PATH PLANNING ALGORITHM IN A THREE-DIMENSIONAL DETERMINISTIC ENVIRONMENT WITH OBSTACLES USING PARTICLE SWARM ALGORITHM

N.N. Chernyshev, T.V. Nizhenets

Abstract: the main factor in increasing the efficiency of the process of functioning of unmanned mobile vehicles is the organization of their optimal movement from the starting point to the target point without colliding with obstacles. Path planning allows an infinite number of solutions, so we formulated the path construction problem as an optimization problem with an objective function corresponding to the shortest collision-free path. The solution of the path planning problem in three-dimensional space becomes more complicated compared to the movement on a plane, since the computational time increases exponentially with the increase in the dimension of space. The article proposes a path planning algorithm based on particle swarm optimization to reduce the time of searching for the shortest collision-free path in a three-dimensional deterministic environment filled with static convex obstacles. The functionality of the proposed algorithm is illustrated by simulations with different locations and numbers of obstacles. The results of numerical studies suggest that the developed algorithm based on the particle swarm method effectively performs path planning in a three-dimensional deterministic environment with a complex space distribution of obstacles.

Key words: path planning, three-dimensional space, deterministic environment, obstacles, particle swarm optimization

APPLICATION OF A COMPONENT-BASED SOFTWARE ENGINEERING IN THE DEVELOPMENT OF INFORMATION SYSTEMS WITH MICROSERVICE ARCHITECTURE

A.A. Ryndin, D.V. Shitikov

Abstract: the article discusses software components and their use for system analysis, development, commissioning, management and information processing in information systems based on microservice architecture, as well as their subsequent support and development. The described technology of software components supports the creation of a specific style, including components, component models, interfaces, contracts, sets of component types, and component frameworks. The component approach to the architecture of information systems is considered from the point of view of a design pattern, which can be described by modeling the interaction of components of different types. The component model presented imposes constraints on component developers, and the component design enforces these constraints in addition to implementing and providing the necessary services. The advantages of switching to a microservice architecture using abstract contracts for the implementation of components common to various systems are shown. The implementation of a corporate portal built on microservice architecture and divided into separate services, including an authorization system, an organizational structure, a time tracking system, a vacation system, which have their own databases and interact with each other via API, is presented. The code listing of the implementation of the component model in the java language is given. For these services, common interfaces are allocated that allow sharing the same dependencies.

Key words: component-based software engineering, interface, contract, component model, component diagram

PROCEDURE FOR CONSTRUCTING FAST MICROPROCESSOR CENTRIFUGE AUTOMATIC CONTROL SYSTEM REGULATOR WITH SPECIAL TYPE OF TRANSFER FUNCTION CONVERSION

A.N. Annenkov, O.V. Belousova

Abstract: the choice of the regulator of the automatic control system is determined by the requirements to the law of change of the specified value, the nature of which, in a determining way, affects the quality of the technological process and the main consumer characteristics of the equipment. With the help of mathematical packets, it is possible to obtain a Z-transformed transfer function of the regulator at a certain value of the quantization period. Rounding the coefficients of the Z-function even in the third or fourth sign in high-speed systems leads to the loss of its statistical properties by the regulator, which creates certain difficulties when implementing a discrete model. When simulating a discrete regulator, the value of the quantization period in time should be greater than or equal to the sampling time value, which is indicated when entering values in the unit of the discrete transfer function. If this condition is not met, the regulator will lose its properties. When

simulating discrete regulators that use Z-transformations, they are replaced by a zero-order extrapolator. This technique significantly reduces computation time and eliminates the need for microcontroller discreteness calculations. To obtain functions describing the law of change in the centrifuge speed, the least squares method gave the best results. The linear decay section of the control signal introduces smoothing into the zone of exit to the stationary mode of operation and, if necessary, can be corrected for duration and amplitude. Taking into account the parameters of the control signal generation, it can be said that the implementation of the program start of the system with constant acceleration can be performed on most 8-bit microcontrollers. The work describes the basics of a new technique for constructing a fast-acting microprocessor controller of an automatic control system, which differs in approaches to selecting transfer function conversion means

Key words: automatic control system, process quality, regulator transfer function, fast-acting objects, discrete model, approximation, centrifuge speed law, least squares method, control signal synthesis, equivalent forward-exact function, direct and inverse Laplace transformation method

NATURAL THERMAL CONVECTION OF A NEWTONIAN FLUID IN A SQUARE CAVITY WITH A CONSTANT HEAT FLOW THROUGH "WETTED" SURFACES

V.I. Ryazhskikh, V.A. Sumin

Abstract: based on the Oberbeck-Boussinesq equations, we synthesized a mathematical model of thermal free convection in a closed square cavity with a known heat flow through the “wetted” surface and no heat inflow through the free surface. We wrote a closed system of equations that describes the process both in dimensional and dimensionless quantities. We obtained a system of equations in dimensionless quantities, the nonconjugate nature of which made it possible to split the original problem into two subproblems: thermal and hydrothermal. Using the apparatus of Fourier integral transformations, we obtained an analytical solution of these subproblems. We show the dynamics of thermal and hydrothermal processes that occur in a Newtonian fluid when heated in a closed square container with imperfect thermal insulation. The computational experiment showed that as a result of heat supply to the liquid, two vortices with rotation in different directions are formed. As the temperature on the walls increases, the liquid rises, and below the axis, it rotates counterclockwise, and above the axis, it rotates clockwise, which corresponds to the known physical concepts of the movement of a liquid in a heating field. With an increase in the values of the Grashof coefficient, the value of the maximum (minimum) of the stream function increases (decreases), thereby the mathematical model physically correctly describes the structure of the temperature and hydrothermal fields

Key words: newtonian fluid, Oberbeck-Boussinesq equation, analytical solution, free convective flow

STRUCTURE OF MULTIFUNCTIONAL SYSTEM FOR MONITORING THE CONDITION OF TECHNICAL MEANS

G.V. Petrukhnova, I.R. Boldyrev, M.G. Usachev

Abstract: we discuss the relevance of the tasks of creating and improving the means of measuring and monitoring the state of technical objects. We indicated that there are three kinds of information operations in metrology: perception, reproduction and processing, and only eight varieties of perception operations and the same number of reproduction operations. We present canonical operations of perception and reproduction, as well as their corresponding characteristics and corresponding experimental information operations. We present a model of the control object. For quantitative and qualitative characteristics of information operations, we give examples of relevant consumer information operations. According to the classification of information operations, we developed the structure of a multifunctional data collection system for monitoring the condition of technical facilities. We designed this system for the implementation of information operations "control" and "control test". The multifunctional data collection system (MDCS) serves to increase the competence of service personnel when working with production resources and for carrying out control, measurement and repair work. At the same time, the technical objects themselves may have a different nature. Depending on the nature of the technical object, means other than those contained in the MDCS may be used for its control. The point-to-point interchangeability of the MDCS modules makes it easy to upgrade the system and configure it to perform the required tasks. The modularity of the MDCS allows it to be used as a training stand.

Key words: data acquisition system, information operation, control, measurement, control test, measurement test, microcontroller, MDCS

t / (n – 1)-VARIANT PROGRAMMING

D.V. Gruzenkin, V.V. Edreev, D.A. Panteleev

Abstract: there are such kinds of industry and human activity where software reliability is critically important for some control system correct functioning. To improve software reliability, there are many approaches, including those based on software redundancy. For example, recovery blocks and N-version programming are the most popular among them. However, there are also alternative approaches that are much less sanctified in the literature, for example, t/(n-1)-variant programming. Although the description of this approach is presented very sparsely in publications, it is used in scientific papers and dissertations to compare its effectiveness with the effectiveness of N-version programming voting algorithms. This paper provides a general description and additional explanations for the t/(n-1) approach, and also reveals the points missed in the original articles. In addition, based on this approach, we compiled an algorithm that was not actually described in the original articles, and the principles of its operation were analyzed using a model example. The algorithm presented in the article allows solving not only specific tasks, but can also be applied to a whole tasks class. The article describes an experiment in which the efficiency of an algorithm based on t/(n-1)-variant programming is compared with N-version programming voting algorithms and the recovery blocks approach. The results of the experiment are also presented

Key words: t/(n-1), software reliability, software redundancy, N-version programming, recovery blocks

ENGINEERING CONTENT MANAGEMENT AS PART OF DIGITAL ASSEMBLY LAYOUTS

A.N. Yurov

Abstract: the work considers methods for placing engineering information (linear dimensions, specifications, etc.) as part of the imported assembly unit by means of the Open CASCADE geometric core. The development is connected with the research of export formats and obtaining from them the structure of digital models of parts in the assemblies, entering technical specifications and building linear dimensions in the product layout. The software design uses technology to work with CAD data exchange formats, solutions that allow you to obtain model geometry and technical information from the files.

To justify the creation of the software component, a structural description of the design module is given when engineering data is introduced into a digital product layout, a process for loading an assembly unit is presented, which should be accompanied not only by extracting the geometry of each part model of the assembly, but also by obtaining names for all the units that are part of the assembly unit. An algorithmic solution has been prepared to extract the list of assembly part names. In addition, an algorithm for setting linear dimensions, where the positioning of each dimension is determined by the control points and the plane in which the dimension will be placed is proposed.

The development is prepared for use in the Linux Manjaro operating system based on 64-bit architecture.

Key words: CAD export data formats, engineering data, digital product layouts, Open CASCADE geometric core, open source operating systems

DEVELOPMENT OF SOFTWARE FOR VALIDATION OF NETWORK STANDARDS

K.I. Nikishin

Abstract: distributed networks are often used. Distributed networks also include wireless networks. Wireless networks are used to manage autonomous objects. The article discusses wireless communication network standards, including those for work in unmanned aerial vehicles, such as IEEE 802.11 and MAVLink standards, since wireless technologies for transmitting information are more widespread and used in various fields (telecommunications, smart home, technical monitoring, Internet of Things, unmanned technologies). The features and format of message transmission according to IEEE 802.11 and MAVLink network standards are discussed in detail. To research the IEEE 802.11 and MAVLink standards, a specialized software for validating these standards was developed, which ensures the sending of messages and decrypts them separately by fields. Validation of the correctness of all blocks of the transmitted message is carried out and an error message is output to the user in case of non-compliance with the standards. The article discusses the methodology of testing and testing software in the case of transmission of various message formats. When the program was working with test data, the confirming results of the program were obtained, and all the results coincided with the results of manual verification.

Key words: distributed networks, Ethernet, wireless networks, network standards, IEEE 802.11, MAVLink, message transmission.

Radio engineering and communication

LOCALIZATION COVERAGE ANALYSIS OF THz COMMUNICATION SYSTEMS WITH A 3D ARRAY

A.V. Bashkirov, I.S. Bobylkin, A.A. Kuzyemkin, V.R. Timoshilova

Abstract: the article considers the problem of assessing the position and orientation of a user equipped with a three-dimensional (3D) array receiving terahertz signals of the far zone via a downlink from several base stations with known positions and orientations. We derived the Kramer–Rao boundary for localization of the problem and determine the coverage of the system under consideration. We compared the distributions of the lower margin of error of a traditional planar matrix and configurations of a three-dimensional matrix at different positions and orientations of user equipment (UE). Our numerical results obtained for array configurations with an equal number of elements show a very limited coverage of the planar array configuration, especially in the UE orientation range. Conversely, the three-dimensional array configuration offers generally higher coverage with negligible performance loss in certain UE positions and orientations. During the analysis, we carried out work to find the boundaries of position errors (PEB) and orientation (OEB), with the help of which a quantitative assessment of the coverage for arrays of two-dimensional and three-dimensional configurations was obtained. We also simulated a single base station (BS), which compares PEB and OEB in different positions and orientations, as a result of which we estimated the THz coverage.

Key words: 3D array, localization, THz communication, constrained CRB, coverage.

OPTIMIZATION OF THE THERMAL MODE OF THE NODE ON THE PRINTED CIRCUIT BOARD USING THE BAYESIAN APPROACH

N.V. Tsipina, R.N. Khoroshaylov, I.A. Turetskiy

Abstract: the article describes a method combining Bayesian optimization (BO) with a model of a thermal network with concentrated capacities, which is effective for optimizing the thermal regime of PCB nodes. As electronic devices become smaller and more complex, the importance of optimizing the design to ensure efficient heat dissipation increases. However, such optimization of the design is difficult, since it is necessary to take into account various restrictions associated with the location and different temperature conditions of the components that emit heat. This research is aimed at improving performance and optimizing the thermal regime using neural networks. Bayesian optimization using a Gaussian process was combined with a model of a heat network with concentrated capacities, and its performance was tested. As a result, BO successfully found the ideal layout of the elements on the printed circuit board. As a result of the BO, it is possible to obtain the ideal placement of elements in about 1/150–1/90 of the calculation time. In addition, BO found the optimal solution in about 7 minutes out of 10 million layout templates. It has been estimated that this amounts to 1/1000 of the CPU time needed to analyze all the layout patterns.

Key words: Bayesian optimization, printed circuit board, heat network model, heating element

METHODOLOGY OPTIMIZATION OF THE TOPOLOGY OF THE TURNS OF THE PLANAR WINDING

O.Yu. Denisov, A.A. Moiseenko, S.M. Fyedorov

Abstract: the purpose of this work is to describe the methodology for creating the topology of planar turns, which reduces the losses associated with ohmic resistance, the main subject considered in this article is the losses on active resistance in the turns of the winding, reducing them, in turn, one have to modify the turns. In the study of this area of knowledge, the concept of calculating the resistance of turns lying in the same plane was presented, it was also tested on modeling by finite element methods. The main reasons for the occurrence of losses in the topology of the turns of a planar winding, the influence of these losses on the parameters of products are also considered. Most engineers do not model the topology of the turns of a planar winding, which leads to the design of a suboptimal winding option. It is shown that when modeling the design of the topology of the turns, it is possible to reduce the losses in the winding, which leads to an increase in the efficiency. On the example of a power coil of a switching power supply, the influence of optimization on the parameters of a planar winding is shown. Also in this example, you can see the use of the proposed methodology and the list of software used. As a result of the work, active losses on the planar winding were reduced by 7.3%, based on these theoretical data.

Key words: efficiency, planar winding, losses, power, power supply module, winding optimization, topology, winding turns, winding resistance

SPEECH EXTRACTION USING A PARTIALLY ASYNCHRONOUS MICROPHONE ARRAY WITHOUT REPEATED SAMPLING

A.V. Bashkirov, I.S. Bobylkin, A.A. Kuzyemkin, V.R. Timoshilova

Abstract: this article examines the problem of identifying speech sources recorded by several spatially separated devices, each of which has several microphones and processes signals at different speeds. Most methods of asynchronous array processing are based on determining the sampling frequency offset and resampling. But these offsets can be difficult to estimate if the sources and microphones are shifting. We propose a source separation method that does not require bias estimation or signal resampling. Instead, we distribute the propagating array into several synchronous subarrays. All arrays are used together to evaluate the statistics of a changing signal over time. These statistics are used to develop separate, time-varying spatial filters in each array. We demonstrate a method for combining speech recorded on both stationary and moving microphone sensors. The article describes in detail experiments on speech separation, as a result of which it turned out that the proposed method of asynchronous separation is effective in decomposing sources. The use of this method also involves situations where there are more sources than microphones. The article also discusses an experiment with holding a meeting as a scenario with moving wearable arrays, during which an analysis of the effectiveness of speech separation was carried out.

Key words: asynchronous microphone array, special microphone array, propagating arrays, sampling frequency offset, sound source separation, spatial filtering, speech enhancement

ANTENNA WITH RECONFIGURABLE PLASMA CORNER REFLECTOR

I.A. Barannikov, E.A. Ishchenko, S.M. Fyedorov, B.A. Shiyanov

Abstract: the article deals with the antenna with reconfigurable reflector. Its operating frequencies are in the UHF band and are located at frequencies from 637 to 648 MHz. A plasma vibrator antenna is used as the transmitter. The reflector is a corner-shape with an angle between the walls of 60°. The walls of the reflector are made of plasma elements, which are gas-discharge tubes capable of switching on and off at very short intervals. When on, they are a conductive surface and reflect electromagnetic waves, and when off, waves pass them freely. This allows, by turning certain groups of plasma elements on and off, to change the position of the reflector in space. The design of the reflector and the width of the radiation pattern in the horizontal plane allows for uniform radiation in all directions across the horizon. Also, since a plasma antenna is used as a transmitter, a covert mode with a reduced radar cross-section (RCS) is possible. The characteristics of the antenna were determined by electrodynamic simulation. The efficiency of the covert mode was evaluated by comparing the RCS of the plasma antenna and its metal counterpart. The results show that the antenna has a high radiation efficiency and significantly lower RCS values in the stealth mode.

Key words: plasma antenna, reconfigurable reflector

THE RATIONALE FOR NETWORK SLICING USING DEEP LEARNING IN WIRELESS NETWORKS (5G/LTE)

T. Le Anh, T.L. Vo Minh, B. Daneshmand

Abstract: now and in the future, 5G mobile networks, mobile communications and wireless networks must meet the standards of low latency, high reliability, increased capacity, greater security and fast user connection. Mobile operators are constantly looking for solutions that allow multiple independent subscribers to operate on the same 5G network. One such solution is the use of Network Slicing (NS) technology to allocate finite network resources on the same physical infrastructure. Data-driven decision making is critical for future communications networks due to the exploding traffic growth. To effectively manage the distribution of network resources and network availability, machine and deep learning in the network was used. We used key performance indicators (Key Performance Indicators - KPIs) to analyze incoming traffic and predict fragments of network resources for the distribution of unknown devices. Intelligent resource allocation allows you to effectively use the available resources on existing network fragments and provide high load balancing. The model used makes an intelligent decision and selects the most appropriate network fragment

Key words: Network Slicing (NS), Key Performance Indicators (KPIs), deep learning, normalization, Software-Defined Networking (SDN)

METHOD FOR DETERMINING THE PARAMETRIC RELIABILITY OF SEMICONDUCTOR DEVICES

A.S. Kostyukov

Abstract: in the modern world, development of various electronic devices cannot be imagined without the use of semiconductor elements. These elements have a number of undeniable advantages, and are most in demand in the modern electronics industry. In connection with all of the above, the question of testing and determining the reliability indicators of semiconductor elements is acute in order to screen out defective components. To date, there are several ways to determine the reliability of these elements. The article presents one of such methods for determining reliability, based on statistical calculation algorithms. Based on the method shown, I developed a new improved method for determining reliability. In particular, the new methodology takes into account the initial data of the statistical sample, and also includes a number of additional indicators in the calculation. At the end of the article, I give the results of calculations of the reliability indicators of microcontrollers of the ATmega family, both according to the new method of determination, and according to the old calculation method. Based on the results obtained, I made a comparison with the reference values taken from the design documentation for the devices. As a result of this comparison, I revealed that the developed method for determining the reliability allows obtaining the values of complex coefficients with an error of ± 10% in comparison with the reference values.

Key words: reliability, semiconductor element, ATmega, uptime

Mechanical engineering and science of machines

IMPROVING THE QUALITY OF MANUFACTURING PARTS FROM METAL-POLYMER COMPOSITE MATERIALS

V.I. Maksimenkov, M.V. Molod, D.S. Grebennikov

Abstract: the article discusses the use of composite materials in domestic and foreign aircrafts. We show their advantages, providing solutions to issues of weight reduction and increasing the strength of parts, assemblies, aggregates and the whole product. At the same time, we note disadvantages associated with low impact resistance, which reduces the effectiveness of their use in highly loaded airframe zones. One of the ways to solve this issue is the use of metal–polymer composite materials (MPCM) in structures. We formulated the purpose and objectives of the study and gave manufacturing options of MPCM, which is a combination of aluminum blanks and PCM. Considering that the PCM has a low plasticity-1-2%, we considered the process of separate deformation of aluminum sheet and PCM. The shaping of the aluminum sheet was carried out by the method of skinning. The applied tight punch was made of aluminum alloy by casting, which, after processing, ensured the process of forming the sheet to a given curvature, followed by its use for laying out and temperature control in an autoclave. One of the important tasks to be solved is to ensure uniformity of deformations and ensure stable properties in the resulting workpiece during fitting. This is achieved by reducing friction on the surface of the punch using the solution given in Patent No. 2459680. We analyzed the formation of samples from PCM and developed the technological process of manufacturing parts from MPCM, which includes all stages from obtaining the workpiece, to the process of fitting, subsequent laying out, temperature control and control of the finished part. Here we present the results of tensile testing of samples from MPCM – aluminum – D16CHAT, from PCM and MPCM, which tested the strength and plastic characteristics of the tested materials. We carried out a weight calculation of the components of the MPCM, which revealed the weight efficiency of the developed MPCM design compared to SD16CHAT. We revealed an increase in the strength of the MPCM cladding and a weight reduction of more than 20%. The use of this MPCM manufacturing technology allows us to ensure an increase in the quality of the parts obtained with the required accuracy.

Key words: Punch, MPKM sheathing, friction, carbon fiber, CNC equipment.

ON THE EFFECT OF SURFACE OXIDATION DURING ANNEALING ON THE ERIKSEN PLASTICITY OF WELDED JOINTS OF SHEET TITANIUM ALLOYS

A.B. Kolomenskiy, S.V. Shahov, R.T. Mustafin, B.A. Kolomenskiy

Abstract: it is known that in the manufacture of titanium welded structures, annealing is used to reduce residual stresses, which is usually carried out in air. Heating at temperatures above 300 ºC is accompanied by the appearance of interference-colored oxide films, and at temperatures above 550-600 ºC - gas-saturated layers, the effect of which on the mechanical characteristics has not been sufficiently studied. The effect of

oxide films formed during annealing on the Eriksen ductility of the base metal and welded joints from sheet titanium alloys was studied. The work was carried out both on the base metal and on welded billets of titanium alloys VT1-0, PT7M, and VT6ch, which are widely used in the manufacture of aircraft. Part of the sheet blanks had a gas-saturated sublayer. We established that oxide films formed during annealing at temperatures up to 550°C slightly (by no more than 7%) reduce the Eriksen ductility of low-strength titanium alloys and can have a positive effect on the technological ductility of a high-strength titanium alloy. The presence of a gas-saturated sublayer in this case can increase the ductility of both the base metal and welded joints of these alloys.

Key words: titanium alloys, welding, annealing, oxide films, plasticity according to Eriksen

SELECTION OF TECHNOLOGICAL PARAMETERS FOR OBTAINING HIGH-QUALITY STEEL BODY CASTINGS BY COMPUTER MODELING

L.S. Pechenkina, M.S. Frolov

Abstract: analyzing the experience of using CAD programs on the example of using SKM LP LVMFlow, it became possible to assert that they certainly solve problems in analyzing the causes of casting defects and optimizing technological processes, therefore this topic is relevant. The object of the study was a “housing” part weighing 37 kg made of low-alloy chromium-molybdenum steel, which is included in a very common assortment of many industries. It can be used in harsh environments over a wide range of pressures and temperatures. Thanks to these parameters, it has found its wide application in the oil and gas industry. It is used as a shut-off valve in an oil pipeline when operating under high pressure when interacting with SO_2, which is an unfavorable condition for many steels. There are requirements for dynamic alternating loads, the parameters of which our part corresponds to. A number of other compliance requirements for corrosion resistance and tightness are also provided. The weight of the body with sprues is 168 kg. In this part, a stable defect is observed - this is shrinkage porosity, which is detected during its manufacture as a result of machining. Therefore, this detail was of interest for modeling using the LVMFlow software package. The scientific novelty of the work is determined by the optimal selection of criteria that affect the provision of a dense structure in a steel casting subject to high shrinkage. The purpose of the study is to use the applications of Solidworks and LVMFlow CAD programs in sand mold conditions with production technological indicators that ensure the efficient melting of a perfect casting, to design model-flask equipment and improve the manufacturing technology of the "Body" part from steel. Shortening the tooling manufacturing period and choosing the best casting production option, without unnecessary melting, is the advantage of switching to end–to-end development of technology and tooling for the production of the casing when casting into sand molds. We considered some concepts affecting the defect "Shrinkage porosity" when casting into sand molds, namely: the power of the solidifying casting, the direction of solidification, the heat-accumulating tendency of the molds and rods, the supply of melt into the casting. When considering these concepts, we made an assessment and the degree of influence on the amount of shrinkage was revealed.

Key words: casting, model tooling, solidification, computer modeling, molding mixture, defect, shrinkage.