ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS - APPLIED ASPECTS

DEVISING A MODEL OF OPTIMAL CONTROL OVER THE LOGISTICS SYSTEM UNDER UNCERTAINTY (p. 4-9)

Volodimir Dorovskoy, Aleksandr Zhelezniak, Olga Babina, Inna Antipenko, Vladislav Budnik

An objective of the study is to improve the quality of decisions via formalizing each specific optimization problem in the analysis of the logistics system under uncertainty. In multi-criterion conditions, the most promising approach to the assessment problem is the formation of a generalized scalar multi-factor assessment of $P(x)$ on a set of particular criteria $k_j(x), j=\overline{1,m}$, which requires solving the problem of a structural and parametric identification of the models of formation – P1 (x).

The principal peculiarity of this problem stems from the fact that the assessment procedure is an intellectual process of the decision maker (DM) or experts, i. e. it is necessary to identify the model of intellectual activity. The baseline data of any task for optimization of the logistics system (OLS) consist of uncertain and determined values of various types. The study has determined optimization criteria, controlled variables, and their limitations, which allowed devising new mathematical identification models and optimization techniques. The devised algorithm allows determining the necessary conditions for optimal solutions. The formulated theorem specifies the conditions for obtaining an optimal solution to optimize the tracking mode of terminal control under uncertainty. Its peculiar feature is the choice of three initial prerequisites, namely: parametric models, an optimality criterion, and optimal solutions. The obtained results of a two-stage optimization can serve as a basis for constructing specific optimal control systems that use two modes, such as “a search for the optimum (reference) value of the controlled variable” and “tracking of the optimum value.” They also allow scientific justifying, posing and solving the problem of identification of a two-level model of optimal control over the volume and cost of the logistics system in accordance with the two most important criteria for practical application: the criterion of a maximum profit and the criterion of a minimum cost.

Keywords: optimization criterion, parametric model, the normalized values of profit, terminal control, two-level optimal control, logistics system, uncertainty, multi-factorial assessment, optimistic criterion, mathematical identification models.

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DEVELOPMENT OF A MATHEMATICAL MODEL OF PROFESSIONAL ACTIVITY (p. 10-18)

Oleg Zaritsky, Volodymyr Sudik

Practical issues of the development of a mathematical model of professional activity are considered. The development is based on the authors’ previous studies on the analysis and formalization of structural and informational models of decision-making processes, communication, information processing, educational and qualification level as components of the general structural model of professional activity.

The main objective of the study is to obtain and analyze the results of simulation of certain activities applying the mathematical model developed.

Development of the mathematical model was carried out using the methods of structural analysis and mathematical statistics for the simulation data processing.

Two versions of the model are proposed. The basic one takes into account structural elements that describe the professional activity in terms of the job. The complete model includes the employee characteristics required to perform the job.

The research results can be used in the development of computational modules of information technologies and systems of classification, analysis and evaluation of professional activity, as well as for automation of the processes of classification and coding of technical economic and social information.

The proposed model versions (basic and complete) allow for the minimum difference in the job carried out within the framework of professional activity, which significantly extends the analysis and classification depth compared to existing approaches. The obtained correlation coefficients indicate the reliability and validity of the developed model.

Keywords: job analysis, mathematical model of professional activity, information system of job evaluation.

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RESEARCH OF UNCERTAINTIES IN SITUATIONAL AWARENESS SYSTEMS AND METHODS OF THEIR PROCESSING (p. 19-27)

Khrystyna Mykich, Yevhen Burov

Situational awareness as the understanding of the system environment is a mandatory part of any decision support system. Formation and maintenance of situational awareness is a complex process. It comprises the stages of sensor data collection and interpretation, as well as updating of knowledge about the current situation for making correct decisions. However, all stages of this process are subject to various uncertainties and errors. They affect the knowledge about the environment and correctness of decision making using this knowledge. Various types of uncertainties have been researched and formalized. The work deals with the study and formalization of uncertainties that arise at different stages of situational awareness formation and reduction of adverse effects. The paper analyzes various models for defining and presenting the situational awareness formation process in order to find a common platform and mechanisms related to different process stages. Existing classifications, manifestations and influence of uncertainties on situational awareness at various stages of its formation are also discussed. The paper proposes methods to reduce the impact of uncertainty at all stages. The results of the analysis are appropriate for use in intelligent decision support systems for reducing the impact of different types of uncertainties in the process of situational awareness formation. Applying the ontological modeling methods as a basis for analysis provides a holistic view of the causes of uncertainties for various stages of the SA formation process, makes it possible to analyze their interdependence, create and re-use knowledge about the causes of uncertainties for specific application areas.

Keywords: situational awareness, uncertainty, model, interpreted system, decision making, relevance, ontology, fuzziness.

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FUNCRIONAL AND ANALYTIC REPRESENTATIONS OF THE GENERAL PERMUTATIONS (p. 27-38)

Oksana Pichugina, Sergey Yakovlev

The study introduces the notion of a functional representation of a set of points in the Euclidean space, suggests a classification of such representations, as well as describes the polytope-surface and the surface-polyhedral approaches to the functional representations of the general permutations. The study proves the existence of both strict and non-strict functional representations of the set, suggests a number of strict representations that are based on the studied properties of two classes of symmetric functions, and presents the visualization and analysis of strict representations of small permutation arrays.

The study uses the general permutations to present a new continuous reformulation of nonlinear problems, which allows devising exact and approximate optimization algorithms that have the following properties: (a) they are based on the penalty method and the augmented Lagrangian method, (b) they do not use permutohedron restrictions, and (c) they can be combined with convex extensions of objective functions from the set to a compact.

The obtained strict representations form a framework for new continuous relaxations of the combinatorial set and its

subsets. Consequently, they can be the basis for new optimization methods and algorithms over the general permutations. The methods can be applied to numerous practical problems if they are formulated as nonlinear unconditional problems on permutations and their generalizations.

Keywords: functional representation of a set, the general permutations, the permutohedron, combinatorial optimization.

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OPTIMIZATION OF PACKING POLYHEDRA IN SPHERICAL AND CYLINDRICAL CONTAINERS (p. 39-47)

Olexander Pankratov, Tetyana Romanova, Yurii Stoyan, Andrey Chuhai

The study focuses on the problem of packing a given set of arbitrary polyhedra allowing continuous rotations in a container of a minimal size (a sphere with a minimal radius or a cylinder with a minimal coefficient of homothety). Non-overlapping and containment constraints are described by means of radical-free quasi-phi-functions. This allows building a mathematical model as a nonlinear programming problem with a domain of feasible solutions that is described as a system of inequalities with smooth functions. The proposed solution strategy includes a fast algorithm for generating feasible starting points and the COMPOLY-S optimization procedure that reduces the nonlinear programming problem with a large number of variables and a large number of inequalities to a sequence of smaller size problems and smaller number of non-linear inequalities. The COMPOLY-S procedure significantly reduces the computational cost (time and memory) and allows an efficient use of modern local and global NLP-solvers, such as IPOPT, Baron, LindoGlobal and GloMIQO, for solving nonlinear programming problems.

Keywords: packing, polyhedra, continuous rotations, quasi-phi-function, mathematical model, nonlinear optimization.

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MODELING OF TERRITORIAL COMMUNITY FORMATION AS A GRAPH PARTITIONING PROBLEM (p. 47-52)

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The territorial community formation process as a graph partitioning problem is considered. The main goal of territorial community formation is to reduce the budget and save public funds. The formation process of communities where settlements, which make up the community, have an administrative building, healthcare institution, high school, kindergarten is investigated. Additional restrictions are imposed on these indicators for uniform distribution of the region's population and community incomes. The minimum distance from the community center to other settlements is taken as a function of the goal of territorial community formation. The mathematical model of this problem, which is a modified graph partitioning problem is developed. The modification lies in using specific constraints arising from the problem statement. The notion of independence of communities and adjacency of individual councils is introduced to build efficient territorial community formation algorithms. This allowed us to formalize the problem from a mathematical point of view. In turn, this made it possible to develop an algorithm for solving this problem, which is to use genetic algorithms to solve the existing problem. The developed model and algorithm of territorial community formation are tested. According to the expert group on the TC formation, the resulting solution showed satisfactory results.

Keywords: graph partitioning, genetic algorithm, NP-complete problem, territorial community, settlement.

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