ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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BITWISE METHOD FOR THE BINARY-CODED OPERANDS CONVERSION BASED ON MATHEMATICAL LOGIC (p. 6–14)

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This paper addresses the development and examination of the unconventional highly-efficient bitwise tuple-tabular logical-reverse method, underlying the construction of precision models of computational information converters, represented in the form of unipolar binary-coded operands with a positionally-ordered notation.

Modern models of converters, built using traditional methods, are typically not computationally loaded and are the aligning components that ensure the required form of information representation both at the input and output of the computing device. At the same time, they have a number of constraints that require hardware support, which leads to an increase in the weight and dimensions, compromises reliability and energy-time indicators, and increases the cost.

Therefore, development of the new unconventional method that converts various types of positionally-ordered binary-coded operands into certain values for a code combination and vice versa, using the same tabular compliance data (previously calculated) is a relevant task.

The method implies the construction of compliance tables based on formal logic; determining the values for corrective constants using the XOR operation; the elimination of information redundancy owing to the tuple decomposition and the synthesis of components for the model of a computational converter of information. The totality of procedures ensures the versatility, high performance speed and reliability, reduces energy consumption while maintaining the precision of results.

Verification of the proposed logical-mathematical model for constructing an effective method that converts various types of binary-coded operands has been confirmed by calculating the corrective constants given in tables, as well as during an experiment. The experiment was conducted on the designed physical model with a single numeric memory unit that converts a binary code into the Gray code and vice versa.

The proposed original multifunctional computational converters make it possible, at lower energy-time and hardware costs, to solve local control tasks in the computer-integrated systems for special purposes in order to manage high-speed technological processes or handle autonomous physical objects.

Keywords: components of computer-integrated systems, code conversion, binary-coded operands, bitwise tuple-tabular logical-reverse method.

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DEVELOPMENT OF TEST OPERATIONS OF DIFFERENT DURATION IN TERMS OF INPUT FOR THE VERIFICATION OF EFFICIENCY FORMULA (p. 14–21)

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Determining an indicator for the estimation of effectiveness of system operations is an important stage for optimization of technological processes of any enterprise. This step predetermines the established mode of functioning of all its system processes.

The fact that all technological processes should be optimized using an agreed optimization criterion is an axiom. Such a possibility appears only in one case – if we apply the efficiency formula as an optimization criterion in all functional systems. This approach maximizes financial possibilities of the owner of an enterprise.

The problem is to identify a structure that corresponds to the structure of the original efficiency formula among a set of evaluation indicators that are identical in terms of formal characteristics.

There are classes of standard models of operations define now for the practical solution of this problem. Each of them has its own functional orientation. The most developed are the classes of reference models of simple operations.

In relation to the classes of reference models of operations with distributed parameters, there is a solution of the problem operational processes with the same duration in time, as well as for processes with different duration of resource expense by an output.

In the proposed study, we define a limited class of models of operations with distributed parameters of different duration by an input. The creation of such a class of operations is quite a difficult task, since it is necessary to take into account a time factor and to enable possibility of comparison of operational processes of different duration.

To solve this problem, at the first stage, we formed global models of simple operations of different duration with predetermined rating efficiency. At the next stage, we formed reference models of operations with distributed parameters by an output of different duration by compositing.

The development of the verification method by determining a class of operations with distributed parameters in terms

of input of different duration in time improves reliability of verification results of the estimated indicator significantly. It is necessary to perform the verification procedure whenever we intended to use it as an indicator of effectiveness.

Keywords: verification of estimated indicator, operation with distributed parameters, class of operations, method of verification.

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CONSTRUCTION OF THE METHOD FOR BUILDING ANALYTICAL MEMBERSHIP FUNCTIONS IN ORDER TO APPLY OPERATIONS OF MATHEMATICAL ANALYSIS IN THE THEORY OF FUZZY SETS (p. 22–29)

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This paper considers four methods for finding parameters of the analytical expressions of sigmoids, data on which are given numerically. We have conducted a comparative analysis of the approximation effectiveness using sigmoids by applying the least squares method, by the direct calculation of constants based on values at the equilibrium and saturation threshold points, by the Taylor expansion and splines using an example with different thresholds of equilibrium, sensitivity, saturation. It has been demonstrated that the direct calculation of two constants based on the threshold points of equilibrium, sensitivity, or saturation, could easily, in terms of an algorithm, find two coefficients. It has been shown that when approximating with sigmoids employing the method of least squares the error of the approximating function depends on the symmetrical selection of grid points relative to the equilibrium threshold. We have investigated construction algorithms of membership functions based on two base functions – sigmoid functions of two types of flash and recession. We have built a set of standard membership functions of triangle, trapezoid, rectangle in the form of a product operation. The conditions have been formulated under which the curved shapes of the membership functions are formed, as well as the influence of approximation coefficients on the magnitude of deviations; the properties of completeness and sufficiency have been examined.

It has been demonstrated that such a procedure aimed at forming membership functions based on the totality of numerical values as the approximation spline does not make it possible to meet the requirement for the limit of interval of the value domain.

We have derived a general solution to the optimization problem using the analytical membership functions and compared it to the results of its solution in the Bellman-Zadeh statement.

We have analyzed the properties of transformed operations on fuzzy sets using the example of an optimization problem. It has been demonstrated that the solution in this new statement has two advantages. First, it is derived by applying an optimum search operation employing methods of classical mathematical analysis, using the conditions for a stationary point and conditions for the unchanged signs of second derivatives. Second, it is searched for using the operations of differentiation and root derivation, even under conditions for non-linearity, by commonly known methods by newton-kantorovich or recurrent approximation.

Keywords: analytical membership functions, fuzzy operations, standard set, construction algorithm, properties of completeness, optimization problem.

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DEVELOPMENT OF THE MARKOVIAN MODEL FOR THE LIFE CYCLE OF A PROJECT'S BENEFITS (p. 30–39)

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This study has improved the standard P5 (Personnel, planet, profit, process, product), which has already been widely applied globally in the practice of project management. However, the standard P5 provides a scheme of the life cycle of projects' benefits, which makes it possible to represent the lifecycle processes only at the qualitative level. In order to pass to the quantitative estimates, it has been proposed to apply the Markovian chain that maps a phenomenological representation of complex systems without considering their physical character.

We have constructed a cognitive Markovian model of the life cycle of a project's benefits using the communications between the states of the project system. The cognitive structure of the life cycle is similar to a directed graph where vertices indicate the state of the system, and links are the communications between them. We have proposed an approach to determining transitional probabilities based on the evaluation of communications, taking into consideration the time costs to perform operations in the form of rules. The character of communications between states $s \rightarrow j$ in the Markovian chain defines the magnitude of transition probabilities π_{sj}. The time costs required for each state are divided into five intervals π_{sj}: {0} – no costs; {0.01–0.1} – insignificant time costs; {0.1–0.3} – the lowest level of time costs; {0.3–0.7} – average time costs; {0.7–1.0} – the largest time costs. The logic of choosing values for conditional transition probabilities in the Markovian chain makes it possible to determine data for the simulation of

the trajectory of the life cycle of projects' benefits in the coordinates of the probabilities of states of the system and steps.

It has been shown that the application of the Markovian chains is rational in order to represent the life cycle of projects' benefits. An analysis was performed to determine a certain level of technological maturity of the project environment (organization), which corresponds to the totality of values for transition probabilities. We have studied the influence of the level of technological maturity of the project environment (organization) on the projects' efficiency.

Another example of the implementation of the project aimed at forming the positive image of an educational establishment by applying the frontal information communication via television, the press, by taking part in mass political activities, has also revealed positive estimation. The probability distribution at the beginning of the project ($V1$) and upon its completion ($V2$) differs significantly. The implementation of the project increased the magnitudes of probabilities of states $p7$ (Benefit) and $p8$ (Additional benefit). At the beginning of the project: $p7^{(V1)}+p8^{(V2)}=0.14+0.05=0.19$. Upon implementation of the project: $p7^{(V1)}+p8^{(V2)}=0.22+0.08=0.30$. The evaluation of this project aimed at positive image formation of an educational establishment showed that the results obtained do not contradict the hypothesis about the possibility of applying the Markovian chains to determine the characteristics of the life cycle of a project's benefits.

Keywords: cognitive scheme, Markovian chain, level of technological maturity, life cycle, life cycle development trajectories.

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RAY TRACING SYNTHESIS OF IMAGES OF TRIANGULATED SURFACES SMOOTHED BY THE SPHERICAL INTERPOLATION METHOD (p. 39–47)

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The problem of imaging by ray tracing of triangulated surfaces smoothed by the spherical interpolation method was solved. The method of spherical interpolation was mainly designed to interpolate the triangulated surface with the subsequent aim of imaging this surface by the method of ray tracing. This approach makes it possible to combine the method of ray tracing with the accumulated base of models with a triangulated surface. The method of spherical interpolation is universal and enables construction of plane and spatial smooth curves drawn through arbitrarily set points. The proposed interpolation algorithm is based on a simple algebraic surface, sphere, and does not use algebraic polynomials of the third and higher orders. Analytical relations for realization of each stage of construction of an interpolating surface by this method were given. For imaging the interpolating surface, an iterative algorithm (ITA) of calculation of the point of intersection of a projection ray with this surface was constructed. The proposed ITA has an ability of a broad paralleling of computations. An algorithm of constructing points of an interpolating surface was developed with its step coinciding with the step of the iterative computation process which makes it possible to execute the algorithm of imaging and construct the surface point in a single ITA pass. The study results were confirmed by simulation of the imaging process in the Wolfram Mathematica package. Thus, the problem of combining new methods of constructing smooth geometric forms of triangulated surfaces and the method of ray tracing was solved which, in general, will improve realism of synthesized scenes in computer graphics.

Keywords: ray tracing, projection ray, modeling curves and surfaces, quadric, spherical interpolation.

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CONSTRUCTING A METHOD FOR THE CONVERSION OF NUMERICAL DATA IN ORDER TO TRAIN THE DEEP NEURAL NETWORKS (p. 48–54)

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This paper analyzes known types of deep neural networks, the methods of their supervised training, training the networks to suppress noise, as well as methods for encoding data using images. It has been shown that deep neural networks are suitable in order to effectively solve classification problems, in particular for medical and technical diagnosing. Among the deep networks, the convolutional neural networks are promising because of their simple structure and application of common weights, which makes it possible for a network to separate similar features in different parts of images. Training a convolutional network may prove insufficient for some diagnosing tasks, which is why it is advisable to consider modifications to the training method using data encoding and training to suppress noise in order to obtain a better result.

We have proposed a method for training a convolutional neural network using numerical data converted to bitmap images, which would improve the accuracy of a network when solving the problems on classification and which would make it possible to apply the convolutional neural networks and their advantages in image processing by using tabular data as input. In addition, the proposed method requires no additional changes to the structure of the network.

The method consists of four stages – the normalization using a method of min-max, conversion of data into two-dimensional images applying the float or thermometric encoding methods, the generation of additional images with the distortion of input data, and the preliminary training of a deep network.

The constructed method was implemented in software and investigated when solving a number of practical tasks. Results of solving the practical tasks on technical and medical diagnosing have shown the effectiveness of the method at small numbers of the resulting classes and training instances. The method could prove useful when diagnosing a defect at the early stages of its manifestation when the volume of training data is limited.

Keywords: convolutional neural networks, deep learning, data conversion, bitmap images.

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ONTOLOGICAL SUPPORT FORMATION FOR CONSTRUCTIVE-SYNTHESIZING MODELING OF INFORMATION SYSTEMS DEVELOPMENT PROCESSES (p. 55–63)

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The globalization of information systems (ISs) in the process of continuous operation and modernization creates new problems and reveals specific representations of IS tasks. Such a complex industry IS, requiring appropriate ontological support, is the unified automated system for managing freight traffic of Ukrzaliznytsia (ACS FT UZ-U). To develop the infrastructure information subsystems such as rolling stock and traction staff, traffic management, finance, personnel and a number of others, it is necessary to develop interconnected ontological support.

Therefore, methods and means of ontological support of constructive-synthesizing modeling (OCSM) have been developed, designed to support the processes of multistage creation, a long period of operation and the continuous development of the ACS FT UZ-U. The results obtained are distinguished by universalism, as they provide opportunities for representing the evolution of the object (IS) and the content of ontologies in the OCSM.

The formation of models and methods of the OCSM has been obtained by expanding relations and mappings as well as by creating new generating structures, complementing classes of signatures with new constructive relations. At the same time, the model of a unified, universal and customizable ontological constructive structure (OCS) has been developed. The OCS takes into account the requirements for representing the processes of expanding the subject area as well as unifying knowledge. For CSM problems, methods and means of modeling the conceptualization processes of developing objects have been created and constructive calculus has been devised for the generating class of mappings along with methods for constructing higher-order ontological objects. For the ontological support of the CSM processes in the context of expanding subject areas, the inference methods in the model of the OCSM constructive structure have been improved and procedures for meaningful, structural and related deducibility have been proposed together with multilevel inference methods.

Examples have been given of the implementation of the currently existing procedures for creating new applications of the automated system ACS FT UZ-U using the proposed CSM tools. The examples demonstrate the adequacy of the developed models and means of the OCSM for the implementation of procedures for the development and maintenance of complex railway ACSs.

Keywords: ontological support, constructive modeling, conceptualization, methods of inference, automated systems.

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