ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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ASPECTS OF PROGRAM CONTROL OVER TECHNOLOGICAL INNOVATIONS WITH CONSIDERATION OF RISKS (p. 6-14)

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The dynamic system of control of technological innovations is considered. Its dynamics is described by a vector linear discrete recurrent ratio and influenced by control parameters (controls) and an uncontrollable parameter (vector of risks or obstacles). In this case, the risks in the system of control of technological innovation will imply factors that influence negatively or catastrophically the results the processes, considered in it.

To solve the problem on control over technological innovations, we proposed methods based on the construction of predictive sets – reachability regions of the considered dynamic model. These are the sets of all permissible states of a phase vector of the system at an assigned moment, correspondent to the fixed program control and to all permissible vectors of risk. This procedure is accompanied by the minimax-based method for finding a guaranteed result. Its essence is that the value of the worst (maximum) vector of possible risks is the least compared with similar values for the others at minimally guaranteed optimal control. Thus, we minimize the impact of risks in the problem of control of technological innovations, where the risks are uncontrollable parameters. This is implemented based on selection of such optimal control, which would guarantee the obtained result under the influence of any maximal risk from the set of permissible risks.

The proposed method enables the development of effective numerical procedures that make it possible to implement computer modeling of dynamics of the studied problem, to form program minimax control over technological innovations and to obtain an optimal guaranteed result.

The results reported here could be used for economic-mathematical modeling and for solving other problems on the optimization of data forecasting and control processes under conditions of insufficient information and in the existence of risks. In addition, the developed modeling toolset could form the basis for development of appropriate software-hardware complexes to support making effective control decisions in the innovation activity.

Keywords: program control, technological innovations, dynamic system, minimax result, reachability region.

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EXPONENTIAL AND HYPERBOLIC TYPES OF DISTRIBUTION IN MACROSYSTEMS: THEIR COMBINED SYMMETRY AND FINITE PROPERTIES (p. 14-25)

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This paper proposes the extended entropy method that identifies certain new relations in the organization of macro systems and which sheds light on several existing theoretical issues. It is shown that the type of distribution within the macrosystem is determined by the ratio of the kinetic properties of its agents – "carriers" and "resources". If the relaxation time is shorter for the "carriers", there forms the exponential type of distribution; if it is shorter for the "resources" – there forms the extreme hyperbolic distribution with a heavy tail. Analytical expressions were derived for them and their spectra. A convenient technique to parametrically record them via modal characteristics was devised.

Author discovered the existence of the combined symmetry of these two types of distributions. They can be regarded as alternative statistical interpretations of a single state of the macrosystem.

Distributions of real macro systems possess finite properties; given the natural constraints, they form the right bounds. The proposed method makes it possible to determine their coordinates based on the extreme principle, considering the right bounds of finite distributions as a product of self-organization of macro systems. Strict ratios were constructed, taking into consideration the finite features of distributions. Parametrically, they depend on the specific volume of "resources", and the magnitude of a form-parameter – ratio between modal and boundary coordinates.

The value of the obtained results is in that they shed light on a number of problematic issues in the statistical theory of macro systems, as well as include a set of convenient tools in order to analyze two types of distributions with finite properties.

Keywords: macro system, entropy, entropy modeling, finite distributions, hyperbolic distributions, distributions with a heavy tail.

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DEVELOPMENT OF THE METHOD FOR REDUCING A MODEL TO THE NONDIMENSIONALIZED FORM (p. 26-33)

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We proposed the method that makes it possible to transform a mathematical model into the nondimensionalized form with a less number of nondimensionalized magnitudes, than it is prescribed by the Pi-theorem (in English literature – the Buckingham theorem, in French literature – the Vaschy theorem). The procedure of transformations is formalized and does not require highly qualified researchers for its implementation. The method is based on the synthesis of principles of the standard approach to nondimensionalization and natural measurement units. The solution of a nondimensionalization problem is based on the use of matrix methods.

The desire to transform a model towards a decrease in the number of magnitudes, included in it, without losing information, is stimulated by a number of emerging benefits. The possibility to obtain an assigned amount of information at fewer physical and numerical experiments, as well as new solutions, is implemented.

As a result of the research, there is a possibility to decrease the number of magnitudes, included in the transformed mathematical model. This is due to the introduction of proper measurement units (normalizing magnitudes) for each model separately, which corresponds to introduction of a natural coordinate system. The procedure is standardized and can be applied to any model, which is characteristic of the standard nondimensionalization methods.

Feasibility of the method was demonstrated using an example of reducing the model of hydraulic impact in pipes to the nondimensionalized form. The variants with and without taking into consideration of dissipative forces were explored. In each case, nondimensionalization was performed using the standard method and by using the developed procedures. In both cases, the application of the proposed method made it possible to decrease the number of nondimensionalized magnitudes compared with the results of using the standard approach.

Keywords: modeling of technical systems, model nondimensionalization, decrease in dimensionality of modeling space.

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ALGORITHM FOR THE SIMPLIFICATION OF SOLUTION TO DISCRETE OPTIMIZATION PROBLEMS (p. 34-43)

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Typically, the search for solutions in discrete optimization problems is associated with fundamental computational difficulties. The known methods of accurate or approximated solution of such problems are studied talking into consideration their belonging to so-called problems from P and NP class (algorithms for polynomial and exponential implementation of solution). Modern combinatorial methods for practical solution of discrete optimization problems are focused on the development of algorithms which allow obtaining an approximated solution with guaranteed evaluation of deviations from the optimum. Simplification algorithms are an effective technique of the search for solutions to an optimization problem. If we make a projection of a multi-dimensional process onto a two-dimensional plane, this technique will make it possible to clearly display a set of all solutions to the problem in graphical form. The method for simplification of the combinatorial solution to the discrete optimization problem was proposed in the framework of this research. It is based on performance of decomposition of a system that reflects the system of constraints of the original five-dimensional original problem on a two-dimensional plane. This method enables obtaining a simple system of graphic solutions to a complex problem of linear discrete optimization. From the practical point of view, the proposed method enables us to simplify computational complexity of optimization problems of such a class. The applied aspect of the proposed approach is the use of obtained scientific results in order to provide a possibility to improve the typical technological processes, described by systems of linear equations with existence of systems of linear constraints. This is a prerequisite for subsequent development and improvement of similar systems. In this study, the technique for decomposition of a discrete optimization system through projection of an original problem on two-dimensional coordinate planes was proposed. In this case, the original problem is transformed to a combinatorial family of subsystems, which makes it possible to obtain a system of graphic solutions to a complex problem of linear discrete optimization.

Keywords: linear programming, discrete optimization, constraints system, determining an optimum, combinatorial method, Gauss-Jordan method, decomposition, graphical solution.

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DEVELOPMENT OF STRUCTURE AND METHOD OF EFFECTIVE BINARY STABILIZATION OF QUALITY PARAMETER IN DYNAMIC SYSTEMS (p. 44-52)

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The issues of stabilization of quality parameters of dynamic processes are considered to be well studied. Traditionally, the negative feedback technology is used for this purpose. The concomitant moment of the negative feedback technique use is the need of research of the dynamic system stability in the range of admissible controls, the choice of the stabilization criterion and stabilization parameters.

The examples of dynamic systems with continuous and batch technological products feed show that the introduction of negative feedback is not the only alternative allowing to stabilize the quality parameters of output products.

It is shown that the problems of dynamic systems stabilization are related to the fact that control signals are transmitted as part of control signals of nonlinearity of the system technological part. In this regard, there are problems of stability and quality of stabilization.

The stabilization method that is free from the influence of the technological part and the system-based sign for classifying system objects are proposed. Using this sign allows classifying the system objects relative to the technological subsystem or the control subsystem.

The method also provides for the use of system-based principle to determine the optimal control parameters of the stabilization process using the verified criterion of resource efficiency.

Using the proposed method allows creating automatic dynamic systems, built on a single architectural principle.

Keywords: feedback, parameters stabilization, dynamic system synthesis, stabilization parameters choice.

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OPTIMIZED SMOOTHING OF DISCRETE MODELS OF THE IMPLICITLY DEFINED GEOMETRICAL OBJECTS' SURFACES (p. 52-60)

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When using many modern methods of automatic generation of surface meshes of implicitly defined geometric objects, the accuracy of approximation in the vicinity of surface singularities (holes, breaks, etc.) is lost. To improve surface meshes of geometric objects, various methods of smoothing are used. The existing smoothing methods are focused on triangular elements, but optimization of surface meshes of geometric objects on the basis of elements of another shape (for example, quadrangles) is less studied.

The paper proposes the mathematical apparatus based on the use of the energy functional for each model node. The proposed functional considers the distance from the current node to the adjacent nodes and the distance from the geometric centers of the incident elements to the surface.

The algorithm for minimizing the energy functional for smoothing surface meshes of implicitly defined geometric objects is developed. The developed algorithm is a modification of the Gaussian method for the case of search for a minimum in the local coordinates of a polygon formed by neighboring elements. The algorithm is local: minimization is performed consistently for each model node, so its repeated application provides models with more accurate approximation of the boundary.

The developed algorithm for minimizing the functional does not require the insertion of new nodes. As a consequence, it is possible, using a single procedure, to optimize meshes based on triangles, quadrangles or mixed type (containing triangles and quadrangles simultaneously). As a result, the accuracy of the approximation of surfaces in the vicinity of their singularities increases, as demonstrated by the examples of smoothing models of complex objects.

Keywords: geometric object, mesh, implicit function, smoothing, surface, energy functional.

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DEVELOPMENT OF A TECHNOLOGY OF STRUCTURING GROUP EXPERT JUDGMENTS UNDER VARIOUS TYPES OF UNCERTAINTY (p. 60-68)

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The study considers the problem of structuring expert judgments formed under conditions of uncertainty of different nature and in presence of conflicting expert evidence. The method of aggregating group expert judgments that are formed under conditions of various types of uncertainty helps synthesize the group opinion, taking into account various forms of representing the preferences of experts (interval, fuzzy and crisp expert judgments). The proposed procedure makes it possible to synthesize a group decision in the event that there is a group or several groups of experts in a group of experts who express their preferences using different forms of expert judgments.

This approach allows reflecting accurately the expert preferences regarding the object being analysed, without restricting the experts to a rigid form of presenting assessments.

In order to analyse the obtained expert information and to get individual expert ratings of the analysed objects, the method of pairwise comparison and its modification were used in the study.

It has been established that for the aggregation of crisp expert estimates, more precise combined results can be obtained by applying rules for redistributing conflicts of the theory of plausible and paradoxical reasoning. To aggregate interval expert judgments, one of the combination rules of the theory of evidence is recommended. It has been determined that in order to improve the quality of the aggregate results, it is advisable to establish a procedure for combining expert inputs, for example, taking into account the degree of dissimilarity and the structure of expert evidence.

The obtained results are intended to help improve the quality and efficiency of the processes of preparing and making decisions while solving the problems of analysing and structuring expert judgments.

Keywords: expert preferences, aggregation of expert judgments, method of pairwise comparison, combination rules.

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