

CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

A. YU. PARSHIN, V. KH. NGUYEN. PERFORMANCE ANALYSIS OF MIMO COMMUNICATION SYSTEM WITH DIFFERENTIAL CODING IN THE PRESENCE OF SCATTERERS

Keywords: Internet of Things, MIMO, wireless sensor networks, differential space-time block coding, capacity, scatterers, Alamouti coding, COST-259, Rice factor.

This paper studies the characteristics and performance of a communication system using differential space-time block coding in Rice channel. Channel capacity is analyzed in the presence of scatterers located in the region where transmitting and receiving devices are installed. A three-dimensional COST-259 compliant model of scatterer locations is used to estimate the changes in signal amplitude and phase during propagation. The aim of the study is to study system performance using differential block coding, which requires no estimation of channel matrix at a receiving end for different power ratios of direct beam and diffusion component. This work analyzes ergodic capacity and bit error probability as a function of signal-to-noise ratio when using differential coding. The results show the negative effect of scatterers on link efficiency and the advantages of differential coding with Alamouti coding.

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V. A. BELOKUROV, Q. T. NGUYEN. CALCULATION OF PROBABILITY DISTRIBUTION DENSITY OF POLYNOMIAL COEFFICIENT ESTIMATES IN THE LEAST SQUARE METHOD

Keywords: probability distribution density, least squares method, polynomial coefficients.

The issues of calculating probability distribution density of polynomial coefficients which are obtained using the least squares method, are considered. The aim of the work is to derive the distribution laws of polynomial coefficients estimates calculated using the least squares method. The analytical form of probability distribution densities of these coefficients is necessary to calculate a detection threshold when detecting signals against the background of non-stationary noise. The paper provides analytical expressions for corresponding probability distribution densities. In order to determine the reliability of the results obtained, simulation modeling was carried out, within which the corresponding histograms were obtained being used in Chi-square goodness-of-fit test. Test statistics corresponding to the significance level of 0.05 is 5.42 and 6.92, respectively.

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D. S. POTEKHIN, Y. M. SKRYABIN. AIRCRAFT LOCATION INFORMATION AND MEASUREMENT SYSTEM SENSORS PLACEMENT

Keywords: electrostatic location, electrostatic monitoring, electrostatic fluxmeter, electrostatic probe, aerial reconnaissance vehicles.

The accuracy of location and response time to the aircraft of information and measurement system of electrostatic location, which is based on passive measurements of electrostatic field strength at the points of protected area, are considered. The aim of the work is to determine the distance that the aircraft overcomes after crossing the guarded perimeter before it is detected, as well as the influence of sensor location on the accuracy of response. The results were obtained taking into account the use of a convolutional algorithm for digital processing of full length of electrostatic signals arising from the movement of a charged flying apparatus near a sensor. The error in calculating target coordinates is analyzed, taking into account the error in calculating electrostatic signal features. The answer to the question of sensor placement step is given not

only from the viewpoint of signal/noise level, as it was proposed earlier, but also on the basis of the accuracy of its current coordinates calculations.

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A. E. KUTSEV, A. E. SEREBRYAKOV. METHODS FOR INCREASING ACCURACY IN STRAPDOWN INERTIAL NAVIGATION SYSTEMS

Keywords: strapdown inertial carbon system, operating principle, filtration, analysis.

The article discusses the principles of operation of strapdown inertial navigation systems and provides an overview of methods for filtering and signal recovery, as well as their classification. It also considers the essence of methods to increase the accuracy of navigation systems using input data to form a multidimensional space, which is then reduced to a smaller number of measurements. The use of feedback in classical Kalman filters and neural networks is also discussed.

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MATHEMATIC AND SOFTWARE COMPUTER SYSTEMS AND COMPUTER NETWORKS

D. A. PEREPELKIN, V. T. NGUYEN. NEURAL NETWORK MULTIPATH ROUTING IN SOFTWARE DEFINED NETWORKS BASED ON ANT COLONY OPTIMIZATION ALGORITHMS

Keywords: software defined networks, neural network routing, multipath routing, deep learning, recurrent neural networks, swarm intelligence, ant colony optimization.

Currently, the widespread demand for the implementation and use of various cloud solutions is a modern trend and a driving force for the development of network technologies. The growth of cloud application services provided through data centers with different network traffic needs demonstrates the limitations of traditional routing and load balancing methods. The integration of software defined networking (SDN) technology and artificial intelligence (AI) methods provides effective resource management and operation of computer networks. In this paper, an approach to neural network multipath routing in SDN based on ant colony optimization algorithms is proposed. An architecture and model of an artificial neural network are developed to solve the problem of multipath routing in SDN, which is capable of predicting the shortest paths based on communication link metrics. To optimize the hyperparameters of the neural network model, the paper proposes to use the algorithms of the ant system and the ant colony system. A visual software system SDNLoadBalancer has been developed and an experimental topology of the SDN has been designed, allowing a detailed study of the processes of neural network multipath routing in the SDN based on the proposed approach. The results obtained show that the proposed neural network model has the ability to predict routes with high accuracy in real time, which allows implementing various load balancing schemes in order to increase the performance of the SDN.

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I. YU. KASHIRIN. FORMAL SOFTWARE MACHINES FOR OBJECT-ORIENTED LANGUAGES: C++

Keywords: formal software machines, algorithmic algebras, program optimization, object-oriented programming, algorithmic languages.

Mathematical apparatus of formal software machines which is an ordered set of universal algorithmic algebraic systems is considered. Algebraic systems make it possible to adequately and uniformly describe and analyze program code for significantly different programming languages, such as C, Lisp, Prolog, Python. Algebraic systems are divided into algebras of working with RAM, algebras of constants, algebras of control syntactic constructions and algebras of program code interpretation. The signature of formal software machines allows us to consider

composition and decomposition of all program code elements for the synthesis of simple structures into complex algorithmic structures or the analysis of complex programs into simplest structures. The article shows that formal software machines can be used not only for non-object languages, but also for structuring object-oriented programming languages.

An example of an object-oriented program in C++ is given, the possibility of its formal analysis and obtaining object-oriented code from functionally equivalent non-object programs is shown. As a result of the experiments performed, the effectiveness of using formal software machines to optimize program code with increased efficiency on a variety of complex programs is shown. The aim of the work is to present the effective use of formal software machines not only for the analysis and optimization of non-object programs, but also for object-oriented approach.

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A. V. VOSTRYKH. SIMULATION AND ANALYTICAL MODEL TO EVALUATE THE EFFECTIVENESS OF GRAPHICAL USER INTERFACE VISUAL AESTHETICS

Keywords: graphical user interface, simulation and analytical model, visual aesthetics, efficiency, load, performance.

The article discusses the scientific task to increase the performance of users in software products, which directly depends on the efficiency of program graphical user interfaces execution. The aim of the work is to develop scientific, methodological and instrumental tools that allow both to evaluate program interfaces in terms of visual aesthetics effectiveness, and to compare the programs that are similar in functionality and purpose. Also, these tools allow us to both assess the performance of users in the analyzed programs and predict the level of their performance during the working day. To achieve this aim, the article identifies interface loads that affect the user during the working day when using programs; the composition of these loads was determined in the form of spectra of effectiveness indicators that assess visual aesthetics of interfaces. Analytical models of cognitive, visual and motor loads were also built. The composition of factors influencing the performance of users in addition to interface loads was also determined. Original formula to calculate user performance when using interfaces of various programs is proposed. A formalized approach that allows one to visualize the dynamics of user performance when using various interfaces, as well as to compare the interfaces of programs similar in functional content in order to select the most effective one is proposed. An original simulation-analytical model is offered to assess the effectiveness of interface visual aesthetics which, in addition to automating the computational processes of evaluating and comparing interfaces, allows real-time monitoring of increase or decrease in cognitive, visual and motor loads depending on changes in characteristics interfaces and user models, as well as predict the level of user performance during the working day.

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INTELLIGENT INFORMATION SYSTEMS AND TECHNOLOGIES

V. P. KORYACHKO, S. D. VIKULIN, A. V. VOLKOV. APPLICATION OF CLASSTERIZATION METHODS TO ANALYZE THE PROPERTIES OF MATERIALS

Keywords: machine learning, cluster analysis, material science, k-means, elbow method, silhouette method, dendrogram.

The problem of developing cluster analysis methods to study basic characteristics of materials for the purpose of further development and implementation of intelligent search system in the field of materials science is considered. The aim of this work is to develop cluster analysis methods to study the basic characteristics of materials for further development and implementation of intelligent search system in the field of materials science. Clustering is carried out using the k-means algorithm, and validation of the results is carried out using intra-cluster and inter-cluster analysis. The determination of optimal initial parameters of cluster analysis method was

carried out using elbow and silhouette methods. A collection of materials was successfully decomposed into clusters, and data hierarchical structure was visualized using a dendrogram, which confirmed the effectiveness of the method proposed.

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MATHEMATICAL AND COMPUTER MODELING

V. A. BOCHAROV, T. M. VOLOSATOVA, M. V. FILIPPOV, L. V. CHICHAIEVA, S. A. PRODAN.
DECOMPOSITION AND AGGREGATION OF FUNCTIONAL SYSTEM MODELS

Keywords: functional model, functional decomposition, modeling language, semantics, mathematical method.

The article is devoted to the search for new, more efficient tools and methods of model based system design and analysis. The field of the research includes functional modeling being the source of target system functional properties in the conditions in which it operates. System modeling is defined as using virtual analogues instead of physical things, which under certain assumptions and simplifications have properties similar to the material system. Within the framework of this study, the problem of reducing the functional complexity of entire target system to a certain number of simpler functions is solved, the analysis and synthesis of which fits within the capabilities of available mathematical methods and computing tools. To solve this problem, we propose a general abstract metamodel of system functions, the connections of its parts, as well as a theory that allows «disassembling» and «assembling» system models into its individual semantic parts, while functional integrity is kept. The aim of this research is to increase the effectiveness and to reduce R&D time of critical technologies and systems using a modern national system engineering platform.

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SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

Y. R. MURATOV, A. I. EFIMOV, A. S. YEPIFANOV. ALGORITHM FOR SIMULTANEOUS LOCALIZATION OF MULTIPLE DATAMATRIX CODES ON IMAGE

Keywords: binarization, localization, bar codes, DataMatrix codes, QR codes, classifier, classifier with Haar features, classifier with boundary features, tree classifier.

This paper proposes an algorithm for localizing multiple two-dimensional barcodes of DataMatrix or QR type in an image with low computational complexity. A distinctive feature of the algorithm is high localization accuracy due to the use of built-in classifier, which is based on data about potential areas of interest. For each area of interest, the classifier takes into account its dimensions, proportions, and the density of filling the entire area of two-dimensional barcode with black pixels. The algorithm was designed based on the need to optimize calculations on industrial bar code scanners that have limited performance. For the proposed algorithm, a comparative analysis was carried out with existing algorithms to localize two-dimensional barcodes based on two-dimensional Gaussian, tree classifier and classifier with Haar features, highlighting the quality metric expressed as a percentage of recognized codes.

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A. A. DENISOV, A. I. NOVIKOV. ANALYSIS OF IMAGE KEY POINT DETECTION, DESCRIPTION AND MATCHING METHODS

Keywords: keypoint, descriptor, detector, SIFT, SURF, FAST, FREAK, BRISK, KAZE, ORB.

The aim of the work is to describe and conduct comparative tests of known detecting and describing image key points methods and algorithms, as well as to establish pairwise correspond-

ence between key points of two images. The objective of the work is to identify the strengths and weaknesses of each of the algorithms. The following algorithms for detecting and describing keypoints were compared in the experiments: SIFT, SURF, FAST/FREAK, BRISK, KAZE and ORB. The comparison of keypoint detectors was carried out according to the criteria of performance and the number of keypoints found. The descriptors were compared in terms of accuracy to establish a correspondence between key points of two images and computational time for key points describing and matching them.

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BIOMEDICAL INFORMATION SYSTEMS

L. A. KOROBova, T. A. EYNnullaev. CREATION OF A VIRTUAL NARROW-DIRECTED 3D MODEL OF HUMAN VISION ORGANS

Keywords: diagnosis, narrow-focused system, 3D model, non-invasive research, diagnostics, virtual image, own level, multiscale modeling.

The article discusses the development and use of a digital twin that allows testing a narrow-focused medical diagnostic system. The aim of the work is to develop a 3D model of human visual organs. The task of developing a diagnostic system for detecting pathologies with any visual changes in the eyes or the appearance of unpleasant sensations in the eyes is becoming relevant. Such diagnostic systems, together with a user himself, will allow detecting eye diseases at early stages, and in turn, inform a user about general state of health. It has long been proven that timely studies of «windows of the soul», identifying changes in blood vessels allow us to talk about the detection of any disease, for example, memory loss and other cognitive impairments. Diseases not associated with eye diseases are determined by changes in iris. The reason for this is that eyes are a part of the body in which everything is interconnected. In this study, an attempt to develop a digital model of human eye was made, for its further use in a decision support system to determine health status of human body.

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A. V. KROSHILIN, S. V. KROSHILINA, D. A. PEREPELKIN, A. A. POPOVA. COMPUTER MODELING OF DECISION SUPPORT PROCESSES FOR A DENTIST BASED ON SEMANTIC NETWORKS

Keywords: intelligent analytical system, semantic networks, fuzzy sets, management in organizational systems, decision support theory, production rules.

The use of modern technologies can allow dentists to manage their practice more effectively. In daily management tasks, a specialist often has to evaluate hypotheses about which there is incomplete or insufficient information. Due to the complexity of accurate estimates under conditions of uncertainty, it becomes necessary for the decision-maker to justify the choice of a single option from a variety of suitable ones. When designing an organizational system that includes analytical information system, it is necessary to take into account the presence of some doubts about the clarity of symptoms of a particular disease. At the same time, uncertainty about the presence of specific disease in a patient persists even when all its symptoms are clearly expressed.

Information and mathematical support of the proposed decision support system designed to control the process of choosing a dental treatment option is based on semantic networks, fuzzy set theory, system analysis, decision support theory, management theory in organizational systems. Dentist enters clinical picture data into the program after examining the oral cavity: the number of preserved teeth, IROPSIS, carious cavities according to Black, bruxism, allergoanamnesis, vitality, dental mobility, hygienic index, etc. In addition, clinical conditions such as input data are used, which lead the doctor to the best variant of functional design. The output data are management decision (type of removable or non-removable orthopedic rehabilitation option) and recommendations for treatment regimen.

The aim of the work is mathematical and computer modeling of management decision-making processes of a dentist using the theory of semantic networks.

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PHYSICAL ELECTRONICS AND NANOELECTRONICS

M. V. LENKOV, E. V. TININA. FEATURES OF POST-DISCHARGE PROCESSES IN A DIODE AT THE STAGE OF DISCHARGE EXCITATION PULSE DECAY

Keywords: diode, plasma, decay, current, anode, voltage, recovery, conductivity, delays, duration.

From a practical point of view, a number of gas-discharge devices make the important case when the recovery of reverse voltage occurs with a delay due to the phenomenon of excessive post-discharge conductivity, which is associated with reverse current flow. The paper analyzes the features of post-discharge processes during the restoration of reverse voltage at diode anode with an incandescent cathode at the cut-off stage of excitation pulse. The processes at the initial stage of pulse cutoff are considered simultaneously with the effect of reverse current on the duration of voltage recovery at the anode. The analysis is carried out with the diffusion mechanism of plasma decay. In the course of the work, an expression of particle flow to the anode at the initial stage of post-discharge processes was obtained, a connection between reverse current to the anode and the duration of excitation pulse cutoff was established. The duration of delay in restoring the reverse voltage at diode anode in the case of excessive post-discharge conductivity was also estimated.

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