FEFU FAR EASTERN FEDERAL UNIVERSITY

AMUR STATE UNIVERSITY AmSU 1975

PROGRAM and ABSTRACTS

WORKSHOP ON COMPUTING TECHNOLOGIES AND APPLIED MATHEMATICS

FAR EASTERN FEDERAL UNIVERSITY

VLADIVOSTOK

JULY 11–15, 2022

The International Workshop on Computing Technologies and Applied Mathematics provides a forum for experts and researchers to exchange original results and valuable ideas in different aspects of using computing technologies and advanced methods of applied mathematics in science and engineering.

Organized by Far Eastern Federal University and Amur State University

PROGRAM COMMITTEE

Prof. Alexander Chebotarev
Prof. Valeriya Gribova
Prof. Andrey Kovtanyuk
Prof. Anna Maslovskaya
Prof. Evgeni Nurminski
Prof. Sergey Shary

ORGANIZING COMMITTEE

Prof. Alexander Samardak
Prof. Andrey Plutenko
Dr. Lubov Yatsevich
Dr. Elena Veselova
Mr. Andrei Sushchenko
Mr. Nikolai Park

CONFERENCE VENUE

Far Eastern federal University (Ajax Bay 10, Russky Island, 690922 Vladivostok, Russia)

WORKSHOP HOST

Far Eastern Center for Research and Education in Mathematics

TOPICS

- Computer technologies and data analysis in engineering and bioinformatics
- Mathematical modeling and computer simulation of physical and biological phenomena
- Optimization-based simulation for complex systems
- High performance scientific computing in applications

July 11 Monday

Location: Column Conference Hall, Building B, Level 6

Time	Announce
16:00–17:30	Arrival day **Registration**
17:00–19:00	Welcome Party

July 12 Tuesday

Location: Pacific Rim Hall (“Tihookeanskij Rubezh”, “Tochka Kipeniya”), Building A, Level 8

Time	Announce
8:30–9:00	Late Registration
9:00–9:30	**Workshop Opening** **Evgeni Nurminski** *Far Eastern Mathematical Center* **Andrey Plutenko** *Amur State University* **Alexander Samardak** *Far Eastern Federal University*
Plenary Session **Chair: Evgeni Nurminski**	
9:30–10:15	**Sergey Shary** SOLVING DATA FITTING PROBLEMS UNDER INTERVAL UNCERTAINTY *Novosibirsk State University*
10:15–11:00	**Nataliya Stankevich** MATHEMATICAL MODELLING OF PATHOLOGICAL DYNAMICS OF NEURON-LIKE NETWORKS *National Research University Higher School of Economics*
11:00–11:30	**Coffee Break**
Session # 1 **Chair: Vladimir Pimenov**	
11:30–11:50	**Alexey Rukavishnikov** INFLUENCE OF WEIGHTED FUNCTION EXPONENT IN WFEM ON ERROR OF SOLUTION FOR HYDRODYNAMIC PROBLEMS WITH SINGULARITY *Khabarovsk Federal Research Center FEB RAS*
11:50–12:10	**Anna Ryabokon,** Oleg Tkachenko, Viktor Rukavishnikov FINITE ELEMENT ANALYSIS OF MATHEMATICAL MODEL FOR PIPE SYSTEM *Khabarovsk Federal Research Center FEB RAS*
12:10–12:30	Andrey Kovtanyuk[1], **Evgeni Marushchenko**[2], Renée Lampe[1] FINITE ELEMENT MODELING OF THE MICROVASCULAR BLOOD FLOW [1] *Technical University of Munich* [2] *Far Eastern Federal University*
12:30–12:50	**Ekaterina Tashirova**, Vladimir Pimenov COMPUTER IMPLEMENTATION OF NUMERICAL METHODS FOR SOLVING FRACTIONAL DIFFUSION EQUATIONS WITH DRIFT TERM AND FUNCTIONAL DELAY *Ural Federal University*
12:50–13:10	**Lubov Moroz**, Anna Maslovskaya 2D TIME-FRACTIONAL MODEL OF DIFFUSION-WAVE PROCESSES AND COMPUTING TECHNIQUES FOR ITS BIOLOGICAL APPLICATION *Amur State University*

Time	Announce
13:10–14:00	**Lunch**
Session # 2 **Chair: Alexander Chebotarev**	
14:00–15:30	**Aleksandr Gonchenko**[1], Evgeniya Samylina[2] CHAOTIC DYNAMICS IN THE NONHOLONOMIC MODELS OF CELTIC STONE [1] *Lobachevsky State University of Nizhny Novgorod*, [2] *National Research University Higher School of Economics*
14:20–14:40	**Elena Chausova** MODEL PREDICTIVE CONTROL OF CONSTRAINED DYNAMIC SYSTEMS WITH INTERVAL AND STOCHASTIC UNCERTAINTY AND ITS APPLICATION IN SUPPLY CHAIN MANAGEMENT *Tomsk State University*
14:40–15:00	**Alexander Prolubnikov** ON THE REPRESENTATIVENESS OF APPROXIMATE SOLUTIONS OF DISCRETE OPTIMIZATION PROBLEMS WITH INTERVAL OBJECTIVE FUNCTION *Omsk State University*
15:00–15:20	**Andrey Kovtanyuk**[1]**,** Alexander Chebotarev[2], Tim Seleznev[2], Renée Lampe[1] OPTIMIZATION PROBLEM OF CEREBRAL OXYGEN TRANSPORT [1] *Technical University of Munich* [2] *Far Eastern Federal University*
15:20–15:40	**Nadezhda Maksimova**[1], Roman Brizitskii[2] INVERSE PROBLEM FOR ELECTRON DIFFUSION COEFFICIENT RECOVERING [1] *Amur State University* [2] *Institute of Applied Mathematics FEB RAS*
15:40–16:00	Roman Brizitskii, **Zhanna Saritskaia** BOUNDARY CONTROL PROBLEMS FOR NONLINEAR REACTION-DIFFUSION-CONVECTION MODEL *Institute of Applied Mathematics FEB RAS*
16:00–16:30	**Coffee Break**
16:30–16:50	Roman Brizitskii[1], **Angelina Donchak**[2], Anna Brizitskaya[2] MATHEMATICAL MODEL OF GAMMA OPTION GREEK BASED ON THE REACTION-DIFFUSION EQUATION [1] *Institute of Applied Mathematics FEB RAS* [2] *Far Eastern Federal University*
16:50–17:10	Robert Namm[1], **Georgiy Tsoy**[1], Ellina Vikhtenko[2] ON THE CONVERGENCE OF THE METHOD OF SUCCESSIVE APPROXIMATIONS FOR THE QUASI-VARIATIONAL SIGNORINI INEQUALITY [1] *Khabarovsk Federal Research Center FEB RAS* [2] *Pacific National University*
17:10–17:30	**Alexander Zhiltsov** MODELING A BODY CONTAINING A THIN DEFECT WITH A PARAMETER *Far Eastern State Transport University*

July 13 Wednesday

Location: Pacific Rim Hall ("Tihookeanskij Rubezh", "Tochka Kipeniya"), Building A, Level 8

Time	Announce
Plenary Session **Chair: Sergey Shary**	
9:00–9:45	**Vladimir Pimenov** NUMERICAL METHODS FOR SYSTEMS OF DIFFUSION AND SUPERDIFFUSION EQUATIONS WITH NEUMANN BOUNDARY CONDITIONS AND WITH FUNCTIONAL DELAY *Ural Federal University*
9:45–10:30	Plenary Talk **Anna Maslovskaya** COMPUTATIONAL TECHNIQUES FOR MODELING OF BACTERIAL COMMUNICATION UNDER VARYING DYNAMICAL REGIMES OF EXTERNAL EXPOSURE *Amur State University*
10:30–11:00	**Coffee Break**
Session # 3 **Chair: Andrey Kovtanyuk**	
11:00–11:20	**Sergey Gordin** SIMULATION MODELING OF DYNAMIC PROCESSES IN DISTRICT HEATING'S *Komsomolsk-na-Amure State University*
11:20–11:40	Konstantin Nefedev[1], **Igor Nalivaiko**[2], Mikhail Chesnokov[1], Vladislav Strongin[1], Konstantin Soldatov[1] DEVELOPMENT OF AN ALGORITHM FOR NUMERICAL CALCULATION OF THERMODYNAMIC CHARACTERISTICS OF TRIMERIZED AND TRIDENT LATTICES DIPOLE SUPERSPIN ICE [1] *Far Eastern Federal University* [2] *Institute of Applied Mathematics FEB RAS*
11:40–12:00	Oxana Zhdanova, **Galina Neverova** MATHEMATICAL MODELING OF THE EVOLUTIONARY DYNAMICS OF PLANKTON COMMUNITY *Institute for Automation and Control Processes FEB RAS*
12:00–12:20	**Nikolai Park**[1], Alexander Chebotarev[1], Andrey Kovtanyuk[2] COMPUTER MODELING OF COMPLEX HEAT TRANSFER WITH MOVING SOURCES [1] *Far Eastern Federal University* [2] *Technical University of Munich*
12:20–12:40	Konstantin Nefedev[1], **Mikhail Chesnokov**[1], Igor Nalivaiko[2], Vladislav Strongin[1], Konstantin Soldatov[1] THE DEVELOPMENT OF AN ALGORITHM FOR CALCULATING THE DENSITY OF STATES FOR ISING-TYPE MODELS [1] *Far Eastern Federal University* [2] *Institute of Applied Mathematics FEB RAS*
12:40–13:00	**Elena Veselova**[1], Anna Maslovskaya[1], Alexander Chebotarev[2] COMPUTER SIMULATION OF FERROELECTRIC DOMAIN STRUCTURE DYNAMICS: IMPLEMENTATION IN COMSOL MULTIPHYSICS [1] *Amur State University* [2] *Far Eastern Federal University*
13:00–14:00	**Lunch**
Session # 4 **Chair: Konstantin Nefedev** Administrator of online session (MS TEAMS): Andrei Sushchenko (sushchenko.aa@dvfu.ru) See the link to the online session on https://ctam.amursu.ru/conference-program/	

Time	Announce
14:00–14:15	**Zhengmao Ye** FUZZY ADAPTIVE CONTROL FOR TARGET TRACKING SIMULATION OF AUTONOMOUS VEHICLES *Southern University (USA)*
14:15–14:30	Polina Vinogradova, **Albert Livashvili** SIMULATION DYNAMICS OF THE NANOPARTICLES IN A LIQUID-PHASE MEDIUM, TAKING INTO ACCOUNT THE CONCENTRATION DEPENDENCE OF THE VISCOSITY COEFFICIENT *Far Eastern State Transport University*
14:30–14:45	Lyubov Grishina[1], **Arthur Zhigalov**[1], Irina Bolodurina[3], Evgeniy Borshhuk[2], Dmitry Begun[2], Yulia Varennikova[3] DATA REPRESENTATION FOR A CARDIOVASCULAR DISEASE PREDICTIVE MODEL BY DEEP LEARNING METHODS *[1] Orenburg State University,* *[2] Orenburg State Medical University of the Ministry of Healt* *[3] Medical Information and Analytical Center of the Orenburg region*
14:45–15:00	**Alexey Golubev** MODELING AND SIMULATION OF CEREBRAL BLOOD FLOW AUTOREGULATION CONSIDERED AS AN OUTPUT REGULATION CONTROL PROBLEM *Ishlinsky Institute for Problems in Mechanics RAS*
15:00–15:15	**Vladimir Bogdanov**[1], Igor Chabunin[2], Semen Silaev[2], Yaroslav Oreshin[2] SHOCK-ABSORBING DEVICES BASED ON TOROIDAL THIN-SHELL STRUCTURES AND ALGORITHMS FOR THEIR CALCULATIONS *[1] Moscow Higher Combined-Arms Command School; State University of Management* *[2] Moscow Higher Combined-Arms Command School*
15:15–15:30	**Ivan Kazantsev**[1], Rauan Turebekov[2], Murat Sultanov[2] REMOVAL OF STRIPE NOISE IN REMOTE SENSING IMAGES USING RIDGE FUNCTIONS *[1] The Institute of Computational Mathematics and Mathematical Geophysics* *[2] Khoja Akhmet Yassawi International Kazakh-Turkish University*
15:30–16:00	**Coffee Break**
15:45–16:00	**Andrei Banshchikov** SYMBOLIC COMPUTATION IN ANALYSIS OF DYNAMICS OF ORBITAL GYROSTAT *Matrosov Institute for System Dynamics and Control Theory SB RAS*
16:00–16:15	**Andrey Kechahmadze**, Yury Kosolapov DETECTION METHOD OF ILLEGITIMATE CODE EXECUTION *Southern Federal University*
16:15–16:30	**Artem Menisov** THE METHODS FOR DETECTING AND NEUTRALIZING INFORMATION SECURITY THREATS OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES *A.F. Mozhaysky Military-Space Academy*
16:30–16:45	**Murat Sultanov**[1], Vladimir Misilov[2], Yerkebulan Nurlanuly[1] EFFICIENT PARAREAL ALGORITHM FOR SOLVING TIME-FRACTIONAL DIFFUSION EQUATION *[1] Khoja Akhmet Yassawi International Kazakh-Turkish University (Kazakhstan)* *[2] N.N. Krasovskii Institute of Mathematics and Mechanics UB RAS*
16:45–17:00	**Vladimir Bogdanov**, Igor Chabunin, Vitaly Peyders, Roman Mukhin COMPUTER SIMULATION OF KINEMATIC EFFECT ON THE DRIVER OF SOLID MODELS OF WHEELED AND TRACKED VEHICLES *Moscow Higher Combined-Arms Command School*
17:00–17:15	**Wang Fengling** APPLICATION OF LAGRANGE RELAXATION METHOD TO MAXIMUM COVERAGE PROBLEM *Heihe University (China)*

July 14 Thursday

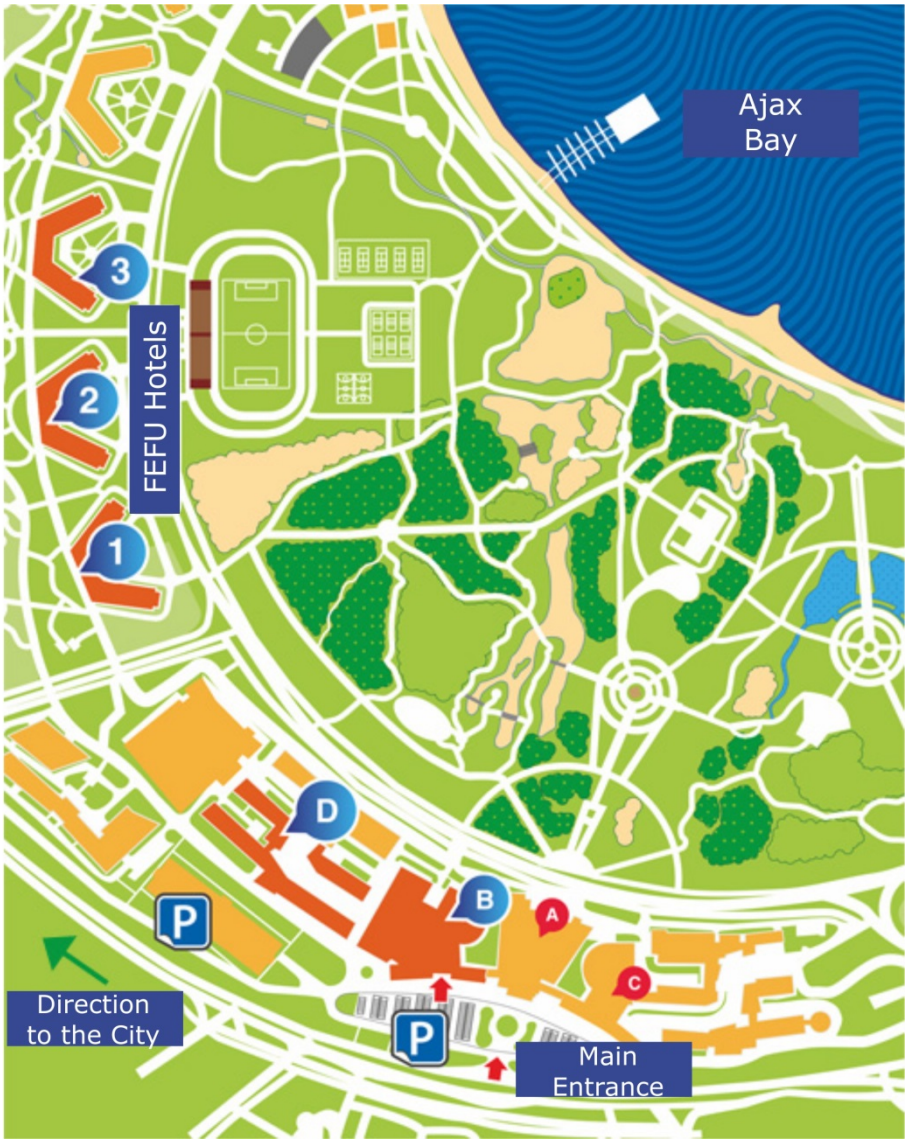
Location: Pacific Rim Hall ("Tihookeanskij Rubezh", "Tochka Kipeniya"), Building A, Level 8

Time	Announce
Plenary Session **Chair: Alexander Chebotarev**	
9:00–9:45	**Gennady Alekseev** INVISIBILITY PROBLEM IN ELECTROMAGNETISM, ACOUSTICS AND HEAT CONDUCTION. INVERSE DESIGN METHOD *Institute of Applied Mathematics FEB RAS, Far Eastern Federal University*
9:45–10:30	**Oleg Tkachenko** COMPUTATIONAL SIMULATION OF NONLINEAR DYNAMIC BENDING OF A CURVED CYLINDRICAL SHELL *Khabarovsk Federal Research Center FEB RAS*
10:30–11:00	**Coffee Break**
Session # 5 **Chair: Gennady Alekseev**	
11:00–11:20	**Ivan Yarovenko**[1], Igor Prokhorov[1], Ivan Kazantsev[2] SCATTER CORRECTION TECHNIQUE USING MULTIPLE-IMPULSE SOURCES IN COMPUTED TOMOGRAPHY [1] *Institute of Applied Mathematics FEB RAS* [2] *The Institute of Computational Mathematics and Mathematical Geophysics*
11:20–11:40	**Evgeny Kovalenko**, Andrei Sushchenko MULTI-ANGLE FOCUSING OF HYDROACOUSTIC IMAGES OBTAINED FROM SIDE-SCAN SONAR *Far Eastern Federal University*
11:40–12:00	Igor Prokhorov[1], **Polina Vornovskikh**[1], Evgeny Ermolaev[2] COMPARATIVE ANALYSIS OF THE ERROR OF THE SINGLE SCATTERING APPROXIMATION FOR 2D AND 3D IMPULSE OCEAN SOUNDING MODELS [1] *Institute of Applied Mathematics FEB RAS* [2] *Far Eastern Federal University*
12:00–12:20	**Aleksei Kashirin**, Sergei Smagin NUMERICAL SOLVING OF BOUNDARY INTEGRAL EQUATIONS OF SCATTERING PROBLEMS AT IRREGULAR FREQUENCIES *Khabarovsk Federal Research Center FEB RAS*
12:20–12:40	**Yuliya Spivak** COMPUTER DESIGN OF CYLINDRICAL CLOAKING SHELL FOR THE MAGNETOSTATICS MODEL *Institute of Applied Mathematics FEB RAS* *Far Eastern Federal University*
12:40–13:00	**Alexey Lobanov** NUMERICAL SOLUTION OF CLOAKING PROBLEM FOR 3D MODEL OF ELECTROSTATICS IN THE PRESENCE OF ANISOTROPIC LAYER *Institute of Applied Mathematics FEB RAS* *Far Eastern Federal University*
13:00–13:20	Andrei Sushchenko, **Elizaveta Liu** INVESTIGATION OF SEABED MORPHOLOGY USING OPTICAL TECHNIQUES *Far Eastern Federal University*
13:20–14:00	**Lunch**
14:00	**Social Program**
18:00	**Conference Dinner**

July 15 Friday

Location: Hilltop ("Sopka") Conference Hall, Building B, Level 7

Time	Announce
Plenary Session **Chair: Oleg Tkachenko**	
9:00–9:45	**Evgeni Nurminski** PROJECTION ALGORITHMS AND VERY LARGE-SCALE OPTIMIZATION *Far Eastern Federal University*
9:45–10:30	**Konstantin Nefedev** INFORMATION ERA *Far Eastern Federal University*
10:30–11:00	**Coffee Break**
Session # 6 **Chair: Evgeni Nurminski**	
11:00–11:20	Luybov Grishina[1], Arthur Zhigalov[1], **Irina Bolodurina**[1], Alexander Lositsky[2], Evgeny Borshchuk[3], Alexandra Voronina[2] INTELLIGENT SYSTEM FOR AUTOMATIC IMAGE DESCRIPTION OF OPTICAL COHERENCE TOMOGRAPHY [1] *Orenburg State University* [2] *Fyodorov Eye Microsurgery Federal State Institution* [3] *Orenburg State Medical University of the Ministry Health*
11:20–11:40	Elena Amosova, **Kirill Kuznetsov** MACHINE LEARNING FOR SOLVING THE INVERSE AND SUBDIFFERENTIAL BOUNDARY VALUE PROBLEM OF COMPLEX HEAT TRANSFER *Far Eastern Federal University*
11:40–12:00	Evgeni Nurminski[1], **Aleksander Zatserkovnyy**[2] PROCESSING OF PUBLIC VIDEO CAMERAS DATA FOR CITY TRAFFIC ESTIMATION [1] *Far Eastern Federal University* [2] *V.I. Il'ichev Pacific Oceanological Institute FEB RAS*
12:00–12:20	**Andrei Velichko** CLOUD SIMULATION SERVICE FOR PRODUCTION LOCATION PROBLEM *Far Eastern Federal University*
12:20–12:40	**Alexey Smagin**[1]**,** Sergey Smagin[2] SEMANTIC SEGMENTATION OF MESHED FENCING CONSTRUCTIONS AND SEARCHING BREAKS [1] *Mining Institute FEB RAS* [2] *Khabarovsk Federal Research Center FEB RAS*
12:40–13:00	Tatiana Pak, **Aleksei Akulov**, Anna Bezotosnaia THE MATHEMATICS A CLASSIFICATION SYSTEM FOR STREAMING OR RECORDED SPEECH USING ALGORITHMS OF ARTIFICIAL RECURRENT NEURAL NETWORKS OF THE LONG SHORT-TERM MEMORY ARCHITECTURE *Far Eastern Federal University*
13:00	**Discussion** **Evgeni Nurminski** FAR EASTERN CENTER FOR RESEARCH AND EDUCATION IN MATHEMATICS: CURRENT STATUS, MODERN CHALLENGES AND PROSPECTS *Far Eastern Federal University*
13:30	**Workshop closing**


Ajax
Bay
FEFU Hotels
3
2
1
D
B
A
C
P
P
Direction
to the City
Main
Entrance

Solving data fitting problems under interval uncertainty

Sergey Shary

Federal Research Center for Information and Computational Technologies
shary@ict.nsc.ru

Key words: interval uncertainty, data fitting, weak compatibility, strong compatibility, maximum compatibility method

In our work, we develop a practical technique - maximum compatibility method - for computing estimates for the parameters of linear regressions under interval uncertainty, discuss the interpretation of the estimates obtained and their features.

Mathematical modelling of pathological dynamics of neuron-like networks

Nataliya Stankevich

HSE University
stankevichnv@mail.ru

Key words: mathematical modelling, neuron-like network, Hodgkin-Huxley-type model, pathological behavior, dynamical systems

Mathematical modeling is one of the easiest ways to study the behavior of complex system uncluding neuron networks. In this case, it is convenient to use dynamical systems as an object of study. Emergence of undesired dynamics in systems of interacting cells is often associated with pathological conditions. However, how such conditions can be stabilized on a population level from dysregulation on the level of single cells is unclear. Using the generic Hodgkin–Huxley formalism to describe physiological bursting activity of neuron-like-cells, we study here how a dysregulation on a single cell level can dominate the dynamics of the cellular population. The dysregulation is mimicked by introducing a potassium-like ion channel with a decreased opening probability due to non-monotonic voltage dependence, which subsequently stabilizes a silent state in addition to the bursting activity. We found that when all of the cells have acquired channel defects, a coupling range exists for which the silent pathological state is a dominant dynamical behavior of the system, despite the small basin of attraction of the silent state on the single cell level. We considered different topologies of networks including homogeneous, heterogeneous, multiplex heterogeneous and star-like networks.

Influence of Weighted Function Exponent in WFEM on Error of Solution for Hydrodynamic Problems with Singularity

Alexey Rukavishnikov

Computing Center of the Far Eastern Branch of the Russian Academy of Sciences, Khabarovsk
78321a@mail.ru

Key words: Navier-Stokes equations, weighted FEM, corner singularity

The concept of an R_v-generalized solution for a hydrodynamic problem with reentrant corner on the boundary of a polygonal domain is defined. An approximate method for

solving the problem is constructed. A numerical analysis is carried out and the question of the influence of the weighted function exponent in the weighted finite element method on the error of the solution in the vicinity of the reentrant corner in the norm of the space $C(\overline{\Omega})$ is experimentally studied. A comparative analysis has been carried out and the advantage of the weighted method over the classical approach has been shown.

Finite Element Analysis of Mathematical Model for Pipe System

Anna Ryabokon, Oleg Tkachenko, Viktor Rukavishnikov

Computing Center of the Far Eastern Branch of the Russian Academy of Sciences
anyuta.riabokon@yandex.ru, olegt1964@gmail.com, vark0102@mail.ru

Key words: finite element analysis, intersecting shells, mathematical model

A pipeline section with irregular geometry is considered. The equilibrium of this mechanical system is described by reduced differential equations from two independent variables in Cartesian coordinates. Part of conjugation conditions is replaced by the sleeve contact on the intersection line, as a result of which both the computational domain and the system of equations are divided into independent ones. A three-dimensional model of the original problem in CAD system is constructed. An analysis by the finite element method is carried out, in which the geometric parameters of the system, algorithms for constructing meshes, dimension of finite elements, and types of pipe connections are varied. Permissible error of replacing the full contact conditions with the sleeve contact is obtained.

Finite element modeling of the microvascular blood flow

Andrey Kovtanyuk, EvgeniMarushchenko

Far Eastern Federal University
kovtanyu@ma.tum.de, maruschin@gmail.com

Key words: blood flow in microvessels, finite element modeling, Stokes equation

A numerical algorithm based on the Finite element method to simulate the blood flow in microvessels is constructed and implemented. The results of the finite element modeling is compared with in vitro data to choose optimal boundary conditions.

Computer implementation of numerical methods for solving fractional diffusion equations with drift term and functional delay

Ekaterina Tashirova, Vladimir Pimenov

Ural Federal University
linetisa@yandex.ru, v.g.pimenov@urfu.ru

Key words: numerical methods, fractional diffusion equations, functional delay, numerical experiments

The presence of fractional time derivatives in diffusion equations in combination with the nonlinear delay effect requires a complex technique of fractional discrete Gronwall inequalities to prove convergence. The additional presence of a term with the first derivative (drift term), on one hand, complicates the numerical algorithms of the solution, on the other hand, simplifies the technique of error research. Previously developed and

sufficiently effective algorithms based on the Alikhanov method have been investigated, but only for constant concentrated delay. In this paper, computer calculations are performed for various numerical methods for equations with the effect of functional delay, for example, for variable or distributed delay. This effect requires additional interpolation and extrapolation.

A test research of a purely implicit method, analogous Crank-Nicholson method in combination with the L1-method and modified L1-method for calculating the fractional integral, an analogue of the Alikhanov method was performed. The first method uses piecewise constant interpolation, the other methods use piecewise linear interpolation of the discrete history of the model. All methods use extrapolation by extending. The results of computer experiments represent good consistency with the theoretical results of investigation of the error orders.

2D time-fractional model of diffusion-wave processes and computing techniques for its biological application

Lubov Moroz, Anna Maslovskaya

Amur State University
LubovеP@mail.ru, maslovskayaag@mail.ru

Key words: diffusion-wave equation, fractional derivative, finite-difference scheme, bacterial population, bacteria communication model, computational experiment

Model descriptions of many phenomena of diffusive nature, representing spatial and temporal changes in substance concentrations accompanying the complex processes often do not agree with the real observations. Such processes can be accompanied by significant gradient changes in the analyzed characteristics or a very long waiting time for aftereffects. One approach to constructing mathematical models of nonstandard diffusion and transport phenomena in heterogeneous, complex-structured and hereditary systems is based on the use of the analytical apparatus of fractional calculus. For example, time-fractional PDEs allow us to describe time memory effects which are common for different bacterial species.
In the present study, we develop the computational techniques for the time-fractional model of reaction-diffusion processes as a generalization of the classical model to analyze various dynamical regimes in complex systems. By varying the orders of fractional derivatives, we can get equations describing diverse processes: subdiffusion (slow wandering), classical diffusion, and superdiffusion (accelerated wandering).
The computational algorithm is constructed by means of implicit finite-difference schemes supplemented by an iterative procedure. The program application is developed in Matlab for numerical simulation of the diffusion-wave process. The comparison analysis of simulation results for Caputo, Grünwald-Letnikov and integer derivatives was carried out. In addition, we applied the designed program for computer simulation of bacterial cooperative behavior. Computational experiments indicate the realistic time-dependent fluctuations of signal compounds corresponding to the superdiffusion mode.

CHAOTIC DYNAMICS IN THE NONHOLONOMIC MODELS OF CELTIC STONE

Aleksandr Gonchenko[1], Samylina Evgeniya[2]

[1]*Lobachevsky State University of Nizhny Novgorod*
agonchenko@mail.ru

[2]*National Research University Higher School of Economics, Nizhny Novgorod*
samylina_evgeniya@mail.ru

Key words: nonholonomic model, strange attractor, mixed dynamics, Lorenz discrete attractor

We study dynamical properties of a Celtic stone moving along the plane. Both one- and two-parameter families of the corresponding nonholonomic models are considered, in which bifurcations are studied that lead to changing types of stable motions of the stone and also to the onset of chaotic dynamics. We also show that chaotic dynamics of the nonholonomic model of Celtic stone can be very diverse: there are observed both strange attractors of various types(in particular, discrete Lorenz-like attractors and Shilnikov spiral attractors) and mixed dynamics, when attractor and repeller intersect and almost coincide.

This work was supported by the grant of the Ministry of Science and Higher Education of the Russian Federation agreement No. 075-15-2019-1931 at the Laboratory of Dynamic Systems and Applications of the National Research University Higher School of Economics. A. Gonchenko thanks Russian Science Foundation, grant 20-71-10048 (Numerical study of Shilnikov spiral attractors)

Model predictive control of constrained dynamical systems with interval and stochastic uncertainty and its application in supply chain management

Elena Chausova

Tomsk State University
chauev@mail.ru

Key words: linear dynamic system, interval analysis, model predictive control, interval-stochastic uncertainty, multi-objective optimization, quadratic programming, inventory control, supply chain

The paper is devoted to a discrete-time linear system with constraints on states and control inputs under conditions of interval and stochastic uncertainty. We use the model predictive control approach and derive the optimal controls by minimizing the expected quadratic performance index with constraints and interval assigned uncertain inputs. We reduce the problem to a quadratic programming problem using the interval analysis tools and the multiple-objective optimization techniques. As a result we obtain the optimal control strategy that leads the system to the setpoint. The developed results are applied to the inventory control problem in the supply chain. A numerical example is studied.

On the representativeness of approximate solutions of discrete optimization problems with interval objective function

Alexander Prolubnikov

Omsk State University
a.v.prolubnikov@mail.ru

Key words: discrete optimization, interval uncertainty, approximate solutions

We consider discrete optimization problems with interval uncertainty of its objective function's coefficients. For the coefficients, we model its measurement errors by intervals of their possible values. A possible optimal solution of a problem is a solution that is optimal for some possible values of the coefficients. The probability of obtaining of the possible optimal solution is the probability to obtain such values of the coefficients that the solution is optimal. A possible approximate solution is a solution that is obtained by some predefined approximate algorithm, e.g. by the greedy algorithm, for some values of the coefficients. The probability of obtaining of the possible approximate solution is the probability to obtain such values of coefficients that the solution be the result of the algorithm operating for the problem. For both optimal and approximate possible solutions, we call a solution representative if the probability of its obtaining is bigger than some boundary value. Otherwise the solution called unrepresentative. The mean (optimal or approximate) solution is the solution that we obtain for the mean values of interval coefficients, i.e. for the centres of the intervals. For discrete optimization problems with interval uncertainty of its objective function coefficients, we show that the share of instances of such problems with unrepresentative mean approximate solution may be large enough for rather small values of modeled errors and boundary values. The same is true for any other possible approximate solution.

Optimization problem of cerebral oxygen transport

Andrey Kovtanyuk, Alexander Chebotarev, Tim Seleznev

Far Eastern Federal University
kovtanyu@ma.tum.de, chebotarev.ayu@dvfu.ru, seleznev.te@dvfu.ru

Key words: oxygen transport in brain, finite element modeling, iterative algorithm

Cerebral oxygen transport model with unknown surface sources is considered. An iterative numerical algorithm based on Finite element method is constructed and implemented. The results of numerical experiments are discussed.

Inverse problem for electron diffusion coefficient recovering

Roman Brizitskii[1], Nadezhda Maksimova[2]

[1]*Institute of Applied Mathematics of Far Eastern Branch Russian Academy of Sciences*
mlnwizard@mail.ru

[2]*Amur State University*
knnamursu@mail.ru

Key words: electron diffusion coefficient, the inverse problem, the multiplicative control problem

The inverse problem for electron diffusion coefficient recovering from the charge density measured in some fragment of a charged ferroelectric is considered. Within the framework of the optimization approach, this problem is reduced to the multiplicative control problem.

A solvability of the considered extremum problem is proved, an optimality system is derived and on its basis a numerical algorithm for solving the inverse problem is constructed.

Boundary control problems for nonlinear reaction-diffusion-convection model

Roman Brizitskii, Zhanna Saritskaia

Institue of Applied Mathematics FEB RAS
mlnwizard@mail.ru, zhsar@icloud.com

Key words: nonlinear mass-transfer model, boundary control problem, optimality system, numerical algorithm

The solvability of boundary control problem for a nonlinear model of mass transfer is proved in the case, when the reaction coefficient depends nonlinearly on the concentration of substance and depends on spatial variables. The role of the control is played by the concentration value specified on the entire boundary of the region. Optimality systems are derived for the specific reaction coefficients for extremum problems. Based on the analysis of these systems numerical algorithms for solving extremum problems are constructed.

Mathematical model of Gamma Option Greek based on the reaction-diffusion equation

Angelina Donchak[1], Roman Brizitskii[2], Anna Brizitskaya[1]

[1]*Far Eastern Federal University*
donchak.aan@students.dvfu.ru, anna_lobunec@mail.ru

[2]*Institute of Applied Mathematics FEB RAS*
mlnwizard@mail.ru

Key words: convection–diffusion–reaction equation, maximum and minimum principle, inverse coefficient problem, optimality system, multiplicative control problem

A mathematical model of a Gamma-Greek option containing four assets is constructed with the help of the boundary value problem for a convection–diffusion–reaction equation considered in four-dimensional bounded domain. The domain under consideration is a rectangular parallelepiped formed by a Cartesian product of the segments [ai, bi], i=1,2,..,4 because the price of each asset varies within the range [ai, bi]. For purpose of solving boundary value problem the maximum and minimum principle is established. The inverse problem of recovering the coefficient which decreases the price (or profit) of an option is studied. According to the optimization approach this problem is reduced to a multiplicative control problem.

On the convergence of the method of successive approximations for the quasi-variational Signorini inequality

Robert Namm[1], Georgiy Tsoy[1], Ellina Vikhtenko[2]

[1]*Computing Center of Far Eastern Branch Russian Academy of Sciences*
rnamm@yandex.ru, tsoy.dv@mail.ru

[2]*Pacific National University*
vikht.el@gmail.com

Key words: elastic body, quasi-variational inequality, fixed point

When modelling the contact problem between an elastic body and a rigid surface, two one-sided boundary conditions arise simultaneously. The first condition guarantees the non-penetration of the body into a rigid surface (Signorini's condition), and the second condition indicates the possibility of an elastic body slipping along a rigid surface only if the tangential stress reaches a critical value (Coulomb's friction law). In this case, the critical value itself depends on the desired normal stress. This circumstance significantly complicates the mathematical formulation of the problem. It is formulated as a quasi-variational inequality, and its solution is reduced to finding a fixed point of a certain mapping that depends on the normal stress in the contact zone. We investigate the method of successive approximations for solving a quasi-variational inequality and prove the convergence of the method in the two-dimensional case.

Modeling a body containing a thin defect with a parameter

Alexander Zhiltsov

Far Eastern State Transport University
egrevid@gmail.com

Key words: body with a crack, Lagrange functionals, duality methods, saddle point
The problem of a two-dimensional body with a defect, whose properties are characterized by a fracture parameter, is considered. To solve the problem, it is proposed to use a dual method based on the modified Lagrange functional. A proof of the theorem on the saddle point of the Lagrange functional is given.

Numerical methods for systems of diffusion and superdiffusion equations with Neumann boundary conditions and with functional delay

Vladimir Pimenov

UrFU
v.g.pimenov@urfu.ru

Key words: Systems of diffusion equations, space fractional equations, functional delay
A feature of many mathematical models is the presence of two equations of the diffusion type with Neumann boundary conditions and the effect of delay, for example, in the model of interaction between a tumor and the immune system. In the report, the orders of convergence of analogues of implicit methods are studied, and the results of numerical experiments are presented, including on model examples from biology and medicine. Also, for a system of space fractional superdiffusion-type equations with delay and Neumann boundary conditions, an analogue of the Crank-Nicolson method is constructed. To approximate the two-sided fractional Riesz derivatives, the shifted Grunwald-Letnikov formulas are used; to take into account the delay effect, interpolation and extrapolation of the discrete history of the model are used. The solvability of the resulting linear system of equations and the stability of the algorithm are proved, and the order of error of the method is studied.

Computational techniques for modeling of bacterial communication under varying dynamical regimes of external exposure

Anna Maslovskaya[1], Yixuan Shuai[1], Christina Kuttler[2]

[1]*Amur State University*
maslovskayaag@mail.ru, 706603568@qq.com

[2]*Munich Technical University*
kuttler@ma.tum.de

Key words: communication in bacterial population, reaction-diffusion model of quorum sensing, antibiotics action, finite-difference iterative scheme, Monte-Carlo simulation, stochastic bacterial dynamics, computational experiments

Nowadays, deterministic approaches are widely used for in silico studies to examine the bacterial communication process in terms of reaction-diffusion models. In the current study, we consider ”quorum sensing” as a special case of cell-to-cell bacterial communication attributed to Pseudomonas putida bacterial strains. There are several ways how to fight pathogenic bacteria, including reducing bacterial populations due to the application of different dynamical regimes of external exposure. In this matter, we propose a modification of the basic model assuming an antibiotics and natural enzymes treatment for regulation of the “quorum” level.

The mathematical model is formalized by an initial-boundary value problem for a system of reaction-diffusion partial differential equations. The equations include generation terms, taking into account changes in a biomass density. The model describes space-time distributions of special compounds that characterize the quorum sensing. The numerical solution of the 2D problem is based on a hybrid computing procedure, which includes a finite difference method combined with Monte-Carlo simulation of population dynamics. The computational algorithm is implemented in Matlab. A series of computational experiments are performed to estimate key chemical compounds during the growth of bacterial populations and degradation under application of different strategies of treatment.

Development of an algorithm for numerical calculation of thermodynamic characteristics of trimerized and trident lattices dipole superspin ice

Igor Nalivaiko, Mikhail Chesnokov, Konstantin Nefedev, Vladislav Strongin

Far Eastern Federal University
nalivaiko.in@students.dvfu.ru, chesnokov.ma@students.dvfu.ru, nefedev.kv@dvfu.ru, strongin.vs@dvfu.ru

Key words: Metropolis, Ising-type nanomagnets, artificial spin ice lattice, algorithm, parallel calculations, CUDA

We are doing the research on the thermodynamic properties and phase transitions of two-dimensional arrays which consist of dipole coupled Ising-type nanomagnets. In our work, were research trident (Trident) and triangular type lattices (Trimmer). The Metropolis method is used to investigate phase transitions depending on the lattice parameter,

frustrations, and the influence of an external field on the system. For optimization and acceleration, the algorithm uses CUDA parallel calculation technology.

Mathematical modeling of the evolutionary dynamics of plankton community

Oxana Zhdanova, Galina Neverova

Institute for Automation and Control Processes FEB RAS
galina.nev@gmail.com, axanka@iacp.dvo.ru

Key words: prey – predator community, competition, Holling type II function, evolution, dynamics modes

The paper proposes and studies a model of the evolutionary dynamics of plankton community. Phytoplankton is assumed to consist of two genetic groups competing for resources and differing by the trait of toxicity. Zooplankton consumes non-toxic phytoplankton due to its selective choice of food. The evolutionary scenario of the development of two different phytoplankton genotypes is shown to depend significantly on competitive intensity between them.

Computer modeling of complex heat transfer with moving sources

Nikolai Park[1], Andrey Kovtanyuk[2]

Far Eastern Federal University
Technical University of Munich
pak.nm@dvfu.ru, kovtanyu@ma.tum.de

Key words: non-linear PDE system, iterative algorithm, finite element modeling

An initial-boundary value problem for quasilinear equations of radiative-conductive heat transfer, simulating the process of endovenous laser ablation, is considered. An iterative numerical algorithm based on Finite element method is proposed and implemented. The dependence of temperature fields on parameters of irradiation is studied.

The development of an algorithm for calculating the density of states for Ising-type models

Mikhail Chesnokov, Igor Nalivaiko, Konstantin Nefedev, Vladislav Strongin

Far East federal University
chesnokov.ma@students.dvfu.ru, nalivaiko.in@students.dvfu.ru, nefedev.kv@dvfu.ru, strongin.vs@dvfu.ru

Key words: the density of states, Ising-type nanomagnets, artificial spin ice lattice, Monte Carlo, parallel calculations, CUDA

We are working on the development of an algorithm for calculating the density of states for two-dimensional arrays consisting of dipole-coupled Ising-type nanomagnets. As an object of study, an artificial spin ice lattice, the Cairo lattice, was used. The algorithm is based on both approximate methods (greedy algorithm, Monte Carlo) and local brute force search. For optimization and acceleration, the algorithm uses the technology of parallel calculations CUDA.

Computer simulation of ferroelectric domain structure dynamics: implementation in COMSOL Multiphysics

Elena Veselova[1], Anna Maslovskaya[1], Alexander Chebotarev[2]

[1]*Amur State University*
salmashova@mail.ru, maslovskayaag@mail.ru

[2]*Far Eastern Federal University*
chebotarev.ayu@dvfu.ru

Key words: "reaction-diffusion" system, Landau – Ginzburg – Devonshire – Khalatnikov model, 2D mathematical model, finite elements method, computational experiment, polarization, domain structure

Ferroelectrics have become a subclass of promising polar dielectrics for numerous engineering applications due to a wide range of important properties. The most significant applications of ferroelectrics in science and technology are associated with the general mechanisms of polarization switching and domain structure dynamics induced by an external exposure.

The study is devoted to the numerical implementation of the 2D mathematical model of ferroelectric domain structures dynamics. The model is considered within the framework of the Landau – Ginzburg – Devonshire thermodynamic approach supplemented by the Landau – Khalatnikov equation to express the polarization dynamics in ferroelectric materials. The physical system is formalized by an initial-boundary value problem for semilinear parabolic partial differential equations, which describe the space-time distribution of polarization in ferroelectrics. We performed a finite-element implementation of the model and designed a user interface application in the COMSOL Multiphysics platform. A series of computational experiments are conducted to visualize various domain structure configurations on the example of ferroelectrics with the fist-order phase transitions.

Light-induced dynamics of nanoparticles in a liquid-phase medium, taking into account the concentration dependence of the viscosity coefficient

Albert Livashvili, Polina Vinogralova

Far Eastern State Transport University
livbru@mail.ru, vpolina17@hotmale.com

Key words: liquid-phase medium, Partial differential equation, Viscosity, Diffusion, concentration convection Electrostriction

The work theoretically studies the dynamics of the concentration of nanoparticles, which is under the influence of laser radiation with a uniform intensity profile. The corresponding transport equation takes into account the dependence of the viscosity on the concentration and is presented as a non-linear second-order partial differential equation. Its analytical solution is obtained and analyzed.

Investigation of the Efficiency of Graph Data Representation for a Cardiovascular Disease Predictive Model by Deep Learning Methods

Lyubov Grishina[1], Arthur Zhigalov[1], Irina Bolodurina[1], Evgeniy Borshhuk[2], Dmitry Begun[2], Yulia Varennikova[3]

[1]*Orenburg State University*
grishina_ls@inbox.ru, leroy137.artur@gmail.com, prmat@mail.osu.ru

[2]*Orenburg State Medical University of the Ministry of Health*
be@nm.ru, doctorbegun@yandex.ru

[3]*Medical Information and Analytical Center of the Orenburg region*
oob51@mail.orb.ru

Key words: natural language processing, graph model, cardiovascular disease, convolutional, neural networks, support vector machine, medical information systems, disease prediction model

Currently, cardiovascular diseases (CVD) are the most common cause of death in the world. Artificial intelligence methods provide extensive opportunities for extracting new knowledge from the raw data of medical information systems (MIS). This study is aimed at building a model for predicting the diagnosis of CVD based on patient complaints at a doctor's appointment using NLP methods. The formation of the initial data set is based on a graph model of the patient's medical history with CVD according to the visit protocols. A comparative analysis of machine learning models such as the naive Bayesian classifier, the support vector machine and convolution neural networks is carried out. As a result of the experiments, the most effective model for predicting CVD was selected.

Modeling and Simulation of Cerebral Blood Flow Autoregulation Considered as an Output Regulation Control Problem (Online)

Alexey Golubev

Ishlinsky Institute for Problems in Mechanics RAS
v-algolu@hotmail.com

Key words: intracranial hemodynamics, cerebral autoregulation, nonlinear control, output tracking

A mathematical model of cerebral blood flow in the form of a nonlinear dynamical system is considered. The cerebral blood flow autoregulation modeling problem is treated as an output regulation control problem. Nonlinear control theory techniques are applied to construct the relevant control laws which should help us understand the mathematics behind cerebral blood flow autoregulation mechanism of a healthy human. The cerebral blood flow autoregulation simulation results are presented.

Shock-absorbing devices based on toroidal thin-shell structures and algorithms for their calculations (online)

Vladimir Bogdanov[1], Igor Chabunin[2], Semen Silaev[2], Yaroslav Oreshin[2]

[1]*Moscow Higher Combined-Arms Command School (MVOKU); State University of Management*
vvbogd@yandex.ru

[2]*Moscow Higher Combined-Arms Command School (MVOKU)*

tchabunin@rambler.ru, vvbogd@hotmail.com, vvbogd@yahoo.com

Key words: thin shell structures, crash box, damping, shock-absorbing devices, high performance computing

An approach to the creation of shock-absorbing devices based on thin-shell shell structures of toroidal shapes near-catenoid is described. The questions of algorithmization the strength-stiffness calculations of thin-shell construction, the usage of high-performance computing in the creation of prototypes of structures, as well as its practical application of the developed models in damping devices are touched upon. Based on the research carried out by authors, the number of utility models have been proposed (for patents of the Russian Federation).

Removal of stripe noise in remote sensing images using ridge functions

Ivan Kazantsev[1], Rauan Turebekov[2], Murat Sultanov[2]

[1]*The Institute of Computational Mathematics and Mathematical Geophysics*
kazantsev.ivan6@gmail.com

[2]*Khoja Akhmet Yassawi International Kazakh-Turkish University*
rauan.turebekov@ayu.edu.kz, murat.sultanov@ayu.edu.kz

Key words: image processing, noise removal, stripe interference, Radon transform, ridge function

The article deals with the problem of removing noise that has some anisotropy in a certain direction in images received as a result of remote sensing. Such interference can occur with satellite imagery of the surface of Earth and planets due to the peculiarities of the imaging equipment. In the article, the method of removing such noise using ridge functions is considered. The use of this approach is based on singular value decomposition of the Radon transform. The numerical experiments on real-world images demonstrate the efficiency of the techniques proposed.

Symbolic computation in analysis of dynamics of orbital gyrostat

Andrei Banshchikov

Matrosov Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences
bav@icc.ru

Key words: orbital gyrostat, stability of equilibrium positions, degree of instability, gyroscopic stabilization, solution of systems of inequalities, parametric analysis, software package of computer algebra, symbolic-numerical modelling

The paper presents the possibilities of symbolic computation in the study of the dynamics of rotational motion along a circular orbit of a gyrostat in a Newtonian central field of forces. In accord with the problem of Lyapunov's stability from the equations of perturbed motion in the first approximation, in the space of the introduced parameters, the regions are found in which there is gyroscopic stabilization of unstable equilibria. The results were obtained with the help of application software and functions of symbolic-numerical modeling of the computer algebra system "Mathematica".

Detection method of illegitimate code execution (online)

Andrey Kechahmadze, Yury Kosolapov

Southern Federal University
kechahmadze@sfedu.ru, itaim@mail.ru

Key words: vulnerability, exploit, protection, API call's distance

Vulnerabilities in system or application software pose a serious threat to the security of information systems using this software. Automated search for vulnerabilities using technologies such as symbolic execution and fuzzing does not guarantee the absence of vulnerabilities in the code. Security can be improved through updates and using intrusion detection systems. With this approach, the vulnerability of the code must be known. For unknown vulnerabilities, detection of their exploitation is considered more difficult, since in this case the protection system must be able to distinguish between legitimate and illegitimate code execution. In this work, the following approach is proposed to detect illegitimate code execution. Since the program code that exploits the vulnerability usually contains a call to some application program interface function (API), the distance between adjacent API calls, calculated as the difference between the addresses of neighboring API calls, can be used to detect such a call as illegitimate. The essence of the method is to calculate the distance between the current and previous calls with the subsequent comparison of the obtained value with the distances from the profile of typical distances built in the training phase. The following results are obtained and presented in the work: 1) a method for constructing a profile of typical distances for a protected program is proposed; 2) a model for exploiting vulnerabilities was built; 3) experiments were carried out to estimate the frequency of false positives and false negatives depending on the duration of the training phase.

Efficient Parareal Algorithm for Solving Time-fractional Diffusion Equation

Murat Sultanov[1], Vladimir Misilov[2], Yerkebulan Nurlanuly[1]

[1]Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan
murat.sultanov@ayu.edu.kz, yerkebulan.nurlanuly@ayu.edu.kz

[2]Krasovskii Institute of Mathematics and Mechanics, Ural Branch of RAS
v.e.misilov@urfu.ru

Key words: Caputo fractional derivative, time-fractional diffusion equation, parallel computing, parareal method

The work is devoted to developing efficient parallel algorithms for solving the initial boundary problem for the time-fractional diffusion equation. Traditional approaches to parallelization are based on the space domain decomposition. In contrast, the parareal method is based on the time domain decomposition and an iterative predictor-corrector procedure. The fast solver on a coarse grid is used to construct the initial approximations for subtasks (solved by accurate solvers on fine grids) and for correcting the solution of subtasks. The subtasks may be solved independently for each subinterval of time. This allows one to implement the efficient parallel algorithms for various high-performance architectures. Currently, this method is widely used for problems for classical differential

equations with integer orders. But it is much less commonly used for the fractional equations. In this work, the parareal algorithm for solving the initial boundary problem for the time-fractional diffusion equation is implemented using the OpenMP technology for multicore processors. The numerical experiments are performed to estimate the efficiency of parallel implementation and compare the parareal algorithm with the traditional space domain decomposition.

Computer simulation of kinematic effect on the driver of solid models of wheeled and tracked vehicles (online)

Vladimir Bogdanov[1], Igor Chabunin[2], Vitaly Peyders[2], Roman Mukhin[2]

[1]Moscow Higher Combined-Arms Command School (MVOKU): State University of management
vvbogd@yandex.ru

[2]Moscow Higher Combined-Arms Command School (MVOKU)
tchabunin@rambler.ru, vvbogd@hotmail.com, vvbogd@yahoo.com

Key words: computer modeling, kinematic impact, micro profile of the road surface, random process, high-performance computing

At present numerical methods for solving differential equations of motion are widely used to study oscillatory processes in a mobile machine, its stability and steerability properties. They allow the use of dynamic systems of almost any complexity, taking into account the nonlinear appearance of the characteristics of its elastic and damping elements. But for their effective use and obtaining the right results, it is necessary to have an array of ordinates the micro profile adequate to the real road. In the vast majority of works devoted to the study of vehicle vibrations, two-dimensional models are considered that allow us to study vibrations only in the longitudinal plane. However, in recent years there has been a tendency to use 3D-models that allow determining the linear movements of its constituent elements in all directions and angular movements in all planes, as well as speeds and accelerations. In such cases, it is necessary to have an array of ordinates of the microprofile over the entire road surface, i.e. it is necessary to simulate the kinematic effect on the propulsion, which requires the use of powerful computing resources that realize the full potential of high-performance computing.

Theoretical analysis of cloaking problem for 3D model of heat conduction

Gennady Alekseev

Institute of Applied Mathematics FEB RAS, Far Eastern Federal University
alekseev@iam.dvo.ru

Key words: Inverse problem, heat conduction, solvability, optimality system

The direct and extremal problems for the 3D heat conduction model are formulated which are associated with designing spherical thermal cloaking device. The solvability of both problems is proved. An optimality system is constructed that describes the necessary conditions for an extremum. Some properties of optimal solutions which are consequences of the structure of the optimality system are established.

Computational Simulation of Nonlinear Dynamic Bending of a Curved Cylindrical Shell

Oleg Tkachenko, Viktor Rukavishnikov

Computing Center of the Far Eastern Branch of the Russian Academy of Sciences
olegt1964@gmail.com, vark0102@mail.ru

Key words: numerical experiment, bent pipeline, asymptotic series, dynamics

Curvilinear segment of the pipeline is mathematically described as an elastic shell, which is loaded with internal fluid flow and external resistance. The process of this segment displacement under the action of internal and external loads is investigated. A three-dimensional initial-boundary value problem of finding the stress-strain state of a pipe depending on the coordinates and time is formulated. A nonlinear mathematical model is constructed, consisting of several initial-boundary value problems for systems of differential equations. The solutions of these problems allow us to find successive approximations of the solution to the original problem, separated by powers of a small parameter. Algorithms for performing computational experiments based on the constructed mathematical model have been created. Asymptotic and numerical solutions are found for particular cases covering practically important applications of the proposed mathematical model. The consistency of the obtained results with known scientific data is established.

Scatter correction techniq using multiple-impulse sources in computed tomography

Ivan Yarovenko[1], Igor Prokhorov[1], Ivan Kazantsev[2]

[1]*Institute of Applied Mathematics FEB RAS*
yarovenko@iam.dvo.ru, prokhorov@iam.dvo.ru

[2]*Institute of Computational Mathematics and Mathematical Geophysics, Siberian Branch of the Russian Academy of Sciences*
kazantsev.ivan6@gmail.com

Key words: tomography, radiation transfer equation, inverse problem

The study is devoted to the tomography problem as an inverse problem for integro-differential radiation transfer equation. The problem is to determine the attenuation coefficient with known outgoing radiation flux. We have proved vanishing of scattered component of radiation flux density with probe pulse duration tending to zero. The main problem for practical application of this theoretical result is the construction of radiation source with ultra short pulse duration. We propose to use the irradiation of the medium by a series of pulses with different duration to construct an extrapolation of the ballistic component of the outgoing radiation. Finding the attenuation coefficient from a known ballistic component is a well-studied problem of Radon transform inversion. The method proposed was tested in numerical experiments using Shepp-Logan digital phantom filled with proportional scattering medium. The proposed extrapolation method gives good fit for lower values of the scattering proportionality coefficient. An increase in value of scattering proportionality coefficient leads to degradation of extrapolation quality.

Multi-angle focusing of hydroacoustic images obtained from side-scan sonar

Evgeny Kovalenko, Andrei Sushchenko

Far Eastern Federal University
kovalenkoq@gmail.com, sushchenko.aa@dvfu.ru

Key words: side-scan sonar, multi-angle focusing, radiative transfer equation

The inverse problem for the nonstationary radiative transfer equation with appropriate initial and boundary conditions is studied. The desired function included in the boundary conditions is the bottom scattering coefficient. The source is assumed to be pulsed, and the receiver is assumed to have a receiving antenna radiation pattern of finite width, which affects the defocusing of objects when constructing a hydroacoustic image.

An analysis of the algorithm of multi-angle focusing of objects is carried out. Various masks of decision were investigated for this algorithm. As an answer, the maximum, minimum, average values and jumps in the derivative were selected. When processing real data, the choice of masks does not become obvious. In addition, two processes of echolocation survey were simulated. The first - with the use of SSS, which requires the conduct of several tacks along the sounded area of the seabed. The second is a multi-beam echo sounder, which allows one tack to obtain an image of the seabed at different viewing angles.

The multiview focusing algorithm was tested on data obtained on the basis of real images of the seabed. This approbation showed the efficiency of the algorithm not only for the reconstruction of homogeneous objects (simple geometric figures), but also on a strongly changing bottom. The accuracy of the solution was analyzed depending on the width of the receiving antenna radiation pattern.

Comparative analysis of the error of the single scattering approximation for 2D and 3D impulse ocean sounding models

Polina Vornovskikh[1], Evgeny Ermolaev[2], Igor Prokhorov[1]

[1]*Institute of Applied Mathematics FEB RAS*
vornovskikh.polina@gmail.com, prokhorov@iam.dvo.ru

[2]*Far Eastern Federal University*
ermolaev.ev@dvfu.ru

Key words: radiative transfer equation, pulsed ocean sounding, scattering coefficient, inverse problem, Monte Carlo methods

A mathematical model in the work that describes the process of pulsed high-frequency acoustic sounding in a fluctuating ocean is considered. The inverse problem for the non-stationary equation of acoustic radiative transfer is investigated. It consists in finding the coefficient of volume scattering from the angular distribution of the radiation flux density at a given point in space. In the single scattering approximation, a formula is obtained to find the scattering coefficient. A series of computational experiments was carried out to substantiate its use in acoustic sensing of a fluctuating water medium. A numerical

analysis has shown that the application of the single scattering approximation is justified at least at a sensing range of the order of 100 meters. Moreover, double and triple scattered fields have the main effect on the error.

Numerical solving of boundary integral equations of scattering problems at irregular frequencies

Aleksei Kashirin, Sergei Smagin

Computing Center, Far Eastern Branch of the Russian Academy of Sciences
elomer@mail.ru, smagin@ccfebras.ru

Key words: time-harmonic scattering problem, integral equation, irregular frequencies, numerical method

A three-dimensional time-harmonic scalar scattering problem is considered. It is reduced to Fredholm boundary integral equations of the first kind with a single unknown function. These equations are correctly solvable if the exterior wave number is not an eigen value of the associated interior Dirichlet problem. Otherwise, they can have infinitely many solutions or no solutions. We propose the method which can find numerical solutions of the scattering problem at these irregular frequencies. Numerical examples are given.

Numerical solution of shielding problem for 3D model of electrostatics in the presence of anisotropic layer

Alexey Lobanov

Institute for Applied Mathematics, Far-Eastern Branch of the Russian Academy of Sciences
alekslobanov1@mail.ru

Key words: Inverse problems, shielding problem, optimization method

An economical numerical algorithm for solving the problem of designing a shielding device for a 3D model of electrostatics is proposed and implemented. The algorithm is based on the use of a multilayered shell. Its first layer is anisotropic, and the remaining layers are filled with one of two predefined isotropic materials according to an alternating design scheme. It is shown that the applying of the developed algorithm enables us to design easy-to-implement shielding shells with high efficiency.

Investigation of Seabed Morphology Using Optical Techniques

Elizaveta Liu, Sushchenko Andrei

Far Eastern Federal University
liu.er@dvfu.ru, sushchenko.aa@dvfu.ru

Key words: Bathymetry problem, Optical bathymetry, Remote sensing, Radiation transfer

The main source of information on seafloor morphology is the problem of bathymetry, which involves studying the bottom of water bodies, including oceans, lakes, rivers, etc. Ocean bathymetry can be based on acoustic methods using multibeam sonars or remote sensing techniques using satellites practically. The paper deals with remote sensing of the ocean using optical methods. Using the radiation transfer theory, the solution of the direct

problem was derived for calculating the simulated signal in case of two media conjugation according to the Fresnel law. To solve the inverse problem, formulated as determination of the function describing deviation from a reference, a numerical scheme was obtained by approximating the derivatives by finite differences. A series of computational experiments were conducted for numerical analysis of the obtained formulas.

Intelligent system for automatic image description of optical coherence tomography

Arthur Zhigalov[1], Luybov Grishina[1], Irina Bolodurina[1], Alexander Lositsky[2], Evgeny Borshchuk[3], Alexandra Voronina[2]

[1]*Orenburg State University*
leroy137.artur@gmail.com, grishina_ls@inbox.ru, prmat@mail.osu.ru

[2]*Fyodorov Eye Microsurgery Federal State Institution*
eyedoct@yandex.ru, ofmntkvoronina@gmail.com

[3]*Orenburg State Medical University of the Ministry Health*
be@nm.ru

Key words: deep learning, image analysis, optical coherence tomography, automatic image description, convolutional neural networks

Currently, the development and implementation of an intelligent system for automatic image description of an optical coherence tomograph (OCT) will reduce the time of image processing and, consequently, the diagnosis of diseases. In this regard, the purpose of this study is to develop an automated intelligent system for the comprehensive identification of pathological cases of the retina using deep learning methods.

Deep Learning For Solving Subdifferential Boundary Value Problem Of Complex Heat Transfer

Kirill Kuznetsov[1], Elena Amosova[2]

[1]*Far Eastern Federal University*
kuznetsovks17@gmail.com

[2]*Far Eastern Federal University(FEFU),Institute for Applied Mathematics, Far Eastern Branch, Russian Academy of Sciences*
el_amosova@mail.ru

Key words: Machine learning, deep learning, neural networks, complex heat transfer, subdifferential boundary value problem

A method for solving a stationary subdifferential boundary value problem of complex heat transfer based on deep learning is proposed.
The system of equations consists of the heat conduction equation and P_1- approximation of the radiative transfer equation. The database of experiments is generated. Experiments are based on the numerical solution of the stationary problem of conductive and radiative heat transfer using the Newton method in the FreeFem++ software package.The boundary value, dependent on the radiation intensity, is determined. A neural network was trained on the generated database. The results were obtained and evaluated. The potential of deep learning in solving such problems was shown.

Cloud Simulation Service for Production Location Problem

Andrei Velichko

Far Eastern Federal University
vandre@dvo.ru

Key words: digital economy, transportation, cloud platform

The paper deals with the problem of decision-making support for production location problem. It describes the mathematical model of production location. The main criterion of potential production location is the minimization of total cost of delivery of raw materials to the place for production from all locations of input products. The problem belongs to the class of binary and linear mathematical programming problems with linear constraints. Based on the model, the software tool is implemented as a cloud service on heterogeneous computing architectures. The simulation module is made on a high-performance server platform, the control and visualization modules are produced with IACPaaS cloud platform. The paper demonstrates the simulation of potential production location and the problem of self-sufficiency for the Russian Far East regions based on input data provided by open statistics sources.

Semantic segmentation of meshed fencing constructions and searching breaks

Alexey Smagin, Sergey Smagin

Khabarovsk Federal Research Center of the Far Eastern Branch of the Russian Academy of Sciences
smaginkhv@gmail.com, si-smagin@yandex.ru

Key words: algorithm, computer vision, semantic segmentation, machine learning, software

The issues of automated monitoring of the condition of mesh enclosing structures used on farms producing marine biological resources are considered. An algorithm is proposed for identifying breaks in mesh fencing underwater conditions and is implemented as a complex of programs in Python using the OpenCV computer vision library and U-net CNN. The results of testing the algorithm are presented. It is shown that computer vision effectively copes with the classification of network cells in noisy and medium-noisy underwater images.

The mathematical model of the classification system for streaming or recorded speech using algorithms of artificial recurrent neural networks of the long short-term memory architecture

Alexey Akulov, Anna Bezotosnaia, Tatiana Pak
Far Eastern Federal University
akulov_as@dvfu.ru, bezotosnaia.adm@dvfu.ru, pak.tv@dvfu.ru

Key words: natural language processing, artificial neural networks, deep neural networks, artificial intelligence, statistical classification

This article presents one of the possible approaches to natural language processing for the task of classifying speech in streaming mode or in a recorded format. A chain of

algorithms is considered, starting with an overview of currently available implementation tools, models and libraries available in the Python programming language. The general architecture of these models is considered, the format of input and output data is analyzed and processed.