# ABSTRACT AND REFERENCES

## MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

### DEVELOPMENT OF THE DECISION SUPPORT SUBSYSTEM IN THE SYSTEMS OF NEURAL NETWORK PATTERN RECOGNITION BY STATISTICAL INFORMATION (p. 4-12)

**Elena Arsirii, Olga Manikaeva, Alexandra Vasilevskaja**

The decision support subsystem in the neural network pattern recognition system, allowing to reduce the subjectivity and increase the quality of expert decisions in the construction of training samples by the statistical data of observations over the state of the management facilities of the production or social environment is developed. A functional structure of the NNPR system of the management facilities of the production or social environment by statistical information is proposed. According to the proposed structure, the problem-oriented NNPR system consists of subsystems of the initial data preparation for the PR and storage of the aggregated data, neural network models, and knowledge about the management facility of the production or social environment, as well as the support of the decision-making about its state. The decision support subsystem based on the proposed method of support of the classification decision-making using the Kohonen self-organizing layer is developed. The developed method of support of the classification decision-making provides a consistent implementation of the stages of self-organizing of neurons of the Kohonen computing layer, the calibration of the elements of the output vector of the training sample and their final labeling. An example of implementation of the proposed subsystem of support of decision-making about the class of the initialized labor protection project based on the expert estimates of the current level of the organization and working conditions at the enterprise is given. Using the developed decision support subsystem in the systems of NNPR by statistical information allows to adjust the decisions of the DM in accordance with the decisions of the neural network output machine, and thereby increase a relative share of correct expert estimates by 20 % on average and reduce false estimates for a number of pattern recognition problems by 50 %.

**Keywords**: decision support system, pattern recognition, knowledge representation models, Kohonen neural networks.

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### SELECTIVE PATTERN MATCHING METHOD FOR TIME-SERIES FORECASTING (p. 13-18)

**Alexander Kuchansky, Andrii Biloshchytskyi**

The selective pattern matching method for forecasting the increment signs of financial time series is proposed. This approach is based on indexing the time series to find similar sites in their dynamics based on the K-nearest neighbors method and selective grouping of these sites by the increment signs observed when completed. Similar sites are identified by calculating measures of similarity between the supporting and non-supporting stories of time series. Depending on the representation of time series, Hamming measure or Euclidian measure can be used for indexing. Before applying the method, it is recommended to carry out the procedure of pre-forecasting fractal time series analysis for determining the levels of persistence, antipersistence and randomness of time series, identifying the availability of memory and determining the medium length of quasicycles. The parameters, defined based on the pre-forecasting analysis are used in forecast generation by the described method. The proposed method can be used as part of information forecasting and decision support systems, including those used in the currency market to improve the accuracy of forecasting the increment signs of time series.

**Keywords**: time series, forecasting, indexing, increment sign, pattern matching.

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## RESEARCH OF ABSOLUTE AND FIGURED ABSOLUTE CONVERGENCE OF THE BRANCHED CONTINUED FRACTIONS OF THE SPECIAL FORM (p. 19-26)

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The paper deals with the issue of convergence of one of the generalizations of continued fractions – branched continued fraction (BCF) of the special form with two branches, which has been proposed by the Polish mathematician W. Siemaszko in solving the problem of compliance between the formal double power series and a sequence of rational approximations of the function of two variables.

Unlike continued fractions, approximations of which are constructed unambiguously, there are many ways to construct approximations of BCF of the general and special form. The paper examines the conventional approximations of one of the structures of figured approximations of the studied BCF, which is associated with the problem of compliance. The formulas of difference between two approximations (two conventional, two figured, figured and conventional) were given.

Using the majorant method and known results of the theory of convergence of continued fractions, the theorem on some sufficient conditions for absolute and absolute figured convergence of BCF of the special form with two branches towards the same border was proved. It was shown that the values of the studied BCF and its approximations belong to a circle, the radius of which depends on the values of BCF elements on the first floor and the constants appearing in the formulation of the theorem.

By choosing different values for these constants, it is possible to obtain various signs of absolute and figured absolute convergence of BCF of the special form.

**Keywords**: continued fractions, branched continued fractions, approximation, absolute convergence, figured absolute convergence, majorant fraction.

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## THE USE OF CONVOLUTION OPERATORS IN THE TASKS OF EDGE DETECTION (p. 27-31)

**Sergey Petrov, Igor Marchenko, Boris Dibrov**

Despite the prevalence of the Kenny algorithm in the edge detection, insufficient attention has been paid to the optimal selection of the convolution matrix. The paper describes typical algorithms to detect the object edges in the image and use the peculiarities of convolution operators in the Kenny algorithm. The research uses a base image size of 13,225 units. Thus, the experiments have proved that the Sobel operator is optimal, in general, for the Kenny algorithm. We have also considered the Roberts operator and the Previtt operator as alternatives and proved that they effectively process individual cases but generally give worse results. We have made a comparative analysis of advantages and disadvantages of all the operators. The paper presents an example of a detailed calculation of the gradient by using the Sobel operator in the Kenny algorithm after the preceding use of the Gaussian filter. The result of the study is verification of the optimal choice of the Sobel operator for the Kenny algorithm.

**Keywords**: the Kenny algorithm, the Sobel operator, the Roberts operator, the Prewitt operator, detection of the edges, gradient.

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## MONITORING DISTRIBUTED COMPUTING SYSTEMS ON THE BASIS OF THE DETERMINED SHORTEST PATHS AND SHORTEST HAMILTONIAN CYCLES IN A GRAPH (p. 32-45)

**Sergey Listrovoy, Sergii Minukhin, Elena Listrovaya**

The tasks of monitoring the Distributed Computing System (DCS) are associated with optimization of the order (sequence) of surveying the monitored objects, such as resources (clusters and cluster nodes), carried out tasks (downloads), communication channels, and database servers. The problems are solved due to the use of plug-ins that include programs to initialize the startup and operation of remote services (agents), while the latter provide control over the DCS performance. Since the size of each of the transmitted commands to initialize the remote services of the monitored objects is several kilobytes and there are thousands of the DCS-controlled nodes, the volume of the transmitted information reaches 4–5 Mbytes. The amount of the transmitted results of assessing the state of the monitored objects in the DCS, which can be about $4^{12}$ per one object, and the volume of each object – about 4 Kbytes – largely affect the bandwidth of communication channels.

This accounts for the necessity to optimize the survey time for the monitored objects via minimizing the time for control over the DCS objects in real time. The problem is solved due to the method implemented in two stages: finding the shortest path and the shortest Hamiltonian cycle in a random graph describing the topology of the DCS communication channels. The proposed DCS-monitoring methods allow optimizing the survey time for the monitored objects in polynomial time and consequent improving the quality of performance and the quality of service provided to the DCS users in real time.

**Keywords**: distributed computing system (DCS), monitoring, agent, remote access, delay, graph.

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## THE MATHEMATICAL MODEL AND THE METHOD OF OPTIMAL STOCHASTIC CONTROL OVER THE MODES OF THE WATER MAIN OPERATION (p. 45-53)

**Andrei Tevyashev, Olga Matviyenko**

The study is devoted to the problem of increasing the efficiency of water mains in the present circumstances of transition to the three-band electricity tariffs. We have devised a new class of optimal stochastic discrete-time control over complex dynamic objects that is distinguished by additional extreme and probabilistic constraints on the phase variables. The suggested mathematical formulation of the optimal stochastic control over the modes of the water main has probabilistic constraints on the phase variables. We have also proposed a new strategy for the optimal stochastic control over the modes of the water main. The strategy takes into account the specific features of the water main as an object of stochastic control that operates in a stochastic environment, which allowed devising an effective method to solve the problem. It is shown that transition from the classic deterministic tasks of control over the modes of water mains to stochastic problems ensures a much lower (up to 9 %) electricity cost.

**Keywords**: optimal stochastic control, probabilistic constraints on the phase variables, water main.

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## CONSIDERING IMAGE STRUCTURAL PROPERTIES WHILE ESTIMATING COMPRESSED JPEG IMAGE QUALITY (p. 54-64)

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Application of lossy compression methods involves the occurrence of distortions, so the problem of evaluating the level of these distortions is urgent. When using the DCT transformation, the main objective of quality assessment is selecting a statistical distribution model of the DCT coefficients of the image and the methods for estimating the parameters of the model.

A universal method of estimating the level of distortions that arise due to JPEG compression of images of any structural content is developed in the paper. To determine the image quality, PSNR metric is used. A key feature of the proposed method lies in involving various statistical models for computing the quantization noise variance of the DCT coefficients. In particular, for models of the DCT coefficients in the form of the double gamma distribution and the generalized Cauchy distribution, calculation-handy expressions for the quantization noise variance of the DCT coefficients of JPEG images are obtained. Using the double gamma distribution to solve the above problem is first proposed.

The well-known Laplacian model provides a relatively accurate estimation of PSNR only for those images that mostly consist of regions rich in small parts. While for the images, which contain significant regions of monotonicity, the model in the form of the double gamma distribution provides a much better result.

The accuracy of the obtained theoretical expressions is confirmed by the results of experiments with grayscale JPEG images.

**Keywords**: JPEG image, quality, estimation, compression, DCT coefficients, probability distribution.

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## DEVELOPMENT OF THE ALGORITHMS OF CORRECTION OF CORRELATION MATRICES (p. 65-76)

**Telman Abbas Aliev, Naila Fuad Musayeva, Ulkar Eldar Sattarova, Narmin Eldar Rzayeva**

Statistical methods are widely used in solving problems of automatic management of industrial objects, as they enable us to determine the dynamic characteristics during normal operation of objects. The statistical correlation method for determining these dynamic characteristics is based on the solution of an integral equation that includes the correlation functions $R_{XX}(\tau)$ and $R_{XY}(\tau)$ of the input $X(\tau)$ and output $Y(\tau)$ signals. It allows us to obtain the dynamic characteristics of an object without disturbing its regular operation mode. However, the application of these methods for constructing mathematical models of real-life industrial objects presents the following certain difficulty. Interferences and noises are imposed upon the useful signal, hindering the calculation of the estimates of their static characteristics. The paper presents one possible option of creating alternative methods and technologies for eliminating the error induced by noise during the formation of correlation matrices. The proposed general algorithms allow for reducing these matrices to the similar matrices of useful signals.

Two presented alternative robust technologies enable one to solve these problems both in the absence of a correlation between the useful signal and the noise and in the presence of such. The validity of the result is controlled by duplication the obtained estimates of the elements of matrices by both methods. In many real-life industrial objects the need to apply the procedure of normalization of the estimates take place. This leads to an additional error, which also leads to the disruption of adequacy of the results. In the paper, the general methods and technologies for eliminating that error are proposed.

**Keywords**: stochastic process, identification, technological parameter, noise, noisy signal, correlation function, correlation matrices, normalized estimates, dynamics models.

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