

Summaries of All Articles

K. A. Beklemysheva, I. B. Petrov, A. V. Favorskaya

Numerical simulation of processes in rigid deformable media in the presence of dynamic contacts using a grid characteristic method

A number of problems of dynamic deformation in the presence of moving contact surfaces are considered. A grid characteristic method using a two-dimensional irregular triangular grid and a hybrid scheme with 1-2 order of approximation is adapted. An algorithm for calculating the force of friction and the force of static friction is proposed. The numerical solution to wheel rolling and shear waves generation problems is obtained.

Key words: mechanics deformable rigid body, grid-characteristic method, irregular grid, Delaunay triangulation, dynamic contact, collision detection, friction, seismic surveys, falling load method.

M. G. Belyaev

Approximation of data generated by Cartesian product

We propose an approximation method for data samples generated by the Cartesian product of an arbitrary number of multidimensional factors. The method is based on an expansion of the functions dictionary, which is constructed as the tensor product of other dictionaries. Such smaller dictionaries are obtained as solutions of approximation problems in each factor of the Cartesian product. We also introduce a special kind of penalty in order to control smoothness of the model in each factor. Decomposition coefficients of the global dictionary are optimally found as a solution of regularized least squares. Regularization parameters that specify model smoothness are calculated using the leave-one-out error. Factorized data structure allows one to make all calculations with the global dictionary computationally efficient. The proposed approach is successfully used in real applications.

Key words: sample-based approximation, tensor product, dictionary of functions.

E. V. Burnaev, P. D. Erofeev, P. V. Prikhodko

Extraction of the most sensitive directions in the approximation problem by Gaussian Process Modelling

For many industrial problems it is necessary to reconstruct unknown dependency based on its values using the given sample. One of the most efficient methods for solving this problem is an approximation based on gaussian processes. It is known that one of the most popular ways to model the covariation of the gaussian process is an exponential covariance function based on the weighted Euclidean distance. However, this a priori assumption on the covariance structure of the data source implies that directions of the most significant variation of the studied dependency are expected to lie along original coordinate axes. This assumption may not be satisfied in practice. We propose the effective way to model the covariance structure of the data for the general case. The efficient algorithm of hyperparameters tuning is described. On a number of examples we demonstrate that the proposed method also allows one to solve the effective dimension reduction problem. Finally, we propose a statistical test that allows one to estimate the reduced dimensionality of the data. All statements are confirmed by the experimental results of a number of test problems. The general efficiency of the proposed procedure is demonstrated by a real problem in the aerospace industry.

Key words: effective dimension reduction, gaussian processes, Mahalanobis distance.

Yu.N. Volkov, Yu.S. Polyakov

Modeling investment projects' impact on national economy dynamic using multi-sectoral macro-models

This paper elaborates multi-sectoral dynamic optimization model of national economy with an investment project incorporated and without. Identification of the model parameters is carried out on the statistics of the economic development of the Russian Federation. The model is used to find an optimal allocation and an optimal quantity for domestic investment to the national economy. In the versions with investment projects incorporated and without we investigate the efficient allocation of investments across sectors.

Key words: multi-sectoral macro-model, Input-output model, Gross domestic product, investment project.

M. I. Isaev, K. V. Isaeva

On the class of graphs having strong mixing properties

We study three mixing properties of a graph: large algebraic connectivity, the large Cheeger constant (isoperimetric number) and a large spectral gap from 1 for the second largest eigenvalue of the transition probability matrix of the random walk on the graph. We prove the equivalence of these properties (in a sense) and give probability estimates for a random graph to satisfy these properties. In addition, we present asymptotic formulas for the numbers of Eulerian orientations and Eulerian circuits in an undirected simple graph.

Key words: algebraic connectivity, isoperimetric number, Laplacian matrix, Eulerian circuits and orientations.

E. O. Krymova, E. A. Chernousova

Oracle inequality for exponential weighting of ordered smoothers

This paper deals with recovering an unknown vector from noisy data with the help of a family of ordered smoothers. The estimators within this family are aggregated using the exponential weighting method and our goal is to derive oracle inequalities controlling the risk of the aggregated estimate. Based on probabilistic properties of the unbiased risk estimate, we show that the exponential weighting permits to improve Kneip's oracle inequality [1].

Key words: ordered smoother, exponential weighting, unbiased risk estimation, oracle inequality.

E. G. Molchanov

Combinatorial properties of polyhedral cone classes in the recourse distribution problem

Solving the inverse problem of resource allocation results in the study of the moment problem whose solution reduces to the problem of belonging a vector to the special type cone – conical hulls of cutting region's spectral vertices. The combinatorial properties of such cone classes are considered. The connection with wiring diagrams (wirings), discrete-convex sets, unimodularity are discussed.

Key words: wiring diagrams, rhombus tilings, cone classes, discrete-convex sets, unimodular systems, generalized Hauthakker-Johansen model.

M. O. Solntseva, B. G. Kuharenko

Clustering methods application for the nodes of a graph with sparse adjacency matrix in logistics

The solution to the problem of the optimal allocation of logistic centers in supply chain is considered in a transport network graph by various clustering algorithms. Subdivision of the nodes from the transport network graph into clusters is carried out according to the results of preliminary data mining, which are presented by the significantly sparse adjacency matrix of the graph. The procedures of minimal Steiner tree construction and truncating are considered as an alternative approach to the clustering problem.

Key words: data mining, graph analysis, sparse adjacency matrices, clustering algorithms, Steiner trees, transport networks, logistics.

G. B. Yuzhakov

Fast Algorithm for Constructing Histograms of Oriented Gradients

The problem of describing images as part of the recognition problem in computer vision is studied. The technique based on histograms of oriented gradients is proposed. Methods for optimizing the computation speed are described, such as working with matrices, a technique for constructing the integral images, thinning, a method for simulating slip and auxiliary descriptors. It concludes with an algorithm for implementing the main types of descriptors based on histograms of oriented gradients. The computing experiment shows the efficiency of the proposed technique.

Key words: histogram of oriented gradients, integral image, integral bins, sliding window, simulation of sliding, thinning, auxiliary descriptors.

V. N. Bondarik A. E. Koucheryavy

Internet of Things Growth Forecast up to the year 2030

The Internet of Things (IoT) concept and thing definition are considered. The client base changes are analyzed. The existing technology analysis and IoT growth forecast are made by the associative method and logistic curve, respectively. The carrier business model changes in accordance with the IoT concept implementation are considered.

Key words: self-organizing network, Internet of Things, client base, growth forecast.

E. M. Gabidulin, N. I. Pilipchuk, A. V. Urivskiy, O. V. Trushina

Secure information transmission in telecommunication networks

The analytical review of works devoted to secure information transmission in telecommunication networks is presented. A communication network is a subject of different adversary attacks. Someone wants to observe and analyze traffic, the others can embed their own packets to prevent correct receiving at the destination side. The papers under review suggest different tools to prevent adversaries. Cryptography is the main approach. Interesting topics are an anonymity transmission when a receiving or (and) a transmitting party wants to be unknown. There are many approaches to provide anonymity of parties. Basically, we include works of the past five years.

Key words: telecommunication network, network coding, information security, adversary, cryptosystem, anonymity.

A. A. Grigoriev

Opportunistic Routing Algorithms

For one model of opportunistic wireless network, we construct routing algorithms based on classical routing Dijkstra and Bellman-Ford methods. Some simple conditions on path-metrics are given leading to the optimality of proposed algorithms.

Key words: wireless network, routing, opportunistic routing.

A. S. Kuzmenkov, A. E. Polyakov, L. V. Strygin

Review of state-of-the-art architectures of the PLL frequency synthesizers

At present, numerous treatises and textbooks cover the field of frequency synthesis. There are detailed thematic treatises by the most renowned experts and researchers [1–5]. However, the review of researchers' works shows that nowadays the analysis and comparison of relatively new architectures of PLL frequency synthesizers give a large research field. It should be noted that the design and development of the PLL is an urgent problem because practical applications using advanced microwave generators require constant technical progress, new functions, the reduction of size, power consumption, and price.

This article contains small introductory provisions about PLL, the principal specification constrains of conventional architectures of frequency synthesizers, the review and comparison of actual architectures of the PLL from open press.

Key words: frequency synthesizer, architecture, phase noise, frequency setting time.

L. N. Alyabyeva

Absorption and circular dichroism spectra of LaBGeO₅ doped with Nd³⁺ ions

The absorption and circular dichroism spectra of $LaBGeO_5 : Nd^{3+}$ in theregion 200–950 nm are investigated. The spectra are measured at 8 K. The electron transitions of Nd ions, occupied La^{3+} positions in ninefold oxygen polyhedra with symmetry C_1 are observed. All transitions are active in both absorption and circular dichroism spectra. The dipole strength D_{om} , rotatory strength R_{om} and anisotropy factor g are calculated for some bands of good resolution.

Key words: circular dichroism, stilwellite, neodymium, low temperatures, absorption.

I. A. Varfolomeev, [V. N. Gorelkin], V. R. Soloviev

Monte Carlo simulation of charge transfer in diamond

Monte Carlo simulation is carried out to analyze the evolution of the distribution function of nonequilibrium charge carriers in a boron-doped diamond in the external electric field at 10K. In a pure diamond the conductivity is positive. In the presence of a boron dopant, which is responsible for effective recombination of low-energy charge carriers, positive and negative charge fluxes with respect to E-field direction are equalized, and differential negative mobility is observed. These observations agree with the results of previous works, which predict a possibility of differential negative mobility in a diamond for holes having energy in a specific energy interval. Moreover, for the initial «bi-directional» charge carrier velocity distribution, the integral negative mobility is observed. Key words: diamond, hole, Monte Carlo, absolute negative mobility, distribution function.

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*A. M. Perepukhov, O. V. Kishenkov, S. V. Gudenko, A. V. Maximychev, D. A. Aleksandrov,
L. I. Menshikov, E. V. Korostylev*

NMR studies of pore space in silicates and ^1H relaxation of liquids in porous media

The ^1H magnetization relaxation of water and hydrocarbons in such model porous media as glass balls and in natural quartz sand is studied. The fluid relaxation time spectra are single-line in model porous media and multiple-line in quartz sand. The surface relaxivity values measured for the model porous media are used for the estimation of the pore size in quartz sand. EPR is used to detect the chemical nature of the active centers which account for the paramagnetic mechanism of the surface relaxation of ^1H magnetization.

Key words: NMR relaxation, silicate rocks, surface paramagnetic centers.

A. V. Vaganov, Y. G. Yermolaev, A. D. Kosinov, N. V. Semionov, V. I. Shalaev

Experimental study of flow structure and transition in the boundary layer of a delta wing with blunted leading edges at Mach numbers 2,5 and 4

The experimental results of the mean and pulsating flow characteristics of plane delta wings obtained at Mach 2, 2,5, 4 and at angles of attack 0° , 5° and 10° are presented in the paper. We use a model with sweep angle $\chi = 55^\circ$ and blunted leading edge (radius of bluntness 2 mm). The measurements are carried out using CTA hot-wire and the total pressure tube. The size and characteristics of flow inhomogeneity on the span of the plane delta wing and the laminar-turbulent transition in the center of symmetry of the model are obtained. The most significant flow defects are recorded in the center of the model and at some distance from the center. At zero angle of attack and $M = 4$, we find intense low-frequency pulsations of mass flow near to the trailing edges which are localized on the transverse coordinate and extend for a considerable downstream distance. Measurements of the total head tube show a significant increase in skin friction in this area.

Key words: supersonic speed, experiment, wind tunnel, blunted delta wing, laminar turbulent transition, hot-wire anemometry.

A. V. Lysenkov, S. V. Pavlik

Methodology development for calculating the aerodynamic characteristics of propellers

This paper is devoted to the development of methodology for calculating the aerodynamic characteristics of propellers using the commercial software ANSYS. The accuracy of this universal solver is assessed as applied to the numerical analysis of flow around the propeller. To understand the various factors affecting the accuracy, calculations are carried out on several meshes as well as for several levels of free-stream turbulence. The viscous flow (RANS approach) around the propeller model, with account taken of the geometric features, is studied in a broad range of flow velocities and propeller revolutions. As a result, it is found that the developed methodology yields sufficient accuracy to carry out preliminary design studies. An example of the practical application of the methodology is given.

Key words: propeller, computational methods, comparison with experiment.

N. B. Stepanova

Properties of the cold intermediate layer in the southeast Baltic Sea on the basis of 2004-2008 field data and the possibility of its ventilation by shelf waters during the spring period

On the basis of the field data collected in scientific cruises in the southeast part of the Baltic Sea (Gdansk Basin) during five years (2004-2008), the characteristic features of the cold intermediate layer (CIL) in summer time are identified when this layer is most clearly manifested in the general vertical thermohaline structure of a water column. Generalized analysis of the temperature, salinity and density of the CIL waters in the chosen region of the sea is performed and presented for the first time. The possibility of the penetration of coastal waters formed in March over shelves and underwater slopes of the Sambian Peninsula into the CIL region of the Gdansk Basin is analyzed. Comparative analysis of the temperature, salinity and density of coastal shelf waters with the CIL waters in open part of the sea in summer time suggests the existence of (a) the cascading of denser waters from the shelf into the intermediate layers of the sea during early spring warming and (b) up- estuary transport in the intermediate layers of the Baltic Sea in spring and summer.

Key words: hydrophysics, thermohaline structure, cold intermediate layer, place-Baltic sea.