Informatics, computer engineering and control

POINT OPTIMIZATION OF THE LAMINAR FLOW OF A VISCOUS FLUID IN A NETWORK CARRIER

S.L. Podval'ny, V.V. Provotorov, V.N. Hoang, Z. Tran

Abstract: the paper considers the problem of point optimization of a differential-difference system of equations, the formalisms of which represent the process of a laminar flow of a viscous fluid in a network carrier and a discretely changing time variable. In this case, the analysis of multiphase media is allowed. We present the conditions for unique weak solvability of the differential-difference system and the continuous dependence of the weak solution on the initial data. External influence on the mathematical model of the transfer process (differential-difference system) is carried out with the help of influences concentrated in all internal points of conjugation (branching) of the network carrier of a continuous medium. The observation of the state of the differential-difference system is carried out in the entire range of the spatial variable with a discretely changing time variable, the minimizing functional is given by a coercive quadratic form and a positive operator, which guarantees the uniqueness of the solution of the optimization problem. The study essentially uses the conjugate state and the conjugate system for the original differential-difference system of equations. Necessary and sufficient conditions for determining the optimum of the problem of point optimization of a differential-difference system of equations are obtained. We show the relationship between the differential-difference system of equations with a discretely changing time variable and the evolutionary differential system of equations with a continuously changing time variable

Key words: directed graph, differential-difference system, adjoint system, point optimization

DETERMINATION OF NEURAL NETWORK CONFIGURATION PARAMETERS FOR APPROXIMATION OF EXPERIMENTAL TENSILE CURVES

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Abstract: we described a method for solving the problem of approximating experimental tensile curves by artificial neural networks with architecture of multilayer perceptron. Computer modeling of the neural network was performed in Knime Analytics Platform. The RProp method was used to train the network. The quality of the approximation was assessed by the values of the MSE и R^2 indicators. The number of hidden layers and the number of neurons in them affects the quality of modeling in a direct proportional relationship. With an increase in these indicators, an increase in the dimension of the matrix of weight coefficients of connections between neurons is observed. In this regard, the question of the optimal choice of the internal structure of the network is relevant. The influence of the neural network configuration on the quality of the approximation was studied using tensile curve of specimen was made of hot-rolled steel with a pressing degree of 37%. The best results were obtained for the model with 4 hidden layers with 40 neurons in each layer. The found configuration of the neural network was tested on the same material from hot-rolled steel with pressing degrees of 16% and 6%, on high-strength boron steel, on gray cast iron, and on a polypropylene composite material with long glass fiber. The conducted studies have shown that a neural network with the found configuration can be successfully used to approximate the tensile curves of specimens made from different materials

Key words: tensile curve, approximation, multilayer perceptron, neural network configuration

HYSTERESIS MODEL OF MOISTURE EXCHANGE IN THE UNDERLYING SURFACE

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Abstract: the dynamics of moisture content in the underlying surface and the atmosphere plays a key role in models of atmospheric processes and phenomena. In particular, the processes of the genesis of intramass clouds, evaporation fogs, smoke, etc. are directly related to soil moisture content and atmospheric humidity. In addition, taking into account the significant contribution of moisture content to the energy of the atmosphere, this parameter is a key factor in the formation of meso and microscale movements of air masses. Finally, the atmospheric and related soil moisture content, together with the baric and temperature fields, actually determine the presence (absence) of such natural hazards as showers, thunderstorms, icing, etc. In this regard, the improvement of models of the dynamics of the moisture content of the underlying surface seems important and interesting task. The paper proposes a new model that describes the dynamics of moisture content in the soil, based on the hysteresis relationship between the specific moisture content in the soil and the matrix potential. This model is formalized by means of a system of differential and algebraic equations. In this case, the Preisach converter is used as a model of hysteresis connections - a model of a continuum system of non-ideal relays connected in parallel. The results obtained within the framework of a computational experiment - the dynamics of moisture content over a finite time period are compared with real data on the example of territories located in the southern part of Russia and Uzbekistan

Key words: soil moisture content, hysteresis, differential equations, Preisach converter

LIGHTING AND MODEL RENDERING WITH IMPORTED GEOMETRY IN ASSEMBLY UNITS OF DIGITAL PRODUCT LAYOUTS

A.N. Yurov

Abstract: the approaches that provide object's illumination and visual representation of models as a part of the assemblies are considered. Digital layouts of assembly units, which are represented by export data formats in modeling systems, are used as initial object models. To substantiate the development of the software module, a structural description of the design solution for high quality display of models with photorealistic features was prepared. A software solution was created that provides functionality to visualize and display models as part of an assembly with effects that correspond to the conditions of behavior of objects in the real world. The software module in the implementation of rendering of models, which are part of the imported assemblies, is made on the classes and methods of the open geometric kernel Open CASCADE, where through dialogs, as well as with the help of auxiliary elements, visualization and lighting of object surfaces is made. Besides, the software implements tools for viewing and representing models in a separate scalable window, has functionality for changing model colors, deleting individual models in the assembly, shows the composition of the imported assembly if the specified records are placed in the export data format. The development is prepared for use in the Linux Manjaro operating system based on 64-bit architecture

Key words: model representation, object rendering, digital product layouts, Open Cascade geometric kernel, opensource operating systems

MULTI-LEVEL SIGNAL ADAPTATION IN NON-STATIONARY CONTROL SYSTEMS

S.L. Podval'nyy, E.M. Vasil'ev

Abstract: here we considered the problem of constructing adaptive controllers for non-stationary automatic control systems. We note that the known signal adaptation schemes do not provide the desired quality of regulation in a wide range of changes in the parameters of the object. We suggested that this disadvantage can be eliminated if, to solve the problem, we use the principles of modularity and multi-level control, which together constitute the evolutionary concept of the multi-alternative structure and functioning of complex systems. To implement signal adaptation on the basis of these principles, we propose to divide the original high-order object into structural and physical elements of a low order. We show that if the dynamic complexity of each structural element of the object in terms of the number of dominant roots of the characteristic polynomial does not exceed the second order, then for any selected element the simplest one-level signal adaptation subsystem with an explicit reference model can be implemented. Each such subsystem has significant amplitude and phase stability margins, which makes it possible to ensure high quality of adaptation in any of them. The structure of the control system is proposed, containing a multilevel signal adaptation circuit, which is a hierarchically subordinate connection of single-level circuits with two parallel channels: a channel with object cascades and a channel with the corresponding reference model cascades. Such an organization of a multilevel scheme excludes the sequential accumulation of adaptation errors in each stage. We studied a mathematical model of a multi-level signal adaptation scheme has been compiled, and its adaptive capabilities. We note that in order to ensure a zero steady-state error, it is advisable to cover the adaptation circuit with an additional deviation control loop with an integrator in the forward channel of the system. We present the results of numerical simulation of the proposed multi-level adaptation scheme in comparison with the traditional one-level scheme and confirmed the high efficiency of the multi-alternative approach to the control of non-stationary systems used in the work

Key words: non-stationary control systems, multi-alternative concept, multi-level principle, signal adaptation

DETERMINING THE USER'S MOVEMENT PATTERN ON A SIMULATOR

A.A. Siukhin, S.V. Karpushkin

Abstract: training and testing of mining industry specialists require the use of special devices based on running simulators. Simulators should provide realistic conditions of movement during testing, but the presence of a delay in the reaction of the running simulator prevents the timely response of the hardware to the user's actions. The untimely reaction of the simulator throws users off balance, especially when using visual aids – virtual reality helmets. The paper describes the principle of searching and using user's movement patterns for adaptive control systems of simulators with observer cameras, which is based on the search for patterns in successive frames from observers. Patterns with the same number of frames are used to form the user's movement pattern. The choice of frames for the template was carried out by the value of the average modal value characterizing the image in the frame, so the user's movement pattern is collected from frames previously received from observers. The paper presents a user movement pattern obtained as a result of the implementation of the described principles. The use of the presented approach requires the introduction of a preliminary frame analysis module and does not require changes in the design of the simulator with observation cameras. The prospects for using the found template for solving the problem of compensating for the reaction delay of a running simulator are described

Key words: algorithm, control system, running simulator, machine vision, delay compensation, action patterns

METHOD OF CALCULATING THE RANGE OF INFRARED SCANNING SYSTEMS OF PASSIVE TYPE

D.A. Smirnov, A.M. Delendik, A.V. Nikolenko, S.Yu. Vakhmin, K.V. Nikolenko

Abstract: the article presents and reveals a computational and experimental technique for the range of infra-red scanning systems of the passive type, which is part of the technical vision system. We note that in this article, the technical vision system is understood as a complex of on-board equipment intended for viewing during sequential scanning of the underlying earth's surface, which can be represented as consisting of special components, the angular magnitude of which is equally similar to the short angle of the angle of the technical vision system. In some cases, a target landmark is detected in a short area of vision, while the microelectronic circuit multicontroller issues a short-term command pulse, which affects the components of the electrical circuit structure with switching the target search regulations to the target capture regulations and its automatic continuous tracking. The maximum range at which a target with a specific probability should be detected is determined by the numerical ratio: signal/noise. The energy of the accompanied target signal is also recorded when a target landmark is detected at the maximum range with the specified values and characteristics. It is necessary to define the so-called detection parameter. It is determined by the detection curves based on the set values of the detection quality indicators – the probability of correct detection and the probability of a false alarm

Key words: range calculation method, computational and experimental method, technical vision system, infrared scanning systems, passive systems, recognition and detection of objects of interest

COEFFICIENT INVERSE PROBLEM IN THE MATHEMATICAL MODEL OF THE REFINING PROCESS KINETICS

Le Van Huyen

Abstract: within the framework of the mathematical model of the kinetics of the oil refining process, the inverse problem was studied: to determine the reaction rate constants from the given concentrations of the starting substance and products. A technique for solving this problem based on the method of finite differences, the method of interpolation of the initial data - the cubic spline and the Tikhonov's regularization method is proposed. As a result of the calculations performed, approximate reaction rate constants will be found. In order to assess the acceptability of the found approximate reaction rate constants, the agreement between the measured and calculated concentrations of the starting material and products will be checked. For this, statistical parameters will be used: The Pearson correlation coefficient and the Nash-Sutcliffe efficiency indicator. The found approximate reaction rate constants make it possible to predict the concentrations of the initial substance and products at any time by solving a system of differential equations. For example, when it is necessary to determine the concentration of substances at some point in the past, but we cannot make a measurement or in the future without taking a measurement. Moreover, from the found approximate reaction rate constants, it is possible to determine the indicators in the reactions of the oil refining process, such as activation energy, temperature

Key words: inverse problem, mathematical model, chemical kinetics, oil refining process, finite difference method, cubic spline method, Tikhonov's regularization method

POSITIONING NORMALS ON THE TOPOLOGICAL SURFACES OF ASSEMBLY PART MODELS

A.N. Yurov

Abstract: when designing systems that are responsible for partial or fragmented automation, it is necessary to conduct research regarding those components of engineering software products, where it is really expedient. Operations with normals can be in demand when setting dimensional directions, technical requirements as part of an assembly unit, as well as the analysis of mutual intersections of surfaces of part models as part of assembly units in the design of products. To automate the process of entering dimensions into a model, it is necessary to correctly determine the dimensioning direction, otherwise the dimension will be hidden by the shape of the digital model object. One solution to the problem of determining the direction of dimensioning is the approach of positioning normals to the surface, on which I give control points, relative to which I created the dimensions. I considered in the work the components of the geometric kernel, providing the division of the assembly unit into separate object-models, the topology of models, as well as the order of facet extraction from the form of the model. I defined the scheme for developing a software solution to develop a software application. I created an autonomous user interface of the application with the implementation of normals construction by means of Open CASCADE. I performed implementation for Linux operating systems with 64-bit architecture

Key words: model representation, surface normal construction, digital product layouts, Open Cascade geometric kernel, open-source operating systems

DIRECT AND INVERSE PROBLEMS FOR PASSIVE ZONES OF CONVEYOR PROCESSING OF EXTENDED OBJECT

N.M. Mishachev, A.M. Shmyrin, I.I. Suprunov

Abstract: the paper considers the problem of additive conveying processing of an extended object in the presence of three successive conveyor zones. The first and third zones are passive, in these zones the change in the properties of the object is described by some local deterministic law, an example of which is the heat equation. Additive processing of the object takes place in the second, active zone. The processing algorithm was described earlier in the articles of the authors. The initial data for the algorithm are the profiles of the properties of the object at the exit from the first zone and at the entrance to the third. At the same time, the initial data of the general problem are other profiles, namely, the profiles of the properties of the object at the entrance to the first zone and at the exit from the third zone. To find the two required profiles, it is necessary to solve the direct problem for the deterministic self-action of the object in the first passive zone of the conveyor and the inverse problem for the self-action in the third passive zone. The movement of an object can be described in Lagrange coordinates (i.e. in the object coordinate system) or in Euler coordinates (i.e. in the conveyor coordinate system). In this paper, the Euler coordinates are used to solve direct and inverse problems

Key words: conveyor processing, passive zones, direct and inverse problems

RESEARCH OF TRAFFIC TRANSMISSION IN A SOFTWARE DEFINED NETWORK USING CISCO PACKET TRACER

K.I. Nikishin

Abstract: distributed computer networks simplify the network architecture and network administration, increase network fault tolerance and the possibility of a backup process. This type of network includes a software defined network (SDN). SDN is a promising and in-demand technology for the transmission of heterogeneous traffic, in which software-based controllers or APIs are used to direct it to the network and interact with the underlying hardware infrastructure. The goal is research SDN using simulation modeling through specialized network programs to assess the transmission of traffic in the network, bandwidth and latency. Some part of the traffic transfer to the SDN using the device of the CPN Tools package Petri nets is described. Simulation modeling was carried out in the Cisco packet tracer program. A network of SDN with a single controller in Cisco packet tracer was developed and investigated. The features of network configuration, formation of IP addresses, masks and gateways are described. The movement of traffic to the PC was investigated, the speed of packets in the network and the proportion of packet loss, as well as the correctness of the operation of equipment in the network were evaluated. The developed Cisco packet tracer model presents diagrams of the status of hosts and network devices (switches, routers), shows the number of ping commands sent to hosts and the percentage of packets that reached them, for network devices – the percentage of their management status

Key words: software defined network, Ethernet, OpenFlow, heterogeneous traffic, Petri nets, CPN Tools, Cisco Packet Tracer

ON THE APPLICATION OF BIG DATA STRUCTURE REGULARIZATION IN A DISTRIBUTED EVALUATION SYSTEM FOR EMERGENCY PARAMETERS

S.S. Kolmogorova, N.O. Golubyatnikova

Abstract: over the past decade, the number of machine learning methods, as well as their areas of application and approaches, has increased significantly due to the need to develop more accurate and reliable forecasting models. An approach to predicting the parameters of an electromagnetic field based on the Apache Spark Streaming distributed environment is considered. Initially, data from various real-time electromagnetic field sensors are processed to the level of structured data, which is the input to the prediction model, which focuses on predicting the type of value given several classes. In addition, in order to improve the prediction performance, a regularization method was used for feature selection to reduce overfitting. The described architecture is an integration of Apache Kafka, Spark and Cassandra and is recommended for application monitoring and predicting the state of systems of various profiles. Experimental analysis shows that the use of the regularization method increases the efficiency of the recurrent neural network in predicting the parameters of the electromagnetic field. The proposed model is able to effectively use mixed applied data, reduces the likelihood of model overfitting and reduces computational costs

Key words: electromagnetic field, streaming data, machine learning, Apache Cassandra, Apache Kafka, Apache Spark, big data, electrometry, prediction, distributed data collection system

Radio engineering and communication

DEVELOPMENT OF AN OPTIMAL CONTROL SCHEME FOR A D-CLASS HIGH-FREQUENCY AMPLIFIER

A.V. Bashkirov, I.V. Sviridova, R.N. Khoroshaylov

Abstract: in audio amplifiers with switchable mode, control loops were used to improve the sound quality of the amplifier. Since these amplifiers use high-frequency modulation, it is necessary to design the controller carefully. In addition, the quality factor of the output filter can have a big impact on the controller's ability to suppress noise and track the audio signal. This article presents design methods for modern management. The developed control method makes it easy to solve the problem of designing a high-performance controller when the output filter has a high-quality coefficient. The results show that the controller is able to provide a clear improvement in the overall level of harmonic distortion with an improvement of up to 30 times compared to an open loop with a clear reduction in noise, which allows for better sound quality. The principles of modeling the state space and how it can be used in combination with Class D amplifiers are given. Modern methods of control theory will be applied to design and simulate an integrating controller with full state feedback for use with a Class D high-frequency bridge amplifier

Key words: class D amplifier, modeling, optimal control, state space model

DIGITAL METER OF THE EFFECTIVE VALUE OF THE SIGNAL

V.P. Litvinenko, Y.V. Litvinenko, D.V. Shatilov

Abstract: a digital meter of the effective value of arbitrary waveform signals is considered. The computational algorithm implements a direct determination of the desired value without the need to recalculate readings depending on the signal shape, does not require synchronization with the processed signal, and provides the formation of the final result after the arrival of each next symbol with a minimum of simple arithmetic operations and high measurement accuracy. The analysis of the characteristics of the meter is carried out, the influence on the accuracy of the asynchrony of the sample of signal samples with its periodicity is considered. The requirements for the bit capacity of the analog-to-digital converter and the sample size of the samples of the measured signal are formulated. Statistical simulation of a digital meter has been carried out, estimates of the error of the result have been obtained. Models of a high-precision AC voltage source based on a digital-to-analog converter (DAC) and an effective voltage value meter based on a field-programmable logic integrated circuit (FPGA) have been implemented, and an assessment of the necessary hardware resources has been carried out. The results of measurements of constant and variable (harmonic and sawtooth) voltages formed on the basis of precision reference voltage sources are obtained. The meter can be used in the design of digital AC voltmeters and ammeters, the readings of which do not depend on the waveform, allow for a simple hardware implementation and provide the ability to measure both low-frequency and high-frequency alternating signals

Key words: effective signal value, measurement, error, modeling, programmable logic integrated circuits

INVESTIGATION OF A DUAL SPHERICAL ELECTRIC FIELD STRENGTH SENSOR WITH COMPOSITE SENSITIVE ELEMENTS

S.V. Biryukov, A.V. Tyukin, L. V. Tyukina

Abstract: the paper investigates a new type of electroinduction spherical electric field strength sensors, related to dual sensors. Sensors dual in design are divided into three groups. These include sensors with overhead, composite and separate sensitive elements. Previously, the author studied sensors with attached sensitive elements. This work is devoted to the study of dual sensors with composite sensitive elements. The study was carried out in order to improve the metrological characteristics of known electroinduction spherical sensors, when used in highly inhomogeneous electric fields. The results of the study showed that dual sensors have better metrological characteristics than the known ones. When conducting research, the relationship between the error of a dual sensor from the inhomogeneity of the field and its angular dimensions of the sensitive elements was established. Taking into account this relationship, a mathematical model was compiled, using which the angular dimensions of the sensor's sensitive elements were optimized from the point of view of the minimum error and the maximum spatial measurement range. As a result of modeling, the optimal angular dimensions of the sensing elements of a dual sensor with composite sensing elements were established equal to θ_1=46,38°, θ_2=49,02° and θ_3=90°. These angular dimensions of composite sensitive elements correspond to the minimum possible error δ=±2,25 %

Key words: electric field strength, measurement, double sensors, double sensors, composite sensing elements, error due to field inhomogeneity

METHOD OF INTERACTION OF TRAIN RADIO COMMUNICATION CHANNELS, ENSURING THE SECURITY OF DATA TRANSMISSION

M.V. Khoroshaylova, A.V. Turetskiy, R.N. Khoroshaylov

Abstract: the paper discusses the principles of data transmission over a radio channel, in order to ensure information security, as well as to prevent threats when transmitting information over a radio channel. To experimentally determine data on the channel capacity, packet transit time, data on packet losses in the radio network, experiments were carried out on interaction with the train via a digital communication channel, taking into account the requirements for information security. The experiments performed show that for any packet size in a standard digital radio communication system, with an increase in the load on the system, the packet transit time increases. The experiment proved that the system satisfies the requirements for packet transit time with a transmission rate of up to 1.4 Kbps. During the experiment, the issues of communication between the radio unit center and the TETRA switching center, the connection of the radio unit center with electrical interlocking systems, the modernization of the on-board equipment of the locomotive and the verification of the operation algorithms of the on-board and stationary equipment were considered. It has been found that the performance of the TETRA digital radio system results in regular failures of the SIRDP-E (Radio Channel Based Train Interval Control System)

Key words: data transmission packets, information security, bandwidth, digital communication channel

Mechanical engineering and science of machines

UNPROFILED TOOL ELECTRODE FOR COMBINED REMOVAL OF BURR IN POINTS OF JOINING MATCHING COMB SURFACES

O.N. Kirillov, V.P. Smolentsev, G.A. Sukhochev, S.S. Yukhnevich, E.V. Kotukov

Abstract: the article considers the possibilities of combined processing of burrs in grooves with a complex geometric shape with a non-profiled brush electrode. We proposed the design of the brush electrode for removing burrs. The brush-brush consists of a holder and a working part made of metal wire. The working part is placed in a dielectric ring made of a plastic material located on the outer surface of the ring, and a solid one located on its outer surface. The dielectric ring has a hole in the form of a cone. The hole with its smaller diameter is located on the side of the metal wire working part. In this case, the ring has a height not exceeding the depth of the machined groove of the part, without taking into account the maximum geometric dimensions of the burr to be removed. The dielectric ring has two inner diameters, the larger one is determined by the minimum width of the groove without taking into account the double thickness of the processed burr, and the smaller one is made not less than the diameter of the working wire part at the maximum recommended for this type of processing, the packing density of the wire in the bundle. The working part of the brush-brush electrode is selected with a length that is not less than the depth of the groove being cleaned, and a diameter at the junction of the working part and the holder of the brush-brush equal to the largest width of the processed groove in the product. We considered a method for removing burrs with a non-profiled electrode with a brush-brush in the grooves of the cooling fins of liquid-propellant rocket engines. Here we give the practical results of the experiment on the removal of burrs in the grooves obtained by milling

Key words: burrs, combined treatment, electrode, brush-brush, working medium, rocket engine