CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

S. N. Kirillov, P. N. Skonnikov. WINDOW SIZE DETERMINATION PROCEDURE FOR THE ALGORITHM OF LOCAL WEIGHTED SUMMATION OF MULTISPECTRAL IMAGES

Key words: complexing of multispectral images, infrared range, weight summation, window processing, Fourier transform, spatial frequencies, upper frequency, linear approximation.

The problem of multispectral image fusion is considered. The known algorithms performing the fusion of such images are listed. The problem of choosing a window size that is relevant for the algorithm based on local weighted summation is disclosed. The aim is to develop a procedure for automatic window size determining for a referred algorithm of image fusion. According to the main operation principle of this algorithm, the association between the required window size and the sizes of the objects shown in the images is established. A procedure for automatic sizing of windows based on two-dimensional discrete Fourier transform is proposed. A database consisting of 50 images of various spectral ranges with measured sizes of the present objects is compiled. To evaluate the quality of the procedure proposed, two criteria were used: average relative error and the value of correlation coefficient. Optimum value of upper spatial frequency determination level is obtained. The average error in determining the size of objects by the method proposed is 42 % with a correlation coefficient between measured and calculated sizes of objects being equal 0,6.

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Yu. N. Parshin, **M. V. Grachev.** COMPARATIVE ANALYSIS OF THE ALGORITHMS TO SEARCH LOAD IMPEDANCES OPTIMAL VALUE OF MULTI-CHANNEL RADIO SYSTEMS WITH MUTUAL INFLUENCE

Key words: multichannel radio system, reconfigurable radio, load impedances, optimization, genetic algorithm, Nelder-Mead simplex method, mutual influence.

Multichannel radio systems are widely used to solve various types of problems. Decreasing the size of radio systems leads to the appearance of mutual interchannel influence, i.e., the change in mutual impedances matrix. In this regard the mismatch between load impedances and output impedances of antenna system being the part of multi-channel radio system arises. Reconfiguration increases the efficiency of system resources. Optimizing load impedances maximizes the resulting output signal-to-interference ratio. Reconfiguring load impedance requires a procedure for optimizing its values as well as estimating technical implementation of the values obtained. The aim is to compare the efficiency of optimization algorithms using the criterion of time/accuracy in the problem of tuning load impedances of a multi-channel radio system with mutual influence. The problems of studying the algorithms for optimizing load impedances and estimat-

ing efficiency have been defined and solved. A modification of fitness function has been carried out.

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A. Yu. Parshin. EXPERIMENTAL ESTIMATION OF NON-GAUSSIAN FLICKER-NOISE PARAMETERS

Key words: flicker noise, non-Gaussian model, experiment, optimal processing, signal-to-noise ratio.

The article deals with the experimental study of the possibility to receive and process ultra-low-power signals in information transfer systems of the Internet of things. A feature of the systems under consideration is low information transfer rate, which leads to efficient usage of signals with small bandwidth. During processing, narrow-band signals are transferred in frequency to the region of strong exposure to low-frequency flicker noise. The aim of the paper is to solve the problem of estimating and compendating the effects of flicker noise by means of theoretical modeling of noise to create a compensation algorithm, as well as the estimation of noise parameters based on experimentally obtained implementations. For flicker noise implementations, non-Gaussian character is estimated by calculating the excess factor.

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E. P. Vasilyev. MODELING OF MICROWAVE MULTI-CHANNEL SWITCHES

Key words: optimization technique, target function, optimal modeling, microstrip switch, analytical models, X-band.

In this paper, we propose a new technique for optimal modeling of multichannel switches using matrix analysis methods and the target function that takes into account two functioning states with different weighting factors. The aim of the work is to develop an effective method for multi-parameter synthesis of microstrip switches with verification of theoretical results using two, three and four-channel p-i-n diode switches of X-band beam type with increased working attenuation in locking mode and with little time for computing process. The feasibility of using Fletcher-Paul method of multicriteria optimization is substantiated. The influence of losses, dispersion, roughness and multilayer conductors is taken into account. The simulation results in the X-band of microstrip switches with parallel and series-parallel connection of p-i-n diodes in the path confirm the effectiveness of the proposed method.

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A. I. Kalinkin, T. S. Kislitsyna, I. A. Kudinov, I. A. Lyutkov, I. S. Kholopov. CALIBRATION OF THREE-AXIS MEMS ACCELEROMETER USING LEVENBERG – MARQUARDT METHOD FOR APPLIED PROBLEMS OF PHOTOGRAMMETRY AND IMAGE SUPERIMPOSITION

Key words: MEMS accelerometer, calibration, sensitivity ellipsoid, Levenberg – Marquardt optimization algorithm, projective camera, inertial measuring unit, Perspective-2-Point problem, image superimposition, panoramic image.

The article studies the error in estimating the vector of calibration parameters of three-axis MEMS accelerometer using non-linear Levenberg-Marquardt optimization method with different number of points on the surface of sensitivity ellipsoid. The aim of the work is to study the influence of measurement errors from MEMS signals of angular coordinate accelerometer, caused by error in estimating its calibration parameters with small number of calibration positions on the quality of solving two applied problems of digital image processing: 1) forming video panoramas and 2) positioning according to the data from a single camera and two reference emitters. It was shown that when calibrating MEMS of ADXL345 accelerometer the decrease in recommended number of calibration positions by 40 % and 80 % leads to the increase in absolute error in roll and pitch estimation to 1,5° and 3°, respectively. Such an absolute error in measuring angular coordinates when solving Perspective-2-Point positioning problem leads to the increase in relative error in measuring spatial coordinates of the object to 2,2 % and 4,3 %, and absolute error in measuring angular coordinate of the course to 2° and 4°, respectively. In the task of forming panoramic images, a false roll of objects and terrain is observed.

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O. G. Sherstneva, A. A. Sherstneva. SOLUTION TO THE PROBLEM OF COMMUNICATION NETWORK ANALYSIS WITH RELIABILITY INDICATORS

Key words: infocommunication system, section, information flow, matrix, state graph, reliability, communication network, program, modeling.

The article considers the problem of the influence of reliability indicators on the value of maximum information flow in communication networks. The article is aimed to solve the problem of determining minimum cross-section between any pair of switching nodes of communication network and to calculate reliability indicators of the communication lines used. Communication network is presented as a graph. To solve the problem, graphical and matrix calculation methods are used. To determine reliability indicators a graph of the states of communication lines was compiled. The article derives formulas to calculate availability factor and average time of communication line being in inoperative state with undetected failure. According to the calculation formulas and using simulation program, the graphs of dependences between main reliability indicators and the intensity of incoming load, failure rate as well as the intensity of communication line restoration were built.

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G. A. Sheroziya, M. G. Sheroziya. CALCULATING THE AMOUNT OF INFORMATION CONTAINED IN A CONTINUOUS SIGNAL

Key words: amount of information contained in a continuous signal; communication channel bandwidth; Shannon-Kotelnikov sampling theorem; differential entropy; determination of the maximum frequency in the signal; additivity; invariance; uneven samplings; zero function.

The article notes that the well-known expression for differential entropy $H = -\int_{-\infty}^{\infty} p(x) log p(x) dx$ leads to a number of insurmountable difficulties. In particular, an expression for information throughput of a communication channel being derived from it $I = f_m \log(\frac{F}{W} + 1)$, also has some drawbacks, including the possibility of the communication channel to transmit infinite information in the absence of noise. Evaluating the information contained in a continuous signal, the authors have proposed to rely on the Shannon-Kotelnikov theorem on samplings. If the original function can be restored from the samplings, and all the samplings can be set from the function, then the set of samplings obviously contains all the information presented in the function. Therefore, it is possible to establish what information is contained in a continuous signal by the samplings corresponding to this signal and by the Shannon formulas for a discrete case. The aim of work is to derive a formula for evaluating the information contained in a continuous signal.

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MATHEMATIC AND SOFTWARECOMPUTER SYSTEMS AND COMPUTER NETWORKS

D. A. Perepelkin, A. N. Saprykin, M. A. Ivanchikova, S. S. Kosorukov. DEVELOPMENT OF SOFTWARE TOOLKIT FOR ORGANIZATION OF CLOUD VIDEO CONFERENCING

Key words: distributed computing, digital cloud platform, cloud computing, cloud service, cloud video conferencing.

The problem of building a distributed cloud video conferencing service is considered. The aim of the work is to develop software tools for organizing cloud video conferencing in higher education system. The architecture and operational scheme of the developed cloud service are outlined in depth, the structure of main directories and class diagram for organizing video streaming are provided. The network infrastructure of cloud video conferencing service is based on the principles of software defined networks technology to assure flexible management of video data flows. The prototype of cloud video conferencing service proposed in the paper may potentially be used in numerous areas of activity.

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K. V. Bukhensky, A. N. Konyukhov, A. B. Dubois, A. S. Safoshkin. PECULIARITIES OF FUZZINESS TRANSFORMATION ON MULTIPLICATION LR-TYPE FUZZY NUMBERS

Key words: fuzzy set, LR-type fuzzy number, membership function, shape function, index of math fuzziness, spread vagueness, Zadeh's extension principle, alpha-cut of fuzzy set.

The aim is to investigate fuzziness transformation while multiplicating LR-type fuzzy numbers (FNs) in accordance with Zadeh's extension principle. This work is the proceeding of the former investigation of fuzziness transformations on linear operations with FNs, particularly the addition. As a measure of math fuzzi-

ness the Yager's index of fuzziness with linear Hamming metric has been used. The conditions of invariance, increasing and decreasing of fuzziness as well as the possible range of changes have been theoretically proven. In order to test theoretical results several numerical experiments has been accomplished.

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SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

V. K. Klochko. PROCESS PREDICTION ALGORITHM BASED ON ALTERNATIVE MODELS

Key words: Algorithms, prediction, processes, mathematical models.

Process prediction algorithm based on consideration of two and three alternative models differing in degree of increase or decrease of process model values is proposed. The aim of the work is to improve the accuracy of process prediction by developing an appropriate prediction algorithm. In accordance with the proposed algorithm, a combined forecast is set in the form of a linear combination with the weights of forecast values of alternative models. Weights are calculated automatically by a proximity criterion of combined prediction due to new incoming process data. Additionally, a table of forecast values depending on weights is constructed allowing to make a forecast manually. An example of predicting an epidemic process is given. The algorithm can be used in processing data systems in predicting processes of various physical natures.

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V. K. Klochko, **V. P. Kuznetsov**. MATHEMATICAL MODELS FOR IMPROVING ACCURACY CALCULATION OF POPULATION LIVING STANDARDS

Key words: Algorithms, forecasting, population incomes, mathematical models.

Mathematical models to calculate indicators of population living standards in Russian Federation regions according to the data of Federal State Statistics Service (FSSS) published in the form of histograms of income obtained by interviewing the population are given. The known approach to calculating the indicators is based on histograms approximation with lognormal distribution. The approach proposed differs from others by the use of distributions mixture and estimation of lognormal distributions parameters in several years sequence. The aim of the work is to develop different mathematical models of population income of the Russian Federation regions taking into account the data of population survey for several previous years, which make it possible to increase the accuracy of calculating indicators of population living standard in the regions of Russian Federation. Specific algorithms for calculating living standards based on the proposed approach have been presented. The possibility of calculating indicators in the regions of Russian Federation taking into account their correlation with indicators of Russian Federation is being discussed. Examples of the calculations confirming the operability of the algorithms offered are given. Algorithms can be used in FSSS practice.

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A. I. Bobikov, **T. S. Bubnova**. MANAGING UNSTABLE OBJECTS AND OBJECTS WITH INTEGRATOR USING THE COMBINATION OF CONTINUOUS IMMUNE AND PID REGULATORS

Key words: object with delay, object with integrator, unstable object, Smith predictor, continuous immune regulator, PID regulator.

This article presents a control algorithm for unstable objects and objects with an integrator with delay, using immune and PID controllers in conjunction with Smith predictor. The aim of the work is to increase the speed of control system, reduce the magnitude of overshoot, as well as reduce the influence of disturbing effects in comparison with the results of the system without immune regulator. In addition, the problem of ensuring the stability of the system is solved with the increase in delay time of the object within acceptable limits. The obtained simulation results implemented in Matlab / Simulink package clearly demonstrate the effectiveness of the developed design methodology.

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PHYSICAL ELECTRONICS AND NANOELECTRONICS

V. G. Litvinov, V. S. Litvinova. STUDYING THE CAPACITANCE-VOLTAGE CHARACTERISTICS OF METAL-SEMICONDUCTOR POINT BARRIER CONTACT

Key words: point barrier contact, semiconductor, capacitance-voltage characteristic.

The problem of theoretical analysis of a physical model of point metal-semiconductor barrier contact and its experimental confirmation is considered. The aim of this work is to study electrophysical properties of semiconductor micro- and nanostructures using the method of capacitance-voltage characteristics and atomic force microscopy for the development of ideas about physical processes in semiconductor structures of nanometer sizes. Based on the solution of the Poisson equation in the approximation of three-dimensional distribution of electric field the expression for the distribution of electric potential in semiconductor in point metal-semiconductor barrier contact is obtained. The study has experimentally shown that when the size of barrier contact decreases to the value being commensurate with Debye length the nature of the dependence between electric barrier capacitance and reverse voltage at point metal-semiconductor barrier contact changes.

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N. V. Rybina, A. V. Alpatov, N. B. Rybin. CRITERIA FOR DETERMINING THE SURFACE STRUCTURAL COMPLEXITY

Key words: surface, structural complexity, two-dimensional detrended fluctuation analysis, scale space, correlation parameters, Si, noise, harmonics.

The algorithm for determining surface structural complexity of solid-state materials based on two-dimensional detrended fluctuation analysis and scale space method is presented. The aim is to develop criteria for determining surface structural complexity by the values of slope angle tangent of fluctuation function on spatial scale dependence and the number of inflection points on it. Using the de-

veloped algorithm, the surface image of Si layer with implanted Ag+ ions subjected to pulsed laser annealing has been studied, and correlation parameters have been obtained. The studied surface has had high structural complexity.

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K. E. Seregin, N. V. Konenkov. X-ISLANDS OF STABILITY AT PHASE MODULATION OF QUADRUPLE MASS FILTER HIGH-FREQUENCY VOLTAGE

Key words: quadruple mass filter, phase modulation, parametric resonance, X-islands of stability, resolution, transmittance, sorting time, Gaussian ion beam.

The article considers the task to determine ion-optical characteristics of X-islands of stability in quadruple mass filter for HF voltage phase modulation. The aim of the work is to determine basic parameters (viz., resolution, transmittance) for upper X-islands of stability in quadruple mass filter formed by HF voltage phase modulation. X-islands are the islands being formed along the isolines of β_x characteristic exponent on coordinate (a, q) plane for Mathieu equation parameters. The work uses the method of mathematical modeling of the process with the ions moving through QFM (quadruple mass filter) being the basis for modified stability diagram on coordinate (a, q) plane as well as for mass peak corresponding to the stability area under consideration (X-island) in the diagram received. The results of the research are presented as graphs.

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K. E. Seregin, N. V. Konenkov, A. A. Dyagilew. STATISTICAL ACCEPTANCE OF X-ISLAND OF STABILITY OF QUADRUPLE MASS FILTER

Key words: quadrupole mass filter, frequency modulation, parametric resonance, X-stability islands, resolution, transmission, scanning time, Gaussian ion beam, acceptance, emittance.

In the article the effectiveness of ion source matching with Gaussian beam is compared with acceptance of quadruple mass filter (QFM). The aim of present research is the comparison between the effectiveness of ion source matching and acceptance of QFM which is used to investigate first stability region and X – stability island with the stated statistical method. The peculiarity of the task is the investigation of QFM operation mode with comparatively high resolution value $R_{0,1} = 6000$. Mass filter works in a customary mode (high peak of the first stability region) and in X – stability island initiated by RF voltage frequency modulation. The effectiveness of mentioned ion source matching with the analyzer in X-island is by an order higher. The effectiveness is evaluated with the help of several random distributions of initial coordinates and velocities of stable trajectories.

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