

CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

M. V. GRACHEV, A. A. TITOV. ANALYSIS OF METHODS AND ALGORITHMS FOR DESIGNING ENERGY-EFFICIENT WIRELESS IOT SENSORS

Keywords: information transmission system, energy efficiency, IoT, Bluetooth Low Energy, power consumption.

The problem of increasing the energy efficiency of wireless IoT sensors is considered. The task is to find the optimal combination of operating modes of wireless IoT sensor to ensure the highest energy efficiency. The aim of the work is to increase energy efficiency of autonomous wireless IoT sensors by optimizing the operating modes of its receiving and transmitting module. In order to identify the operating modes of IoT wireless sensor, as well as to assess the level of power consumption in various operating modes, the study of wireless IoT Bluetooth tag is conducted. A comparative analysis of operating modes, as well as power consumption of IoT tags with Bluetooth 4.0 and 5.2 versions is carried out. The results obtained are of practical importance for the design and operation of energy-efficient information transmission systems of the Internet of Things network.

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V. S. PARSHIN, V. D. NGUYEN. REFERENCE SIGNAL FORMATION WHEN MEASURING DISTANCE WITH FM RANGE FINDER BY MAXIMUM LIKELIHOOD METHOD

Keywords: maximum spectral component, maximum likelihood method, interfering reflectors, distance measurement error, frequency ranging, likelihood function, difference frequency signal, reference signal, interference amplitude, interference location.

The article analyzes the error in estimating the distance by rangefinder with frequency modulation of the emitted signal, caused by the influence of interfering reflectors. The reason for the appearance of interfering reflections is the presence of parasitic reflecting elements in rangefinder working area, along with useful reflector. Reducing the influence of interfering reflectors on the accuracy of distance estimation is achieved by including in reference signal composition the likelihood function of the component caused by the influence of interference. The specificity of interference caused by interfering reflectors is that it is a signal with non-random unknown parameters. To include such interference in reference signal composition of likelihood function, it is necessary to estimate its amplitude, phase. The aim of this work is to determine the error in measuring the distance when including in reference signal composition the likelihood function of the signal corresponding to interference, with a preliminary estimate of its amplitude and phase.

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V. T. DMITRIEV, E. S. CHERENTAeva, M. A. CHERENTAev. MODIFICATION OF THE ALGORITHM FOR CLASSIFYING NOISES ON IMAGES USING A BACK PROPAGATION NEURAL NETWORK

Keywords: image noise classification, noise models, image denoising, image filtering, statistical moment, multi-layer neural network, back propagation method, gradient descent.

A modification of image noise classification algorithm using back propagation neural network has been developed. The aim of the work is software implementation of noise classification neural network with the modification of preliminary processing algorithm with an increase in the number of neural network layers, as well as testing the resulting classifier on a set of real satellite images. An algorithm for preliminary data processing for training the neural network has been developed. The probabilities of correctly determining the type of noise have been obtained and compared with the values for other known classification methods. The authors have shown that the modified neural network provides better classification for multiplicative and Gaussian noise compared to known algorithms.

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G. G. ZHUK. ZERO MICROWAVE RADIOMETER WITH SIMPLIFIED DESIGN OF INPUT MICROWAVE UNIT AND WITH INCREASED FLUCTUATION SENSITIVITY

Keywords: zero microwave radiometer, increasing fluctuation sensitivity, high-temperature noise generator, low-temperature noise generator, transistor noise source.

The paper presents the results of developing a zero radiometer with a simplified design of input microwave unit. The aim of the work is to create a microwave radiometer with a simplified design of input microwave part of the receiver to reduce weight and size parameters and power consumption without deteriorating its technical characteristics. It is shown that the use of LNA as a low-temperature noise generator allows implementing the zero method without using high-temperature noise generators. Theoretical assessment has shown that the fluctuation sensitivity of zero microwave radiometer with a simplified design of input microwave unit is 1.4 times higher than that of the original circuit design. At the same time, simplification of microwave zero radiometer design leads to a decrease in weight and size parameters and power consumption, which makes it promising to be used in small-sized unmanned aerial vehicles..

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INTELLIGENT INFORMATION SYSTEMS AND TECHNOLOGIES

I. YU. KASHIRIN. VECTORIZATION OF TEXT BASED ON ICF+ ONTOLOGY IN ENSEMBLES OF ML MODELS TO CLASSIFY ELECTRONIC RESOURCES

Keywords: Bert models, ontological models, text vectorization, tokenizer, retriever, political news, ensembles of ML models, forecasting, semantic similarity.

The original technology of designing and applying machine learning models, as well as their ensembles, for classification and complex analysis of English-language political texts of domestic and pro-Western electronic media is considered. An end-to-end example of software implementation in Python v.3.10, Anaconda v.2.1 is considered. In

technology software implementation, the following components are used: search retriever, Python patterns, intelligent insertion of special tokens. The effectiveness of the technology presented is confirmed by a series of practical experiments using the example of solving the problem of binary classification of news articles by ideological orientation into pro-Western and pro-Russian. The results of the study will be useful in forecasting crisis political situations.

The aim of the work is to present a new way of ontological vectorization of political news, which allows analyzing and predicting social situations of various levels of detail.

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T. E. ZEYNALLY, D. G. DEMIDOV. LOAD FORECASTING USING RECURRENT NEURAL NETWORKS TO DETERMINE NODE PRIORITY IN A DISTRIBUTED SYSTEM

Keywords: distributed system, information system, computer software, node prioritization, RNN, LSTM, machine learning, forecasting.

This paper examines distributed systems composed of peer nodes that iteratively perform useful workloads. The specific feature of the systems considered is that priority is calculated among peer nodes – without a coordinator node. The problem of prioritizing nodes for executing specific tasks is defined for these systems, and existing scientific research on this topic is analyzed. The aim of the work is to develop a method for predicting the priority of a node for executing a payload in systems with the above-described properties. An analysis of iterative workloads characteristics is conducted to determine and describe possible prioritization scenarios and to identify parameters and characteristics that influence priority. The result of the analysis is a method for calculating priority that enables the system to adapt to current conditions and distribute the load rationally. The identified characteristics allow adaptation of prioritization scenarios for specific tasks and improvement of node resource utilization. The paper describes experimental setup – a system of three nodes iteratively performing useful workloads. The data collected from this setup is used to train a neural network. Methods for predicting node priority using machine learning techniques are described. The main result of the work is a recurrent neural network model that predicts the priority of a node for executing useful workloads, based on the information from previous time intervals. The paper describes model input and output data. The inputs to the model include characteristics of iterative process and time series of historical load indicators on a node. The output value is a priority indicator for next time interval. The accuracy of forecasting model is evaluated. The application of the proposed method helps to effectively utilize the resources of distributed information systems. Practical applications of the results obtained in the course of the work are presented.

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NGUYEN KHAC HOANG DUONG, A. S. POLETAEV, A. G. CHENSKY. FORECASTING OF DAILY AMPLITUDE VARIATIONS OF VLF RADIO SIGNALS USING RECURRENT NEURAL NETWORKS

Keywords: VLF signal, ionosphere, machine learning, neural network, time series, RNN, LSTM, forecasting.

The article explores the application of Long Short-Term Memory (LSTM) recurrent neural networks to forecast the daily variations in the amplitude of Very Low Frequency (VLF) signals. Based on the data collected at the receiving station in Irkutsk along JJI (Japan) – Irkutsk transmission path with a frequency of 22.2 kHz, a model to predict

daily amplitude variations of VLF signals over various time intervals has been developed. The data from July 1 to July 16, 2017, were used for training and testing the model, with prior preprocessing to optimize computational resources. Experimental studies confirmed that the model achieves high accuracy in long-term forecasting. Specifically, for a 24-hour forecast, average error values were as follows: RMSE – 0.000596, MAPE – 11.51 %, and NMAE – 5.96 %. The analysis of the results demonstrated that the model effectively captures the overall trend of daily amplitude changes, with higher prediction accuracy for signals that are closer in season and conditions to training data. These findings validate the effectiveness of LSTM neural networks in predicting VLF signal amplitudes and highlight their potential for applications in radio communication and ionospheric monitoring.

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A. M. KUZNETSOV. FORECASTING MODULE FRAMEWORK ARCHITECTURE IN SOCIOLOGICAL RESEARCH INFORMATION-ANALYTICAL SYSTEM

Keywords: Information-analytical system (IAS), sociological research, framework, forecasting, neural networks, LSTM, BERT, machine learning, time series, regression analysis, SARIMAX.

The article presents forecasting module framework architecture in sociological research information-analytical system (IAS). The integration of modern approaches and predictive analytics methods for analyzing and forecasting social processes is considered, including linear and logistic regression, time series models (ARIMA, SARIMA, SARI-MAX), machine learning methods, and neural networks (LSTM, BERT). The module provides good forecast quality, flexibility and adaptability of analysis taking into account complex dependencies in the data.

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MATHEMATICAL AND COMPUTER MODELING

V. A. BOCHAROV. ON THE WAY TO INTERACTIVE FUNCTION – ROLE MODELING

Keywords: cyber-physical system, functionality, functional-role specification, equivalent transformation, realization, semantics.

The work contains a description of principles and methods for forming the models of cyber-physical systems in the volume of basic diagrams and functional logic, which ensure the derivability of external properties of the system - functionality and behavior from internal properties – its structure. Modeling implements the projection of target characteristics of the system on system requirements, and functionality integrates it with behavior – a finite state machine that determines the change of system states depending on the change of conditions. The main construct is the relations of partially ordered sets that can be studied using mathematical methods. For their adaptation to the development process, a method for direct integration of natural languages, the languages that engineers use to think, with algorithmic languages that are operated by computing systems is proposed. The result of integration is a language that operates with the semantics of relations of functions, the roles of their elements, phases, modes and functional connections, on the one hand, and the results of system's operation in external environment, on the other. Formalization of systems based on functional-role specification (FRS) specially created for this purpose provides the ability to interpret the target characteristics of a system in its system requirements, and then decompose them, guided by

the principles of rationality and minimal complexity. At the same time, decomposition ensures equivalence «by construction» based on semantic rules, so the developer can increase dimensionality and complexity threshold of a system being developed without increasing efforts in analysis and synthesis. The developer also gets the opportunity to develop a cyber-physical system step-by-step (interactively), first achieving the goal in any available way, and then simplifying the obtained result, finding simpler implementations of the mechanisms of functions. The process of interactive functional decomposition is shown on the example of air conditioning system used in aircraft. This development is intended for implementation in a promising CAD system designed to work in problem-oriented formulation of scientific and technical problems.

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SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

A. G. SKORIKOV, I. S. KHOLOPOV. DEVELOPMENT OF MATHEMATICAL MODEL OF LASER TRIANGULATION RANGEFINDER WITH STRUCTURED LIGHT AND LOW-RESOLUTION CAMERA

Keywords: photogrammetry camera calibration, image imposition, homography matrix, test-object.

The problem of simulation modeling of formation and subsequent superposition of planar object images from multispectral cameras the homography matrix for which is estimated from the image of a universal planar test object is considered. The developed parametric model allows setting external and internal parameters of cameras, spatial coordinates of observation objects, measurement errors, forming frames from virtual cameras and performing their combination. As a result of simulation modeling, the authors have shown that in order to achieve the value of matching quality criterion based on the calculation of local area overlap area not worse than 0.8, permissible RMS errors of placement of test object reference emitters and estimation of their pixel coordinates should not exceed the values of 2.5 mm and 0.14 pixels, respectively.

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V. A. EREMEEV. INTEGRATION OF SPACE HYPERSPECTRAL EARTH OBSERVATION DATA WITH SYSTEMS FOR MODELLING THE PROCESS OF SOLAR RADIATION TRANSMISSION TO THE SATELLITE

Keywords: Earth hyperspectral imaging, video-information path of hyperspectral data, atmosphere spectral transmission coefficients, hyperspectrometer and reflection from the Earth objects.

The paper considers the issues of improving the accuracy of measuring spectral reflectance coefficients of the Earth's surface objects using data from space hyperspectral imaging of the Earth, with the involvement of information from modern modeling systems of this process. One of the primary issues is identified and resolved, namely the challenge of linking radiometric measurements to a singular discrete grid of wavelengths of radiation emitted by the Sun and reflected by the objects within the observed scene. Various approaches and criteria for evaluating the precision of this solution are then considered.

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INFORMATION-MEASUREMENT AND CONTROL SYSTEMS

A. A. SOTNIKOV. THEORETICAL PRINCIPLES AND METHODS OF SIGNAL SIMULATION IN INFORMATION CONTROL SYSTEMS

Keywords: information processes, multidimensional signals, simulation modeling of processes, numerical data processing, technical means for ensuring the functioning of telecommunication systems.

Main theoretical principles and methods of practical application of simulation modeling in telecommunication systems are considered. The aim of the work is to generalize basic theoretical principles of simulating the signals with various physical nature as information processes, and to develop methodology for building software and hardware complexes of simulation modeling in real time. Software and hardware complexes are designed to ensure the functioning of telecommunication systems, radar and sonar stations.

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A. M. ABRAMOV. METROLOGICAL TEST METHOD EFFICIENCY ANALYSIS WHEN CALCULATING ADC INTEGRAL NONLINEARITY

Keywords: modeling, analog-to-digital converter, measuring signal, integral nonlinearity, error, modulus, histogram, time, code.

The paper considers the problem of modeling a new method of ADC metrological testing, which reduces the requirements for reference measuring instruments in terms of accuracy class taking into account nonlinear component of measurement signal (MS). The aim of the work is to evaluate the effectiveness of a new method by means of simulation modeling in LabVIEW graphic programming environment, by comparing the calculated one with the given (true) integral nonlinearity (INL) of ADC. Modeling was carried out on real conversion function (CF) of 12-bit ADC at various combinations of average number of ADC code appearances per quantization interval and additive noise amplitude. The maximum deviation of real shape of generated MS from ideal linear shape was 2 % of MS input range. The simulation results have shown that a new method can accurately estimate ADC integral nonlinearity with an error of less than 1 LSB (least significant bit).

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PHYSICAL ELECTRONICS

M. V. DUBKOV, M. A. BUROBIN, K. A. VETSHEV, A. D. VETSHEVA. INFLUENCE OF CONDITIONS FOR INPUTTING CHARGED PARTICLES ON TRIPOLE MASS ANALYZER ANALYTICAL CHARACTERISTICS

Keywords: tripole mass analyzer, inlet aperture, mass peak, resolution, mass peak intensity.

The influence of input aperture shift and shape on the analytical characteristics of a tripole mass analyzer is studied. The influence of input aperture shift relative to analyzer axis on its analytical characteristics is investigated by numerical modeling of tripole mass analyzer operation. It is shown that the permissible shift of water aperture from corner electrode, which does not lead to a significant deterioration in analytical characteristics, is 0.05 of distance from analyzer axis to hyperbolic electrode. The influence of

various configurations (oval, cross-shaped, T-shaped) of input aperture on analyzer analytical characteristics is also studied. It is shown that tripole mass analyzer with input aperture in the form of oval hole elongated along OX axis, i.e. between hyperbolic electrodes, has the highest quality factor.

The aim of this work is to study the influence of offset and shape of input aperture on the analytical characteristics of tripole mass analyzer.

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BRIEF REPORTS

G. V. OVECHKIN, A. N. PYLKIN. ON THREE SIGNIFICANT ANNIVERSARIES OF CODING THEORY

Keywords: coding theory, optimization coding theory, error-correcting codes, binary codes, symbolic codes, error propagation, multi-threshold decoding algorithm.

The problem of error correction when transmitting data over noisy channels, the effective solution of which is based on the use of error-correction codes and methods for their decoding is considered. The aim of the work is to familiarize the reader with the main stages of coding theory development. The most significant results, the appearance of which led to the emergence and development of both classical coding theory and optimization coding theory are described.

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