

CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

I. A. Ermolaev, I. M. Somov, I. S. Kholopov. DEVELOPING A MATHEMATICAL MODEL TO MAKE A DECISION ON SETTING UP SPOOFING CLUTTERS TO SATELLITE RADIO NAVIGATION SYSTEMS

Key words: satellite radio navigation systems, spoofing clutters, inertial navigation systems, microelectromechanical sensors, Euler angles, quaternions, Kalman filter.

The solution to the problem of detecting the fact of setting up spoofing clutters to satellite radio navigation systems by comparing navigation information from consumer equipment and auxiliary inertial navigation system is considered. The aim of the work is to develop a mathematical model that implements the simulation of navigation data from each of the systems, and to compare them with decision threshold. Geometrical formulation of the problem and the algorithm to make a decision on setting up spoofing clutters are presented. Mathematical modeling has been performed for the trajectory of the object with consumer navigation equipment in ascending spiral with constant linear speed for the time interval of 120 sec length.

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L. V. Aronov. USING REED-SOLOMON CODES IN UNDERWATER WIRELESS OPTICAL COMMUNICATION CHANNEL WITH INTENSITY CODE-PULSE MODULATION

Key words: underwater optical wireless communication channel, optical wireless communication, free space optical channel, mathematical model, underwater communications systems.

Data transmission maximum distance in underwater wireless optical communication channel (UWOCC) with pulse-code intensity modulation (PCM) is estimated. The aim of the work is to investigate the possibility to use Reed-Solomon codes for increasing real time video data stream transmission distance, without increasing radiation power. The article presents bit error rate (BER) modeling depending on the range for various values of electrical bandwidth. The calculations were carried out for UWOCC without correcting coding, as well as with Reed-Solomon codes. The use of Reed-Solomon codes is shown to provide a gain in maximum range of not less than 38 meters with channel bandwidth of 100 MHz, not less than 32 meters with channel bandwidth of 1 GHz, and not less than 30 meters with channel bandwidth of 10 GHz. The spread in maximum length values lies in the range between 7 and 13 meters depending on electric channel bandwidth.

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V. V. Zolotarev, G. V. Ovechkin, Ch. T. Zhung. SIMULATION OF CONCATENATED MULTITHRESHOLDS DECODING ALGORITHMS OF VARIOUS TYPES FOR GAUSSIAN COMMUNICATION CHANNELS

Key words: error-correction coding, Gaussian channel, multithreshold decoder, error propagation, symbolic code, concatenated scheme, convolutional codes, block codes, decoder complexity, throughput, Optimization Theory, self-orthogonal code, Reed-Solomon code.

Methods of simple implementation of concatenation in binary Gaussian channels based on multi-threshold decoders (MTD) for convolutional codes are considered. Cases of

application in the second stage of convolutional codes decoding for both binary and nonbinary classes, known in the Optimization Theory (OT) as symbolic, are considered. A conclusion is made about a very simple implementation and about higher efficiency characteristics of concatenated codes with MTD than those of the previous classical circuits with Viterbi algorithm (VA) and Reed-Solomon (RS) (VA-RS) codes. It is noted that all schemes with MTD have unlimited performance in hardware implementation. A very moderate increase in decoding delay is indicated in comparison with non-concatenated versions of implementation, which is determined by the absence of the need to use traditional two-dimensional concatenated structures.

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V. T. Dmitriev, P. N. Skonnikov. COMPARATIVE ANALYSIS OF ALGORITHMS FOR MULTISPECTRAL IMAGE FUSION

Key words: multispectral image fusion, local weighted summation, infrared range, objective quality index, Piella metric, image dataset, enhanced vision, rescue operations.

The article shows the relevance of the problem for multispectral image fusion during search and rescue operations. Well-known algorithms for such image fusion are considered and implemented. Based on the publicly available datasets of multispectral images a combined database including 496 pairs of images has been compiled to compare the algorithms considered. The results of image fusion using the considered algorithms are obtained. The aim is to compare the known algorithms for multispectral image in terms of objective quality indices. Comparison of fusion results was carried out by two criteria: Piella metric and combined quality index. Based on the results of the comparison, it was concluded that the best values of combined quality index for multispectral image fusion are provided by the algorithms based on local weighted summation, principal components analysis and Laplace pyramid.

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A. V. Safonova, V. I. Martynov. ADAPTIVE CONSTRUCTION ALGORITHM RADAR IMAGE TARGETS

Key words: radar image, maximum correlation algorithm, adaptive algorithm for constructing a radar image of a target, background interference, interference from water surface.

The problem of constructing a radar image of a complex target against the background of water surface is considered. The aim of the work is to develop an effective algorithm for processing radio signals against the background of interfering influences. An adaptive algorithm for constructing a radar image of a target is proposed. The advantages of the proposed algorithm for constructing a radar image of a target in the presence of background interference from water surface in comparison with maximum correlation algorithm are proved. More efficient law for the variation of algorithm adaptation parameter is found.

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MATHEMATIC AND SOFTWARE COMPUTER SYSTEMS AND COMPUTER NETWORKS

K. I. Nikishin. MODELING OF WIRELESS SENSOR NETWORK USING OMNET++

Key words: wireless technologies, wireless sensor networks, self-organizing networks, IEEE 802.15.4 WPAN protocol, coordinator, modeling, OMNET++, Castalia.

In the modern world among all network technologies the wireless technologies occupy a special place. We have the necessity to develop and implement new algorithms and protocols in wireless technologies. The main and most perspective direction in wireless systems is the design of systems for monitoring and control of object parameters. Special place in this direction is occupied by wireless sensor networks (WSN). The aim of the research is to study the protocols of wireless sensor networks and their synchronization algorithms using modern modeling environment OMNET++. The main tasks of the research are to study WSN standards, WSN protocol such as IEEE 802.15.4 WPAN and its modeling with efficiency assessment. The developed model made it possible to verify algorithms and evaluate the performance of network nodes, network bandwidth and efficient power consumption.

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E. O. Khramshina. THE METHOD TO COMPRESS INTERMEDIATE DATA IN DISTRIBUTED MINING OF ASSOCIATION RULES

Key words: data mining, association rules mining, 3D2ARM algorithm, data structures, data transfer, data compression, zero-length suppression method, variable size of array values.

The aim of this work is to decrease memory volume for storage and transfer taken by three-dimensional array in distributed mining of association rules. Volume decrease is achieved due to sparse array and variable size of array element values. Array elements with non-zero values are written as a number pair: the offset from the previous element with non-zero value and the value itself. To separate numbers, one of the bits in a byte is used as a service one, to point the end of the value. The experiments have shown that this method allows file size 74 % less on average in comparison with the original array. Software in Java programming language has been developed for these experiments. The compression method together with 3D2ARM association rules algorithm can be used to develop distributed mining of association rules.

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INTELLIGENT INFORMATION SYSTEMS AND TECHNOLOGIES

A. S. Alyoshkin. RESEARCH AND ANALYSIS OF TRANSPORT PROBLEMS IN URBAN ENVIRONMENTS

Key words: road traffic forecasting, radial basis function network, RBFNN, particle swarm optimization, PSO, intelligent transportation systems, ITS, line planning.

This article considers the approaches for the tasks of traffic situation forecasting and building optimal planning systems. The aim is to study and analyze problems in the field of traffic automation, carried out through a review of foreign sources devoted to the tasks and algorithms of this subject area. Various topics and approaches selection in a given area is carried out. A translation is provided-as a presentation of foreign sources.

Common approaches and problems when solving the tasks of forecasting road situation are given.

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K. V. Bukhensky, A. N. Konyukhov, K. V. Anisimov. RAPID CALCULATION OF CONSEQUENTS FUZZINESS INDICES AFTER MAMDANI IMPLICATION AND FURTHER AGGREGATION

Key words: fuzzy set, LR-type fuzzy number, membership function, shape function, index of fuzziness, integral functions of fuzziness index, antecedent, consequent, Mamdani implication, linguistic variable term, cross-factor.

The aim is to – 1) obtain the analytical formula for consequent index of fuzziness after Mamdani implication (rule); 2) derive the analytical formula for fuzziness index of a fuzzy set (FS) gained after aggregation of arbitrary number subnormal consequents of Mamdani implication. This work is the proceeding of former research on the project «Fuzziness transformations in fuzzy inference systems (FIS)». As a measure of math fuzziness a Yager's index with linear Hamming metric was used. The analytical formulas for integral functions of fuzziness index for some shape functions (IFFI SF) of LR-types of fuzzy numbers (FNs) were derived. IFFI SF allows us to calculate FS's index of fuzziness obtained from FNs via logical operations. Common and partial formulas for LR-type FNs with linear and clipped parabola shape functions were represented. In order to test theoretical results several numerical experiments were accomplished. The expressions obtained allow calculating the index of fuzziness for FSs after Mamdani implication and further consequents aggregation without integration procedure thus reducing calculation time dramatically. Formulas may be further analyzed in order to search the optimal conditions of Mamdani type inference in the terms of fuzziness.

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N. I. Tsukanova, K. G. Shitova. SEARCH FOR ACCEPTABLE VALUES OF APPLICATION PARAMETERS FOR LENDING USING NEURAL NETWORK

Key words: client creditworthiness assessment, loan application, deep fully connected neural networks, Python language, Keras library, error back propagation algorithm, conjugate vector, target (loss) function.

The issues of selecting the parameters of client application for lending in order to transfer the borrower from the class «denied lending» to the class «loan issuance is allowed» are considered. The aim of the work is to improve the quality of client's creditworthiness assessment procedure, aimed at increasing the number of borrowers by agreeing with them and/or giving them recommendations on changing loan application parameters. To achieve this aim, the following tasks were solved in the work. A deep neural network has been developed in Python, solving the problem of binary classification of clients by their characteristics into two classes – (admitted, not admitted) to lending. It is shown that the disadvantage of such a procedure is a large dropout of customers who could get a loan and bring the income to bank, but on other stricter conditions. Methodology and algorithm of searching loan application parameters values, allowing the client to be admitted to lending, are proposed.

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V. V. Frolov, G. N. Zholtkevych, O. Yu. Prihodko, Yu. V. Skuryatin. METHOD OF PRELIMINARY SELECTION OF MULTILAYER NEURAL NETWORK ARCHITECTURE FOR POLYHARMONIC SIGNAL APPROXIMATION

Key words: artificial neural network, activation function, approximation, genetic algorithm, feedforward neural network without feedbacks, discrete optimization, median, mean square, absolute error.

The proposed method for preliminary selection of the architecture for narrowing multilayer artificial neural network of direct propagation without feedback with sigmoid activation functions is based on determining the number of layers by the shape of a polyharmonic signal. The authors have proposed to characterize signal shape by the number of inflection points. The article has experimentally proved that the number of layers in multilayer network correlates with the number of inflection points according to the criterion of minimizing absolute error when compared with a universal approximator. The total number of neurons in a multilayer network is determined from the condition that it cannot exceed the number of neurons in a universal approximator. The essence of the method lies in the comparative analysis of absolute error for single-layer and multi-layer network. Resulting configuration of multilayer network can be used as an initial one for further optimization of the structure.

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MATHEMATICAL AND COMPUTER MODELING

A. O. Faddeev, S. A. Pavlova. ABOUT A POSSIBLE MATHEMATICAL METHOD STUDYING THE DYNAMICS OF DANGEROUS PROCESSES GEODYNAMIC ORIGIN

Key words: Geodynamic stability; seismic activity, SWANN diagrams, solar wind, interplanetary magnetic field.

The aim of the study is to analyze the mathematical method of studying the dynamics of dangerous processes of geodynamic origin; the influence of factors that can lead to overvoltages in earth crust is considered.

When analyzing the method under consideration, two-dimensional graphs of changes in solar wind density and magnetic induction of MMP were constructed to determine significant impact of space-earth connections; when preparing the initial fields of quantities used in the construction of SWAN diagrams, the Fourier spectrum was constructed in a two-dimensional Cartesian coordinate system for each series of values; the most significant frequencies, which were used to calculate amplitude-frequency spectrum were identified; spatial SWANN diagrams were constructed.

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I. Y. Klochkova. RESEARCH OF STABILITY OF PARACHUTIST'S MOTION IN SPECIAL CASES

Key words: mathematical model of parachutist movement, equilibrium state, regression analysis, correlation coefficient, parachutist trajectory, parachutist landing speed.

A mathematical model of parachutist movement describing the stage of descent on open parachute is considered.

The aim of the work is to study the system of ordinary differential equations describing the speed of parachutist movements for the presence and stability of equilibrium states. Initially, the system of differential equations determines the relationship between the acceleration of parachute and the velocity for each of three space coordinates. Various

variations of this system of differential equations are considered. Theorems on the number and stability of equality states are proved.

Numerical coefficients values for the system of differential equations based on real data of jumps obtained using a special program installed on parachutist mobile device by regression analysis method are obtained. The equilibrium states for each jump, their stability, practical significance and maximum value of the speed at the time of landing are determined. Theoretical parachutist trajectory for the obtained system of differential equation is constructed; its comparison with actual trajectory is carried out.

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SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

A. I. Novikov, A. V. Pronkin, N. O. Shamin. FREQUENCY METHOD OF FILTERING PERIODIC INTERFERENCE OF DIGITAL IMAGES

Key words: periodic interference, filtering, discrete Fourier transform, amplitude spectrum, local extremum, estimation of mathematical expectation.

The aim of the work is to develop and experimentally test a method for filtering periodic interference of a digital image based on two-dimensional discrete Fourier transform (DFT). Periodic interference in the image in the form of rectilinear bands, or in the form of lines of a more complex structure, but at the same time periodic, corresponds to the local maxima of the amplitude spectrum obtained as a result of performing direct DFT. To filter periodic interference, it is necessary to detect local maxima, reset Fourier coefficients in the vicinity of local maxima and apply inverse DFT to a modified matrix of Fourier coefficients. A simple method for detecting local maxima on amplitude spectrum and an approximate method for forming regions of zeroing the Fourier coefficients in the vicinity of local maxima are proposed. Studies of the results of filtering periodic interference of various shapes, intensities and, in particular, in conditions of additive discrete white noise have been carried out.

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A. I. Novikov, E. Yu. Kholopov. STATIC HAND GESTURES DETECTION USING COMPLEX CONTOUR ANALYSIS

Key words: contours highlighting, gradient detection methods, piecewise linear approximation, contour autocorrelation function, contours proximity criterion.

The aim of the work is to develop and study static hand gestures detection method with the help of complex contour analysis. The application of complex contour analysis implies the solution of several tasks – highlighting hand contours, piecewise linear contour approximation, the calculation of autocorrelation function (ACF for the contour received), comparison of ACF contour with the ACF of reference contour. The algorithms implementing each step of hand gesture processing as well as the results of experimental research of this method on large series of hand gestures are given.

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PHYSICAL ELECTRONICS AND NANOELECTRONICS

A. N. Vlasov, M. V. Dubkov, Yu. V. Cherkasova, A. V. Nikolaev. CREATION AND RESEARCH OF PULSE PLASMATRON WITH INDUCTION DISCHARGE FOR PRODUCING AUTONOMOUS PLASMA FORMATIONS

Key words: pulsed plasmatron, metal electric explosion, pulsed magnetic field, induction discharge, long-lived autonomous plasma formations.

A prototype of a pulsed plasmatron containing semi-open cylindrical chamber with electrically exploding copper conductors of large cross-section creating pulsed toroidal magnetic field, as well as electrically exploding thin wires to create dense plasma being installed has been created and researched. The principle of operation of the plasmatron is based on excitation of an induction discharge during the decay of magnetic field in plasma created by electric explosion of thin wires. The authors have shown that in this case, autonomous plasma formations with anomalous afterglow (about 60 ms) are formed. The aim of the work is to create a pulsed plasmatron with an inductive discharge, as well as to experimentally estimate the parameters of device prototype.

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S. M. Karabanov, D. V. Suvorov, E. V. Slivkin, O. V. Loban, P. P. Bezrukikh, C. C. Belykh. POSSIBILITY OF USING INTERNET OF THINGS TECHNOLOGY IN A MICROGRID BASED ON RENEWABLE ENERGY SOURCES

Key words: Internet of Things, microgrid, solar energy, wind energy.

Microgrid based on renewable energy sources is widely used in many power supply systems of small communities. Solar power plants and wind turbines are often used to generate electricity. For the stable operation of a microgrid, it is important to ensure its operational management and the ability to monitor energy consumption. The microgrid control system based on things solves the problems of collection and processing, object management.

The purpose of this work is to study the use of IoT technologies in microgrid management. Regarding the work of a microgrid based on a solar power plant and a wind generator in Central Europe, Russia. Conducted research on the possibilities and ways of using IoT technologies to control and manage microgrids based on renewable energy sources.

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B. A. Kozlov, I. V. Login, R. A. Shishov. THE EFFECT OF GAS ADDITIVES ON EMISSION PARAMETERS OF LOW-PRESSURE NITROGEN LASER

Key words: low pressure nitrogen laser; average radiation power; radiation energy in a pulse; radiation pulse duration; longitudinal discharge; metastable states; pulse repetition rate.

The effect of helium, neon, argon, and hydrogen additions on the average radiation power level and the maximum pulse repetition rate in a low-pressure nitrogen laser pumped by a longitudinal discharge is studied. It was found that the introduction of helium, neon, argon, and hydrogen into the active element of a nitrogen laser with partial pressure of 5 Torr at optimal nitrogen pressure of 18 Torr promote an increase in average radiation power level by 20 – 30 % and does not affect maximum pulse repetition rate. The addition of neon or argon to pure nitrogen does not lead to noticeable changes in average radiation power and maximum pulse repetition rate. In an active element made of beryllium ceramics 300 mm long and 4 mm in diameter, maximum values

of average radiation power of up to 115 mW were achieved in pure nitrogen ($P_{N_2} = 18$ Torr), 120 mW when using nitrogen with the addition of hydrogen in the ratio $P_{N_2} : P_{H_2} = 18 : 5$ Torr and 140 mW when using nitrogen with the addition of helium in the ratio $P_{N_2} : P_{He} = 18 : 5$ Torr at the maximum pulse repetition rates of 500 – 600 Hz.

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D. S. Makhanko, A. Ya. Payurov. MECHANICAL STRENGTH OF UNCONTROLLED HIGH-PRESSURE SPARK GAP – SHARPENER DESIGN

Key words: spark gap-sharpener, mechanical strength, ceramic insulator, operating pressures, argon arc welding, metal-ceramic soldered joint.

The problem of determining the factors affecting mechanical strength of uncontrolled high-pressure spark gap-sharpeners designed to generate voltage pulses with an amplitude of up to 500 kV with rise times of a fraction of a nanosecond is considered. The aim of the work is to determine by calculation and by direct testing the structural strength of a spark gap-sharpener with working pressure of up to 120 technical atmospheres (kgs/cm²). It was found that when preparing uncontrolled sealed-off high-pressure spark gap-sharpeners in metal-ceramic versions of RO – 48, RO – 43, RO – 49 series with optimal geometric dimensions, from the viewpoint of ensuring necessary electrical strength, when manufacturing a 12H18N10T stainless steel case with wall thickness of 2 mm and high-voltage cone-shaped insulator made of aluminum oxide ceramics of VK94-1 (22HS) type with wall thickness of 3 mm, they can be filled with working gases up to the pressure of 120 technical atmospheres.

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D. S. Makhanko. ELECTRICAL STRENGTH OF UNCONTROLLED SPARK GAP-SHARPENER DESIGN FOR VOLTAGE UP TO 500 KV

Key words: spark gap-sharpener, electrical strength, ceramic insulator, breakdown on insulator surface, spark gap-sharpener design, duration of high-voltage pulse leading edge, high-voltage pulse generator.

The problem of determining the factors affecting electrical strength of uncontrolled spark gap-sharpeners is investigated. The aim of this work is to study the influence of geometric dimensions and shapes of a high-voltage ceramic insulator, high-voltage connector of electrode and the casing of a high-pressure spark gap-sharpener on its electrical strength in the range of dynamic breakdown voltage from 100 to 500 kV. The basic design of spark gap-sharpener has been developed. Practical recommendations are given for engineering of uncontrolled gas-filled soldered spark gap-sharpeners in metal-ceramic design, providing minimum geometric dimensions at voltages up to 500 kV, subnanosecond response times and a resource of at least 3×10^6 actuations in a given operating mode. The industrial production of a series of spark gap-sharpeners of RO – 48, – 43, – 49, – 72 type has been mastered for operating voltages from 100 to 500 kV for use in pulsed X-ray technology.

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B. I. Ognev, S. A. Skladchikov, E. G. Chulaeva. TURBULENCE INFLUENCE TO OPTICAL SIGNAL PROPAGATION WITH WAVELENGTH 1550 NM

Key words: turbulence, optical signals, laser radiation, beam path, optical beam splitting.

In this work authors present computational modeling results of optical signals passage near the receiving sites made in ANSYS program complex. Laser beam is split into several filaments due to the phenomenon of turbulence. Due to the fact that uneven distribution of air refraction coefficients occurs near the receiving sites of optical signal receiving devices in the atmosphere, laser beams are split near the receiving sites. It means that requirements for the receiving sites of optical signals should be increased. To solve the problem with phenomenon of turbulence, several laser transmitters and receivers at different wavelengths should be installed in laser beam propagation installations. It increases the speed of information transfer and the reliability of the devices.

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