ABSTRACT AND REFERENCES
CONTROL PROCESSES

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DEVELOPMENT OF A METHOD FOR DETERMINING THE AREA OF OPERATION OF UNMANNED VEHICLES FORMATION BY USING THE GRAPH THEORY (p. 4-12)

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The results of research into influence of modification of the topology of a heterogeneous formation of unmanned vehicles on the area, covered by this formation are presented. We proposed an approach, according to which the method for modeling the structure of complex technical systems is applied to describe the behavior of unmanned vehicles' formation. The changes in topology and in the covered area as a result of unmanned vehicles' rearrangement within a formation were considered.

Based on the result of present study, a method for determining the area of unmanned vehicles' formation operation involving the graph theory was proposed. Formation of the loaded directed graphs that correspond to the main (star, ring, bus) and mixed (hierarchical star with a bus, hierarchical star with a ring) formation topologies was considered in detail. The adjacency matrix and the loading matrix for the topology "hierarchical star" were analyzed.

In addition, the study conducted allows us to conclude that to ensure a full coverage of a certain territory, the mathematical model of the structure of a dynamic system must be characterized by a random number of vertices that correspond to a variable number of unmanned vehicle in a formation. Various technical characteristics of unmanned vehicles, which belong to different classes by weight or control type, must be considered into account when constructing the matrix of graph loading. Calculation of the area, covered by an unmanned vehicles' formation, is performed as calculation of the area of polygons, assigned by their vertices, using the interpolation concept to count the intermediate values of magnitudes by a discrete set of known coordinate values. Calculation of the formation area is based on the ranges, within which sustainable communication between the drones of different models is provided.

Partition of the loading matrix into subordination units makes it possible to decrease computational complexity and thereby prolong operation of a formation. Application of this approach will allow us to plan more effectively the time and the number of drones in a formation, necessary for covering the territory of the specified size.

Keywords: unmanned vehicle, heterogeneous formation, loaded directed graph, formation operation area.

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TOOLS FOR FORECASTING AND OPTIMIZING THE TUNING PARAMETER OF THE LOWSPEED ENGINE FOR DESIGNING A SHIP WITH THE KITE (p. 13-20)

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The developed simulation (stochastic) mathematical model for calculating fuel consumption of the main low-speed engine of a transport ship with a kite is proposed. The peculiarity of the model is the use of a number of initial probabilistic quantities such as wave height, wind speed, in the form of inverse integral distribution functions of their values. This makes it possible, using a generator of uniformly distributed pseudo-random numbers, to compute the arrays of possible values of the total fuel consumption of the main engine for the entire future operation and to determine the expected value of consumption. Such a simulation model with a pseudo-random number generator serves as a tool for comparing the fuel consumption of the alternative main engines, differing in the value of the “internal combustion engine – turbocharger” matching parameter. The minimum value of the total fuel consumption corresponds to the optimum value of the matching parameter.

Due to the simulation mathematical model, the influence of the “internal combustion engine – turbocharger” matching parameter on the total fuel consumption for the 25-year operation period of the tanker with a deadweight of 26,470 t is investigated with the help of a computer. Its propulsion is provided by the 6S50ME-C7 engine and SkySails 640 m^2 kite switched if the winds are favorable. It is found that the optimum matching parameter corresponds to a point on the propeller curve of the engine with a load coordinate of 60.5 % of the rated value. This refers to a round transatlantic voyage in the Northern Atlantic, mainly in temperate latitudes, with prevailing westerlies and northeast trade winds. Fuel economy in the liner shipping at speeds of about 13.5 knots for these conditions due to the use of the kite is 21 %, from the optimization of the mentioned parameter 3.4 % and in general 24.4 %. At the price of fuel for ship diesel engines of USD 322/ton, the expected value of fuel consumption reduction for the medium-range tanker for the specified period is USD 2,029.000 or USD 81,000/year.

Keywords: simulation model, low-speed engine, turbocharger, matching point, kite, fuel consumption.

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DEVELOPMENT OF A MULTICRITERIA MODEL FOR MAKING DECISIONS ON THE LOCATION OF SOLID WASTE LANDFILLS (p. 21-30)

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We have developed a structure of the multi-criteria model of decision making related to determine optimal sites for the location of solid waste landfills (using the south of Odessa oblast as an example). A special feature of the model is the integration of GIS and the multi-criteria methods of decision-making. Based on the created raster criteria maps in the GIS geodatabase and expert estimation of the significance of criteria, we ranked alternatives according to the degree of suitability. A multilevel hierarchical decision-making structure includes three groups of criteria: environmental, physical, and socio-economic; it takes into consideration the state building requirements to the construction of SW polygons. Such an approach provides for the acceptability of results of the analysis by most stakeholders.

The simulation is performed for the three scenarios that imply the aggregation of layers of criteria into a combined map of suitability using Boolean logic, fuzzy logic, and a combination of methods of weighted overlay and a fuzzy analysis of hierarchies. To account for the uncertainty of original information and subjectivity in expert assessments, we employed an apparatus of fuzzy logic. Piecewise-linear membership functions of the fuzzy set are proposed for the standardization of criteria. We calculated weights of criteria using a modified method of the analysis of hierarchies, in which we used linguistic variables represented by triangular fuzzy numbers to perform the paired comparison of criteria significance.

The results of the simulation show that the use of operations of a fuzzy intersection or a fuzzy combination in order to aggregate a combined suitability map can lead to errors related to the underestimation or overestimation of alternatives. The most acceptable method is a weighted linear combination, or the operation of fuzzy geometric averaging, in cases when it is difficult or impossible to determine the weight of criteria.

Keywords: solid waste, geoinformation systems, multi-criteria analysis of decisions, fuzzy logic.

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ORGANIZATION OF RESPONSIBILITY ACCOUNTING OF CITY ELECTRIC TRANSPORT ENTERPRISES' ACTIVITY (p. 31-36)

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The problems of organization of responsibility accounting of the city electric transport (CET) enterprises' activity are considered. The industry specifics of the activity of tram and trolleybus enterprises are determined. It is substantiated that the organizational and methodical structure of accounting of the CET enterprises' activity is influenced by factors of the internal and external environment. These include state regulation of the industry, peculiarities in relations with customers, the specific nature of the products and technological peculiarities of structural units.

The mathematical model of quality of service of transport enterprise customers on the basis of the verified resource efficiency indicator is developed.

Such a step will allow linking the rating efficiency of transport routes with the problems of structural optimization when choosing the priorities in the maintenance of vehicles. In addition, the developed model allows evaluating the fulfillment of the route schedule, which will increase the confidence of passengers in city transport and increase passenger traffic.

Thus, the proposed solution allows increasing the efficiency of passenger transport by improving the quality of service within the existing budget.

Keywords: mathematical model of quality, management decisions, transport efficiency, responsibility centers.

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DEVELOPMENT OF THE COMPREHENSIVE METHOD TO MANAGE RISKS IN PROJECTS RELATED TO INFORMATION TECHNOLOGIES (p. 37-43)

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A comprehensive method of project risk management is proposed for the field of information technologies based on the combined application of intelligent and expert methods under unstable conditions and constraints for financial and time resources. The method makes it possible to support making a decision based on the formalized technique of identification and estimation of risks, as well as the choice of the initial set of measures to avoid a risk event. This method was investigated based on the universal academic example of a project in the field of information technologies. The result of application of the comprehensive method of risk management is an improvement in the efficiency of an IT project by reducing losses in the project and overspending of financial resources.

Risk model of an IT project based on the Bayesian network is developed, which is the base of the comprehensive method. A risk model of an IT project based on the Bayesian networks makes it possible to study different scenarios of risk occurrence by the simultaneous consideration of different factors in the external environment and internal state in the IT project, as well as their casual relations. The proposed model will make it possible to represent and estimate a risk probability for all possible scenarios and, accordingly, to develop effective measures for risk elimination.

The proposed structure of the Bayesian network of an IT project risk could become a basis for the information technology of risk management in an IT project and an appropriate decision-making support system.

Keywords: comprehensive method, risk management, Bayesian networks, probability, expert methods, IT project.

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DEVELOPMENT OF KNOWLEDGE-BASED CONTROL SYSTEMS WITH BUILT-IN FUNCTIONS OF RULES VERIFICATION AND CORRECTION (p. 43-50)

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Two improved models of control rules were proposed. A model in a form of AND/OR graph; in contrast to the known graphical model of general rules, is based on dividing the rules into groups based on the controlled object state. The graph contains special markup that allows to convert the graph paths corresponding to the rules into Boolean expressions including formulas for both direct and "inverse" rule sets. The basic formulas of the rules model in a form of Boolean expressions cannot be constructed for general rules and based on these formulas the three methods for verification of the rules were developed:

– the method for verifying the control rules premises for inconsistency based on the SAT problem for Boolean formulas;

– the method for verifying the control rules for completeness based on visualization of both "direct" and "inverse" rules with conclusions in "inverse" rules opposite to the conclusions of the original rules;

– the method for verifying reachability of the object state vertices from the control rules.

The main advantage of these methods is that they allow to find errors in the rules at early stages when specialists in the field for which the knowledge-based system is used (experts and decision makers work with them). The specificity of the control tasks makes it possible to do this effectively from the point of view of analysis and verification of the rule quality. The developed procedure of the control rules verification and correction assists in to bringing together and placing in a correct order various types of verification and correct errors in an automated mode.

Main components were proposed for knowledge-based control systems: the rule editor for knowledge engineers and experts and the control system itself which includes extraction of the controlled object parameters essential for analysis as well as analysis of these parameters and their transfer to a DM for making a decision. A rule editor has been developed and control systems for two domains: safe operation with electric installations and control of computer networks. The presented experimental results on the management of the training process using the developed systems have shown that the number of errors in the created rules was reduced. When verifying for reachability of the object states, errors in an average of 5.4 % control rules were found and removed. When verifying for inconsistency of the rule premises, errors were found and corrected on average in 11.5 % of rules. When verifying for completeness, the rules base was expanded by on average of 12.3 %. In addition, due to consulting, verification and correction of the rules, the time spent by trainees on execution of their work was reduced by an average of 8 %.

Keywords: methods for control rules verification, AND/OR graph, Boolean expressions, knowledge-based systems, learning management.

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APPLICATION OF INFORMATION TECHNOLOGIES FOR THE OPTIMIZATION OF ITINERARY WHEN DELIVERING CARGO BY AUTOMOBILE TRANSPORT (p. 51-59)

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We have proven the applicability of modern tools of information technologies to solve a traveling salesman problem using a combinatorial method and a transport problem, which is stated in the form of a road transport network, by the simplex method. The obtained results of solving these problems were employed when making up the optimum itinerary of cargo delivery along international routes. The methods proposed could solve transportation problems of any dimensionality, both balanced and non-balanced in terms of cargo transportation volumes.

Advantageous geographical position of Ukraine and the existence of strong transportation infrastructure is an important basis to form robust economy of Ukraine. The potential of Ukraine in the international market of transportation services is estimated rather high by experts. Based on the Logistics Performance Index, calculated by the World Bank, Ukraine ranks 61, which is the best indicator among all CIS countries. Development of optimal itinerary of cargo delivery along international routes is predetermined by several factors, the main among them being the high cost of transportation services and tough competition between domestic and foreign freight carriers.

The application of information technologies in transportation services opens up new prospects for improving the efficiency of freight transportation. Optimization of cargo delivery schemes is one of the key tasks of transport logistics. Combined use of the described methods for solving open network transportation problems, specifically a method of finding the shortest routes in a road transport network and methods for reducing the unbalanced cargo transportation to the balanced form, makes it possible to obtain considerable synergistical, economical, and organizational-technological effects.

Keywords: road transport network, traveling salesman problem, combinatorial technique, transport problem, simplex method.

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DEVELOPMENT OF METHOD OF MULTIFACTOR CLASSIFICATION OF TRANSPORT AND LOGISTIC PROCESSES (p. 60-78)

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A method of classification of a set of objects and/or processes in transport and logistics systems on the basis of a multifactor analysis was proposed.

Combination of the methods of statistical and factor analysis, the systems hierarchy analysis method and modern methods of logistic analysis has enabled formation of a complex classification model. A three-stage algorithm was proposed for solving multifactor problems of classification in the fields of transport and logistics and the theory of organization of cargo transportation. At the first stage, the factor influence is investigated based on the chosen criterion. At the second stage, a comprehensive analytical indicator is created that characterizes the influence of factors on the objects under study and is based on the systemic hierarchy analysis method. The use of the hierarchy analysis method enables both use of factual data based on a thorough statistical analysis and involvement of experts in solving multifactorial decision-making problems. The use of modern logistic analysis methods in the third stage makes it possible to reasonably divide classification objects in the transport and logistics systems among various numbers of dynamic classes. At this stage, it is also possible to involve experts in the formation of boundaries of classes. The model was implemented using the Symbolic Computing Package in the Maple-7 and the Microsoft Excel environments.

Classification of Ukraine's trading partner countries by indicators of international turnover of certain groups of goods which can be transported in universal containers according to the Ukrainian foreign economic activity classifier (UFEAC) was made. Through simulation, the set of partner countries in foreign trade was divided into three classes. Classification of Ukraine's partner countries by indicators of international turnover of certain groups of goods which can be transported in universal containers in accordance with the Ukraine's foreign economic activity classifier (UFEAC) has allowed us to divide a set of partner countries in foreign trade into three classes. The classification results are in good agreement with the classic ABC analysis. Classification of countries by the criterion of specific value of goods flows has allowed us to divide the set of countries under study into two classes. This is explained by the fact that classification was made for a set of all partner countries in the first example and twenty countries with the largest turnover were previously selected in the second example.

Application of the proposed method of multifactor classification ensures dividing the objects of classification, in general, among different numbers of groups. At the same time, the boundaries of dynamic classes which are formed on the basis of a comprehensive assessment of the factor influence and depend on the concrete formulation of the problem and the criteria taken into account.

The proposed classification method can be used in transport, logistics, customs and brokerage enterprises, as it allows for planning and controlling supply of goods to varying degrees of detail and apply appropriate strategies.

Further development and improvement of this study is possible in the direction of using intelligent systems and algorithms to solve problems of multifactor analysis of transport and logistics systems.

Keywords: classification of transport and logistics processes, multifactor analysis, freight traffic, customs statistics, logistic analysis.

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