MATHEMATICAL MODEL OF THE EVALUATION OF THE PROBABILITY OF THE UNRELIABLE WORK OF THE PROCESSING SYSTEM OF INFORMATION OF THE MULTI-AGENT ROBOTIC COMPLEX IN UNCERTAINTY CONDITIONS

O.V. Petrova, S.V. Ivanov, I.D. Korolev, D.G. Belonozhko

Abstract: a feature of the functioning of autonomous mobile robots, including unmanned aerial vehicles (UAV) is a high level of uncertainty, which is caused by the unpredictability of the environment, the high dimension of the state space, the lack of accurate mathematical models, the hierarchy of management decisions. The article deals with the problem of searching the probabilistic characteristics of finding a multi-agent robotic complex in specific States of operation in the mode of information exchange. The relevance of this problem lies in the fact that one robot cannot perform a large number of diverse tasks, which is characterized by a large flow of information transmitted through the control channels. In this regard, there is a need to ensure sufficient bandwidth management channel group of agents. Implementation of multi-agent robotic complex of diverse tasks is possible only with the use of multi-channel information transmission system. The paper presents an analysis of the principles of multi-channel information transmission system in the control channel. The analysis showed that to solve the problem of information transfer both within the complex between agents and with the external environment, it is advisable to use a multi-channel information transfer system with different channel capacity, while the main channel and spare ones should be determined, which are connected to the work if the main channel cannot process all incoming applications with a probability of 0.95. The purpose of this work is to assess the probability of failure-free operation of the information processing system of a multi-agent robotic complex in the mode of information transmission in the event of a heavy load on the control channel with a special specification. To achieve this goal, a multi-channel Queuing system (QS) with different channel capacity is considered as a multi-channel information transmission system

Key words: large information flow, robotic complex, unmanned aerial vehicle, multi-channel information processing system, queuing system, cyberphysical systems

DETERMINATION OF PARAMETERS OF CONTROL DEVICES IN COMPLEX CONTROL SYSTEMS USING COMPUTER SIMULATION IN MATLAB + SIMULINK ENVIRONMENT

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Abstract: an approach to direct determination of parameters of control devices that provide the minimum values of generalized transient indicators in cascade control systems and control systems with a pulse by the derivative from the intermediate point of the object is considered. Models of control systems are created in the Simulink environment. Objects in models are defined by transfer functions and models in the state space. Models in the state space are formed using the representation of high-order differential equations describing the behavior of objects in the form of a system of first-order differential equations written in the Cauchy form. Fragments of the Mathcad document are given to calculate the elements of the model matrices in the state space. The transition process is formed as a result of integration with a variable pitch of the system of differential equations of the control system model. For each simulation session defined by a single point from the space of values of the input parameters of the model, the number of transition points for calculating the value of the generalized indicator is determined in the Matlab program. The program code fragments for constructing plans for experiments on models of control systems that implement random search, calculating generalized indicators of transient processes in Matlab and determining parameters of control devices that provide minimum values of generalized indicators are presented. Optimal transient graphs are presented in a cascade control system and a system with a pulse by the derivative of the intermediate point of the object

Key words: control systems, transient process, control system model, MatLab, Simulink

PARAMETRIZATION OF SOLID MODELS USING NX OPEN

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Abstract: the article discusses the issue of creating custom tools for the Siemens NX automated design system, designed to parameterize solid-state models presented in the form of an assembly. A list of application programming interfaces provided by the Siemens NX system and designed to develop custom software modules that are integrated into the system is provided. The purpose, architecture, composition, and functionality of tools such as NX OPEN and Journaling are considered. The choice of these tools is determined by the fact that they provide the most effective tools for developing user applications that focus on manipulating solid state models. The relevance of developing an editor for solid-state models is determined by the fact that it is one of the constituent elements of the parametric modeling system under development, which makes it possible to significantly increase the efficiency of creating parametric descriptions of existing solid-state models. The article describes the principles of the developed software, its architecture and describes the classes and interfaces of the Open NX object model used in the application

Key words: parametric modeling, NX API, solids editor

MODELING DYNAMIC INTERACTION PROCESSES USING FUZZY PETRI NETS OF V_F TYPE

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Abstract: the modeling of complex parallel and distributed systems describing the functioning of dynamic objects in conditions of uncertainty is considered. An approach is proposed for modeling complex distributed parallel systems, which is based on the mathematical apparatus of fuzzy Petri V_f networks ($FPNV_f$), which are extensions of ordinary Petri nets with position marking uncertainty. The rule of triggering transitions and the dynamics of changes in the initial and subsequent markings of $FPNV_f$ are determined. An algorithm for the operation and calculation of the structural elements $FPNV_f$ is developed. The proposed algorithm effectively converts real-world data into the internal format used in the modeling environment, solves the problem of solvability of transitions that are in conflict, automatically identifies deadlocks, simplifies and speeds up the modeling process. Using the example of a module of parallel processing devices, it is shown that, the resulting transition sequence fully describes the operation process of the $FPNV_f$. On the basis of a computer experiment, a reachability diagram was obtained as a sequence of matrices

Key words: model, algorithm, fuzzy Petri Nets, incidence matrix, processing module

PROCESSING AND RECOGNITION OF OBJECT IMAGES OBTAINED VIA THE MACHINE VISION SYSTEM OF AN AIRCRAFT

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Abstract: one of the promising means of measurement and navigation in transport is the system of technical vision. The most actual direction of application of systems of technical vision is the solution of a problem of automation of difficult stages of an aircraft's flight. The solution of such problems is relevant for both military aircraft and civil aviation. The paper deals with the problem of determining the brightness center of the beacon for landing, local navigation in the vicinity of an airfield using an algorithm based on the approximation of the dependence of the pixel brightness forming a semi-contrast boundary of the circle using binarization of the image of the led beacon; the method of recognition of objects by comparing the shapes of images both simple and complex with the description of the contours of binary images, comparing the shape of the contours of features according to the rules resembling the procedure of subtraction of numbers, while to determine the center of brightness of the image of the object the brightness of pixels both inside the contour and adjacent (border) pixels of the image was taken into account. It is through this combination of algorithms and methods that these problems are solved in full, and the results of the work can be implemented in practice with increased accuracy

Key words: aircraft, machine vision system, beacon brightness center, pixel brightness, image form, contours of binary images

SYNTHESIS OF ADAPTIVE DIGITAL CONTROL SYSTEM WITH A SPECIFIED STABILITY RESOURCE

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Abstract: the article is devoted to solving the problem of developing an adaptive digital system that can be used to control various technological processes. The analysis of a typical adaptive digital control system with a custom model in which the optimization of the digital controller settings is performed at each quantization step according to an adaptable model of the object is carried out, which significantly increases the computational load on the system. It is proposed to optimize the settings of the digital controller only when reducing the stability margin of the system. For this purpose, a mathematical and software analysis of the stability of the Nyquist criterion for the drift of system parameters was developed. A connection was established between the «forbidden area», which characterizes the stability margin, and the dynamic characteristic of a closed control system. An adaptive digital control system was synthesized with a predetermined stability margin different from a typical adaptive system by including an analysis unit that allows estimating the stability margin by the Nyquist criterion and determining the moment to optimize the digital controller settings. In this case, the sustainability margin is set according to the requirements of a particular technological process. The conducted studies with various parameters of the control object models showed the effectiveness of the proposed adaptive digital system

Key words: adaptive system, object model, digital controller, sustainability margin

SIMULATION OF A FLEXIBLE PRODUCTION SYSTEM ON THE BASIS OF AN AUTOMATED ASSEMBLY SHOP

D.P. Lashchenov, V.L. Burkovskiy

Abstract: the paper is devoted to simulation modeling of flexible industrial systems based on the mathematical apparatus of the theory of mass service (TMS). The most important specificity of these systems is their non-stationary, flexible structure, providing a high degree of adaptation to changing external and internal parameters of technological objects and allowing one to produce a wide range of high-tech products with a continuous process of updating and improving the design. The modern tool environment of simulation modeling AnyLogic provides ample opportunities for the most complete implementation of such models and allows one to visually structure the model of the production system, set all the necessary parameters, restrictions and requirements in order to analyze the operation of the system and form the optimal set of parameters to solve the tasks. The article presents an example of the implementation of a simulation model for the production of electric drive units on the basis of a flexible production system of an assembly shop. The structure of the model is a multi-phase multi-channel queuing system (QS). The presented work contains a detailed description of the composition of the model, the purpose and characteristics of its constituent elements. On the basis of the specified requirements and initial data of the model, an optimization task was compiled. The obtained results of the optimization experiment with the subsequent launch of the model with the obtained optimal parameters are presented

Key words: simulation, mathematical model, flexible production system, technological process, optimization, queuing system, development environment AnyLogic

COMPUTATIONAL EXPERIMENT FOR RISK ASSESSMENT OF UNTIMELY COMPLETION OF APPLICATIONS SERVICE

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Abstract: multi-stage systems with random execution times of individual works are the object of research in this paper. It is assumed that the process of servicing the application is the execution of a set of series-parallel work. Since the service time of the entire application is a random variable, the subject of the research is the development of a mathematical apparatus, which is an estimate of the likelihood of late completion of the service. Partially assigned task has already been solved. In particular, the Program Evaluation and Review Technic (PERT) method was developed, which allows, among other things, estimating the distribution law (up to parameters) of a random variable that represents the duration of the service. However, this method is based on assumptions that almost never can take place for real systems. In this connection, it is necessary to carry out a computational experiment, which makes it possible to evaluate the accuracy of existing estimates, which make it possible to determine the probabilities of untimely maintenance. As the initial data for the experiment, mutual dependence and numerical characteristics of the works, the set of which specifies the application, are submitted. At the output, we get confirmation or refutation of the hypothesis about the normal distribution of the sample, each element of which describes the time for all the work. The results of the experiment indicate the need to obtain more accurate estimates to describe the distribution law of the corresponding random variable

Key words: stochastic multi-stage systems, service time, PERT, distribution function, distribution density, numerical experiment

ANALYSIS OF MUTUAL HEAT EXCHANGE OF A RIBBED SURFACE IN AN ELEKTROTEKHNICAL COMPLEX

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Abstract: a surface is considered with ribs of a rectangular profile that perceive the heat flow from a certain source of heat and dissipate it into the environment due to radiation. To achieve a stationary temperature regime of the mechatronic system having a system of heat sources, it is necessary to create a system of heat sinks whose power is equal to the total power of the sources. The sink is provided by contacting the boundaries of the fuel elements with other structural elements or directly with the external environment. Heat transfer conditions on the surface may vary depending on changes in external conditions. The use of such a heat sink determines the presence of three types of heat exchange in the heat system: thermal conductivity or conduction in solids; convection and radiation at the interface of solids with the external environment; evaluation of each type of heat exchange to build a more rational device cooling system. The relevance of research, characterizing the scientific and technical directivity, production and technological aspects of creating such equipment of the new generation, in the factors of compatibility of opposites "vacuum-resource-digital-function" under the conditions of variable external and internal heat fluxes, highlights the task of thermal rational exchange and protection of integrated non-sealed mechatronic designs

Key words: ribs, mechanotronic systems, heat exchange, heat conductivity, fuel elements, stationary mode

MODERN METHODS OF RADIOCOMMUNICATION CHANNEL ESTIMATION IN CONDITIONS OF MULTIPATH

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Abstract: the article discusses modern methods for estimating a mobile radio channel under conditions of multipath propagation of signals used in OFDM systems, based on the placement of pilot (experimental) data. For systems with orthogonal frequency multiplexing, the main types of positioning of pilot signals are shown, and allocation diagrams are displayed. Key varieties of data interpolation in OFDM are presented: linear, binary, discrete Fourier transform DFT, and interpolation using the MMSE minimum mean square error method. A block diagram is given and the principle of operation of the DFT interpolation is considered using discrete Fourier transform algorithms for N points. Modeling the estimation methods of mobile radio communication channel in the OFDM system with $N_s = 64$ subcarriers, $N_p = 8$ pilot symbols, signal modulation - QPSK was carried out. The Jake model with the Doppler frequency $f_d = 10^{-4}$ and the number of beams L = 4 was used as a multipath radio channel. Evaluation of the effectiveness of the considered methods is carried out according to the dependences of bit and mean-square errors on the signal-to-noise ratio. The advantages of DFT interpolation over other types of approximations are presented. Results and conclusions are given in the conclusion of the article

Key words: radio channel estimation, pilot signal, interpolation

TECHNICAL CHARACTERISTICS OF THE MEANS FOR SATELLITE RADIOCOMMUNICATION WITH UNMANNED AERIAL VEHICLES

N.N. Dolzhenkov, D.G. Pantenkov, A.T. Egorov, A.A. Lomakin, V.P. Litvinenko, V.I. Velikoivanenko, E.Yu. Lu-Ke-Syu

Abstract: at present, unmanned aircraft in the interests of various customers are actively developing in the Russian Federation. At the same time, as of 2019, the domestic industry has developed a type-series of complexes with unmanned aerial vehicles (CUAV) of various classes and purposes — light (“Tipchak”, "Zala 421-04M", "Eleron-3"), medium ("Eleron-10", "Fortpost", "Korsar"), heavy ("Orion"), super-heavy ("Altair", "Okhotnik"), which solve both the tasks of increasing the defense capability and security of the Russian Federation, and meet the interests of civilian consumers. One of the key elements of the UAV is the radio link for transmitting the target information between the UAV and the ground control station (GCS), and it is possible to transmit information between the UAV and the GCS, either directly (point-to-point) or using spacecraft in different orbits (over the horizon radio). It is proposed to use domestic orbital constellations in the geostationary orbit of the “Express” and “Yamal” satellites as satellite repeaters working in KU-frequency range and having a large coverage area in the Northern Hemisphere (with the exception of the polar regions). This allows you to significantly improve the efficiency of the use of CUAV in solving the set targets by increasing its radius of action. This article is devoted to the consideration of the technical characteristics of an experimental model (EM) of a satellite radio communications system (SRCS) in the interests of unmanned aircraft of a long duration developed by the group of companies Kronstadt, EM of the SRCS in order to ensure readiness for carrying out ground complex tests

Key words: complexes with unmanned aerial vehicles, radio line, spacecraft, satellite radiocommunication, experimental sample, satellite radiocommunication facilities, onboard satellite terminal, bench testing, signal-code design, modulation

SERIAL LDPC DECODER WORKING FOR MIN-SUM ALGORITHM AND ITS IMPLEMENTATION ON FPGA

A.V. Bashkirov, I.V. Sviridova, M.V. Khoroshaylova

Abstract: this article discusses the bit-serial LDPC decoder scheme for reducing the complexity of interconnects in fully parallel codes with a low density of parity checks. Bit-sequential decoding also facilitates the efficient implementation of spatially programmable LDPC decoding, which is necessary for decoding a shift program. To simplify the implementation of decoding with a bit sequence, this article proposes a new approximation to the min-sum update function of the decoding algorithm. The new check update rule calculates only the absolute minimum and, if necessary, corrects outgoing messages. Also the 650 Mbps bit-serial (480, 355) LDPC decoder is presented based on the Reed-Solomon code, implemented on the Altera Stratix EP1S80 FPGA. This is the fastest FPGA-based LDPC decoder reported in the literature. The article describes the internal architecture for the hardware-sequential implementation of bit variables and test nodes. It is also discussed that in the modified MS algorithm only the smallest value among all the test inputs should be found

Key words: min-sum decoding, LDPC decoder, bit-serial computation

METHODOLOGY OF OPTIMIZING THERMAL REGIMES OF RADIOELECTRONIC DEVICES WITH POWERFUL LED

A.S. Kushnaryev, O.Yu. Makarov

Abstract: nowadays, high-power LEDs are widely used in electronic devices of the appropriate purpose (lighting, signaling, etc.), which are characterized by considerable heat generation, while the features of their design and installation in devices (ensuring open access to the radiated surface) make it difficult to remove heat from such elements. Modern approaches to simplify their design, such as the development of unpackaged options, also require new solutions to ensure a normal thermal regime. In many ways, the main problem is the efficiency of heat removal from the LED to the external radiator, through a printed circuit board. Therefore, one should use printed circuit boards on an aluminum base, in which the dielectric layer plays an important role. In many ways, the efficiency of heat transfer from the LED to the base of the printed circuit board depends on this layer; therefore, many manufacturers use different materials as dielectric. So a new technology, called alumina, appeared. This article discusses the problem of analyzing and providing thermal conditions for unpackaged high-power LEDs in lighting devices. Examples of thermal modeling of printed circuit boards using various materials as dielectric are given

Key words: LED, printed circuit boards, dielectric, modeling

SUBSTANTIATION OF REQUIREMENTS TO THE COMPLEX OF MEASUREMENT OF THE CHARACTERISTICS OF RADIO THERMAL NOTICE OF OBJECTS

M.G. Kalashnikov, V.G. Kerkov, G.L. Tyurin

Abstract: the article is devoted to the study of the characteristics of radiothermal visibility of objects for their protection against ammunition with radiothermal (radiometric) guidance and aiming systems. These munitions are high-precision means of destruction of ground equipment, the effectiveness of which depends on the radio-thermal contrast of the object of destruction. This determines the relevance of measuring the characteristics of radiothermal visibility of potential targets from the upper hemisphere. The principles of constructing a measuring-modeling complex are considered to study the characteristics of the radio-thermal visibility of objects from the upper hemisphere in the millimeter wavelength range. A block diagram of the measuring-modeling complex, its main characteristics and placement options are given. It is shown that it is most expedient to place the measuring module indoors with a retractable roof and move it on a longitudinal beam scanner or an arch-type scanner. The measuring module should include coaxially connected radiometric receivers of 3 and 8 mm wavelength ranges. The movement of the measuring module along the scanner should be provided in the range of angles of possible observation of the object with ammunition from the air. The control of the measuring module, as well as the processing of information, are carried out programmatically from a console located in the same room as the measuring module

Key words: high precision weapons, site radio-thermal perceptibility, measurement and simulation system, layout option

INTEGRATED COMPLEX OF THE LONG-DISTANCE RADIOCOMMUNICATION FOR INCREASE EFFICIENCY OF THE SOLUTION OF TARGET TASKS BY UNMANNED VEHICLE

N.N. Dolzhenkov, D.G. Pantenkov, V.P. Litvinenko, A.A. Lomakin, A.T. Egorov, A.A. Gritsenko

Abstract: currently, in the Russian Federation, the prospects for the development of combat and civil unmanned aircraft vehicle (UAV) in the interests of special and civil customers, respectively, are due to a number of factors. First of all, the ever-increasing price of manned aircraft and helicopters, the rising cost of training pilots for them – while for the solution of a wide range of tasks, the presence of a person today is not mandatory. In addition, in many countries of the world, active work is underway to develop fundamentally new models and designs of the UAV glider, which would be designed for increased loads in comparison with manned aircraft, as well as to equip such devices with perfect control systems to simplify the work of the ground operator of the complex with UAV. We should not discount human life – the most valuable thing we have. In this regard, the use of unmanned aerial vehicles is an opportunity to reduce human casualties among pilots and automatization of the target tasks. From the point of view of ensuring information exchange between the UAV and the ground control and information processing (GCIP), consisting of unmanned aircraft has two radio transmission command telemetry and target data is a radio link line of sight and satellite radio line through relay of information between the UAV and GCIP through the spacecraft. Since both of these radiolines are composed of a sufficiently large number of common components and functional units, the actual question is the hardware optimization of two radiolines in one with the aim of reducing the weight and size characteristics, the cost of manufacturing and testing, unification in the end. This article is aimed at the integration (hardware Association) of line-of-sight radiolines and satellite radio lines in the structure of complexes with UAV by combining common units that are part of both transmitting and receiving tracks

Key words: complexes with unmanned aerial vehicles, radio line, integration, spacecraft, satellite radiocommunication, increase in efficiency, range, purpose

DEVELOPMENT OF CAPACITIVE ELECTRODES FOR THE RECORDING OF BIOMEDICAL INDICATORS

D.V. Zhuravlev, I.A. Safonov, I.V. Ostroumov, I.S. Anisimov

Abstract: in this article we consider the features of the development of a capacitive electrode intended for the registration of biomedical indicators by improving the existing methods of registering biopotentials in order to improve the quality of the received signal and sensor technology that does not require mechanical or resistive contacts for measurements that meet current development trends of electronic medical systems. Capacitive electrodes will allow one to reach a completely new level of comfort and ease of use of biomedical measuring devices in everyday life, and also allow significant savings, due to the very long period of use of such electrodes. The usefulness of contactless electrodes is in high signal quality in terms of the signal-to-noise ratio. Compared to conventional electrodes, developed capacitive electrodes for measuring bioelectric signals are suitable for use in very high impedance conditions (high resistance, low capacitance) between the body surface and the electrode. The model includes: directly electrode providing non-contact reading of human biopotentials through capacitive coupling; buffer cascade required for matching the receiving part of the device with subsequent cascades; high-pass filter with the required cutoff frequency; voltage divider as a constant voltage mixer for the required value; active filter that serves for the final amplification and low-frequency filtering of the electrical signal

Key words: device of registration of medical and biological indicators, ECG, EEG

MODELING OF GAS FILTRATION PROCESS BY POROUS TITANIUM MEDIA

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Abstract: some precision technological processes associated with high-temperature treatment of active materials require an inert protective medium of high purity. Argon of the highest grade used in such processes has impurities that form compounds that adversely affect the quality of the manufactured product. Thus, obtaining inert media of high purity is an urgent task. A high degree of purity of an inert gas can be obtained using titanium filters. Their effective use requires the construction of a model of the filtration process - the behavior of impurities in the pore channel of the filter, when an inert gas passes through it. We performed a physical and mathematical modeling of the process of argon purification from oxygen in the pore channel of a titanium filter and determined the influence of parameters such as the size of the pore channel, the flow rate of argon, and the filtration temperature on the degree of argon purity passed through the titanium filter. Analysis of the obtained results showed that the longer the channel and the smaller its radius, the higher the purity of the inert gas being filtered. The degree of purification decreases with an increase in the rate of flow of inert gas in the pore space; the degree of purification of argon from oxygen increases with increasing temperature

Key words: absorption, titanium filter, activated admixture, inert gas, filtration process modeling, pore channel, diffusion flux, diffusion coefficient, filtration temperature

MECHANISM OF COMBINED TREATMENT IN THE CAVITATION MODE

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Abstract: the mechanism of mass transfer intensification from the interelectrode space of the products during the combined processing of parts with the application of an electric field is considered. It is shown that the known ways for removing allowances by this method have significant limitations on improving the performance of parts manufacturing due to the reduction in the rate of removal of processed products from the zone of removal of the allowance. A new approach to the intensification of mass transfer is revealed by impulse action on the working environment in order to form a cavitation fluid flow. It is shown that such an approach to solving the mass transfer problem can significantly accelerate the removal of processing products from the gap and maintain the stability of the initial removal rate as they go deeper into the electrode blank. The conditions for the control of the cavitation flow regime of the working medium, which expand the possibilities for the effective use in engineering of combined processing methods, are given. The area of rational use of electrical processing methods in mechanical engineering with the use of cavitation flow of the working environment is substantiated. It is shown that new methods are technically and economically beneficial for obtaining deep through and blind holes in metal blanks. The developed technologies also provide the intensification of the process of separating blanks with a wire electrode-tool using the serial equipment already available at the enterprise, equipped with nozzles to feed a liquid working medium into the groove. In addition, the method is promising for forming complex elements with parts with an increased length of the interelectrode gap, where to ensure high technological performance it is required to ensure stable conditions for the mass production of processing products

Key words: combined treatment, cavitation flow, mechanism, impulse effects, mass transfer, technology