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Effective algorithms of detection of faint space objects streaks

A problem of joint detection and estimation of parameters of faint space object streaks in digital image (frame) is considered. In this work, we propose an effective two-stage algorithm for detecting a streak of a faint space object with unknown orbit and estimating its parameters. At the first stage, the sequential change detection method is used to detect abrupt changes in the statistical properties of the signal along the streak direction and thus to localize the object and preliminarily determine the beginning and end of the streak. At the second stage, the maximum likelihood ratio method is used to more precisely estimate the position of the streak. This two stage approach significantly reduces the number of hypotheses compared to the popular maximum likelihood ratio method. The developed algorithm is tested using both the simulated frames and the real data containing discrete clutter due to stars in addition to the background noise and streaks. In the case of real frames a spatiotemporal regression algorithm is used for clutter suppression. Tests show that the proposed two stage algorithm is able to detect streaks of space objects and accurately estimate their parameters with a signal-to-noise ratio for less than 1.

Key words: space object detection, image analysis, changepoint detection, joint hypothesis testing and estimation, background suppression.

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On the asymptotics of a solitary internal wave in the rarefaction wave mode

Transport flows, diffusion processes of new technologies, processes of filtration and gas dynamics are described by the first order quasilinear equation. The asymptotics of the solution of the Cauchy problem for this equation allows us to introduce characteristics of the dynamic process which are important from a substantive view point, for example, the diffusion rate of new technologies in diffusion models of Schumpeter type technologies. The convergence rate of the Cauchy problem solution to the asymptotics determines the characteristic times for these concepts to be used and depends on the internal waves dynamics. Using the method of characteristics, the paper studies the rate for the solution to reach the asymptotics for the first order quasilinear equation of the scalar conservation law.

Key words: scalar conservation law, asymptotics, internal shock waves.

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Decoding twocomponent subspace codes

The two component subspace code is constructed. The decoding procedure with preliminary determination components is described. The former decoding algorithm is changed. We propose a new criterion to determine which component is the code word – the first or the second component. Instead of the previously used rank criterion, numerical criteria are recommended. The rank criterion determines the component by the rank of a prefix matrix, while the numerical criterion determines by the number of unit elements on the prefix matrix diagonal. Comparisons of these criteria show that the numerical criterion is more efficient in decreasing the error probability, and can be more easily implemented than the rank one.

Key words: coding, decoding, two-component codes, rank, matrix, prefix, space, subspace.

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On a lower bound of connected domination number for graphs with prescribed degree sequence

We consider the lower bounds for the *connected domination number* $\gamma_c(G)$ of the graph G . This can be defined as either the minimal cardinality of a dominating set of vertices inducing a connected subgraph of G , or as a minimal number of nonpendant vertices in a spanning tree of G . We obtain bounds on $\gamma_c(G)$ for graphs with prescribed degree sequence. Our results imply, in particular, sharp bounds for regular graphs and some biregular graphs with leaves.

Key words: graphs, degree sequence, regular graphs, biregular graphs, connected domination, realization graph, lower bound, spanning tree, maximum leaf spanning tree.

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Software implementation of physically unclonable functions

The problem of physically unclonable functions based on field effect transistors modeling is investigated in this research. The method of programming the interpretation of a delay connected with a signal passing through the physical system is suggested. The stability and sustainability estimation of an obtained model is provided.

Key words: physically unclonable functions, information security, machine learning, arbiter, logistic regression, analogue electronics.

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Stationary shock waves in porous copper by SPH simulation

The mesoscopic simulation of stationary shock waves simulation in porous materials by a moving window method is proposed and developed for smoothed particle hydrodynamics. The mesoscopic simulation describes the material by the explicit definition of porous structure and uses an equation of state and strength properties of the bulk material only. To produce stationary shocks in the simulation we apply the constant inflow velocity of porous material to the computational domain but an iterative method for outflow velocity. This iterative method stabilizes the shock front at the prescribed position. The simulation of the shock produced by the standard solid wall boundary condition is consistent with the stationary shock produced in a moving-window.

Key words: shock waves, hydrodynamic simulation, elastoplasticity, smoothed particle hydrodynamics.

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Analysis of the gas field development model

We consider a continuous aggregated dynamic model of gas deposits with interconnecting wells. Various modes of development are analyzed analytically. Problems of maximizing accumulated production and maximizing profit are posed and solved. Problems proposed for the study belong to a class of optimal control problems with a free right end and fixed time. The basic mathematical apparatus is the Pontryagin maximum principle. Additionally, conditions are identified under which a group of deposits in the model representation can be considered as a single deposit.

Key words: optimal control problem with a free right end and fixed time, dynamic model of gas deposits, profit maximization, gas deposits development modes.

Numerical comparison of popular quickest changepoint detection procedures

In this paper, we study the problem of sequential detection of the moment of change in the properties of a random process that occurs in various fields of science and technology. The article provides a comparative analysis of the three most popular procedures: Shiryaev, Shiryaev–Roberts, cumulative sums (CUSUM) for a problem with Gaussian observation (signal to white noise). In the same observation characteristics are obtained from Fredholm second kind integral equations by numerically solving the integral equations by the collocation method. The study shows that in this statement of the problem, the most popular in practice CUSUM procedure works noticeably worse than the Shiryaev and Shiryaev–Roberts procedures.

Key words: changepoint detection, Shiryaev procedure, Shiryaev–Roberts procedure, CUSUM procedure, Gaussian observation, Monte Carlo, Fredholm second kind integral equation, numerical solution.

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Miniature x-ray tubes with field emission cathode from carbon materials

This paper presents an overview of the design and technology of miniature x-ray sources of various types, which can be useful in portable devices for diagnostics and medical therapy, as well as in industrial applications. Several examples of the use of X-ray tubes with field emission cathodes are described. Classic X-ray sources are widely used in medical radiology, radiation therapy, industrial radiography, and crystallography. However, they have a number of significant disadvantages such as high power consumption, the need to cool the anode, a complex design and a large mass. Currently, the use of miniature x-ray devices for diagnostics and therapy of people and animals is expanding. Many research centers conduct intensive research on x-ray machines. The main scientific problem is to obtain an electron gun with a small beam spot size and a short focal length, which allows placing the object under study near the radiation source and a sharp enlarged image.

Key words: X-ray tube, field emission, carbon materials.

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Electron beam plasma systems – new opportunities for lignocellulosic biomass processing technologies

The applications of the nonequilibrium low temperature oxygen electron beam plasma (EBP) to the controlled destruction of softwood lignocellulose destruction is described. The beam plasma effect leads to the amorphization of the crystalline part of the biopolymer and the formation of additional oxygen containing functional carbonyl and carboxyl groups on the surface of lignocellulosic fibers.

Key words: electron beam plasma, lignocellulosic, plasma chemical destruction of biopolymers, plasma chemical modification of the surface.

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Algorithm for detecting meteorological events based on the results of primary processing in a landing aerodrome radar

This study investigates the algorithm for primary processing of a signal reflected from different types of meteorological events in the zone of responsibility of the landing radar (LR). A brief analysis of the results of processing and conducting the LR experiment on the test site is given. It is concluded that the radar can be used to detect weather patterns.

Key words: weather patterns, landing radar, jamming map, threshold processing, spatial processing, temporary processing, radiation pattern.

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Generation of electron beam plasma inside a dielectric container

Plasma generation inside a cylindrical dielectric container filled with a gas by injecting a thin continuous electron beam along the container axis (z -axis) is experimentally investigated. Quartz glass tubes are used as the container, air is the plasma-generating medium. The plasma excitation is studied within wide range of gas pressure $P_m = 10^{-1} - 2 \cdot 10^1$ Torr. Longitudinal distributions of the luminescence intensity $B(z)$ of the container wall and its temperature $T_w(z)$ are studied. It was found that both of these functions have maxima whose positions depend on P_m , but the maxima $B(z)$ and $T_w(z)$ can be at different distances z .

Key words: electron beam plasma, plasma interaction inside the dielectric container.

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Methods of correlation NMR spectroscopy in the study of the structure of hyperbranched polyester BOLTORN H40

A combination of one-dimensional and 2D-correlation NMR spectroscopy methods is developed to study the structure of hyperbranched polyesters. The proportions of terminal, linear and dendritic monomeric units are determined for BOLTORN H40 polyester—31%, 53% and 16%, respectively. The high degree of branching of the BOLTORN H40 structure, which is 0.47, makes it possible to refer this polymer to a class of hyperbranched polyesters that can form micellar nanocontainers.

Key words: NMR, hyperbranched polyester, BOLTORN H40, degree of branching.

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Neural networks development for determining aerodynamic characteristics of small spacecrafts

A possibility to use artificial neural networks to simulate the aerodynamic characteristics of a small spacecraft moving in the low Earth orbit and experiencing the influence of a molecules stream is shown. The developed neural networks make it possible to determine both the integral characteristics of the apparatus such as a maximum moment relative to the selected axis, and the current aerodynamic characteristics (C_x , M_x , M_y , M_z) of a given apparatus as a function of its orientation relative to the flow.

Key words: neural networks, small spacecrafts.

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The effect of injection and suction on the processes of perturbation propagation in the boundary layer under conditions of hypersonic weak interaction

The article studies the processes of the propagation of disturbances in laminar boundary layers at high external flow velocities. Also, there is a thesis to prove that the distributed injection (suction) affects the heat transfer and the velocity profile of the boundary layer. Due to this, the dependence of the propagation velocity of disturbances upstream on the injection parameter (suction) for various values of the temperature factor exists.

Key words: boundary layer, perturbation propagation, weak viscous inviscid interaction theory, hypersonic flow.

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Experimental set-up for the low speed wind tunnel AT-3 of Center of aeromechanics and flight engineering MIPT

The description of measurements techniques in the low-speed wind tunnel AT-3 is presented. The experimental set-up is optimized for boundary layer laminar turbulent transition studies at the elevated free stream turbulence levels. The preliminary results of the free-stream grid turbulence and mean flow measurements are given.

Key words: wind tunnel, hot wire measurements, boundary layer, free stream turbulence.