

Informatics, computer engineering and control

TWO SCHEMES FOR HIERARCHICAL IDENTIFICATION OF QUASILINEAR MODELS

N.M. Mishachev, A.M. Shmyrin, A.P. Shcherbakov

Abstract: the problem of improving the quality of approximation of a neighborhood model based on the analysis of residual data (residuals) of the initial linear model and subsequent hierarchical identification of additional quasi-linear or quasi-polynomial terms is considered. Two schemes of hierarchical identification are studied. In the first scheme, it is assumed that hierarchical clustering (or, more generally, hierarchical partitioning) of a set of tuples of input data is pre-defined. The additional terms of the refined piecewise continuous model correspond to the vertices of the hierarchy tree. In the case of hierarchical clustering of input tuples, the resulting piecewise continuous model can be approximated by a continuous model using unit partitioning. In the second scheme, the hierarchical partitioning of input tuples occurs recursively during the identification process, namely, the elements of the next layer of the hierarchy consist of prototypes of selected intervals or (if available) clusters of a set of residuals of already constructed models of the previous level. The elements of hierarchical partitioning of tuples of input data obtained in this way can have a rather complex form. The second scheme has some similarities with the construction of the Lebesgue integral. Both hierarchical identification schemes can be useful in modeling chaotic or highly oscillating dependencies of outputs on input tuples

Key words: residual data, hierarchical partition, hierarchical identification

CODING METHODOLOGY OF CONTROL AUTOMATS FOR TRAFFIC TRANSMISSION IN A SOFTWARE DEFINED NETWORK

K.I. Nikishin

Abstract: software defined networks (SDN) are a new paradigm in the field of network telecommunications. The difference from classical networks is that the control panel controller interacts with the infrastructure layer at the control level. However, the classical method of transmitting heterogeneous traffic based on the OpenFlow protocol has a number of disadvantages. In order to eliminate the disadvantages of traffic transmission, new methods of traffic transmission, the methodology of complex control of traffic transmission in SDN, the coding methodology of control automats for traffic transmission in SDN have been directed. The coding methodology of control automats is based on Moore digital automats and algorithms for early diagnosis of real-time traffic losses during the transmission of heterogeneous traffic in the OpenFlow switch and the transmission of real-time traffic using a scheduler and a delivery control function in SDN. Control automats have been developed in accordance with the methodology and Moore's digital automats. The modelling of work of control automats on FPGAs of the Spartan 6 family using time diagrams is carried out. Hardware costs for FPGA control automats are estimated. The designed control automats can be part of telecommunications equipment, controllers or OpenFlow switches by means of a designed FPGA or ASIC for monitoring and transmitting traffic to the control system by means of control signals and commands

Key words: software defined network, OpenFlow, heterogeneous traffic, digital automata, Petri nets, control automat, FPGA

USING CONVOLUTIONAL NEURAL NETWORKS FOR DIAGNOSING SKIN CANCER

A.V. Mikhaylusov

Abstract: the study demonstrated the possibility of classifying images of skin lesions obtained using dermatoscopy, with the aim of subsequent diagnosis of skin cancer and other adjacent skin lesions. The classification problem was solved using the apparatus of convolutional artificial neural networks (CNN) using subsampling layers. The structure of the initial training sample is shown, images are prepared for subsequent training of the model. And also the entire set of available training data was divided into test and training sets. The paper presents the main advantages of using convolutional artificial neural networks in solving the problem of image classification, and also describes ways to optimize the model to reduce the resource intensity of the learning process. The main parameters of the architecture of the developed artificial neural network are described, one part of which was tuned with standard values, and the other part was selected experimentally during the study to obtain an optimal model that gave a sufficient classification accuracy and had an acceptable resource intensity. The analysis of the quality of the model operation depending on various settings of the model architecture is carried out and the final version of the network architecture is presented. A graph of the classification accuracy of the final version of the model is given

Key words: convolutional neural network, classification, machine learning, deep learning, diagnostics

Radio engineering and communication

APPLICATION OF VIRTUAL ARRAY TECHNOLOGY FOR PASSIVE DIRECTION FINDERS OF UNMANNED AERIAL VEHICLES

E.A. Ishchenko, Yu.G. Pasternak, V.A. Pendyurin, S.M. Fyedorov, I.A. Chernoiivanenko

Abstract: the article considers the possibility of installing a passive direction-finding complex on an unmanned aerial vehicle. Due to the complex geometric shape of the drone, the patterns of the electromagnetic field are distorted, which leads to a distortion of the characteristics that the direction finder will measure. To solve this problem, it is proposed to use the apparatus of virtual antenna arrays, which allows one, by performing an approximation of the electromagnetic field, to reduce the influence of the carrier body on the patterns of the electromagnetic field. To form a virtual antenna array, we used an algorithm based on the Hankel function, which leads to the fact that it is possible to increase the speed of calculations, as well as to increase the efficiency of the approximation of the electromagnetic field. The obtained simulation results show that the use of virtual antenna array technology can significantly improve the accuracy of electromagnetic wave direction finding, while maintaining a high level of carrier secrecy, since it is not required to emit electromagnetic waves, all systems operate in a passive mode. The use of passive direction finding in this way also makes it possible to increase the range of use of an unmanned aerial vehicle, since it is possible to reduce the power consumption of the system. The article presents a picture of the effective scattering area of an unmanned aerial vehicle, which makes it possible to evaluate the distortion of electromagnetic waves, bearing patterns as well as bearing statistics

Key words: unmanned aerial vehicle, electromagnetic wave direction finder, virtual antenna array

REDUCING THE PROBABILITY COEFFICIENT OF BIT ERRORS IN A DIGITAL COMMUNICATION SYSTEM

I.V. Sviridova, M.V. Horoshaylova, V.A. Markin

Abstract: the error rate reduction using Hamming code in the MATLAB / Simulink environment is simulated and analyzed in this paper. In communication systems, when transmitting and receiving data, errors occur due to unwanted noise and interference in the communication channel, therefore, for efficient data transmission, it is necessary to receive data without errors. The channel encoder adds bits to the transmitted message bits. The channel decoder interprets the received message using redundant symbols to detect and possibly correct errors that may have occurred during transmission. The error control coding technique is to detect and possibly correct erroneously transmitted information by introducing redundancy into the bit stream transmitted over the channel, and ensures safe and reliable data transmission over an imperfect noisy channel. Depending on the nature of the noise, a certain type of error control coding is applied. The analysis and observation of the error rate of the system carried out here using block coding techniques, in particular Hamming code, the results showed that the error rate is reduced to a significant level, and the results are verified using theoretical and practical methods

Key words: bit error rate, data, error control code, MATLAB/Simulink, noise

DIFFRACTION SIDE LOBES IN A FLAT ANTENNA ARRAY WITH A RADIAL GRID

A.D. Bazanova, K.A. Layko, Yu.O. Filimonova

Abstract: in this paper, studies of the position and level of the lateral diffraction maxima of the radiation pattern in a flat antenna array with a radial grid arrangement of radiating elements are carried out. The basic relations for calculating the distances between emitters for different antenna array structures are presented. A comparison of the distance between elements in a rectangular grid with a radial one is given, according to the criterion of equal filling factor of the antenna web with radiating elements, while the area of a rectangular opening is equal to the area of a round one. To do this, the step dependence for the radial grid of the location of the emitting elements in the nodes of the antenna array was shown, calculated at a given step between the emitters in a rectangular grid. The difference between the two structures of flat antenna arrays along the maximum side lobe is shown. The comparison was carried out for antenna array structures containing a different number of elements on the opening: 25 and 145. It is also noted that the radiation pattern of an antenna array with a radial structure has a more uniform distribution of side lobes in different viewing planes φ , compared with a rectangular one. At the same time, it is demonstrated that the highest lateral lobe in the radial structure never reaches the level of 0 dB

Key words: antenna array, side lobe level, diffraction maximum, radial grid, radiation pattern, antenna array pitch

IMPLEMENTATION OF BAND-PASS FILTERS BASED ON SIW TECHNOLOGY

S.I. Derevyankin, E.A. Ishchenko, A.V. Ostankov, S.M. Fyedorov, I.A. Chernovivanenko

Abstract: the article studies the possibility of forming a band-pass filter in SIW design based on E- and H-diaphragms. Formation of a bandpass filter is based on the principle of the appearance of resonant cavities in the wave-water channel. To form a bandpass filter, an SIW waveguide model with a critical frequency of 8 GHz was created, after which resonant cavities were formed in the channel using diaphragms. To determine the dimensions of the diaphragms, models of a rectangular waveguide with air filling and a range of operating frequencies increased by the root of the dielectric constant of the medium times were obtained. By applying the principles of electrodynamic similarity, estimated passband frequencies for the SIW filter were obtained. After the formation of the full SIW model of the band pass filter, it was found that it is possible to maintain high transmission in the passband and rejection in the stopband. The frequency shift from the target value obtained using the electrodynamic similarity method was about 0.5 GHz. The above results show that waveguide bandpass filters can be implemented in the SIW design, which allows for the selection of electromagnetic waves, which will expand the range of devices in which the use of SIW waveguides is possible

Key words: waveguide filter, SIW technology, band pass filter

ESTIMATED PROBABILITY OF RECOGNITION OF DISTORTED IMAGES OF OBJECTS AND SYMBOLS

V.I. Lopin, A.A. Rogozin, S.Yu. Syrbu, G.L. Tyurin

Abstract: an experimental recognition of images of various objects and symbols on the monitor screen by a human operator of an optoelectronic device was carried out when they were distorted by spatial-frequency filtering (simulating the "blurring" of the image by an optical system taking into account its finite angular resolution) and random correlated (uncorrelated) noise (simulating the noise of the receiving path, as well as possible random distortions and interference on the observation track). During the experiment, to assess the degree of distortion of images of objects and symbols, as well as to investigate the potential for their recognition, an indicator was used that characterizes the similarity of the shape of the image of an object with its standard, based on the second derivative of their correlation integral. Based on the analysis and processing of experimental data obtained in the article on the probability of recognition by a human operator on the monitor screen of images of various objects and symbols when they are distorted, the dependence of the recognition probability on the degree of distortion of images of objects and symbols is established and an analytical expression for numerical calculation of the probability of their recognition is obtained. The use of the described approach makes it possible to solve the problem of evaluating the effectiveness of recognition by a human operator of images of objects and symbols, as well as the problem of substantiating the requirements for optical means and objects of observation

Key words: probability of image recognition, images of objects and symbols, human operator, optical-electronic means of observation

ANALYTICAL TWO-DIMENSIONAL PROBABILISTIC RADIO SIGNAL MODEL

D.A. Glushkov, M.Yu. Kalinin, Yu.V. Litvinenko

Abstract: we considered an analytical two-dimensional probabilistic model of a sequence of samples of a radio signal, displaying the type of modulation and other properties of its internal structure, which differs from traditional models of narrowband radio signals. Based on it, it is possible to study algorithms for signal processing in problems of their detection and classification, including on the basis of Markov models, which allows us to implement optimal algorithms for generating solutions with a given reliability. Graphically, the density of variables is represented by a surface in three-dimensional space, the shape of which is convenient to compare with experimental two-dimensional histograms of signals in order to select the most adequate model. With a small number of model parameters, it is possible to implement various forms of two-dimensional probability densities characteristic of signals with different types of modulation. It is possible to construct a combined analytical model in the form of a weighted sum of models with fewer independent parameters, which reduces the possibility of forming complex three-dimensional surfaces of two-dimensional probability densities. The parameters of the model, determined by the results of statistical processing of a sample of signal samples, can be independently used in classification problems of observed random processes. Based on the Markov model, we implemented a simulator of random signals with specified two-dimensional probabilistic properties. On the basis of the proposed analytical model, it is possible to build a universal simulator controlled by the selected parameters

Key words: Markov model, random signal simulator, analytical models of radio signals, two-dimensional histograms of radio signals

THE MAIN STAGES OF THE METHOD FOR PROVIDING ELECTROMAGNETIC COMPATIBILITY FOR MOBILE COMMUNICATION OBJECTS

M.A. Romashchenko, R.G. Konvalov, M.E. Vorob'yev

Abstract: the article outlines the main stages of ensuring electromagnetic compatibility for mobile communication objects. We described the features of the placement of radio-electronic means in confined spaces. We considered the factors causing unintentional interference. We give a block diagram of the main stages of ensuring electromagnetic compatibility and present an algorithm of actions for each stage. The implementation of the algorithm will reduce the levels of unintentional interference to acceptable levels and will provide the possibility of simultaneous formation of radio channels in a moving object on all its radio facilities. The stage of assessing the impact of industrial radio interference on the paths of radio receivers of radio electronic equipment was identified. A block diagram is given with a step-by-step description of tests from several power supply sources. We present including schemes for measuring extraneous and total radio interference and outline the features of the stage of assessing the quality of communication at typical distances when using an auxiliary object of the same type when transmitting articulation tables. The measured quality of radio channel communication will allow one to evaluate the fulfillment of the task of ensuring electromagnetic compatibility. We determined the ways of further improvement of the method of electromagnetic compatibility. The application of the considered methodology contributes to the optimization of time spent in the preparation and conduction of tests, and can also be used for the effective training of young specialists

Key words: electromagnetic interference, radio electronic device, ensuring electromagnetic compatibility

ANALYSIS OF SIGNAL TRANSMISSION ALGORITHMS AND SPEED ADAPTATION IN IEEE 802.11 NETWORKS

I.V. Sviridova, M.V. Khoroshaylova, D.V. Lyalin

Abstract: the article analyzes schemes with adapted speeds and their generalized characteristics. Devices are divided into different categories according to their circuit modeling and functional capabilities in terms of strategies that are used to assess the state of the channel and make decisions. Some algorithms from different categories are implemented in the NS-3 network simulator to evaluate their performance in various protocols and modes. The article presents data for future research that will help improve existing approaches to speed adaptation. Wireless technologies are used in various modern devices due to their ease of use and inherent mobility. Most wireless standards support several data transfer rate parameters that can range from several Mbit/s to several Gbit/s. Achieving the maximum supported data transfer rate is what most modern devices strive for. The IEEE 802.11 standard introduced multi-speed data transmission, since then a lot of research has been conducted on speed adaptation, various parameters are considered that lead to an assessment of the quality and correctness of the adaptation algorithm

Key words: speed adaptation algorithms, Wi-Fi, mobility, interference

STUDYING THE MONOSTATIC SCATTERING CHARACTERISTICS OF THE FIFTH GENERATION FIGHTERS

A.V. Volod'ko, E.A. Ishchenko, S.M. Fyedorov

Abstract: the article discusses two methods for studying the characteristics of backscatter diagrams for the fifth generation military planes: Lockheed Martin F-22A Raptor and Sukhoi Su-57. To determine the characteristics of the monostatic scattering, it is proposed to use asymptotic modeling of the object to obtain a whole picture of the effective scattering area, bright points, and the direction of the reflected waves propagation. Experimental study using ultrasonic radar is also proposed. The study shows that the use of modern aircraft development methods can reduce the RCS of an object, which is confirmed both by full-size models in modeling and by experimental study of scale models. Since an ultrasonic locator was used in the experimental study, in accordance with the rule of electrodynamic similarity, frequencies that correspond to the waves that would irradiate the full-size model were chosen. The results of the study are presented in the form of backscatter diagrams with a step of 1 degree for simulation and 10 for experimental study. The patterns of backscatter diagrams have a similar shape, but there are differences that are caused by a smaller measurement step in the experiment, and the experimental data are presented in the form of dBmV instead of square meters, since no conversion to the values of the effective scattering area was made

Key words: radar, radar cross section, monostatic scattering, fifth generation fighter

FEATURES OF APPLICATION OF A TWO-FREQUENCY GLONASS RECEIVER AS A PART OF DECAMETRE RADIO COMMUNICATION

E.S. Kosinov, M.A. Savel'yev, K.Ch. Kolbaya

Abstract: the article considers the issues of ensuring stability in the automated decameter radio communication systems operation by GLONASS/GPS satellite navigation signals including in the dual-frequency receivers for the ionosphere state in the real time. These receivers usage makes it possible to refuse the methods of the ionosphere active probing by the radio communication system when joining into contact as well as to simplify the entering into communication algorithm and to reduce the communication channel organizing time. The ionosphere state probing active methods rejection makes it possible to significantly reduce the level of interstation disturbances and to improve the electromagnetic environment in the decameter range. Moreover, it is possible to refuse the linking to the means of the frequency dispatch service due to a fairly accurate ionosphere parameters determination in the real time, which allows to increase the decameter radio communication complex mobility and ensure autonomy in their work. Good accuracy characteristics of the ionosphere state passive monitoring using the satellite navigation GLONASS/GPS dual frequency receiver allow to organize the probabilistically-optimal frequency selection close to the optimal operation frequency in determined Earth latitude with the help of the communication complex adaptation equipment. This in turn, greatly contributes to the radio waves single-jump propagation along the radio path to the communication subscriber, reduces the fading level at the subscribers receiver input, allows the operating frequency adaptive change time prediction until the moment of declared quality reduction in the information transmission and increases the communication channel stability in general

Key words: decameter radio communication, monitoring, ionosphere, passive mode, radio communication stability

FEATURES OF CONSIDERATION OF ELECTROMAGNETIC WAVES AS A RAYLEIGH PROCESS

M.V. Solovyov, A.G. Seregin, Yu.B. Ivanov

Abstract: we raised the question of a detailed description of the areas of the theory of electrical communication, the distribution of parameters in which differs from the "usual" distribution most often encountered in all fields of science - the Gaussian (normal) distribution, not only the reasons for such a deviation from the usual picture are given, but also mathematical formalization. Due to the complexity of considering the issue as a whole, we shown only the Rayleigh distribution and, as a degenerate case, the Rice distribution. In addition to physical processes, we described the applied mathematical apparatus from the field of mathematical statistics and higher mathematics, the terms used are introduced, a theoretical base is prepared that allows even a poorly prepared reader to immerse themselves in the subject under consideration. The study provides general information about the theory of electrical communication, propagation of radio waves and statistical radio engineering. We investigated variants of received EMW and features of distribution of their characteristics. The object of the study is the distribution of the amplitude and frequency characteristics of the received waves, the subject is the features of the received waves, taking into account the distortion in the communication channel. The research topic is interdisciplinary in nature and involves the involvement of sources from both the theory of electrical communication and the theory of probability and mathematical statistics

Key words: distribution, Rayleigh, statistical radio engineering, mathematical statistics

ALGORITHM FOR THE SELECTION OF PAUSES IN THE SPEECH SIGNAL UNDER INTENSE ACOUSTIC INFLUENCES

R.S. Vlasov, E.I. Sirenkiy, A.A. Afanasyev, A.V. Pitolin

Abstract: The materials on the study of the possibilities of practical use of the approach to determining pauses in a noisy speech signal, based on the methods of sequential statistics, are presented. Options for assessing the probabilistic characteristics of the speech signal necessary when using the Wald criterion are presented. An algorithm for identifying pauses of the speech signal in conditions of intense acoustic interference is presented. As objects of sequential statistical analysis, the values of the speech signal samples, linear prediction coefficients (LPC) and linear spectral frequencies (LSF) were used. The results of the program developed on the basis of the presented algorithm are given. The results given take into account various variants of input parameters, including the values of the limiting constants of the Wald criterion, the values of the signal/noise ratio of the studied speech signal types of objects sequential statistical analysis. In conclusion, negative phenomena that affect the effectiveness of the approach are noted, and promising directions for further research are proposed

Keywords: speech signal, signal-to-noise ratio, sequential statistics, Wald criterion, LPC, LSF

REDUCING THE DIMENSION OF DATA IN MULTICHANNEL SPATIAL-TEMPORAL INFORMATION PROCESSING SYSTEMS

A.V. Sharamet

Abstract: the article reveals the main features of the application of the principal component method to reduce the dimensionality of the processed information. A feature of this method is four-stage data processing, which allows it to be implemented on the basis of multithreaded computing platforms. It is shown that data centering is carried out at the first stage, the main direction is searched at the second stage, followed by the search for its maximum at the third stage and the search for the remaining vectors at the fourth. These steps can be performed in parallel and separately. The phased array antenna as part of the survey radar station was considered as the object of the study. The need to reduce the dimension is caused by the fact that as a result of an overview of the airspace, information about its azimuth, range and altitude is formed about each aerial object in the most simplified case. The peculiarity of the problem being solved is that such information about the same object is generated in several information channels. According to the results of space-time processing, it is all displayed on the plane in real time. Processing of the experimentally obtained data allowed us to formulate restrictions on the use of the principal component method for solving this problem. It is noted that the presented results allow us to consider this method as the basis of a new direction of development of air object recognition systems

Key words: principal component method, real time scale, space-time processing, multichannel, radar station, circular view indicator

Mechanical engineering and science of machines

DEVELOPMENT OF PROCESSES AND DETERMINATION OF PARAMETERS OF QUALITY ASSEMBLY IN THE ROUTE OF ELEMENTS OF EXTRA-THIN-WALLED CONDUIT OF AVIATION TRANSPORT

S.V. Egorov, S.V. Safonov

Abstract: we present the results of research and experimental design work on the development of methods and equipment that ensure the preparation of elements of an extra-thin-walled conduit for their assembly into a route. We created an experimental setup and working equipment for calibrating the circumferential joints of thin-walled pipes using the methods of "expansion" or "compression" with a multi-sector tool, providing a deviation of the outer diameter of the pipe end for automatic welding of circumferential joints of no more than $\pm 0,15$ mm from the nominal size. We experimentally verified the theoretical dependence to determine the critical compression pressure at which the pipe wall loses stability and a corrugation is formed. The developed equipment was used to create prototypes of pipes from titanium alloys and corrosion-resistant steels, followed by full-scale modeling of pipeline assembly processes. We assembled the calibrated pipes by means of an automatic argon-arc welding with pre-fixation centering clamps and pre-welding. When assessing the quality of welded joints, we found that the welded circumferential seams of all prototypes comply with the requirements of regulatory technical documentation. We carried out the search for latent defects of welded joints using acoustic emission system and ultrasonic flaw detector. The tests carried out by internal static and pulsating pressure showed high strength and durability of welded joints

Key words: assembly, conduit, calibration, extra-thin-walled pipes, butt welding

INFLUENCE OF PARAMETERS OF REVERSIBLE SURFACE PLASTIC DEFORMATION ON THE HARDENED PARTS ROUGHNESS

S.A. Zaides, H.H. Nguyen

Abstract: the article presents the results of experimental studies to determine the influence of the parameters of reversible surface plastic deformation on the roughness of cylindrical parts such as shafts and axles. The influence of 6 main parameters of the SPD process is considered: the frequency of workpiece rotation (n_z), longitudinal feed (S_{pr}), radial interference (t), the initial installation angle of the working roller (α_n), the amplitude of the angle of working roller reverse rotation (α_r) and the reverse rotational speed of the working roller (n_r) on the surface roughness of hardened parts during hardening of C45 steel. To implement the proposed method of finishing and hardening processing, a device for the formation of a reverse circular movement of the working tool (WT), which is installed on a *IK62* lathe was developed. The surface roughness of hardened parts was measured on a Form Talysurf i200 profilometer. Based on the results of experimental studies, rational hardening modes that provide high requirements for the surface roughness of parts were determined: the workpiece rotation frequency is from 75 to 100 rpm, the longitudinal feed is from 0.075 to 0.1 mm/turnover, the radial interference is from 0.07 to 0.08 mm, the initial installation angle RI 90° , amplitude of WT reverse rotation angle from $\pm 10^\circ$ to $\pm 20^\circ$ and reverse WT rotation frequency from 100÷140 up and down strokes/min

Key words: reversible surface plastic deformation, surface roughness, two-radius roller, initial angle of the working tool, reversible rotation speed