ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

## “CORRECT ENTROPY”IN THE ANALYSIS OF COMPLEX SYSTEMS: WHAT IS THE CONSEQUENCE OF REJECTING THE POSTULATE OF EQUAL A PRIORI PROBABILITIES? (p. 4-14)

**Nikolai Delas**

Entropy can clearly reflect the probability of the macrostate of a system only in case of validity of the basic postulate of statistical mechanics—the postulate of equal a priori probabilities of microstates. We have proved that for most non-physical macrosystems it loses its power, and the role of entropy has to be performedby a more general property, which has been found out in this study and called entropic divergence. In accordance with the principle of continuity, it includes the Boltzmann entropy.

The properties of entropic divergence were considered through proving a number of theorems. This property has generally been found to have a minimal effect on the equilibrium state of the system.

The conditional minimum of entropic divergence was disclosed as an example of formalism through which we have derived exponential and marginal hyperbolic distributions that take into account unequal a priori probabilities. The multiplicative form of the combined distribution allows consideration of the process of interaction between two or more macrosystems as the realization of a complex macroexperience.

We have disclosed the possibility of using the research findings for analysing adaptive statistical interaction of aggregate macrosystems. The termsused in the studyfacilitate the development of quantitative methods of such analysis. We have given an example of the possibility of using this approach to compute the exponent in the power-law (hyperbolic) distributions.

**Keywords**: entropic divergence, evolution of complex systems, power-law distribution, entropy production, synergetics.

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## RESEARCH OF POSSIBILITIES OF USING NEURAL NETWORKS IN THE DECISION SUPPORT SYSTEM (p. 15-19)

**Olga Savchuk, Anatoly Ladanyuk**

The possibility of using neural networks in automated control systems for multi-assortment dairy production was considered. In the automatic control theory, many methods were developed that allow to optimize systems in terms of one or another quality criteria, provided that the number of restrictions is fulfilled, but mathematical tools used in the traditional automatic control methods, are not always able to fully ensure satisfactory results under a limited number of input data. Using neural networks allows to perform control of acceptable quality (not necessarily optimal) under uncertainty at a relatively low level of resources spent.

During the research, the structure and learning algorithm of the neural network for the decision support system concerning the dairy plant assortment forecasting for the current day was determined. In the intelligent technology environment STATISTICA NeuralNetwork based on the model obtained, the sensitivity analysis of fuzzy neural network output to a change in the input stream was carried out. Using the neural network allows to take into account nonlinear dependences in problems of forecasting profitable dairy plant assortment, which is important for effective management under uncertainty.

The research conducted are needed to develop the automated control system for multi-assortment dairy production.

**Keywords**: decision support system, neural networks, multi-assortment dairy production.

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## ANALYSIS OF SYSTEM WITH VARIABLE PARAMETERS, INVARIANT TO ADDITIVE INTERFERENCE (p. 20-24)

**Rostislav Dolinskiy**

The analysis of phase-difference modulation features in case of defined type of transmission system and noise type was performed. Interference resistance comparison analysis was carried out for systems, which use phase-difference modulation, regarding additive interference, in condition when systems parameters are variable. As systems which use phase difference modulation of different orders should use corresponding communication systems with constant or variable parameters, such systems are investigated. The research of invariance of the system with variable parameters to additive interference, shaped as harmonic fluctuation with random amplitude, frequency and phase was conducted. Logical scheme of complex signals receiver of phase-difference modulated signals, which are divided into data flows, which are processed in parallel was reviewed. Implementation of phase difference modulation in modern communication systems can bring great benefits for radio networks, which is used for communication with mobile customer terminals. Depending on which interference types are common to the radio network, difference modulation implementation will provide invariance to them, so systems with variable or constant parameters, which use corresponding phase-shift modulation order should be used. The conclusion was made related to the interference resistance of phase-difference modulated signals, in the case of signal characteristics are prior known and change linearly. Usage of phase-difference modulation would grant immunity to the Doppler effect, and focused interference, and this will allow to increase the signal interference immunity for mobile terminals. Received results should be used for further development of modern communication systems, which use orthogonal frequency division multiplexing

**Keywords:** phase-difference modulation, orthogonal frequency division multiplexing, invariance, optimal reception, additive interference, Doppler effect, focused interference.

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## DEVELOPMENT OF THE RECONFIGURATION ACCELERATION METHOD IN THE DYNAMICALLY RECONFIGURABLE COMPUTING SYSTEMS (p. 25-30)

**Yurii Kulakov, Iryna Klymenko, Myroslav Rudnytskyi**

The problem of performance improvement of reconfigurable computing systems, including solving the problem of reconfiguration overhead reduction was considered. A new reconfiguration acceleration method and hardware for its implementation, which allow to minimize the reconfiguration time overhead were proposed. Analytical expressions that formalize the reconfiguration acceleration method, justify the virtually complete removal of unproductive reconfiguration time by reducing the communication component of time that provides an intensive reconfiguration acceleration were obtained. The formalization shows that the volume of the removed unproductive time component is linearly dependent on the number of repetitive tasks. Thus, using the proposed method is the most efficient in the algorithms that contain a large number of similar tasks.

The proposed hardware for schedule management of placement and support of configurations of functional units, based on the multi-level memory, provide effective support of the reconfiguration overhead reduction method and allow to reduce computational complexity of reconfiguration control algorithms and solve the problem of limited resources of internal memory of the FPGA. The designed emulator of the reconfigurable computing system and software model of the reconfiguration acceleration method enable the real-time control simulation of reconfigurable resources. The developed software is a handy tool to study the temporal characteristics of the reconfigurable computing system.

Simulation of the reconfiguration acceleration method for computing algorithms with the multilevel structure, which is experimentally confirmed by theoretical research was performed.

**Keywords**: reconfigurable computing systems, partial dynamic reconfiguration, reconfiguration overhead, accelerated reconfiguration.

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## ORE CRUSHING PROCESS DYNAMICS MODELING USING THE LAGUERRE MODEL (p. 30-35)

**Oleksii Mykhailenko**

The problem of ore crushing process dynamics modeling using the orthonormal Laguerre functions was considered.

The analysis has shown that the maximum sampling interval that will allow to reconstruct the transition process by the discrete sample is 1.3 seconds. As expected, the structure that includes only the first-order Laguerre filter has the worst accuracy. Increasing the number of functions in the orthonormal system leads to the higher modeling quality of the crushing process output. It was also determined that the relationship between the scale factor and mean square error of identification is unimodal in nature, therefore, it is advisable to use optimization methods for finding the optimal value for this parameter.

The research has allowed to reveal the structure and the scale factor of the Laguerre model, and the sampling interval, which allow to ensure the minimum mean square error when using the least squares method for estimating the model parameters.

**Keywords**: crushing process, Laguerre model, identification, sampling interval, modeling.

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## DEVELOPMENT OF THE HYBRID ADAPTIVE METHOD FOR NOISE REDUCTION IN THE BITMAP IMAGE OF THE PART DRAWING (p. 35-43)

**Vera Molchanova**

An original hybrid method FILTRATOR that allows to eliminate the noise in monochrome and binary bitmap images of the part drawings was proposed. The analysis of the characteristics of the scanned images of the part drawings and characteristic noise, not allowing to get a satisfactory result by standard noise reduction methods was performed. The main features of bitmap images of drawings are the presence of fine lines, filtering of which by standard methods leads to disruption of the integrity and coherence of the part contours, as well as specific types of noise and distortion.

The peculiarity of the proposed hybrid method is its phased implementation. At the first stage, monochrome noise is eliminated by the automatic tone adjustment of the monochrome bitmap image of the part drawing based on the analysis of its brightness and contrast histograms. At the second stage, the remaining binary noise is eliminated by adaptive method, which involves selecting an effective combination of filtering methods: the contour mask method, modified aperture method kFill, median, morphological and logical filtering methods, as well as selecting structural elements based on the block-by-block evaluation of the image parameters: contour line thickness, noise type and level.

The proposed hybrid method FILTRATOR effectively eliminates noise in binary bitmap images of the part drawings, while maintaining the integrity and continuity of contours.

The comparative qualitative and quantitative testing results of the FILTRATOR method and spatial, frequency, and morphological

filtering methods were given. The comparison was performed using the MSE, PSNR and UQI criteria. The result of the comparison showed the superiority of the FILTRATOR method in terms of filtering quality of artifacts in scanned bitmap images of the part drawings.

**Keywords**: drawing, monochrome, binary, noise, contrast, contour, method, aperture, primitive, filter.

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## ROBUST VERIFICATION AND ANALYSIS OF THE PRE-CLUSTERING ALGORITHM WITH A-PRIORI NON-SPECIFICATION OF THE NUMBER OF CLUSTERS (p. 43-48)

**Volodymyr Mosorov, Taras Panskyi, Sebastian Biedron**

The range of the implementation of cluster analysis is wide, it extends from many technical applications to different branches of science, such as biology, medicine, computer sciences and psychology. The main purpose of the cluster analysis is dividing the investigated objects into homogeneous groups, or clusters, according to certain criteria and investigating the process of natural grouping of these objects. It means solving the task of grouping data and revealing in them a relevant structure.

The unsupervised learning methods (clusterization) as opposed to the supervised learning methods (classification), marks of output objects, that is, determining each object belonging to the certain cluster, as well as the number of the clusters are not given from the very beginning of the process. The created clustering algorithm without a-priori information about the number of the clusters belongs to the group of pre-clustering algorithms. Pre-clustering is the procedure of checking the possibility of clustering the input data. Checking this possibility answers the question whether data can be divided into more than one cluster.

The process of verification of the parameters of the pre-clustering algorithm concerns testing the rule of decision making for different types of input data. The selected cases of input data considered here are the input data with the normal distribution law having been grouped into one or two clusters.

**Keywords**: clustering method, cluster, heuristic algorithm, verification, rule of thumb, decision making rule.

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## DEVELOPMENT OF THE MATHEMATICAL MODEL OF THE PROBLEM OF REENGINEERING TOPOLOGICAL STRUCTURES OF LARGE-SCALE MONITORING SYSTEMS (p. 49-55)

**Vladimir Beskorovainyi, Kseniia Podoliaka**

The paper deals with the development of a mathematical model of the multicriteria problem of reengineering topological structures of large-scale monitoring systems. Based on the analysis of current projects and publications, many indicators that have a significant impact on the structural and topological characteristics of large-scale monitoring systems were singled out. The basic problem of reengineering topological structures of large-scale monitoring systems was formulated and formalization of the most frequently used private efficiency indexes of options was performed, objective function of additional costs was improved by taking into account the reuse possibility of existing equipment and simplified (in terms of reducing memory used). Relations for assessing the operativeness, reliability and survivability given their explicit dependence on the parameters of the topological structure of the system were proposed. The mathematical model allows to obtain solutions taking into account the

constraints and assessing the options in terms of cost, operativeness, reliability and survivability.

**Keywords**: large-scale monitoring system, structure, topology, reengineering, efficiency, multi-criteria problem, model.

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## METHODS OF CONVERTING MULTIDIMENSIONAL MEASURING INFORMATION TO A NUMBER BY MEANS OF DIFFERENTIAL EQUATIONS IN PARTIAL DERIVATIVES (p. 59-62)

**Alexandr Stanovskyi, Oleksandr Schmaraev, Igor Prokopovich, Dmitro Purich, Pavel Shvets, Viktor Bondarenko**

We have proved that finite difference representation of differential equations in partial derivatives is the most effective method of converting multidimensional measuring information to a single number. The devised conversion methods use Laplace's elliptic equations and Fourier's parabolic equations.

To convert information,we have solved a number of tasks. We have devised a method of elliptic conversion of static images of the measured object by means of finite difference representation of Laplace's differential equation in the second-order partial derivatives, which means a change of the current value of the pixel brightness to a new one that has two gradations of brightness––black and white. Pixel summation turns the relative number of black pixels into a single number as a result of elliptic conversion. We have improved the method of parabolic conversion of dynamic images of the measured object by means of finite difference representation of Fourier's differential equation in the second-order partial derivatives,which means a change of the current value of the pixel brightness to a new one that has two gradations of brightness––black and white. Pixel summation turns the relative number of black pixels into a single number as a result of parabolic conversion. We have used the devised methods of industrial testing of metrological support for the technological process of continuous casting of copper ingots. The testing has proved technical and economic effectiveness of the approach.

The paper contains examples of technical and economic effectiveness of the devised methods in metallurgical production.

**Keywords**: metrological support, processing of images and video streams, elliptical and parabolic conversion.

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