ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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DEVELOPMENT OF A METRIC AND THE METHODS FOR QUANTITATIVE ESTIMATION OF THE SEGMENTATION OF BIOMEDICAL IMAGES (p. 4–11)

Oleh Berezsky
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0001-9931-4154

Mykhailo Zarichnyi
Ivan Franko National University of Lviv, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-6494-2289

Oleh Pitsun
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0003-0280-8786

We analyzed modern digital microscopy. In order to categorize digital microscopy, the following criteria are introduced: level of automation, software level, the level of application of network technologies. To quantitatively estimate the quality of image segmentation, we devised the technique based on a metric approach using the Fréchet and Hausdorff metrics. Modern algorithms for calculating the Hausdorff and Fréchet distances were analyzed.

We have introduced the Fréchet distance between trees. It was proven that the Fréchet distance between trees is a metric. We devised a method for estimating a distance between trees of the non-convex regions, based on finding skeletons of regions and determining the distance between them. The algorithm for finding the Hausdorff distance between the non-convex regions is described. We constructed the algorithm for finding a distance between the non-convex regions based on the Fréchet metric between trees.

The developed algorithms are included into a hybrid intelligent system for automated microscopy, which is designed to process histological and cytological images.

The algorithms were tested using the results of segmentation of histologic and cytologic images from a database as an example.

Keywords: Fréchet metric, Hausdorff metric, non-convex regions, biomedical images, segmentation error.

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DEVELOPMENT OF THE METHOD FOR DYNAMIC REGULARIZATION OF SELECTED ESTIMATES IN THE CORRELATION MATRICES OF OBSERVATIONS (p. 11–18)

Valeriy Skachkov
Military Academy, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-2432-4176

Victor Chepkyi
Military Academy, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-0637-9432

Hennadii Bratchenko
Odessa State Academy of Technical Regulation and Quality, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-0314-8188

Helena Tkachuk
Military Academy, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-3434-2709

Nadiia Kazakova
Odessa State Academy of Technical Regulation and Quality, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-3968-4094

The problem of formation of sample estimates of correlation matrices of observations by the «computational stability – consistency» criterion is considered. The problem of zero eigenvalues inherent in the problem of static regularization of sample estimates of correlation matrices is revealed. The solution of this problem by the static regularization method leads to the fact that the sample estimate of the regularized matrix is similar, but not identical to the original one in terms of consistency. Therefore, the problem of investigating the regularization of the sample estimate of the correlation matrix with respect to the solution of inverse problems under a priori uncertainty is actualized. In such a situation, the regularizing parameter of the inverse problem should be updated in real time as the input data arrive. To solve the revealed problem, an alternative method of dynamic regularization is proposed. In the study, the computational stability, convergence and consistency of sample estimates of correlation matrices of observations under a priori uncertainty are analyzed. The optimum function of dynamic regularization of sample estimates of correlation matrices of observations is obtained, the evaluation of which does not require prediction data and additional computing resources to search for the optimum value of the regularization parameter. The numerical results confirming the main findings are presented. The developed method of dynamic regularization of sample estimates of correlation matrices is an alternative to static regularization and allows resolving the «computational stability – consistency» contradiction when forming sample estimates of correlation matrices. Unlike static regularization, the procedure of dynamic regularization unambiguously connects the optimum dynamic regularization function with the matrix dimension and the size of the observed sample, which allows eliminating the problem of choosing the regularization parameter under a priori uncertainty with respect to the input data of the computational problem. In addition, the dynamic regularization method is characterized by simplicity of computational operations in real time in the absence of a priori information.

Application of the method of dynamic regularization of sample estimates of correlation matrices extends the capabilities of a wide class of information systems that are designed to solve ill-posed inverse problems under a priori uncertainty.

Keywords: static regularization, dynamic regularization, stability, convergence, consistency of estimates, correlation matrix.

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FORECASTING THE EMERGENCY EXPLOSIVE ENVIRONMENT WITH THE USE OF FUZZY DATA (p. 19–27)

Oleh Zemlianskiy
Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0002-2728-6972

Ihor Maladyka
Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0001-8784-2814

Oleg Miroshnik
Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0001-8951-9498

Ihor Shkarabura
Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0002-3882-7623

Galina Kaplenko
Dnipropetrovsk State Agrarian and Economic University, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-9545-8414

We resolved the scientific and technical problem to improve the efficiency of a decision-making processes carried out by a head of emergencies elimination of accidents at potentially dangerous objects by forecasting an emergency explosive environment under conditions of uncertainty.

We completed a formalized statement of the problem of identification of the concentration of an explosive gas-air mixture, which makes possible to use fuzzy input and output data. We determined the aspects of solution of the problem of forecasting with a use of expert conclusions in the case of absence or unreliability of input data.

We developed the technology of forecasting of parameters of an emergency explosive environment based on the obtained results. The proposed technology can be used in the post-emergency period to clarify fields of an explosive environment. A neuro-fuzzy network can be re-trained in the shortest possible time and used to solve a forecasting problem at all possible points in the zone of explosive environment on the base of the results of measurements of explosive concentration of devices. In addition, this technology can be used to clarify initial values of parameters of an accident, which will improve and objectify a decision making carried out by the head of emergencies elimination.

Keywords: gas-steam-air explosive environment, models and methods of forecasting, fuzzy data, emergency.

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ANALYSIS OF LOGICAL-DYNAMIC ARGUMENT CONVERSION PROCESSES IN ARITHMETIC DEVICES OF DIGITAL CONTROL SYSTEMS (p. 28–34)

Mahmoud M. S. Al-Suod
Tafila Technical University, Tafila, Jordan
ORCID: http://orcid.org/0000-0002-2025-9816

Oleksandr Ushkarenko
Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0002-3159-330X

Lev Petrenko
Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine

The procedure for analysis of logical-dynamic processes of argument conversion in arithmetic devices of digital control systems was developed. Disadvantages and limitations of the formal methods used to describe processes in control systems were described and a graph-analytical method for describing the processes of argument conversion was proposed. Analysis of the logical-dynamic processes of conversion of data arguments in adders and multipliers used in digital control systems was performed. Sign-positional notation makes it possible to significantly increase speed of adders and multipliers in digital control systems. In this case, a necessity of formation of scientifically substantiated analytical rules for conversion of logical arguments and functional structures through which they are implemented appears. The analytical description of the processes of conversion of information arguments in digital control systems allows one to form their mathematical models with increased technological and informational qualities as well as solve optimization problems. The summation process in arithmetic devices is realized in accordance with the logic of argument conversion of the ternary notation. The axioms of the ternary notation can serve as a theoretical basis of the process of summation of arguments implemented in the binary notation format. The proposed approach enables evaluation of speed of the performed arithmetic operations with the use of various digital codes and opens up the possibility of improving the methods and algorithms of data processing in digital control systems.

Keywords: logical-dynamic process, argument conversion, partial product, graph-analytical model.

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DEVELOPMENT OF ALGORITHMS FOR BIOMEDICAL IMAGE SEGMENTATION BASED ON PRELIMINARY MARKUP AND TEXTURE ATTRIBUTES (p. 35–44)

Yuriy Batko
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0002-6732-4865

Natalia Batryn
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0001-5449-6302

Grygoriy Melnyk
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0003-0646-7448

Serhiy Verbovyy
Ternopil National Economic University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0001-8009-7508

Tamara Datsko
I. Horbachevsky Ternopil State Medical University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0001-9283-2629

Petro Selskyy
I. Horbachevsky Ternopil State Medical University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0001-9778-2499

Biomedical images are used for diagnosis and treatment of malignant neoplasms. Images of normal and pathological cells and tissues are derived using light microscopes. These images are the objects of study in histology and cytology. One of the most important stages in the automation of measuring optical and geometrical parameters of images is the segmentation of micro objects. Analysis of biomedical images is complicated due to the highly variable parameters and weak contrast in most micro objects.

The use of point connections for segmenting the images has several advantages: processing images of any type, splitting micro objects that are in contact, insensitivity to noise. A method of image segmentation based on preliminary markup implies splitting a color image into homogeneous regions, calculating the coefficient of relation between adjacent points, and merging points into homogeneous regions. The algorithm allows for the automated segmentation.

A texture segmentation method involves computing values of spatial moments for each point of the image. A feature space, obtained in this way, is segmented by the algorithm. The algorithm calculates thresholds based on mathematical expectation. This makes it possible to identify such complex micro objects as the layers of cells, cross-sections of blood vessels and ducts.

The quality of segmentation was estimated using a metric approach. The developed segmentation algorithms made it possible to improve quality of the biomedical image segmentation by 18–21 % on average.

Keywords: histological and cytological images, segmentation, preliminary markup, spatial moments, segmentation estimation.

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DEVELOPMENT OF A MATHEMATICAL MODEL OF EEVALUATION OF ROAD-AND-TRANSPORT ASSETS AS A COMPONENT OF INFORMATION-AND-MANAGEMENT SYSTEM (p. 45–57)

Olena Slavinska
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-9709-0078

Vyacheslav Savenko
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-8174-7728

Anna Kharchenko
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-8166-6389

Andrey Bubela
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-5619-003X

The mathematical model of evaluation of road-and-transport assets based on the level of real qualitative state was developed. The study was performed in connection with the lack of evaluation methods that take into account specifics of the assets of the road-and-transport complex. This problem is caused by absence of scientifically substantiated criteria for property evaluation of road assets.

As a result of this study, the conceptual model for evaluating the road-and-transport infrastructure assets was developed. Unlike the conventional approach, the constructed conceptual model of the evaluation procedure is based on application of a qualimetric model and a multilevel hierarchical system of indicators. This approach has enabled elucidation of the real physical wear converse to the level of qualitative state of the asset which is the basis for a fair evaluation.

The conceptual model of evaluation was laid in the basis of construction of a mathematical model that, in contrast to the conventional approach, takes into account the qualitative

state of linearly extensive objects. The disadvantages of application of the developed mathematical model include the necessity of estimation of errors and the level of expert competence. However, the calculations made in testing of this model gives the right to assert fairness of the asset evaluation which is an input parameter to the information-and-management system of the road-and-transport infrastructure.

The study results create a favorable environment for making managerial decisions on the assets as the objects of management in the road-and-transport complex and can be used by enterprises and organizations of the complex.

Keywords: asset value, evaluation, information-and-management system, level of qualitative state, qualimetry.

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DEVELOPMENT OF ONTOLOGICAL SUPPORT OF CONSTRUCTIVE-SYNTHESIZING MODELING OF INFORMATION SYSTEMS (p. 58–69)

Vladislav Skalozub
Dnipropetrovsk National University of Railway Transport named after academician V. Lazaryan, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-1941-4751

Valeriy Ilman
Dnipropetrovsk National University of Railway Transport named after academician V. Lazaryan, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0003-0983-8611

Victor Shynkarenko
Dnipropetrovsk National University of Railway Transport named after academician V. Lazaryan, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0001-8738-7225

The methodology and means of ontological support of the processes of constructive-synthesizing modeling of complex information technologies have been developed in the study. The requirements for the applied ontology of constructive-synthesizing modeling have been formulated along with developing and specifying the conceptualization methods, axiomatics, the output system and performers that provide effective modeling for a wide range of subject areas.

The theoretical basis of constructive-synthesizing modeling has been devised as the underlying principle of applied ontologies, with examples of the formation of concept models of subject domains.

In ontology, constructive-synthesizing models of subject domains have been formed and presented on the basis of a single constructive structure containing primary classes of ontology instances, active binders of operators of actions and performers. It ensures universality and opportunity to use the models for developing and setting them in subject domains of modeling.

The completed formalization of the ontology design allows improving the quality of automated processes of creating intelligent information technologies for structurally complex areas of modeling. This methodology is based on the paradigm of constructivism of all components of subject domains, on the revealed properties and unified models of representing concept structures, concepts and basic relations in CSM. At the same time, it has been made possible to create and maintain models of conceptual systems of subject domains that are different from taxonomy, given the uncertainties in the choice of the structure of conceptual models, both for systems of concepts of subject areas and their distinctive features.

Keywords: constructive-synthesizing modeling, ontology, conceptualization, unification of models, constructive object.

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TECHNOLOGY AND SOFTWARE TO DETERMINE ADEQUATE NORMALIZED CORRELATION MATRICES IN THE SOLUTION OF IDENTIFICATION PROBLEMS (p. 69–76)

Ulkar Sattarova
Azerbaijan University of Architecture and Construction, Baku, Azerbaijan
ORCID: http://orcid.org/0000-0002-0174-1412

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 $R_{XX}(i\Delta t)$ and $R_{XY}(i\Delta t)$ of the input $X(i\Delta t)$ and output $Y(i\Delta t)$ signals. It allows one 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 algorithms allow for reducing these matrices to the similar matrices of useful signals**.**

It is demonstrated in the paper that in the traditional approach, due to the normalization of estimates in the diagonal elements of the correlation matrices, the noise-induced errors disappear, while appearing in the remaining elements. As a result, the expected effect of improving the conditionality from the transition to normalized correlation matrices is not achieved. The technology and software for eliminating this defect are proposed, despite the problems with matrix conditioning. A new software for the rapid formation and analysis of numerous computational experiments confirming the effectiveness of the developed technology is proposed.

Keywords: real signal, noise, correlation function, normalized correlation matrix, equivalent correlation matrix, input signal, output signal.

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