ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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DEVELOPMENT OF A METHOD FOR APPROXIMATE SOLUTION OF NONLINEAR ORDINARY DIFFERENTIAL EQUATIONS USING PENDULUM MOTION AS AN EXAMPLE (p. 4-11)

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A method of deletion of dimensions for a mathematical model which gives the number of variables less than that prescribed by the π-theorem was proposed. In a number of cases, it is possible to exclude from consideration all similarity criteria or, in other words, achieve self-similarity in them. In the framework of deletion of dimensions, this is expressed in a transition from criteria to similarity numbers. Thus, information is reduced without its loss.

The limit reduction of the number of variables in the mathematical model makes it possible to use analytical approximation dependences as approximate solutions. Such dependences are obtained from the initial solutions by using the coefficients of stretch, which corresponds to the group methods for solving equations. It was proposed to use solutions of the linearized forms of the original nonlinear equations as initial solutions. Such approach makes it possible to take into account physical character of the change in the studied quantities in the approximation dependences when solution of nonlinear equations cannot be realized using standard functions.

Efficiency of the method was illustrated by the example of study of the pendulum motion, which is a counterpart of inertial link of the second order in the theory of automatic control. Solutions were obtained for the cases of presence and absence of environmental resistance. The last variant is interesting by the feasibility of comparing the proposed and available analytical solutions in terms of elliptic integrals.

Keywords: deletion of dimensions of a mathematical model, group methods of solution, second order inertial link.

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DEVELOPMENT OF MAXIMUM CLIQUE DEFINITION METHOD IN A NONORIENTED GRAPH (p. 12-17)

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The paper recommends the MCP solution method with small time complexity $O(2n^3\log_2 n)$, that allows from one viewpoint solving such problems as definition of the maximum independent sets and minimum vertex covers in graphs, as well as isomorphism of graphs and isomorphic embedding, as far as all those problems may be converted within polynomial time into MCP. This set of problems is formal models of a wide range of management problems in rail transport information systems, and the solution thereof requires the algorithms for their realization with small time complexity. Therefore, the time complexity decrease is an actual task. In the paper, admissibility of decreasing the time complexity of the suggested procedure A for solving MCP is based on using the subsidiary procedure B for defining the estimates of the largest graph clique values, and on its basis the method of the problem solution is described in the paper as procedure A. Procedure A allows forming the cliques on the base of each vertex of graph *i*. As the process of clique formation on the base of each vertex may be independent, then procedure A may be effectively vectorized. It makes possible in case of using processing cells for solving the MCP to decrease the time complexity of its operation to $O(2n^2\log_2 n)$, and the mentioned complex of the problems will be solved in a real-time scale.

Keywords: cliques in non-oriented arbitrary graph, parallel computing methods.

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INFORMATIONEXTREME MACHINE LEARNING OF THE CONTROL SYSTEM OVER THE POWER UNIT OF A THERMAL POWER MAIN LINE (p. 17-24)

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The study considers a method of deep machine learning of a decision-making support system of control of a power unit of a thermal power plant. We developed a method within the framework of information-extreme intelligent technology, it is based on maximization of informational capacity of a control system in the process of machine learning. We developed categorical models of information-extreme machine learning with optimization of control tolerances to recognition attributes and levels of selection of coordinates of averaged binary vector-realizations of recognition classes. We considered a modified Kullback information criterion as a criterion for optimization of learning parameters. We implemented algorithms of machine learning with polymodal and unimodal decisive rules. We formed a learning matrix based on archival data of the operation of Shostka thermal and power plant. The results of physical modeling showed that the use of

polymodal decisive rules does not provide a high functional efficiency of machine learning. We ordered the alphabet of recognition classes to the magnitude of deviation of a functional state of the technological process from the standard regime for the application of unimodal decisive rules. At the same time, we constructed unimodal decisive rules according to geometric parameters of hyper-spherical containers of recognition classes x by the enclosed structure. We proved experimentally that the use of the unimodal classifier gives possibility to construct decisive rules, which error-free by a learning matrix. The obtained results give possibility to provide high functional efficiency of machine learning of control systems of technological processes whose classes of recognition intersect substantially in a space of attributes.

Keywords: information-extreme intelligent technology, machine learning, decision making support system, information criterion, power unit, thermal power plant.

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MULTICLASS RECOGNITION OF OBJECTS TECHNICAL CONDITION BY CLASSIFIER BASED ON PROBABILISTIC NEURAL NETWORK (p. 24-31)

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The paper deals with the efficiency study of the classifier developed based on the probabilistic neural network for multi-class diagnostics of a complex spatial object in the presence of multi-site damage. For recognition, the multidimensional diagnostic feature vector is used, the values of the features may have a deviation of ±5 % for the defect-free condition of an object, and exceed the permissible deviation in case of occurrence and development of damage. For the vector containing 5 diagnostic features, 6 classes of technical condition of an object are substantiated. Formation of sets of training and test input vectors, used for the classifier training and testing is performed. In order to evaluate the multi-class recognition efficiency, the coefficient, which is a percentage of the probability of correct classification of test vectors, is used. The analysis of the dependence of the efficiency coefficient on the characteristics of the classifier and the set of training vectors is carried out. It is found that error-free multi-class recognition of the object condition over the entire set of input vectors with different values of deviation of feature elements is provided in the range of values of the classifier parameter spread of [0,02; 0.07]. It is revealed that the greater the diagnostic feature deviation in test vectors, the greater the influence of the dimension of the set of training vectors on the multi-class recognition efficiency. The minimum size of the set of training vectors (68 vectors) and the limit value of diagnostic feature deviation in test vectors (17 %), which provide error-free multi-class recognition by the developed classifier are determined.

Keywords: multi-class recognition, neural network classifier, diagnostic feature vector, probability of correct classification.

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IMPROVING EFFICIENCY OF PROVIDING DATA GROUP ANONYMITY BY AUTOMATING DATA MODIFICATION QUALITY EVALUATION (p. 31-39)

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In the work, a modification of the method for solving the task of providing data group anonymity is proposed, which implies automated solution selection without expert participation. Modification lies in identifying solutions to the task, in which outliers are detected automatically and don't match the outliers in the initial distribution of the information about the group of respondents. Thus, automating the solution selection improves data group anonymization efficiency by reducing the time necessary for their analysis for masking sensitive features of the distribution.

Testing the developed modification is done by solving the task of masking regional distribution of military personnel in the state of New York. As a result of solving the corresponding group anonymization task, 1,000 solutions were obtained. It is established that only 24 out of 1,000 solutions, or 2.4 % of the total number, are feasible, i. e. the ones in which all the outliers are masked. Automated selection of such a small number of solutions is significantly faster than the manual approach, which speaks in favor of the proposed modification for improving data group anonymization efficiency.

Keywords: memetic algorithm, group anonymity, microfile, outlier, modified Thompson tau technique.

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DEVELOPMENT OF THE METHOD FOR CREATING EXPLICIT INTEGRAL DYNAMIC MODELS OF MEASURING TRANSDUCERS (p. 40-48)

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Increasing requirements to measuring transducers lead to the need to improve and propose alternatives of their mathematical description. The application in this case of differential equations of various types testifies to great computational complexity of the given problem statement. In this regard, constructively relevant are the methods for creating integral dynamic models of measuring transducers that enable expansion of the tools for computer simulation.

The method considered in present paper implies determining a pulse transient characteristic and leads to the formation of the operators (cores) of measuring transducers in the form of integral mathematical dependences, that is, explicit integral dynamic models.

The method of obtaining an analytic expression of the pulse transition function of measuring transducers with lumped parameters is represented as a solution to the homogeneous differential equation that corresponds to the specified non-homogeneous differential equation. This technique is easily illustrated on the examples of measuring transducers of the first and second order.

The principle of determining a pulse transient characteristic for measuring transducers with distributed parameters by the assigned equations in partial derivatives is the same as for the case with lumped parameters.

Keywords: integral dynamic model, pulse transition function, measuring transducer, differential equation.

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DEVELOPMENT OF THE MODEL OF MINIMAX ADAPTIVE MANAGEMENT OF INNOVATIVE PROCESSES AT AN ENTERPRISE WITH CONSIDERATION OF RISKS (p. 49-56)

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The authors consider a discrete dynamic system, containing an object – the innovative process (IP). Its dynamics is described by the vector linear discrete recurrent ratio and is influenced by controlled parameters (controls) and an uncontrolled parameter (the vector of risk or obstacle). In this case, risks in the system of IP management at an enterprise will imply the factors that influence negatively or disastrously the results processes, considered in it.

To solve the set problem, a general model of IP management for organization of minimax adaptive management in the selected class of permissible strategies of adaptive management was formalized. It was proposed to use a deterministic approach for modeling and solution of the original problem in the form of dynamic problem of minimax IP management (optimization of the guaranteed result) at a given moment of time, with consideration of risks. To solve the problem of minimax IP management in the face of risks, the authors propose the method that is reduced to implementation of solutions of a finite number of problems of linear and convex mathematical programming, as well as a discrete optimization problem. Solution of the set problem of minimax IP management allows obtaining the optimal guaranteed (minimax) outcome.

For effective implementation of the resulting mathematical apparatus in practice of work of enterprises, the detailed model of multicriteria optimization of IP management at an enterprise in the face of risks was developed, which describes dynamics of the studied process to the full. Generated optimization criteria and the system of phase constraints of the model take into consideration possibilities of production capacities, as well as meet the requirements for IP.

The proposed method makes it possible to develop effective numerical procedures that enable us to implement computer modeling of dynamics of the considered problem, to formulate adaptive minimax IP management at an enterprise and to obtain the optimum guaranteed results.

The presented results could be used for economic-mathematical modeling and solution of other problems of optimization of processes of data forecasting and management under conditions of information deficit and existence of risks. In addition, the developed tools of modeling can be the basis for development of appropriate software and hardware complexes for supporting effective managerial decision making in practice.

Keywords: innovative process, modeling, risks, optimization, minimax adaptive management, guaranteed outcome.

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A NEW METHOD FOR SOLVING THE PROBLEM ON THE ORGANIZATION OF WAGON FLOWS UNDER CONDITION OF ENERGY EFFICIENCY OF TRANSPORTATION (p. 57-62)

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The paper considers solving a problem of rational organization of wagon flows in a polygon of selected technological railroad stations using a technique for solving a knapsack problem employing set functions. Based on the results of present work, the authors developed a method for solving a knapsack-type problem that makes it possible to adapt the algorithm of solving a vector optimization problem to the rational system of organizing wagon flows in trains without using differentiation operations and to solve a basic optimization problem employing the Lagrange multipliers. The applicability of the Lagrange method was proved for the problems on a conditional extremum in terms of set functions. Its special feature is the rejection of Boolean variables. We confirmed correctness of the mathematical notation of solution to a knapsack-type problem and proved adequacy of the proposed algorithm, as well as adapted it for adjusting a plan of freight trains formation in order to improve energy efficiency of transportation. By reducing the complexity of the problem, it has become possible to reduce computer processor time needed for calculation, and employ this algorithm when designing an automated work place (AWP) for an engineer responsible for planning the formation of trains. It should be specially noted that a reduction of the time needed to solve a problem makes it possible to timely adjust the plan of freight trains formation, to eliminate a lot of irrational variants when handling wagons at technical stations.

The proposed algorithm helps identify variants to direct train flows to the most promising destinations at minimal energy cost for transportation. Limitations of the proposed approach include a closed cycle of routes of the loaded wagons

and part of these routes traveled unloaded until the next loading. In some cases, there is a need to change a weight of the train composition, associated with fractures of weight, and, therefore, a change in the balance between wagon flows and train flows.

Keywords: knapsack problem, set function, vector optimization, organization of wagon flows, energy efficiency of transportation.

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