the students to master a new material. However, the presentation of algorithms in programming languages will always limit the programmer, make him describe a set of possible actions of the language, and not express what he can imagine at understanding the problem. As a result, a programmer restricts gradually his natural ways of data manipulation and actions to the level of linguistic resources. Formed thinking patterns are caused by the language, which is often perceived as a way of thinking that is characteristic for programming. The conclusion from the above is paradoxical: the focus of learning programming to the development of thinking actually leads to its decline and, perhaps, the only useful thing is a student ability to adapt to objectively existing restrictions. The highest level of thinking, which is usually able to achieve a programmer, is combinatorial thinking [1]. Such thinking is not conducive to the development of new methods. They appear not because of, but in spite of the objective combinatorial activity of a programmer. In other words, the methods are developed at the expense of natural talent of some outstanding individuals abilities, unspoiled by a routine of programming work.We present an alternative approach based on rejection of thinking patterns in teaching. The main idea of the approach is separation of two types of activity

in the program construction: development of the program sketch, which does not take into account the resource constraints, and mapping the sketch to a real computer. We show the advantages of this approach for the development of thinking and, in particular, when teaching parallelism. The approach develops proposed in [1] teaching methods based on challenge tasks.

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Combinational circuits model of Kazakh and Russian languages morphology

The problem of constructing a finite transducer with one state for the two-level morphology of inflectional languages, namely, the direct transformation of word endings into grammatical characteristics is investigated. This problem is studied on the base of Kazakh and Russian languages, which are inflectional languages. For solution of this problem a trivial Mealy automaton with one state (combinational circuit) and a multi-valued mapping is used.

The question of morphological analysis is important in natural language processing. Determining of the base finite state approach in morphological analysis is a two-level morphology concept proposed by Koskenniemi (1983), implemented through the use of finite state transducers (FST). In this paper we consider the possibility of using combinational circuits for two-level morphology of inflectional languages. Combinational circuit is a trivial Mealy FST, namely, FST with one state:

$$y(t) = f_y(x(t)), \tag{1}$$

where x(t) – input of the machine, y(t) – output of the machine, t – current time, f_y – the output function of the machine. The advantage of combinational circuit is its high speed. Essentially, combinational circuit is a mapping of x(t) onto y(t).

The set of endings of Kazakh language is necessary for the construction of multi-valued mappings:

F_s: $X_s \mapsto Y_s$ (for source language),

F_t: $Y_t \mapsto Z_t$ (for target language),

where X_s source language endings,

Y_s - grammatical characteristics of words of source language,

Y_t - grammatical characteristics of words of target language,

Z_t - the endings of target language.

The steps of machine translation, using combinational circuits in scheme of translation are described below: 1) Input of this scheme is a sentence of source natural language. 2) Marking out words in the sentence. 3) Finding part of speech characteristic for words. 4) Split words into stem and ending. 5) Morphological analysis of words with combinational circuits: "ending" - "grammatical characteristics". 6) Translation of the stem from the source language into the target language. 7) Transfer grammatical characteristics of a source language word into grammatical characteristics of a target language word. 8) Morphological generation of endings for target language words from grammatical characteristics of source language words using combinational circuits. 9) Compounding of word stems of the target language with the endings. 10) Implementation of structural transfers from the source language sentence to the target language sentence. Output of this scheme is a sentence of target natural language.

The mappings of combinational circuits are in the steps 5 and 8 for the Kazakh and Russian languages pair. These mappings allow getting the corresponding word ending in the target language for each word in the source language. Joining the stem and the ending in the target language produces the required output word. After that, phrases and sentences of target natural language are produced by joining words into a sequence.

We study the problem of completeness of the finite transducer's input for the analyzed languages. Determination of transducer input's completeness for morphological analysis gives a guarantee that all the words of the analyzed language will be accepted. For agglutinative languages the problem of determining the completeness of the set of possible endings is a complex issue. In this article, we define the completeness of a set of endings in Kazakh language. The proposed technology is implemented for the Russian-Kazakh machine translation, translation quality assessment performed by the method of BLEU.

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Database design for the sectoral frame of IT qualifications within TEMPUS project "QUADRIGA"

One of priority objective of Tempus project "QUADRIGA" is development of the project of a sectoral frame of qualifications (SFQ) in the field of information technologies on the basis of the All-European recommended frame and taking into account experience of the European and Russian higher education institutions. Implementation of the project will allow to provide a basis for modernization of educational programs, to promote closer cooperation and mutual understanding between universities and employers (the enterprises, industries, public sector) that will be useful to graduates of higher educational institutions of Central Asia and will allow to strengthen the Centers of Career in higher education institutions of Central Asia for expansion of opportunities of graduates in employment and creation of high-quality employment. Today participants of the project developed the project of a database for a sectoral frame of qualifications taking into account influence of professional competences on formation of the contents, the purposes and problems of disciplines of higher educational institutions. Thanks to the developed structure of a database it is possible to track interrelation between the labor functions, necessary for successful work in sector of IT technologies, and educational competences of discipline; to see and estimate process of formation of professional competences of the graduate of a higher educational institution; to define the education level demanded for assimilation of necessary skills (undergraduate studies, magistracy, PhD doctoral studies), etc. In the future the team of the QUADRIGA developers will make an attempt to use this database for development of an educational program of IT specialties.

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Технология создания метрических справочников и конкордансов русских поэтических текстов

В литературоведении возникает необходимость автоматизации анализа различных уровней структуры стиха, а также автоматизированного составления на основе такого анализа метрических справочников к корпусам стихов, словарей рифм и конкордансов. Целью настоящей работы является изложение технологии автоматизации процесса создания метрических справочников и конкордансов русских поэтических текстов.

При составлении метрических и строфических справочников целесообразно учитывать следующие двенадцать характеристик: количество строк, без учета пустых; метрика стихотворения; стопность; рифмовка строфики; количество мужских окончаний последних слов в стихотворных строках; количество женских окончаний последних слов в стихотворных строках; количество дактилических и др. окончаний последних слов в стихотворных строках; количество нерифмованных мужских окончаний; количество нерифмованных женских окончаний; количество нерифмованных дактилических и других окончаний; количество строк без конечных слов; тип строфической формы.

Для получения большинства из этих характеристик требуется получение фонетической транскрипции (включая ударение) каждого слова корпуса стихов. Расстановка ударений (акцентуация) решается с помощью инструментария автоматической обработки текстов на естественном языке (Проект АОТ), словарь которого содержит порядка 3,5 миллионов акцентуированных словоформ. Известная проблема автоматизации акцентуации — невозможность выбора правильного омографа при наличии разных типов омографии (падежной, межчастеречной и др.). Предполагается, что лингвист может в ручном режиме выбрать нужную форму омографа или, в случае отсутствия слова в словаре, произвести добавление слова в используемый тезаурус.

Для собственно фонетического анализа нами разработан модуль фонетического разбора слов, который основан на акцентуации слов с помощью последовательного применения известных правил фонетики и орфографии.

Разработанные алгоритмы реализованы на языке программирования Python 2.7 в виде программного средства обработки стихотворного текста.

В процессе обработки стихотворения создается лог-файл, показывающий возникновение всех описанных выше случает неоднозначности, при этом в отдельную таблицу записываются слова, которые не были найдены в словаре ударений или у которых ударение неоднозначно. На основании этой таблицы лингвист может произвести добавление слова в используемый тезаурус или выбрать нужную форму омографа.

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ML-Studio - Web приложение для создания и применения мультимедиа лекций

Видео лекция, активно используемая в образовании уже несколько десятилетий, в последнее время вновь находится в фокусе внимания в связи с большой популярностью так называемых массовых открытых онлайн курсов (MOOK). В большинстве случаев видео лекции для MOOK создаются в студийных условиях, что, в силу высокой стоимости и необходимости привлечения специалистов по работе с видео, ограничивает их применение в учебном процессе вуза. В работе предложена и развита технология создания электронных средств обучения на базе видео лекций, ориентированная на широкий круг преподавателей, не имеющих ни специальных знаний, ни дорогостоящего оборудования видеосъемки и монтажа. Подход основан на сопряжении видеозаписи лекционного процесса с синхронизованным рядом интерактивных мультимедиа демонстраций - мультимедиа лекции. Особенностью решения является возможность широкого манипулирования демонстрациями разных типов (растровая, векторная, трехмерная графика, форматированные тексты и др.) посредством команд менеджерам демонстраций, реализованная в манере XWindowsSystem. Мультимедиа лекция может быть успешно объединена с интерактивными экспресс опросами и представлять собой электронное учебное пособие с элементами программированного обучения. Построен и опубликован в Интернет сервис ML-Studio (http://ml-studio.nsuem.ru), позволяющий преподавателю создавать коллекции учебных демонстраций, объединять их в сценарии и записывать мультимедиа лекции. Записанные лекции могут

быть конвертированы в файлы web ориентированных форматов для размещения на сайтах и распространения на локальных носителях. Преподавателями НГУЭУ с помощью ML-Studio был записан и размещен в Интернете (http://lectory.nsuem.ru) ряд мультимедиа лекций для учебного процесса вуза.

Section 5. TECHNOLOGICAL PROCESS AUTOMATION AND CONTROL

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Automation of data geodynamic monitoring on an oil and gas field

Technogenic influence caused by the widespread deployment of exploration and mining, may cause events of geodynamic nature due to geodynamic processes (extensive subsidence of the earth's surface and activation of fault zones).To avoid such manifestations of geodynamic processes need timely execution of quality geodynamic monitoring which includes a gravimetric monitoring is to measure of gravity variations. The main objective of the gravimetric subsoil monitoring is conducting long-term monitoring of the stress-strain state and fluid dynamics of the geological environment, research links anomalous gravity variations over time with the development of deposits [1]. Many companies that are engaged in carrying out gravimetric monitoring would like to have in their arsenal a certain program that would automate all processing procedures starting with the import of raw data from a file gravimeter, finishing the construction of the distribution of gravity variations maps in space for different time intervals (cycles) [2]. This article presents a computer program automating technological processing of refinement the raw data of gravimetric monitoring. The program implements a standard methodology developed and used in research and production centers that deal with geodynamic monitoring. This program allows automating all of the raw data processing procedures of gravimetric monitoring on one of the oil and gas fields, located in the south-eastern part of the Precaspian depression [3]. The program provides an opportunity to change the graphical representation of the gravitational field at different time intervals (cycles). Graphical representation improves the monitoring necessary for the analysis of fault zones and subsidence of the earth's surface. Automation of data geodynamic monitoring on an oil and gas field can improve the quality of processing, interpretation of gravity data and performance specialist.High-quality and effective monitoring of ecological and industrial safety around oil and gas production has great social importance and economic interest for our state.

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An approach to the development of distributed applications for oil extraction problems

In this paper, we propose a new approach to the development of distributed applications for oil extraction problems. From the experience of high performance scientific computing application development for oil-gas industry we found that a concerted cooperation of specialists from different fields is important. So we recommend to organize "Relay race of specialists" in high performance scientific computing application development. Cooperation of specialists can best be described with the help of the approach of passing a baton. A specialist in the oil-gas industry defines the subject of research and makes the statement of the problem. A specialist to whom the baton was passed creates a mathematical model of the problem. Then the baton is handled on to a specialist in the field of numerical methods who finds a corresponding explicit or implicit numerical method. The following stage is the work of a high performance scientific computing application designer. In the implementation stage the baton is passed to a high performance computing specialist, who is responsible for a final programming product. To display the scheme of cooperation with passing on the baton, we use the MDA technology, according to which a computation independent model (CIM), platform independent model (PIM) and platform specific model (PSM) of the application are constructed. In this work, an MDA model of development of distributed applications for oil-gas industry is constructed. This model was used for the development of a specific application to calculate the pressure in anisotropic elastic porous medium on the MapReduce Hadoop platform. In the stage of designing an application of a resource-intensive computing problem, we have to determine general input and output parameters, a class of equations, explicit or implicit methods of calculations and instruments for carrying out parallel computations. The four invariable independent parts of the computational problem are presented in the form of four base components which are responsible for various parts of organization of high performance scientific computing [1]. These components are used in the stage of transformation of CIM model into PIM model of MDA technology. In this work, transformation of PIM model to MapReduce PSM model consists in transformation of UML class diagram to the Java classes with addition

of MapReduce specification to PSM. On the basis of MDA technology, we developed PIM and MapReduce PSM models and transformed the MapReduce PSM model to Java code automatically. The experiments are designed to gain data on working implementation of iterative MapReduce solution. The results allow to conclude that the application works well and with the increase in the volume of the data being processed the performance of Hadoop implementation increases.

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Computer mathematical and biochemical modeling and simulation of the life processes in human kidneys

Motivation and aim. Motivation and aim. The purpose of research is computer simulation of biochemical processes in the human kidney with his daily activities based on mathematical and biochemical methods to describe these processes and diverse library of templates changes in the conditions of their course based on various scenarios of the changing environment and the different nature of their actions. *Methods and Algorithms.* Kidneys – the main organ of the urinary system – play the role of complex biological filters. They are removed from the blood and then excrete water, urea, excess salts, maintain blood ion balance is outputted foreign substances, including drugs, residual reaction products, thereby to maintain the constancy of blood, interstitial fluid, regulated by the total body fluids and the ratio of the amount of these salts in the sodium, potassium, and other substances. The main biochemical and physical processes are filtration processes in a weak electromagnetic field, reabsorption processes, diffusion, chemical processes of splitting of molecules of salts, separation of protein molecules, processes of absorption of substances the body needs. The general direction of our research is the use of modern methods of WPF technology for visualization of complex biochemical processes occurring in the kidney nephron, in terms of identifying the mechanisms of self-regulation processes thin buds in a random environment with the assistance of well-known methods of mathematical physics and bioinformatics. Since these nephrons in the kidney about a million units, it would be interesting to understand how the human body fails to regulate the activities of each of them independently. This contributes under heavy load on the human body to regulate the degree of processing of the blood into the urine. For this purpose, I use of automatic control methods of multiply multidimensional systems. *Results.* Building representative strictly structured database characteristics functioning human kidney with deep classification distinguishes the characteristics of its life. Building an

effective database of various scenarios of changes in the human kidney in a wide range of influence on him changing random environment, making it possible to obtain the most comprehensive information in a different format required. Building an effective technology dispatching dynamic changes of biochemical processes in the human kidney under various conditions by selected characteristics of these processes. Construction of algorithms of mathematical modeling and biochemical functioning of the human kidney under the influence varies in different scenarios of environmental conditions. Creating the rendered model of the functioning of human body.*Conclusion and Availability.* The reported results are the common goals of our research, which are specified through the joint activities with the experts of the National Research Center of Surgery named after A.N. Syzganov and Scientific Center of Cardiology and Internal Medicine (Almaty).

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Synthesis of plans in multi-agent system using the method of positively constructed formulas

In this paper, we consider the use of the logical calculus of positively-constructed formulas (PCF) for making plans of actions for groups of autonomous underwater vehicles (AUVs). Actions of groups and group members are generated at the high level of control system in automatic or semi-automatic mode via the human-machine interface. We presenting an example of formalization of such system and the construction of inferences. The calculus of positively-constructed formulas developed by S.N. Vassilyev and A.K. Zherlov as a logical tool for describing and solving the problems of control. This logical calculus has a number of features (considered in [1, 2]), due to which its use in planning and control problems is more convenient and efficient in comparison to other modern deduction systems. Among others, the least important features, we note the question-answer procedure of inference which making possible the use of PCF for solving problems. Indeed, in this way of searching of deductions, it is easy to pick out the events that can be used to tuning up a strategies of deduction search in automatic mode. And also, with the help of these events the inference machine can communicate with a human operator of the control system. Examples of such events in terms of PCF: *a successful answer to a question*, *adjunction of the base with new atoms*, *refutation of a base*.In contrast to [1] in this paper we consider the full calculus with functional symbols, that is greatly facilitate the formalization of planning and control problems wich demand the declarative specification. Generally speaking, the use of function symbols leads to a complexity of the search of inferences due to the possibility

of emerging the Herbrandt universe while searching the substitutions needed for inference. Therefore, in order to avoid this inefficiency, we limit the language of calculus of PCFs as follows. While formalizing problems it is disallowed the use of formulas containing questions that are simultaneously contain unconfined variables and branching in the tree structure of the formula. This restriction significantly improves the efficiency of the search of inferences, but the class of formulas remains fairly extensive, transcending the class of formulas used for example in the "pure" Prolog.

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Level crossing rate of dual κ - μ random composite process in the presence of Rician distributed interference

In this paper the ratio of two κ - μ random variable product and Rician random variable is analysed. Useful closed form expression for average level crossing rate of proposed ratio is evaluated. Integral is solved by using Laplace approximation formula. Obtained results can be applied for calculation average fade duration of wireless communication system operating over (κ - μ)*(κ - μ) multipath fading environment in the presence of co-channel interference subjected to multipath Rician fading. In this paper the influence of Ricican factor and κ - μ multipath fading severity on average level crossing rate of ratio of two κ - μ random variable product and Rician is random variable considered.

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Analysis of a Direct Expansion Solar Assisted Heat Pump Suitable for Comfort Applications

In this paper the theoretical and experimental studies carried out on a direct expansion solar assisted heat pump (DX-SAHP) under humid weather conditions is reported. Experimental set up used includes a flat-plate solar collectors acting as an evaporator with refrigerant $R22$, a hermetically sealed reciprocating type compressor, a air cooled condenser and an electronic expansion valve. The performance parameters such as energy performance ratio, power consumption, heating capacity, solar energy input ratio and compressor discharge temperature of a DX-SAHP obtained from the experimentation at different solar intensities and ambient temperature are studied. The present analysis indicated that, COP of the system is found to be vary from 1.8 to 2.8, power consumption from 1098 to 1305W, heating capacity from 2.0 to 3.6 kW, solar energy input ratio from 0.1 to 0.4 and compressor discharge temperature from 63.60 to 86.52$^{\circ}C$.

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Algorithm for Recognition of Kazakhstan Vehicle License Plates

Nowadays, an automatic number plate recognition (ANPR) system is a key aspect in traffic congestion. This will help to minimize the different kind of violations on the road. Kazakhstan provide new format of number plate, which differ from previous one. This paper's main objectives is to propose our own algorithm which will be able to recognize new and old formats of Kazakhstan number plates. A short review is performed on the various methods of number plate recognition algorithms. Further explanations of the proposed algorithm are

illustrated in graphical forms to show how the algorithm works. Camera localization is explained in detail taking into account the parameters of Kazakhstan vehicle license plate. This paper concluded with tests and evaluation results.

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Design and development of mobile remote controlled robotic platform

In this work, we describe the process of designing and developing mobile remote controlled robotic platform. The concept of developing robotic platform lies in its high-functionality, flexibility and ease of usage. The robotic platform that is being developed contains: IP PTZ fish-eye camera, Wi-Fi module as the wireless connection mechanism, the combination of Li-Po batteries that gives us 24V 14000 mAh, 6 inch rubber tire wheel with endless track belt, advanced manipulator with 6 DOF with lift capacity up to 4.5 kg and reach envelope of 2.2 m in diameter. Robotic platform can be remote controlled by Xbox controller and operator can see real time video/data sent through fast Wi-Fi router. Weight of platform is 40 kg with 250-550-750 mm size (height-width-length, without manipulator). Manipulator adds 10 kg to weight and 1 meter to height in fully expanded form.

Robotic platform can be used as surveillance robot in situations when human presence is unacceptable [1]. Transformable endless track belt allows robotic platform to move easily at complicated outdoor and indoor environments [2]. IP PTZ fish-eye camera makes the sending of video surveillance data possible in any

direction around the platform.

Another main mission of our development is using robotic platform for bomb disposal and demining. By means of the advanced manipulator, robotic platform can be used in real time transporting and demilitarization of bombs and mines.

Despite of all advances, robotic platform is open to modification and upgrading. Additional equipment, as Geiger counter, can be added for using robotic platform in another scenario. Firmware of robotic platform can be changed for any aim. For now, the platform has built-in controller with functions library that is used to control the behavior of the system. The control of manipulator (robotic arm) is tied with the control of mobile platform into one software with friendly user interface. Operator using Xbox controller through the noted software package can do all remote control operations, and the video transfer exists. As a continuation of the project and as the main part of it, we are planning to enhance the capabilities of the system in self-control by applying the computer vision and path planning mechanisms [3]. Such an algorithms are being developed in our organization, and now the hardware task includes the mounting of additional sensors and computer that is possible to handle such an operations in limited amount of time.

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Analysis of the possibilities for using a uniform Bragg gratingin a tunable dispersion compensator

The article presents a tunable fibre optic dispersion compensator system, consisting of a specially designedcantilever beam and a uniform Bragg grating. It analyses the group delay and dispersion characteristics in the case that there is

no apodization of the gratingand also for a grating with apodization used for modulation of the refractive index. Various apodization parameters were tested, along with their effects on the dispersion characteristics of the entire system properties. It is demonstrated in the paper that the apodization parameter affects the compensator's group delay characteristic. The finite elements method was used to design a compensator of such a shape that enabled chirp to be induced in a grating of a specified shape.A new design is presented for the system, in which the dispersion properties are tuned by the maximum value of the heterogeneous deformation of the compensator. The paper also includes results showing the effect of the maximum value of heterogeneous stress of the grating on the dispersion characteristics of the proposed construction.Communication by means of an optic medium has many advantages, but the main factor limiting its efficiency is dispersion. There are many methods of dispersion compensation. The dispersion compensation fibres in use have a flaw in the form of the compensator's large size [1]. Another disadvantage is the constant length of compensating fibre required for compensation in a fibre optic connection of a specified length, which means that these solutions cannot be applied in networks with optical switching, where the length of the optical connection may vary. Coupled two-cavity allpass filters realised entirely as thin-film structures for dispersion slope compensation of optical fibres have been proposed [2]. Liquid crystals used in optical sensors [3] have also been proposed for the polarization mode dispersion compensation in the Liquid-Crystal Modulator Arrays [4]. Among systems currently used, those based on fibre Bragg gratings are also worth mentioning. The basic flaw of such systems is the fact that the grating of the compensator only works for one wavelength. A solution may be to tune the grating in order to adapt its compensatory properties to a specific wavelength for other requirements, e.g. to obtain a defined scope of group delay.

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Raspberry Pi, Mathematica, and electrical engineering education

The Raspberry Pi is a low-cost small-size computer [1] that enables people of all ages to explore computing and to learn how to program or use programming environment like Wolfram Mathematica [2]. In recent years, computer education has focused largely on office skills and not on understanding how computers work, or how you can use them to create new programs and inventions. The Raspberry Pi redresses the balance. It can be used for games, music, photo editing, and word processing, like any computer. But it can do so much more, providing a gateway into programming and electronics. You can use simplified operating system on an SD card and connect the device to a screen, mouse, keyboard, and Internet. The new concept of teaching electronics courses to electrical engineering students uses a numeric solvers and computer algebra system (such as Mathematica) and low-cost computers for teaching, analysis, and design electronic devices that can be put in working environment with the Raspberry Pi. The methodology is based on more general approach using symbolic processing [3]. Computer algebra system (CAS) is used to formulate circuit equations and prepare for symbolic solving and thus completely specify an electrical circuit by using Mathematica as CAS. Exercises introduce simple real-world circuits [4]. From the symbolic expressions it is possible to design and optimize specific circuits [5]. These way students are free from manual solving large system of equations and are focused on understanding the functional model and simulation of complex electrical systems with complex devices. The new approach is mainly targeted to combine understandings of simple devices, to integrate models into large systems, and to use computer algebra systems instead of manual derivation of responses [6]. Combining visual interpretation from mathematical models with simulating numeric tools, electronic kits, and the virtual instrumentation, the process of analysis and design are integrated into unique development environment that can be used by students of electrical engineering.

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The conception and architecture of the Internet portal for the study of thermophysical properties of materials

Studies of thermal properties of metals at high temperatures are an important scientific problem of great practical significance.

They not only serve as a basis for further development of high-temperature solid-state physics [1], but also allow us to determine the practical use of new materials.

The practical significance of such work is determined by the rapid development of high-temperature equipment, development of new materials with unique characteristics.

Currently, the world's developed and used specialized commercial software packages that allow you to obtain the data on the thermal properties of certain classes of substances and materials. The experience of the practical use of such programs revealed their significant drawbacks. They do not give access to the tables primary experimental data do not allow you to select a model for processing, the models used are not physically well-founded, that does not allow for extrapolation of data, there is no real possibility to predict the properties, etc. In Russia, this trend has not yet been a significant proliferation.

Information technologies have a huge impact on all areas of human activity associated with the accumulation and processing of information. In a relatively short time of existence of information and communications technology has accumulated a huge amount of diverse data submitted exclusively in electronic form. There are problems of access (including remote) users to diverse types and formats of data processing and interpretation of the results of observations of the properties of substances and phase transformations [2].

Integration of information resources into a single information environment and providing access to computing resources - is one of the most important trends in the development of modern information technology. Addressing the creation and integration of information resources and products is becoming a prerequisite for development in many countries, including Russia. The rapid development of global information networks and lead to a change in the fundamental paradigm of data processing, which can be characterized as a transition to the support and development of distributed information resources

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Integrated Approach for Implementing the Virtual Information Infrastructure of the automated process control system

A typical modern automated process control system (APCS) consists of three levels: lower, middle and upper [1-3]. Analysis has shown that currently, the problems of virtualization of infrastructure of middle and upper levels of APCS are successfully being solved. There is a need for virtualization of lower level of APCS associated with the need to automate the process of checking the control system in the office, that is, in the absence of automation objects [4].

To solve this problem laboratory bench based on the virtual instrument was developed and implemented in the educational process. This virtual instrument is a simulator for modeling and studying complex objects: sensors and actuators. To simulate the experiments and to acquire characteristics of the objects we designed a graphical user interface within the "LabVIEW" development environment [5].

For the analysis of the angular velocity of sensor's operation in dynamic mode in order to optimize its dynamic characteristics the block diagram was composed, the overall transfer function of which is calculated as:

$$W(s) = K_{SE}\frac{W_{MN}K_{DT}W_{CD}}{1 + W_{MN}K_{DT}W_{CD}K_{FL}}$$

where K_{SE} - transfer coefficient of a sensor element; W_{MN} - transfer function of the movable node; K_{DT} - transfer coefficient of capacitive displacement transducer; W_{CD} - transfer function of the correction device; K_{FL} - transfer coefficient of feedback loop.

For the purpose of real study of operability of the AVS and verification of its characteristics, an adequate model in Matlab Simulink visual environment was created during the implementation of the previously calculated parameters.

The scheme provides an error calculation in the processing of step-wise output signal by the structure of the sensor. Further, during the subsequent processing of the array of errors, the experimental value of the mean square error is calculated.

In the simulation, a graph of the transition process at the maximum input signal of 150 deg/s was produced, showing the aperiodicity of the achievement of a maximum 5V output signal during approximately $5.7 \cdot 10^7$ sec.

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About the determination of optimal trajectory condition of stowage material

It is proposed forecasting technique of curing processes of filling mass according to the observation of states packing materials carried out in the earlier times. This technique improves accuracy of the forecast of hardening by on the sets of features.

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Discrete-event systems with state observation properties studying

The paper shows the application of the method of logical-algebraic equations (LAE-method) to the study of properties of discrete-event systems (DESs). The LAE-method is the method of mathematical systems theory which lies at the intersection of system dynamics, algebra and logic and serves to synthesize criteria for preservation of the properties of systems connected by special mappings — morphisms. One of the main applications of the preserving criteria thus obtained is the reduction of studying some complex system to studying a much simpler one. To exploit the LAE-method we treat the property of the system under consideration as the property of an algebraic system. Due to the complex nature of dynamical systems the process of algebraizing of their models usually leads to many-sorted algebraic systems (MASs) where the basic sets have the meaning of a state space, a time scale, etc. Next we consider either

of the logical-algebraic equations (LAE) $\mathcal{X}\&\mathcal{P} \to \mathcal{P}'$ and $\mathcal{X}\&\mathcal{P}' \to \mathcal{P}$ where $\mathcal{P}'$, $\mathcal{P}$ are known, and $\mathcal{P}$ is the formula predicate which describes the property of the system S, $\mathcal{P}'$ is the property of the another system (S'), and $\mathcal{X}$ is the subject for the searching. The second equation corresponds to the preservation of properties in the direction opposite to mappings acting from S to S'. Next we employ the algorithm of constructing the solution $\mathcal{R}$ of the chosen LAE which in place of $\mathcal{X}$ guarantee preserving the truth values of formula predicate under mappings of many-sorted algebraic systems to each other [1]. $\mathcal{R}$ is having the meaning of preservation operations and relations only, i.e. having the form of traditional morphisms. Morphisms of dynamical systems proved to be especially usefull, for example, for those procedures of researching stability and other dynamic properties that require a change of variables, since we should ensure that the property under consideration in old variables is equivalent to that one in new variables, or at least guarantee its unidirectional preservation. In this paper the LAE-method is applied to study the properties of DESs with partial observability. DESs model the system evolution by considering the occurence of some sequences of events. Development of DESs theory is driven by the rapid progress of manufacturing systems and communication networks, technological processes, transportation networks and others, primarily man-made systems. To regulate DES behavior the Ramadge-Wonham framework of supervisory control is commonly used, which is adopting ideas from logic, language and automaton theory. In supervisory control theory the concept of observability plays an important role. Based on practical constraints, a subset of observable events is distinguished from all events. Observability was initially defined for event observation only, no state observation was explicitly considered. Using the LAE-method, we will demonstrate that the studying DES with state observation can be reduced to the same problem in the context of event observation.

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Automation of data geodynamic monitoring on an oil and gas field

This work addresses the is sue of geological exploration and search of rich ore deposits. One of the effective methods is a use of logging principle,which consists

in:a well is drilled in 25-35cm diameter, then the well side face is studied, i.e. the ore percentage is determined on the well height. The logging unit specified in this work consists of a main stepper motor, reducer, winch and a shell with telescopic sensor. The sensor consists of ionizing radiation sources, proportional counter used for detector, preamplifier and a sensor movement stepper motor. A motor implements an important function, consisting in lowering and lifting of the logging instrument into the well. Therefore, a motor control function composition, the movement of which will reconcile with the movement of sensor movement motor. All software and control tools will be in the computer (laptop) with a digital converter. The task of creating a new logging unit, based on the use of massive material x-ray, as well as automation of all processes on this machine with the use of modern achievements of information technology and computer technology is relevant for the following features:creation of high technologies for solution of the tasks of exploration and prediction of mineral deposits within the priority of scientific and technological development of the mining and metallurgical industry of the Republic of Kazakhstan;the absence in Kazakhstan and the need to build a mobile logging unit with automated control and information processing system, based on the advanced method of well logging. The process of work covered a research on the development of a new method and technology of computer control and information processing of logging unit, an X-ray radiometrical logging unit mathematical model and control function was developed. The result of modeling electromechanical processes in stepper motor allow to evaluate the accuracy of the set movement, dynamic quality of the system, calculate the mechanical force in system elements and their impact on the main variables of the stepper motor electromechanical processes. The conducted researches identified the possibility of creating a microcontroller control system of electrical drive of logging unit telescopic sensor with the accuracy of a set movement. The results of the study can later be used in creating automated mobile logging unit that can be used in mining metallurgical industry.

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Algorithm for construction of the intellectual control system of the object with inexact parameters and delay on the basis of artificial neural networks

Intellectual control systems recently are considered as one of the most perspective directions in scientific researches. Of particular interest are the principles of intellectual control systems based on different technologies, the creation of modern intellectual technologies as applied to the control of complex dynamic objects [1,2]. Complex technical objects, usually inherent qualities such as delay, large dimension of the control object, unsteadiness, non-linearity, as well as the parameters of the object can be located within certain intervals.

Therefore, the developed control system of complex objects must be such as to ensure the functioning under all conditions with a given indicator of quality.The algorithm for constructing of intellectual control systems of the object with inexact parameters and delay based on artificial neural networks is developed. The intellectual control system of the object with inexact parameters and delay is constructed on the basis of artificial neural networks.

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Application of programmable logic controllers for efficient use of photovoltaic panels

Great electricity consumption and population growth are forcing all countries to deal with the critical problem of reducing the stock of domestic fossil energy resources. Therefore, the proportion of electricity derived from renewable energy sources rapidly increasing in countries around the world. Serbia is yet to build significant capacity power plants that use renewable sources for electricity generation. One of the most promising forms of renewable energy is solar energy. Electricity generation, which is the most useful form of energy, is obtained by photovoltaic conversion of solar energy using photovoltaic cells that are grouped in photovoltaic panels. The highest utilization degree of solar energy is achieved when the angle of incidence of sunlight is 90°, which can only provide by mechanisms for tracking the position of the Sun because the Sun location constantly changing. This paper describes a mechanism that has the ability to monitor shifts the position of the Sun using the programmable logic controllers.

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Diffractive optical elements for a quality checking of the aspherical mirrors of large telescopes

The modern advances in the optics are based on the application of diffractive optical element (DOE). DOEs consist of thin glass plates, one side of which has surface microrelief features and a depth of up to a half of light wavelength (0.4-0.7 micron). The potentials of DOEs are mostly determined by a technology of their production, which shall provide reconstruction of a wavefront form with the given accuracy reaching 1/1000 of light wavelength for some applications.

Such DOE are designed for testing of aspherical mirrors of modern telescopes and shall have an error in production of a circular diffractive structure not more than $0.1\mu m$. Just as the overall dimensions of the element make up several hundreds of millimeters. The one of the best method to produce DOE which uses the polar coordinate system for recording. This principle was used at the Institute of Automation and Electrometry for development of a circular laser recording system precision designed for production of DOE. Circular scanning which is optimal for DOE with axial symmetry is realized by discrete displacement of a recording spot. This method is optimal also for synthesis of DOE with arbitrary pattern.

The extremely large European E-ELT telescope with a 39-m mirror will be biggest in the world (it is planned to put it into operation in 2018). An optical system based on a precision amplitude-phase DOE for checking of prototypes of telescope segments is developed and designed at the Institute of Automation and Electrometry. Inaccuracy of the formed aspherical wavefront with the budget of all manufacturing errors made up 5.3 nm. Besides, our institute developed and manufactured for the Steward Observatory of the University of Arizona (USA) etalon DOEs for testing of aspherical mirrors of Magellan telescopes (6.4-m mirror), the Large Binocular Telescope (2 mirrors of 8.4-m diameter each) and a new infra-red space telescope for the James Webb observatory (JWST) with a 6.6 m mirror, whose launching to Lagrange L2 point is planned in 2018.

This paper presents the results of the above-mentioned error compensation algorithms during the DOEs recording time on circular laser recording system. A method of DOE production with a ability of accurately superposition of the start point in the coordinate system with the rotation axis of the optical preform during the entire recording time was developed and used to produce DOE for testing of aspherical mirrors of modern telescopes.

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The problem of Word sense disambiguation in Machine Translation system of Russian-to-Kazakh languages

Today the problem of the lexical and syntactic ambiguity resolution is a very important issue. We try to solve this problem in our work. So we chose the Rule Based method taking into account all grammatical, morphological, and lexical features of Russian and Kazakh language.

In this work, we offer the method based on Bag of Words (BoW) which solves lexical ambiguity of words [1]. BoW model is one of the ways of representing context vector (CV) for supervised learning technologies. In our model, the sentence represented as a set (multi-set) with its words, disregarding grammar and even word order. The task of lexical analyzer-generation of word and disambiguation in sentence (text) can be easily represented as a task multivalued mapping. Let X and Y - an arbitrary set. A multivalued mapping from the set X into Y is: $F : X \to \Omega(Y)$, where each input word $x_i \in T$ of text T should be attributed to one of the output values of the classes m_j, i $\in M_i$, where M_i - the set of meanings of the word x_i. F is a representation function of multivalued mappings [2]. Below is the segment tables of multivalued mappings (m -mappings) for ambiguous words (in this case homonyms) $X^m \to Y^m$, where $X^m = \{a_k\}$, a_k- initial form of ambiguous words that have the k-th value. Y^m - represented as a matrix consisting of elements CV, that are corresponding words in context for each a_k values.

$$Y_{ij}^m = b_{ij}\mu_{ij} \Rightarrow Y_{ij}^m = \{(b_{1j}\mu_{1j}), (b_{2j}\mu_{2j}), (b_{3j}\mu_{3j})\} \tag{1}$$

where b_{1j} - elements of a particular group of CV, i=1,3 (where b_1- verb group, b_2-noun group, b_3- adjective group), and for each element is given by the ratio of preference (relativity) μ_{ij} of given element in text, in the following range $0 \leq \mu_{ij} \leq 1$. If such b_{ij} words of was found, then in accordance with its relativity to one or another meaning a_k meanings was selected.

The proposed method of multivalued mappings and solving problems with multi-tasking words were applied to a simple sentence in the system of machine translation from Russian into Kazakh language and was implemented as a software application. The advantage of this method is using method of CV and multivalued mappings. In contrast to the other methods, the method of CV handles all components of the sentence, and not just standing around ambiguous words. Due to this, semantically more complete analysis of the text comes out. This method can be successfully applied in various systems of automatic text processing and semantic search for a variety of natural languages.

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Investigation of artificially immune system with using of fuzzy logic

This article deals with the development of an optimal structure of the immune reaction model organism to medicine based on the methods of fuzzy logic system. At present, the immune system is considered by researchers as a source of ideas and methods for solving various tasks in the field of information processing and analysis, mathematical modeling and information security [1]. Currently, the number of works on the development and application of artificial immune systems is increasing rapidly. The first book about the artificial immune system was published in 1998, edited by Dipankar Dasgupta [1]. The immune system - is a structure in which the mechanisms implemented learning, memory, and associative search to solve the problems of recognition and classification. In particular, the immune system can be trained to recognize the important structures (antigenic peptides); memorizing already encountered the structure and use of the laws of combinatorics within gene libraries for efficient generation of detectors structures (variable regions of antibody molecules) interacting with external antigens and the body's own cells. In response to this antigen is not only at the level of individual recognition units but also at the system level through mutual recognition lymphocyte clones of antigen-antibody reactions. Thus, the behavior of the immune system is determined by the totality of the local network interactions. The immune system is of great interest due to its important role in maintaining the integrity of the organism. The properties of the immune system are a remarkable example of local adaptive processes that implement an effective global response. A number of simulation models that describe the reaction of the various components of the immune defense published [2]. Is expanding the scope of application of new methods for solving applied problems, based on the principles of immunology. These methods have various names: artificial immune systems, are based on the principle of immunity, immunological evaluation. In this article the adequate mathematical model of artificial immune system with using of fuzzy logic is investigated. The results of constructing an optimal structure [3] of the immune mathematical model to simulate different algorithms of special reactions formation to medications, depending on the strategies of infection are received.

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Задачи покрытий и упаковок в некоторых приложениях

В работе рассмотрены специальные задачи покрытий и упаковок [1, 2]; проведен анализ взаимосвязи между различными постановками. Многие типы таких задач находят свое практическое применение при проектировании систем контроля (сенсорные сети), в транспортной логистике (складирование материалов), в проектировании установок по магнетронному напылению металлов и др. Более того, благодаря развитию технологий в этих областях, появляется большое количество новых актуальных математических постановок. В первой части работы приведены классификации регулярных покрытий и упаковок, основанных на выборе минимального фрагмента. Введенные обозначения отражают структуру круговых (эллиптических) покрытий (или упаковок) и их уровень сложности. Это позволяет в каждом классе покрытий или упаковок находить модели с наиболее эффективной плотностью (наименьшей для покрытия, наибольшей для упаковки). Методика расчетов была реализована для множества моделей с ограниченной областью и для протяженных полос [3]. Во второй части работы исследуются процессы магнетронного напыления металлов [4]. Предложены способы оценки равномерности напыления металлов на поверхность в зависимости от вида мозаичной мишени и ее удаленности от поверхности. Созданы алгоритмы вычислительных программ, позволяющие выбирать наилучшие типы мозаичных мишеней из данного набора.

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Архитектура программного комплекса интеллектуального облачного сервиса мониторинга состояния и управления для удаленных распределенных объектов

В докладе рассматриваются вопросы создания программного комплекса интеллектуального облачного сервиса, реализующего новый подход к построению автоматизированных систем для мониторинга и управления распределенными удаленными объектами различного назначения. Представлены принципы построения, функциональная спецификация, архитектура программного комплекса. Предложены подходы к обеспечению надежности и производительности. Приведены примеры прикладных систем реализованных на платформе облачного сервиса.

Массовое применение взаимодействующих через интернет автоматических или автоматизированных устройств - общемировой тренд. Хорошие перспективы имеет интеллектуальный облачный сервис мониторинга состояния и управления удаленных распределённых объектов различной природы. Это могут быть природные и технические объекты, физические лица с носимыми датчиками контроля физиологических параметров и проч. На объектах, подлежащих контролю устанавливаются контроллеры с комплексом датчиков. Датчики опрашиваются контроллером, а построенная на его основе система управления формирует команды исполнительным устройствам объекта. Объект имеет канал связи с облачным хранилищем данных в котором накапливаются данные для обработки на более высоком уровне. Целями обработки могут быть: анализ данных, выработка управляющих воздействий, интеллектуальные процедуры принятия решений, организация меж объектного взаимодействия, формирование новых логик мониторинга и управления. Предполагается поддержка автоматических и автоматизированных систем с операторами процессов мониторинга и управления.

Программный комплекс позволяет: организовать каналы передачи данных для взаимодействия объектов управления, операторов и внешних системам, принимать, хранить и обрабатывать данные, поступающие от объектов управления, операторов и внешних систем, предоставлять операторам сервисы по организации удаленного мониторинга и управления объектами.

Программный комплекс имеет модульную структуру в составе: конфигуратор правил и оборудования, конструктор схем контроля, дизайнер отображения данных, модуль анализа данных и прогнозирования, подсистема формирования показателей и построения отчетов, подсистема трансляции данных, подсистема оповещения операторов, подсистема безопасности, подсистема хранения и обработки данных.

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Применение ГИС и WEB-технологий для создания геоинформационной системы "Инвестор"

Для повышения инвестиционной привлекательности территорий муниципалитетов и увеличения бюджета городов в России активно разрабатываются и внедряются инвестиционные карты или геоинформационные системы (ГИС) «Инвестора». Создание таких систем требует интеграции информации о городской территории, содержащейся в базах данных (БД) и на электронных картах существующих муниципальных информационных систем (МИС). Геоинформационные системы «Инвестора» являются уникальными для каждого города и не могут тиражироваться. Поскольку содержащие исходные данные МИС являются специфичными для каждого города, а их структура определяется сложившимися особенностями муниципального управления и длительной историей разработки, в данной работе рассматривается опыт создания ГИС «Инвестора» г. Иркутска, на основе оригинальных технологий и технических решений. Цель разработки ГИС «Инвестора» г. Иркутска – создание для потенциальных инвесторов благоприятных условий, путем обеспечения открытости и доступности информации, необходимой для выбора на территории города объектов представляющих возможный интерес. Система содержит актуальные пространственные и тематические данные об объектах территориальной инфраструктуры города, в состав которых входит общедоступная информация по границам земельным участков, инфраструктуре и населению города и т.д. Основным элементом ГИС «Инвестора» является информационный WEB-ресурс, который разработан на основе оригинальных технологий публикации пространственных и тематических

данных с использованием механизмов декларативных спецификаций.

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Моделирование и управление процессом электролитического рафинирования меди

Рассматривается проблема создания системы поддержки принятия решений (СППР) для повышения эффективности управления процессом электролитического рафинирования меди. Процесс электролитического рафинирования относится к гидрометаллургическим процессам. Существующие в настоящее время системы поддержки принятия решений используются преимущественно для пирометаллургических процессов, например, в алюминиевой промышленности.

Основной целью данной работы являлась разработка математической модели управления процессом электролитического рафинирования меди и построение СППР, как основной части информационно-управляющей системы, на базе математической модели данного процесса.

В качестве исходных данных для построения моделей использованы экспериментальные зависимости выходных показателей (выхода по току и производительности электролизера) от входных параметров (содержания меди в электролите и электродах, содержание серной кислоты) и управляющих воздействий (силы тока и скорости подачи электролита). По полученным массивам экспериментальных данных построены полиномиальные регрессионные уравнения.

Управление технологическим процессом осуществляется по схеме регулирования в режиме настройки. В устройстве управления сравниваются фактические значения выхода по току и производительности электролизера с желаемыми. Математическая модель управления процессом включает в себя модель технологического процесса, технологические ограничения и математическую

модель принятия решения. Моделирование процесса принятия решения включает в себя формирование исходного множества альтернатив и построение функции выбора. В качестве альтернатив в данном случае рассматриваются все возможные состояния системы (электролизера), атрибутами которых являются управляющие воздействия.

На основе построенной математической модели разработаны алгоритмы управления по регрессионной модели и фаззи-управления. Алгоритмы реализованы в СППР, с помощью которой решается задача автоматизации управления процессом электролитического рафинирования меди.

Использование СППР приводит к стабилизации качества управления, так как уменьшается диапазон колебания выхода по току и производительности. Численный эксперимент проводился при данных полученных на промышленном электролизёре, где было установлено 43 анода, и их суммарная площадь составляла 30 м2. Средний показатель выхода по току повышается с 87,46%, что соответствует среднему выходу тока на реальном агрегате, до 88,99% и производительности - с 0,0498т./сут. до 0,0506 т./сут. за один технологический цикл. Таким образом, предложенные алгоритмы управления позволяют увеличить выход по току и производительность, т.е. улучшить качество управления электролизом.

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Организация центра сбора экспериментальных геофизических данных в реальном времени для исследования ближнего космоса

Значительные усилия мирового сообщества в области космической деятельности направлены на развитие методов диагностики и прогноза космической погоды с целью принятия ряда предупредительных мероприятий по снижению вероятности выхода из строя наземных и космических технологических систем во время опасных в геофизическом смысле ситуаций в околоземном космическом пространстве. В 2009 г. в ДТОО "Институт ионосферы"создана и функционирует система мониторинга околоземного космического пространства, которая объединяет следующие гелио- и геофизические комплексы: высокогорную станцию космических лучей, радиоастрономическую и геомагнитную обсерватории. Обсерватории работают в автономном круглосуточном режиме. Ежеминутно на станциях производится измерение наблюдаемых параметров околоземного космического пространства, обработка данных, запись

в банки архивной информации, построение графиков оперативных данных и представление результатов регистрации на сайтах станций (http://ionos.kz). Гелиогеофизическая информация в часовом режиме по FTP-каналам поступает в базу данных системы, сайт комплекса предоставляет среднечасовые оперативные и архивные результаты мониторинга. Интегрированный банк данных представляет собой набор месячных файлов часовых значений. Для решения задач исследования и прогнозирования состояния ближнего космоса, а также для проведения комплексного анализа геофизических данных необходим доступ к оперативным данным обсерваторий в реальном масштабе времени. В настоящее время проводятся работы по существенной модернизации системы, связанные с необходимостью предоставления данных с высоким временным разрешением. В общую систему включены измерения интенсивности космических лучей (данные высокогорного нейтронного супермонитора НМ-64, расположенного на высоте 3340 м над уровнем моря), напряженности магнитного поля Земли (данные геомагнитной обсерватории "Алма-Ата"), плотности потока радиоизлучения Солнца (2740 м над уровнем моря). База данных дополняется новыми видами измерений: гамма-квантов вторичного космического излучения и интенсивности тепловых нейтронов (высота 3340 м над уровнем моря). Для создания центра сбора, хранения и обработки гелиогеофизических данных с высоким временным разрешением в режиме реального времени организована передача оперативных экспериментальных данных в центр сбора данных, разработано программное обеспечение для графического представления оперативной и архивной экспериментальной информации с гелиогеофизических обсерваторий. Создаваемая система сбора, хранения и представления данных сети обсерваторий Казахстана в режиме реального времени предусматривает доступ через Интернет в интерактивном режиме к оперативным и архивным данным гелиогеофизических измерений с высоким временным разрешением как для казахстанских исследователей, так и для мирового научного сообщества.

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Беспроводная интеллектуальная среда измерения, передачи и обработки сведений о характеристиках материалов, изделий

Изложены вопросы инновационного использования интеллектуальных сред и систем в измерении характеристик изделий, материалов. Рассмотрены: состав, содержание, структурная схема созданной интеллектуальной системы, включающей три уровня: физический, сетевой и программный, технологии,

особенности ее использования. Физический уровень включает сенсоры, микроконтроллеры, приемо-передатчики, компьютер; сетевой уровень – беспроводный. Поскольку данная система ориентирована на измерения цветовых характеристик материалов текстильной, целлюзно-бумажной, лакокрасочной промышленности, как готовых изделий, так и в процессе их изготовления, программное обеспечение реализует алгоритм, основанный на имитационной математической модели представления сенсорных данных, синтеза и разложения цвета, полученной и подтвержденной в результате обработки методами математической статистики экспериментальных данных по цветовым характеристикам различных материалов. Результаты измерений цветовых характеристик программно обрабатываются и наглядно выводятся. включая изображение контролируемого цвета материала в естественном виде, полученном путем синтеза его четырех основных составляющих цветов, а также дифференцированно в числовом и натуральном виде по каждому из этих цветов. Реальная апробация системы на примере изделий целлюзно-бумажной, текстильной промышленности показала ее преимущества при проведении измерений цветовых характеристик материалов по сравнению с существующими приборными методами. Для 160-и различных текстильных материалов организована актуальная база данных цветовых характеристик.Представленная система может быть успешно использована и в других различных приложениях, использующих сенсорные технологии.

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Оптимизация непрерывных линейных систем с ограниченным управлением

Введение. Рассматривается задача оптимального управления (ЗОУ) нестационарными линейными системами при наличии внешних воздействий. В основе решения ЗОУ при построении программного управления лежит принцип максимума Понтрягина. Решение этой же задачи при синтезе оптимального управления с обратной связью основано на методе динамического программирования. Разработка различных способов построения регуляторов и соответствующих алгоритмов управления, обладающих необходимыми для приложений свойствами с учетом ограничений на управление, является актуальной задачей современных информационных технологий.

Постановка задачи. Рассмотрим управляемую линейную систему:

$$\dot{x} = A(t)x + B(t)u + f(t), \quad t \in [t_0,\, T], \quad x(t_0) = x_0, \tag{1}$$

$$u(t) \in U(t) = \{u \mid \alpha(t) \le u(t) \le \beta(t), \;\; t \in [t_0,\, T]\}, \tag{2}$$

где $x(t)$ — n-вектор состояния объекта; $u(t)$ — m-вектор управления.

Пусть задан функционал, который зависит от управления и состояния объекта:

$$J(u) = \frac{1}{2}\int_{t_0}^{T} [x^* Q(t)x + u^* R(t)u]\, dt + \frac{1}{2}x^*(T)Fx(T). \tag{3}$$

Требуется найти синтезирующее управление $\tilde{u}(t)$ такое, что соответствующая ему пара $\{\tilde{x}(t), \tilde{u}(t)\}$ доставляет минимальное значение функционалу (3) и удовлетворяет уравнению (1) при ограничениях на управление (2). Для решения ЗОУ (1)-(3) использован метод, основанный на применении множителей Лагранжа специального вида [1, 2].

Теорема. Для оптимальности пары $\{\tilde{x}(t), \tilde{u}(t)\}$ в задаче (1)-(3), необходимо и достаточно, чтобы она удовлетворяла дифференциальному уравнению вида

$$\dot{x} = A_1(t)x - B_1(t)q(t) + B(t)\varphi(x,\ t) + f(t), \quad t \in [t_0,\ T], \quad x(t_0) = x_0. \tag{4}$$

Управление $\tilde{u}(x(t),\ t)$ определяется следующим образом:

$$\tilde{u}(x(t),\ t) = -R^{-1}(t)\left\{B^*(t)\left[K(t)x(t) + q(t)\right] - \lambda_1(t) + \lambda_2(t)\right\}, \tag{5}$$

где функция $\lambda_0 = K(t)x + q(t)$ обеспечивает выполнение ограничения в виде системы дифференциальных уравнений (1), а функции $\lambda_1(t)$ и $\lambda_2(t)$ – соответствующих ограничений (2), налагаемых на управления.

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Иммунносетевая технология управления сложными объектами на базе вычислительных кластеров с использованием виртуальных машин

Развитие новых информационных технологий и инструментов создания виртуальных сред для моделирования производственных процессов привели к возможности разработки современных систем автоматического управления сложными промышленными объектами на основе интеграции классической теории управления и методов исскусственного интеллекта. Алгоритмы искусственного интеллекта, такие как искусственные иммунные системы (ИИС) [1],

генетические алгоритмы, нейронные сети позволяют корректировать стратегию управления за счет способности адаптироваться, подобно живым организмам, в условиях неопределенности параметров. Современные предприятия характеризуются огромным количеством производственных данных, своевременный мониторинг и анализ архивов сообщений позволяет прогнозировать производственные риски и предотвращать аварийные ситуации. При этом к системе автоматизации предъявляются высокие требования надежности и стабильности работы всех аппаратных и программных средств. В связи с этим актуально развитие технологии, позволяющей деликатно внедрить интеллектуальную систему управления на предприятии. Очень удобным в этом плане является перспективное направление работы с виртуальными машинами. Вычислительный кластер может создаваться на базе компьютерного потенциала предприятия для осуществления параллельной обработки потоков данных, поступающих с объектов управления. С помощью виртуальных машин реализуется сеть из нескольких компьютеров, на них тестируется работа вычислительного кластера и распределенного иммунносетевого алгоритма управления [2], а затем подключается к реальной сети предприятия. Данный подход, можно применять не только для динамических систем промышленной автоматизации, но и для ряда других приложений [3].

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Развитие информационно-телекоммуникационных и вычислительных технологий для работы с научными данными На Дальнем Востоке России

На Дальнем Востоке России располагаются учреждения, проводящие фундаментальные и прикладные научные исследования по важнейшим проблемам естественных, технических, общественных и гуманитарных наук. Огромная территория, необходимость решения задач по сбору, обработке и обмену

научной информацией, обеспечение удаленного доступа и управления средствами инструментальных наблюдений и другие актуальные задачи формируют объективные потребности в использовании широкого спектра информационных, телекоммуникационных и вычислительных технологий. В Дальневосточном отделении РАН создана одна из крупнейших некоммерческих сетей региона – Региональная компьютерная сеть ДВО РАН, объединяющая 26 научных учреждений Федерального агентства научных организаций России. Помимо этого, на базе Вычислительного центра ДВО РАН организован Центр данных, где ведется разработка и внедрение ИТ-технологий для работы научными данными. В качестве успешных проектов, в этом направлении, можно выделить такие как:

информационная система «Грант ДВО РАН», предназначенная для решения всего комплекса задач, связанных с проведением конкурсов научных проектов Дальневосточного отделения РАН [1];

программная платформа для создания проблемно-ориентированных интерфейсов для пакетов прикладных программ с целью проведения расчетов в распределенных вычислительных системах [2];

отказоустойчивая информационная система для облачного хранения наборов научных данных [3];

автоматизированная информационная система «Сигнал» для работы с данными сетей инструментальных наблюдений ДВО РАН [4].

За последние 10 лет в Дальневосточном отделении РАН завершено формирование базовой телекоммуникационной и вычислительной инфраструктуры, предоставляющей возможности ученым проводить работы с использованием самых современных информационных технологий. Полученные результаты позволили приступить к реализации проектов, связанных с построением распределенных информационных систем для проведения масштабных комплексных исследований в области наук о Земле. Дальнейшее развитие телекоммуникационных систем на Дальнем Востоке России и увеличение пропускной способности каналов Сети позволит в перспективе перейти к созданию информационных систем и сервисов нового уровня, позволяющих говорить о формировании единого научного информационного пространства региона.

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Разработка компьютерной программы прогнозирования опустывания территории Северо-Казахстанской области

Вегетационный индекс (ВИ) - показатель, рассчитываемый в результате операций с разными спектральными диапазонами (каналами) данных дистанционного зондирования, и имеющий отношение к параметрам растительности в данном пикселе снимка. Эффективность ВИ определяется особенностями отражения; эти индексы выведены, главным образом, эмпирически.

Главным преимуществом вегетационных индексов является легкость их получения и широкий диапазон решаемых с их помощью задач. Так, NDVI часто используется как один из инструментов при проведении более сложных типов анализа, результатом которых могут являться карты продуктивности лесов и сельскохозяйственных земель, карты ландшафтов и природных зон, почвенные, аридные, фито-гидрологические, фенологические и другие эколого-климатические карты [1,2].

Использование индекса условий вегетации IVI, IVCI, SPI, ГТК позволяет учесть естественное изменение спектральных характеристик растительности в течение вегетационного периода, уменьшает влияние природных факторов (погодных условий, экосистемных изменений, почвенных, топографических условий), позволяет сравнивать между собой отсчеты NDVI в разных природных зонах, разных ландшафтах и при разных погодных условиях.

В результате проведенных исследований по полученным вегетационным индексам (IVI, IVCI, SPI, ГТК) предоставленной РГП "Казгидромет"был проведен анализ Акмолинской, Костанайской, Северо-Казахстанской области.

Разработана математическая модель и алгоритм расчета тенденции процессов опустынивания территории Республики Казахстан для Акмолинской, Костанайской, Северо - Казахстанской области. На основе корреляционного анализа были рассмотрены различные методы, выбраны наиболее оптимальные методы анализа данных. Рассчитана степенная функция, экспоненциональная функция, методы экстраполяции, а именно - метод скользящей средней, метод экспоненциального сглаживания, метод наименьших квадратов.

Результаты полученных расчетов дают качественное и количественное согласие с экспериментальными данными.

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