ANALYSIS AND DEVELOPMENT OF SOLUTIONS FOR CAPTURING OBJECTS FROM VIDEO STREAM WITHOUT PRE-TRAINING OF ENTITY RECOGNITION ALGORITHM

A.N. Yurov, M.V. Parinov

Abstract: the article considers algorithmic solutions of the computer vision library, which allow to track objects by capturing some fragment area in the video stream. Additional program libraries are listed, the set of which is necessary to create a software solution based on the Linux kernel. The considered auxiliary libraries are not are not demanding to the hardware part of computing systems and can be installed on microcomputers Raspberry Pi, Orange PI, FriendlyARM, NVIDIA Jetson. In addition, the paper presents the structure of the of the design solution in the form of a class diagram with a description of functional methods in it. Based on the proposed class structure and relying on the implementation of algorithms in the computer vision library, an application was created, in which the object is captured and held in a video stream with the output of coordinates of the object change in the process of the specified object movement. The work of the application was tested on some pre-prepared video stream, as well as in real time on arbitrary objects. In addition, inaccuracies in the application's operation were revealed of the application related to typical algorithms of capturing and holding objects without preliminary training. A cross-platform application structure based on a software tool for automating the assembly of the software from source code, allowing to provide a simple as well as unified management interface and to prepare the process of installing and building packages. The development is prepared for use in Linux Manjaro operating system based on 64-bit architecture, but with the use of the generator of the automated system of project building it is possible to prepare implementation of the program for Windows.

Key words: object tracking, computer vision library, entity recognition algorithms, open source software systems

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ANALYSIS OF GRAPH DATABASE MANAGEMENT SYSTEMS

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Annotation: in the modern information society, data processing has become an important tool for making informed decisions and achieving success in many areas of activity. Different types of DBMS are used for data storage, each of which has its own unique functions, advantages and use cases. Graph DBMS offer a large number of tools and methods for data analysis and processing. This paper reviews the Neo4j graph DBMS, Virtuoso and ArangoDB multimodal DBMS with the support of the graph data model and the Memgraph graph DBMS. Each of the DBMS has its own number of special features and advantages when used. This paper highlights the main properties of each of these DBMS and provides the main scenarios for their use. The advantages and imperfections of the existing DBMS offered on the market and the prerequisites for the development of a metagraphic DBMS are considered. A data model for the DBMS being developed and its software architecture are proposed, including some features of its implementation at the object storage level. The developed model provides optimal modeling of complex processes and processing of large volumes of complex network data

Key words: graph DBMS, graph data model, Neo4j, Virtuoso, ArangoDB, Memgraph, meta graph, metagraph DBMSReferences

MATHEMATICAL MODELING OF A FREQUENCY ELECTRIC DRIVE

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Abstract: it is shown that it is advisable to carry out the study of a frequency electric drive on the basis of mathematical modeling, and simple models are also proposed for the analysis of medium-frequency processes in a frequency converter. The analysis of Simulink solvers and numerical methods of calculating systems of differential equations implemented by them for mathematical modeling of frequency electric drives is carried out. It is established that in the mathematical modeling of electric drive systems, electrical complexes and systems, it is advisable to use variable-step solvers. Frequency drives often use a frequency converter containing a three-phase diode bridge, a capacitor filter and a three-phase bridge autonomous voltage inverter. With a three-phase supply voltage of the frequency converter 380-400 V, the filter is implemented on the basis of series-connected capacitors. It can also be noted that, if necessary, the mentioned frequency converters can be powered with a single-phase voltage of 220-230 V by feeding it between any of the input terminals of the three-phase diode bridge and the common connection point of the filter capacitors. The conducted mathematical modeling of the electric drive indicates that with a single-phase power supply, it is possible to ensure the rated operating mode of the electric motor and an acceptable overload capacity. The results of mathematical modeling are confirmed by experimental verification of the possibility of supplying a single-phase voltage drive with a frequency converter

Key words: mathematical modeling, numerical calculation method, solver, frequency converter, three-phase bridge, frequency-controlled electric drive

METHODOLOGY FOR DEVELOPING THE INTERACTIVE LAYOUT OF A RESIDENTIAL BUILDING

M. Yu. Sergeev, A.S. Bagno, A.M. Nuzhny, N.I. Grebennikova

Abstract: an approach to developing an interactive model of a residential building using the Unity software is considered. The stages of development are: three-dimensional modeling, clarification of the functionality of construction objects, interactivity (interaction with the customer), furnishing, visualization of the result using animation and dynamic effects. The methodology for using interactive 3D models to create and visualize models of residential buildings is considered. Using this approach provides the ability to examine a building from different angles, change the design in real time, and use the design results in a variety of formats, including presentations and websites. An interactive building layout allows you to make informed decisions early in the design process and provides new tools for visualizing and evaluating these decisions. The functionality of an interactive building layout and typical actions for selecting interior design components are considered. The stages of developing an interactive building model are proposed. The benefits of using an interactive 3D model include improved visualization and quality control of the solution in the early stages of construction design. When interacting with the customer, based on the analysis of the simulated room, it is possible to improve color schemes, furniture layout, including interaction with the environment and ease of use

Key words: interactive layout of the building, object design software

SIMULATION PROGRAM FOR PREDICTIVE CONTROL OF THE ETHYLBENZENE DEHYDROGENATION PROCESS

O.G. Neizvestny

Abstract: a specialized software application designed to study and predict the dynamics of a predictive control system for the process of ethylbenzene dehydrogenation in styrene production is considered. The program has a modular structure. Based on the set of functions and options it performs, the application belongs to the class of multifunctional software. The software is a tool for carrying out simulation modeling and parametric synthesis of dynamic systems within the framework of the concept of model-based design. The tools provided to the user allow the following stages of model-based design of automated control systems to be performed: modeling of the control object; constructing forecast horizons for changes in process state parameters; parametric synthesis of a control device; control system modeling; comparative analysis of the results of modeling systems that implement the proportional-integral-differential control law and control based on a predictive controller using predictive models; formation and continuous updating of the information base of possible dynamic scenarios of processes with different settings of the MPC controller. There are two modes of operation of the application, which allows its functionality to be used in design organizations for scientific research, engineering calculations of existing laboratory and industrial ethylbenzene dehydrogenation plants. Also, it can be used as a computer training program for a series of professional disciplines in areas of training for students in higher education related to automation of control in technical systems and digitalization of chemical technological processes

Key words: ethylbenzene dehydrogenation, software, simulation modeling, parametric synthesis, predictive control

ANALYSIS OF THE MAIN FUNCTIONAL CAPABILITIES OF UNMANNED AERIAL VEHICLES

V.A. Malinovkin, N.V. Valuyskikh, V.F. Barabanov, M.N. Aralov, A.V. Barabanov

Abstract: the field of application for drones is expanding more and more. They are capable of performing such tasks as delivering supplies, searching for missing persons, monitoring and detecting illegal activities, measuring radiation levels and temperatures, and taking material samples for analysis. It should be mentioned separately that UAVs contribute to rescue operations, firefighting, field irrigation, and military operations. The main functionalities of unmanned aerial vehicles, such as high quality aerial photography, accurate geo-positioning, remote control of the device, are considered in the article. The following disadvantages of UAVs were identified: lack of functionality or availability of functionality with low accuracy on the route and its adjustment depending on external factors, loss of remote control in case of loss of communication with the drone or camera breakdown. The overview of intelligent decision support systems based on machine learning, deep learning networks, Bayesian networks and game theories was conducted. The comparative characteristic of key parameters is presented: basic affiliation, the need for training, training time, accuracy, performance, the main tasks when using and structure, explanation of the choice of Bayesian networks for solving the task. The article also proposed solutions to the previously mentioned disadvantages. The decision-making system based on the Bayesian network is able to process several data sources, such as: information about the route, information from secondary sources with the coordinates of the difficult terrain and information from the recognized images; and to decide on the further movement. Such an implementation can not only solve the above problems, but also increase the fault tolerance index in the UAV control system

Key words: drones, decision-making system, machine learning, deep networks, game theory, Bayesian networks

TEST CONTROL PROCESSES OF FINITE STATE MACHINES

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Abstract: the object of research is the automation features of test control processes of finite state machines. A finite state machine is used as a model of a digital device or a software module. Test control operation is testing information operation [1], in which a set of in-circuit control input signals is being fed into inputs of finite state machines while output responses to these signals are being taken from other contacts. The control test is presented in the form of a binary matrix and is generated by a pseudo-random number generator. In this case, technology of weighted pseudo-random testing is used. Input weight is the frequency of supplying a single logical signal to the input of the finite state machines. Test control of the finite state machine is carried out on the basis of a given weight vector. The developed software product allows you to determine the input weight input by solving the problem of optimizing the probability distribution of input signals based on a generalized entropy criterion. The software product allows you to manage test objects, to set the weight for each input of the state machine, to select optimization criteria for the vector of weights from the specified set, to set parameters for the optimization process, to conduct test control of the finite state machines, to save information about the test object based on the set vector of weights, to save information about the testing management and the optimization process; to view test results and optimization process. The software product interface is presented. The software product can be used to research the processes of test optimization and test control of various automaton models

Key words: finite state machine, entropy, binary matrix, digital device, software module, test control, automation of processes

SOFTWARE IMPLEMENTATION OF THE LINEAR OPTIMIZATION PROBLEM BASED ON THE ANT ALGORITHM

D.A. Baranov, M.A. Belykh, V.F. Barabanov, N.I. Grebennikova, V.N. Chernikov

Abstract: this article describes the software implementation of linear optimization based on the ant algorithm. The relevance of using natural algorithms is associated with the need for parallel data processing, with the possibility of creating artificial biological systems to solve complex problems. The algorithm involves creating a colony of ants, forming their search paths based on pheromones left by other ants, or randomly. The structure and functionality of the algorithm are implemented as separate objects of the system being developed (classes). The article also provides a mathematical description of various aspects of the algorithm, such as the probabilistic path selection function, pheromone forces update, etc. The visualization of the algorithm operation is given, and in particular, the movement of ants between iterative steps of the algorithm in the process of finding the optimal solution. In conclusion, a comparative analysis is given with some of the available modules, which are implementations of other heuristic algorithms suitable for solving the linear optimization problem. As prospects for the development of software implementations of computing, we can note the direction associated with the unification of various types of natural computing in one system: the ant algorithm is largely similar in characteristics to the bee, which allows you to choose the stronger sides of one of them

Key words: linear optimization, ant algorithm, natural algorithms, heuristic algorithms, swarm intelligence

SIMULATION OF TEMPERATURE DISTRIBUTION ON A THERMOELECTRIC ELEMENT DURING LAMINAR FLOW COOLING

O.A. Dorokhova, I.L. Bataronov , T.A. Nadeina, N.A. Yuyukin

Abstract: on the basis of the model of averaged physical parameters of a thermoelectric material and of the equations of thermoelectric transfer, a boundary condition of the third kind is obtained for finite element modeling of heat transfer in a laminar flow of a liquid heated by a thermoelectric element. The condition includes a temperature-dependent term that causes the effect of "self-heating" of the thermoelectric element and is characterized by a specific thermoelectric criterion parameter that depends quadratically on the electric current density in the thermoelectric element. Based on the similarity theory, the general form of the solution for the temperature field in a liquid is established, as well as its limiting case for a thin thermal wall layer. It is shown that the solution depends only on two criteria parameters – the Peclet number and the thermoelectric criterion parameter. By the method of numerical finite element modeling on a grid of 1.5 million nodes, temperature profiles were obtained over the surface of the thermoelectric element in the range of the Peclet number of 250÷8000, and the thermoelectric parameter of 0÷2.0. The obtained profiles were approximated by a linear combination of cubic root and linear functions with an accuracy of at least 0.5%. The condition of applicability of this approximation is formulated. Using nonlinear transformation of the coordinate system and regression analysis, analytical approximations were obtained for the coefficients of the linear combination depending on the criteria parameters, which determines the unified temperature distribution function on the thermoelectric element. The application of the obtained results to optimize the functioning of a thermoelectric cooler is discussed

Key words: heat transfer, thermoelectric coolers, temperature field, finite element method, correlations

INFORMATION PROCESSING AND DATA SET PREPARATION FOR A CONTROL SYSTEM BASED ON OBJECT DETECTION USING MACHINE VISION

P.Yu. Gusev, V.V. Sokolnikov, V.V. Vetokhin, A.A. Ageev

Abstract: an understanding of the term machine vision as a specific part of machine learning is presented. The prerequisites and directions for the development of neural network architectures are considered. The detection task and the features of their data set preparation for various detection tasks are described. As an example of the applied application of machine vision, a control system for unmanned vehicles is considered. The purpose of this work is to increase the accuracy of the control system for an unmanned vehicle based on machine vision by improving methods for processing initial information and developing a methodology for preparing a data set for training a neural network. The work solves the problems of choosing a neural network architecture, evaluation metrics, quality of training, hyperparameters for setting up the model. Experimental study of data sets for training the model was also carried out. The paper describes the methodology for generating a data set for training the model and describes the main stages of collecting information. The metrics used in the experimental study of data sets for training a computer vision model are presented. A neural network architecture has been selected that provides a solution to the applied problem of controlling an unmanned vehicle. As a result of the experiments, data was obtained that allows us to draw conclusions about the rules for generating data sets for this type of applied problems

Key words: machine learning, machine vision, neural network, control system

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COMPARATIVE ANALYSIS OF MODERN LOSSLESS DATA COMPRESSION ALGORITHMS AS PART OF SOFTWARE SOLUTIONS

M.S. Voitenko, A.S. Voitenko, V.V. Safronov, V.N. Chernikov, M.N. Aralov

Annotation: this paper presents an extensive study of modern lossless data compression algorithms as part of software solutions. Modern software solutions offer not only traditional methods of information compression by mathematical calculations, but also compression through the use of neural networks. The relevance of this research is due to the need for effective data reduction, which helps to save resources, bandwidth, as well as to improve the performance of systems. The article contains a brief description of modern and actual software solutions for lossless data compression, test results of various software solutions for text information compression based on the enwik8 dataset with indication of data compression and decompression time, final volume, compression ratio and input arguments used during testing. A table with comparative characteristics of the functionality of software solutions and compression algorithms used by default in these solutions is also given. Software solutions that have the ability of multithreaded processing, encryption, archiving are highlighted separately. Software solutions with GPU hardware support and based on neural network models are listed

Key words: state-of-the-art data compression algorithms, lossless data compression, lossless data compression software, neural networks, machine learning

MATHEMATICAL MODEL OF THE PROBLEM OF A NON-NEWTONIAN INCOMPRESSIBLE FLOW AROUND SPHERE LIQUIDS AT LOW REYNOLDS NUMBERS

V.S. Kuptsov, A.A. Katrakhova

Abstract: a mathematical model that considers the flow of a non-Newtonian stationary flow of incompressible fluid around a stationary sphere has been constructed. To construct this model, we used previously obtained results of solving the problem of a viscous incompressible fluid flowing around a sphere at low Reynolds numbers. To solve this problem, a spherical coordinate system was used for partial differential equations (in stresses) and the continuity equation for a given flow. A liquid with nonlinear components of strain rates (dilatant liquid and pseudoplastics) was considered as a non-Newtonian fluid. Taking into account this nonlinearity of the deformation field of a given fluid flow, the components of the stress field are calculated. A particular version of the solution to this problem is considered, which coincides with the classical version (flow of a Newtonian stationary flow of a viscous incompressible fluid around a sphere). Analytical formulas were also obtained for the components of the force action of a non-Newtonian fluid on a stationary sphere. Formulas are implemented for specific non-Newtonian fluids analytically or numerically, depending on the type of fluid. A special case of this result coincides with the formula for the force action of a Newtonian fluid on a sphere and coincides with the classical Stokes formula

Key words: mathematical model, partial differential equations, sphere, spherical coordinates, stationary flow, non-Newtonian incompressible fluid

ALGORITHM FOR SELECTING IDENTIFIABLE RADIO CHANNELS BASED ON THE MONITORING HISTORY

A.G. Studenikin, A.B. Tokarev, I.S. Faustov

Abstract: monitoring of the radio environment in the unlicensed 2,4 GHz frequency range is complicated by its joint use by radio emission sources (RES) of different standards. The identification features contained in radio signals can serve as the basis for the RES recognition, but their extraction requires relatively labor-intensive demodulation of the signals. In addition, most standards involve the parallel use of several radio channels, and therefore full control of the radio environment requires parallel operation of a set of demodulators for each of the standards of interest, which is associated with high costs of hardware resources when implemented on an FPGA. Purpose: to increase the efficiency of radio monitoring, it is necessary to propose for each of the standards an algorithm for selecting a radio channel connected to the demodulator, which ensures identification of the widest possible set of RES when implementing only a single demodulator for each of the standards in the equipment. Result: a technique for selecting channels connected to demodulators is proposed, based on creating and updating the monitoring history. The algorithm based on this technique, designed for implementation on the FPGA, makes it possible to increase the efficiency of collecting data on the radio environment during radio monitoring. Practical importance: the introduction of the developed algorithm into the radio monitoring equipment makes it possible to reduce the time for collecting data on the radio environment by 29…56 % in comparison with simpler algorithms

Key words: radio monitoring, signal detection, signal identification, FPGA

THE USE OF GENERATORS OF SPECTRALLY EFFICIENT RADIO SIGNALS FOR THE IMPLEMENTATION OF PHASE SEPARATION OF CHANNELS

S.S. Pechnikov

Abstract: Many methods of channel (signal) separation are known, but in practice, methods with linear separation have become the most widespread. To increase the efficiency of digital communications, it is worth considering the possibility of using systems that implement the principles of frequency and time separation of signals, simultaneously with phase separation. The purpose of this work is to increase the energy efficiency of the signals generated during the phase separation of channels. The article analyzes the method of phase separation of channels, the use of which is limited due to the fact that the orthogonality of the carriers is provided by a phase shift of $\pi/2$ between them. This method provides almost stable operation only with two-channel transmission. In addition, phase modulation signals with increasing positions of the signal constellation increase the number of amplitude jumps, which leads to a significant change in the shape of the envelope and makes it impossible to implement highly efficient nonlinear amplification. The paper investigates the possibility of using spectral-efficient radio signal generators to generate channel signals in order to implement their linear amplification in nonlinear power amplifiers. Two signals of quadrature amplitude modulation at the same carrier frequency are used as channel signals. The analysis of the formation of a group signal from the phase separation of channels is carried out, as well as modeling in the computer-aided design system is carried out. Signal constellations of the resulting group signals with phase separation of channels are obtained. It is established that the most effective is the use of channel signals with different phase modulation indices. Using different values of the phase modulation indices, the number of channel signals included in the group signal can be increased to four

Key words: multichannel communication systems; phase division multiple access; nonlinear amplifier; signal constellation; phase imbalance; signal envelope

RECONFIGURABLE SEMICONDUCTOR PLASMA-BASED PATCH ANTENNA

I.A. Barannikov, S.M. Fedorov

Abstract: The paper deals with the design of a reconfigurable patch antenna capable of dynamically changing its operating frequencies. Changing the operating frequencies of the antenna is accomplished by changing the dimensions of its conducting surface using semiconductor plasma formed by surface PIN diodes. The design of a PIN diode used in the antenna, which is capable of forming plasma, is considered. Mathematical modeling of its parameters is performed. According to the obtained electron concentration of $5 \cdot 10^{18}$ 1/cm^3 the plasma frequency, which determines the interaction of plasma with electromagnetic waves of different frequencies, is calculated. The obtained PIN diodes are proposed to be combined in arrays to increase the area of the generated conducting surface and to reduce the influence of the feeding circuits on the antenna radiation characteristics. The antenna characteristics are obtained through electrodynamic computer modeling for two modes of operation: when no voltage is applied to the diodes and there is no plasma; and when a positive voltage is applied to the diodes and the generated plasma forms additional conducting surfaces. The operating frequencies of the antenna are located in the SHF range and are 18.46 GHz and 20.02 GHz, and plots of antenna return loss, efficiency and radiation patterns for both cases of operation are also obtained. The results showed a slight degradation of the antenna performance when the plasma is on, but the resulting ability to dynamically change the operating frequency range is a significant advantage

Key words: patch antenna, reconfigurable antenna, semiconductor plasma, plasma antenna

ANALYSIS OF THE FORMATION OF DEFECTS IN THE DESIGN OF A PLANAR TRANSFORMER IN A POWER SUPPLY MODULE

A.V. Bashkirov, I.S. Bobylkin, A.A. Kuzyomkin

Abstract: the use of planar products in modern power supply modules is a trend of world leaders in the field of power electronics. The reasons for the transition from traditional winding products are in the structural and technological decisions taken during the development and design of planar devices. For example, a properly executed transformer determines the efficiency and high efficiency of any switching power supply. A transformer in a planar design, at first glance, eliminates the occurrence of problems during the assembly operation, due to the simplicity of the design. However, problems may arise at other stages of production: module testing, testing at different temperature modes and other operations where the electrical parameters of the product are determined. In this article, the causes of the problems of mismatch of electrical characteristics are identified, the analysis of the probability of undesirable losses with unfavorable results of module assembly is carried out. By modeling complex objects like a transformer, it is possible to determine potential risks during the operation of the product, as well as to predict the behavior of the entire functional part of the power supply module. Therefore, in order to confirm the changing characteristics of the planar transformer, simulations were carried out in the modern ANSYS automated design system (CAD) and FEMM software environment. The article also reveals patterns of changes in the magnetic characteristics of the transformer depending on the location of the cores relative to each other

Key words: planar transformer, power supply module, pulse mode, magnetic circuit, magnetic induction, magnetic flux, coupling coefficient

MICROSTRIP BANDPASS FILTERS PROTOTYPING IN THE LABORATORY CONDITIONS

A.E. Rud, L.E. Chernoivanov, I.A. Arzamascev, A.V. Grechishkin

Abstract: when designing UHF and microwave band devices, it is often necessary to be able to quickly refine the results of calculations. Such an opportunity can be provided by mock-up in laboratory conditions. An important issue in this case is the degree of compliance of the calculated parameters with the parameters of the resulting layout, which determines the applicability of a particular method of laboratory layout. Within the framework of this work, a qualitative assessment of the applicability of one of the layout methods is given. The method under consideration consists in the fact that the topology of the microstrip filter is applied to a foil dielectric material using photolithography technology in laboratory conditions with concomitant errors, and the removal of excess copper from the workpiece is carried out by chemical etching. For a qualitative assessment of the applicability of this method, within the framework of this work with its application in laboratory conditions, a mock-up of a microstrip bandpass filter of the 5th order of the Hairpin topology was made. Measurements of the parameters of the manufactured layout were carried out: geometric dimensions and frequency response of the filter. The figures showing the calculated filter, the layout and microstrip resonators magnified under a microscope are given. Based on the comparison of the calculated geometric parameters and the calculated frequency response with the corresponding parameters of the resulting microstrip bandpass filter, a qualitative assessment of the applicability of this layout method is made

Key words: microstrip filter, bandpass filter, prototyping

DUAL BAND BLADE ANTENNA FOR AIRCRAFT UAVs

I.S. Bobylkin, E.A. Ishchenko, S.M. Fedorov, M.V. Parinov, V.I. Nikolaev

Abstract: the article discusses the design of a dual-band fin antenna for implementing a communication system with aircraft-type unmanned aerial vehicles. The proposed antenna has the shape of a fin with two "wings" that act as emitters. Thanks to the use of two emitters of different shapes, it was possible to implement a communication system of two bands 840-876 MHz and 1280-1378 MHz. Due to the fact that the antenna is built on the basis of planar technology, it was possible to significantly simplify the design, minimize the profile, both aerodynamic and geometric, and also maintain the high efficiency of the antenna. The resulting antenna has a wide main lobe of the radiation pattern, and at the same time has a high level of directional coefficient, since the UAV body is used as an antenna reflector. The resulting antenna has a efficiency of 7.67 dB in the lower operating frequency range and 5.99 at the upper operating frequencies. All the main characteristics of the antenna were obtained based on simulation, and the aerodynamic profile of the antenna was also studied. The results obtained confirm the high efficiency of the proposed design, as well as the prospects for using fin antennas on aircraft-type UAVs

Key words: fin antenna, UAV antenna, dual-band antenna, UAV communication systems

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DESIGN OF A ROTHMAN LENS WITH A FUNDAMENTAL WAVE OF MAGNETIC TYPE FOR A MULTI-BEAM ANTENNA SYSTEM OF A KU-BAND MOBILE SATELLITE COMMUNICATION TERMINAL

Yu.G. Pasternak, V.A. Pendyurin, D.K. Proskurin, K. S. Safonov

Abstract: In recent years, phased array antennas have become the key to solving the problem of creating high-speed ground terminals for global satellite communications. In order to meet the high throughput requirement, the ground terminal must transmit/receive a satellite signal with high directivity and an electronically controlled main beam capable of tracking satellites located near the horizon. This requires the use of phased array antennas with several thousand elements, which creates great problems in terms of designing the antenna system, its mass production and high material costs. This article presents a Rothman waveguide lens with a main magnetic wave of the waveguide type H10, where the use of a waveguide wave of the main magnetic type in the body of the Rothman lens and in the delay lines can significantly reduce power losses (compared to coaxial cables), which makes it possible to significantly increase the efficiency the action of passive phased array antennas with a Rothman lens, in addition, powering the lens body with rectangular waveguides with adjacent wide walls makes it possible to increase the number of inputs and outputs of the Rothman lens

Key words: Rotman lens, Rotman waveguide lens

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DEVELOPMENT OF A BLIND RECOGNITION ARCHITECTURE FOR LINEAR BLOCK CODING USING A CASCADE NETWORK

A.V. Bashkirov, M.V. Khoroshailova, A.S. Demikhova

Abstract: this article proposes an architecture for blind recognition of LDPC codes. Most of the coding algorithm for blind recognition of low-density parity checking (LDPC) codes is difficult to apply, and the problem of high temporal complexity and high spatial complexity cannot be solved. The architecture proposed here combines a transformer-based network with a convolutional neural network (CNN). CNN is used for real-time noise suppression, followed by a transformer-based neural network designed to determine the speed and length of LDPC codes. It is assumed that this architecture will be used in the coding scheme for communication channels between unmanned aerial vehicles (UAVs) and users. To train noise-canceling networks and high-performance recognition networks, we create datasets and define loss functions for noise-canceling networks. The simulation results show that this architecture is capable of providing better performance than the standard method, with a lower signal-to-noise ratio (SNR). Compared to existing methods, this approach is more flexible and, therefore, can be quickly applied in the communication channel between the UAV and the user

Key words: coding with blind recognition, low-density code, convolutional neural network, noise reduction, communication channel

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ANALYSIS OF TRANSMISSION AND REFLECTION COEFFICIENTS AT THE INTERFACE OF RADIO WAVE PROPAGATION MEDIA IN CELLULAR COMMUNICATION SYSTEMS

I.S. Kireev, I.V. Zubarev, V.L. Burkovsky, A.I. Panina

Abstract: when developing cellular communication systems, as well as special radio communication systems at the level of a design solution, the calculation and analysis of radio wave propagation processes is an advanced task, since it makes it possible to select transceiver devices and repeaters as a first approximation, as well as select the type of antennas or present requirements for the development of this equipment. When designing communication systems used in an area with relatively predictable terrain, simple models are used that can give an approximate assessment of the effectiveness of communication organization. The presented work provides an analysis of the transmission and reflection coefficients of electromagnetic waves at the interface as applied to cellular communication systems. The analysis is carried out on the basis of representing the magnetic and electric field strength vectors with their complex amplitudes, since this method allows the use of rules for working with complex numbers, which simplifies the task. Based on the results obtained, one can judge the trajectory of the electromagnetic wave falling onto the surface and choose the optimal direction

Key words: cellular communication systems, radio communications, transmission coefficient, incidence coefficient, propagation medium.

CURRENT STATE OF THE TASKS INCREASING THE INTERFERENCE IMMUNITY OF RADIO COMMUNICATION CHANNELS BASED ON ARTIFICIAL INTELLIGENCE SYSTEMS

M.A. Romashchenko, D.V. Vasilchenko, D.A. Puhov

Abstract: the article provides an overview of the current state of the problems associated with increasing the noise immunity of communication channels of unmanned aircraft systems (UAS) using approaches based on artificial intelligence. The main approaches to the use of systems based on artificial intelligence (AI) for detecting and filtering interference, optimizing flight routes taking into account the electromagnetic environment and the response to unforeseen disturbances of the spectrum are analyzed. The following main areas of research were identified that are of interest for use in BAS: adaptive communication systems that change parameters in real time (modulation, bands, central frequencies, etc.); assessment of the threat of electromagnetic interference based on convolutional neural networks; introduction of additional spectrum analysis devices for simultaneous evaluation of information- information about the state of the signal and tracking of the resulting artificial interference; the use of antenna systems with phased antenna arrays; application of AI to control multichannel data transmission and automatic switching between channels; suppression of radio interference sources by a group of unmanned aerial vehicles using AI; prediction of electromagnetic compatibility for a dynamic data transmission line of an unmanned aerial vehicle. The complex application of various approaches adapted to specific application tasks will allow to qualitatively increase the level of communication systems in the UAS

Key words: communication channel, electromagnetic interference, protection, quality improvement, artificial intelligence, unmanned aircraft systems

Acknowledgement: The work was financially supported by the Ministry of Science and Higher Education of the Russian Federation within the framework of the state project (no. FZGM-2023-0011).

ANALYSIS OF THE POSSIBILITIES AND METHODS FOR UPGRADING CONTROL, NAVIGATION AND COMMUNICATION SYSTEMS FOR INDUSTRIAL UNMANNED AERIAL VEHICLES USING THE EXAMPLE OF DJI PRODUCTS

M.V. Parinov, V.V. Vetokhin, S.M. Fedorov

Abstract: the article analyzes the control, communication and payload control systems of industrial unmanned aerial vehicles (UAVs) on the example of DJI products, shows their advantages and disadvantages. The most significant payload variants for practical applications are considered. The characteristics of communication channels are presented, the issues of protection from electromagnetic interference and the reliability of encryption of transmitted data are considered. The security problem associated with the disclosure of the coordinates of the aircraft and the operator is described. Methods and options for modernization are shown in order to eliminate the shortcomings. Considerable attention is paid to software interfaces that allow you to expand and change the functionality of the UAV without interfering with the firmware of the aircraft. The analysis of the content and practical value of the most significant of them is carried out, methods of working with them are shown. Special controllers for controlling UAV functions are considered, schematic solutions and methods of their interaction with aircraft are described. In particular, the creation of a special user controller is considered, which allows adding an additional interface to the standard UAV remote control to control the satellite navigation module and multifunctional resets. According to the results of the performed and published works, the corresponding conclusions were drawn

Key words: unmanned aerial vehicles, communication channels, payload controllers, upgrades, software interfaces, data protection, resets, navigation control

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ANTENNA ARRAY OF DOUBLE-WAY ARCHIMEDEAN SPIRALS EXCITED USING COMMUNICATION PINS IMMEDIED INTO A RECTANGULAR WAVEGUIDE

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Abstract: the growing demand for broadband multimedia services is encouraging the aviation industry to provide bidirectional in-flight communication services in the near future. Civil aircraft are currently equipped with high-speed satellite communications terminals. Until now, satellite communication terminals have been developed for the L- and Ku-band frequencies. Taking into account the trends in the development of technologies for wide-band multimedia applications, there is a need to use higher frequencies, in particular Ka-band frequencies, where the required throughput can be provided. Research shows that for airborne broadband satellite communications, the antenna system is one of the key components in the hardware design. Due to the limitations of mechanically steered antennas, the most promising solution appears to be an electronically steered antenna array using digital beamforming. However, the development of such Ka-band antenna arrays faces high demands in terms of performance, integration and, last but not least, component cost. The result of a study of an antenna array, the elements of which are powered using in-phase and equal-amplitude power dividers in a waveguide design, is described. Design options for emitters are considered; The possibility of implementing phased array antenna (PAR) elements using various types of technology was investigated. An assessment of power losses in multichannel waveguide power dividers has been carried out

Key words: mobile and airborne satellite communications, Archimedes spiral

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APPLICATION OF MACHINE LEARNING ALGORITHMS IN THE TASK OF EVALUATING A WIRELESS COMMUNICATION CHANNEL WITH OFDM

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Abstract: the article discusses the possibility of using a neural network with deep learning algorithms to determine and evaluate the true transmitted data after propagation over a noisy channel during multiplexing with orthogonal frequency division (OFDM). Channel evaluation in OFDM systems is usually implemented in the form of evaluation by pilot symbols, in which known data is transmitted over the channel with a specified period. The most common pilot evaluation of the communication channel is the minimum standard error (MMSE) algorithm. To study OFDM performance and communication quality, it is proposed to use a neural network. Machine learning (ML) algorithms have been applied to evaluate the wireless communication channel. Evaluation is considered as a method of reducing bit errors (BER) and increasing the noise immunity of the signal. The evaluation program with ML is trained using data obtained from the simulation of the OFDM transmitter and receiver in the MATLAB environment. The estimator receives the common-mode and quadrature coefficients of the pilot symbol with 16-QAM modulation, as well as an estimate of the frequency response of the channel using spline interpolation by the least squares method. The performance of the proposed evaluation with machine learning is compared with the traditional evaluation of a communication channel with a minimum standard error MMSE by the dependencies of bit errors (BER) to the signal-to-noise ratio (SNR) The results of the study show that the given ML machine learning estimator can match the performance of standard channel evaluation methods such as MMSE, having comparable bit error dependencies from the signal-to-noise ratio

Key words: channel estimation, modulation, machine learning, neural network, OFDM

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DESIGNING AN LDPC CODING BLOCK FOR A TWO-USER SYSTEM

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Abstract: a low-density parity check (LDPC) coding scheme using deep learning for two user Gaussian multiple access channels with the same rate and equal average power constraints has been developed. For this channel, it is assumed that any pair of rates within the capacity region can be achieved without the need for timing or rate sharing, simply by selecting appropriate codes and using a shared decoder. The proposed neural network model simultaneously optimizes the power allocation and joint decoder for a given power constraint and set of LDPC codes. For any user, the codeword is divided into two parts of equal length and transmitted at two power levels. In the proposed neural network model, the power distribution and trainable weights of the joint decoder are optimized simultaneously. Numerical results show that the proposed scheme achieves better BER performance. Analysis of the decoding threshold showed that optimized joint decoding schemes with LDPC codes can approach the Shannon limit. Numerical results show that the proposed scheme achieves better bit error rate performance than existing schemes for shorter code lengths and fewer decoding iterations

Key words: LDPC codes, Gaussian multiple access channel, joint decoding, deep learning

DETERMINATION OF OPTIMAL PARAMETERS OF THE LASER WELDING MODE OF VARIOUS NICKEL-BASED ALLOYS

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Abstract: optimal parameters of laser welding of thin-sheet structures made of austenitic steel and a high-alloy nickel-based alloy have been determined. With the help of physical and mathematical modeling of thermal processes, the main parameters of the welding mode are determined, providing the required form of penetration and the size of the zone of thermal influence. It is established that the optimal temperature distribution during welding is formed when the beam is shifted to an austenitic steel billet by 0.25 mm. The analysis of the modes on the samples showed a good coincidence of the calculated and experimental data. The results of visual and metallographic control confirm the receipt of defect-free seams with a minimum degree of inconel participation in the formation of the seam section. Calculations of the stress-strain state arising during welding according to the design technology of sheet and tubular workpieces have been carried out. The calculation results show that an almost uniaxial stress state occurs in the parts after welding, which is formed due to high tensile stresses in the near-seam zone. The magnitude of the stresses for each of the workpieces exceeds its yield strength, causing the appearance of plastic deformations in the specified zone. The uniform temperature distribution over the thickness of the workpieces welded using this technology determines the minimum level of residual deformations and the absence of the need for subsequent machining.

Key words: laser welding, inconel, austenitic steel, stress-strain state

THEORETICAL STUDY OF CUTTER KINEMATIC ANGLES WHEN MACHINING PROFILE HOLES WITH EQUIAXED SHAPE

V.V. Kuts, M.V. Mitrofanov, O.N. Kirillov

Abstract: one of the main tasks facing the domestic mechanical engineering, and, in particular, tool production, is the design of metal-cutting tools based on modern computer technologies using mathematical modeling of cutting processes at the development stage. The use of computer technology makes it possible to predict the qualitative and quantitative indicators of the estimated parameters of the cut layer before the manufacturing stage, which in turn makes it possible to make changes to the geometry of the tool and solve problems to improve the processing efficiency before its manufacture. In this article, a study was carried out using the example of the proposed method of shaping profile holes with equiaxed shape, the essence of which is the use of a cutter with a constructive radial feed. Using the developed software, an analysis of changes in the kinematic angles of the cutter was carried out, the intervals for changing the front and rear angles during the cutting process were determined, the contact time of the *i*-th cutter tooth was determined, conclusions were drawn about the unequal loading conditions of the cutter teeth during processing, and the prerequisites were created for the subsequent study of wear resistance tool. The results of the study can be used in the design of metal-cutting tools for shaping faceted internal surfaces, in particular when calculating the values of the rake and back angles of the tool

Key words: equiaxed shaped profile, kinematic angles, mathematical model, cutter, shaping, eccentricity, modeling, front surface, rear surface, contact time

INFLUENCE OF CHEMICAL COMPOSITION AND STRUCTURE ON WEAR RESISTANCE OF LOW CARBON WHITE CAST IRONS

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Abstract: wear resistance is an important characteristic of the durability of the machines and products themselves that operate under friction. It is determined mainly by hardness. Wear-resistant white cast irons are a group of chromium and nickel-chromium cast irons; their main feature is that upon solidification, a carbide phase is released, which imparts high wear resistance during abrasive wear. The application area for wear-resistant white cast iron parts covers many industrial sectors where the durability of parts can be correlated with abrasive wear. There are conditions for selecting a grade of wear-resistant cast iron—working environment and wear rate. The machinability, hardenability and economics of the selected material should be kept in mind. Studying the influence of alloying components on the wear resistance of white cast iron, we can say that the content of elements such as chromium, manganese and nickel have a beneficial effect on the characteristics of products of interest. Many enterprises add to their product range a large number of castings made from the cast iron in question. There is especially insufficient information about low-carbon white cast irons, which characterizes the relevance of the study. The materials under consideration were white cast iron without and with copper content. All tests were carried out on an MI-1M friction machine. It was studied what effect specific load has on the amount of wear. Alloy grade ShKh15 was chosen as a standard. It was found that the smallest difference between the dependences for the alloys and the standard is observed in the load range up to 5 MPa. But starting from a load of 1.5 MPa, it is clear that the specific load directly affects the wear resistance coefficient. Based on the resulting correlation dependences of the relative wear resistance coefficients on the mechanical properties, factors of the chemical and phase composition of the alloys, an analysis of the wear resistance of these same alloys was performed. Previously, a comprehensive assessment was carried out regarding the main austenitizing element - manganese, as well as the influence of the degree of austenitization of the structure. As a result of the study, the dependence of the influence of the content of chemical elements and the austenite content in the structure on the wear resistance coefficient of low-carbon alloys was established. The greatest wear resistance is observed in low-carbon cast irons with a manganese content of two to three percent, which is combined with a structure containing twenty to thirty-five percent austenite. This is explained by the influence of manganese on the structure. Under conditions of abrasive wear, the maximum increases by ten percent, as a stronger compaction of the surface layer is observed. The amounts of martensite, austenite, and carbides that provide the greatest resistance to wear under different conditions were determined in relation to the alloys under study

Key words: wear, casting, white cast iron, structure, wear resistance coefficient

INFLUENCE OF OXYGEN CONCENTRATION ON THE PHASE COMPOSITION OF Fe-Zr-O NANOCOMPOSITES

O.V. Stognei, N.A. Kasatkin, A.V. Sitnikov, A.M. Deryabin

Abstract: the influence of oxygen concentration on the phase composition of nanostructured Fe-Zr-O composites is studied. The objects of investigation were obtained by ion-beam sputtering of a composite target made of a cast metal base (Fe) and oxide plates (ZrO_2). Changing the oxygen concentration in the composites was achieved by changing the partial pressure of oxygen added to argon during sputtering process. Three composite systems were obtained: in pure argon (P_{Ar}=6·10-4 Torr) and with the addition of oxygen P_{O2}=0.6·10-5 Torr and P_{O2}=0.9·10-5 Torr, respectively. The study of the resulting composites showed that varying the partial pressure of oxygen in the chamber allows to significantly change the oxygen concentration in the deposited coatings and change the phase composition of the composites without changing the composition and configuration of the original (sputtered) target. When the composites were obtained in pure argon, a phase of pure iron and unsaturated zirconium oxide ($Fe + ZrO_n$, $n<2$) is formed. The addition of the oxygen leads to the formation of stoichiometric zirconium oxide ZrO_2 and partial oxidation of iron to the wustite phase (FeO). Depending on the amount of oxygen, the iron phase is oxidized completely or partially, therefore the structure of such composites is two-phase or three-phase: $Fe + ZrO_2 + FeO$ or $FeO + ZrO_2$

Key words: nanogranulated composite, ion beam sputtering, stoichiometry, X-ray crystallography, phase composition

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