Automated Systems & Technologies
25-26 May 2015 • St. Petersburg, Russia

METHODOLOGY AND TECHNIC OF INTELLIGENT INTEGRATED DECISION SUPPORT SYSTEMS DEVELOPMENT FOR TERRITORY MANAGEMENT

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Abstract

The general structure of an Integrated Intelligent Decision Support Systems (IIDSS) was presented for a wide range of tasks for territory management. The proposed architecture of an IIDSS allows: 1) to execute all developed software modules with incompatible runtime requirements under various virtual machines within a single hardware server to overcome the problems of heterogeneity on one hand, and the convenience of deploying an IIDSS on the other; 2) to provide an interaction between modules through network communication, taking into account the prospects for further development of the IIDSS towards geographically distributed architectures. We propose to create a software “wrapper” that consolidates a private system for input-output of each module as a standardized data exchange interface. There are advantages of using the intelligent technology for support: 1) use a combination of quantitative and qualitative(fuzzy) information about the management effectiveness of the territory, which will significantly improve the quality of decisions and conclusions; 2) formalization of expert information provided to the expert in a natural language by introducing linguistic variables, which allow an adequate display of the approximate verbal description of objects and phenomena; 3) the proposed method in a fuzzy environment with a synthesized theory of experiments design, and a fuzzy-logic linguistic description of statements. The proposed method minimizes the

number of calls to the expert sand takes into account the complex non-linear nature of the influence of efficiency indicators on a Objects (CO) indicator.

INTRODUCTION

At present, the central role in ensuring the necessary quality control of Complex Objects (CO) of natural and artificial origin belongs to the Integrated Intelligent Decision Support Systems (IIDSS) and the kernel which is Special Mathematical Software (SMS) for decision making [13,17,19].

An IIDSS is required for informational, methodical and instrumental support for the decision-training and decision-making processes in all stages of management. The purpose of the introduction of an IIDSS is to improve the efficiency and quality of functional and management activities through the use of advanced intelligent information technologies, formation of complex analytical information and knowledge, to allow us to develop and make informed decisions in a dynamically changing environment. In the paper we propose a fuzzy-possibilistic approach; an approach using fuzzy logic methods and a theory of experiment design [14,34,35] for solutions of territory management and assessment of the effectiveness of territory management problems.

METHODOLOGY BASIS OF INTELLIGENT INTEGRATED DECISION SUPPORT SYSTEM FOR TERRITORY MANAGEMENT

During the design phase of an IIDSS it is important to quantitatively and qualitatively analyze the effectiveness of the relevant control technology. At the same time, management will focus on the concept of proactive monitoring and management of the structural dynamics of complex objects (CO). The proactive monitoring and management of the structural dynamics of the CO is the processes of assessment, analysis and control of the current multi-structural macro-states of those objects, as well as the formation and implementation of control actions to ensure the transition from the current CO to a synthesized multi-structural macro-state [10,12-14,22]. Proactive management of a CO, in contrast to the reactive control of a CO that is traditionally used in practice, is based upon a rapid response and subsequent prevention of incidents by the creation of innovative predictive and proactive capabilities in the formulation and implementation of control actions in the existing monitoring and management system. Proactive management of a CO also relies on the methodology and technology of complex modelling, which involves a multi-domain description of the study, the combined use of methods, algorithms and techniques of multi-criteria evaluation, and analysis and selection of preferential solutions.

With regard to management of the previously mentioned environmental systems, the following observations about the components of the corresponding vector performance of proactive monitoring and management can be realized. The structure of this vector includes [24]: 1) a generalized qualitative indicator of the natural territory system with a special indicator for forests bonitet?; 2) a generalized quantitative indicator of the lake; 3) a quantitative assessment of the quality of the agricultural field.

Economic estimates can also be considered, such as the cadastral value of the territory, economic benefits from forest management, agricultural field management, water resources management, and the costs of liquidation of ecological disturbances.

Indicators for assessments for cost of resources are important and are special indicators of the AMS. Some of these indicators include the cost of developing hardware and software for the system; the value of the primary flow of informational materials and the results of ground measurements; the cost of training staff; and others. The private indicators for quality management areas include time-cycle operations and the maximum frequency of operation of the system; time required to bring the system into operation; time required for the structural and algorithmic adaptation of operations, and so on.

The most important step when estimating the effectiveness of territory management is the construction stage of the generalized indicator for quality control. At present, a wide variety of methods for solving multi-criteria evaluation of the efficiency of a CO have been developed [1,3-4,8-19,29-35]. These tasks are usually performed as a form of convolution for private assessments, integrated to a scalar characteristic of quality. We refer to these methods: constructing an additive convolution multiplicative convolution functions of distance, the minimum function, and so on.

One of the main drawbacks of the convolution of vector indices is ignoring the possibility of mutual compensation of assessments by functions with different criteria. Key features and relevant issues related to the solution of problems of multi-criteria evaluation, tend to have a computational and conceptual character. Additional information from the decision maker (the expert) is needed for a correct solution to the construction of a convolution.

Depending on the specific problem of estimating the efficiency of a CO, the private parameters are usually a non-linear influence on each other and on the whole integral indicator. On the other hand, the calculation of the resulting figure allows us to determine that the efficiency of the layer is complicated by inaccurate and illegible interval values of private indicators (in the general case, private indicators are defined by the linguistic variables). For the solutions to these problems of territory management and assessment of the effectiveness of territory management, we propose a fuzzy-possibilistic approach; an approach using fuzzy logic methods and a theory of experiment design [14,34,35].

From the perspective of a *fuzzy-possibilistic approach***,** the private indicators efficiency of the layer can be represented in the form of fuzzy events. Then, the task of estimating the efficiency of the CO is to construct the integral index, which is an operation on the fuzzy events with private indicators and their impact on the assessment of the CO's effectiveness.

To take into account the non-linear nature of the impact of these private indicators of the management areas f_i on the effectiveness of the generalized index of the CO, as well as a fuzzy-possibilistic approach of private indicators, we propose the construction of a generalized index using fuzzy-possibilistic convolution. Fuzzy-possibilistic convolution is based on fuzzy measures and fuzzy integrals, and allows us the flexibility to take into account the non-linear nature of the influence of private indicators. The method of multi-criteria evaluation of the efficiency of a CO consists of the following steps [14]:

Step 1: Construction of the evaluation function for different subsets of indicators of the CO by normalizing private fuzzy indicators.

Step 2: Conduction of an expert survey to find the coefficients of the importance of individual indicators.

Step 3: Construction of fuzzy measures (Sugeno λ-measures), which characterize the importance of the various subsets of the CO.

Step 4: Calculation of the integral indicator of the efficiency of the CO based on fuzzy convolution of private indicators using a fuzzy integral evaluation function from subsets of indicators from fuzzy measures.

If the *coefficients of efficiency* of a CO is given by *linguistic variables* (LV) the scale of linguistic assessments should be mentioned with the importance of the criteria and with the method of information convolution. To implement this approach, we propose a combined method for solving the problem of multi-criteria evaluation of the efficiency of a CO using the fuzzy method, and a theory of experiment planning for the flexible convolution of indicators.

The efficiency of a CO is an estimated set of indicators, or linguistic variables. A set of several indicators with the corresponding values of the terms of the decision-maker's view, characterizes the resulting indices expressing a general view of the CO's performance. LV-knowledge, in general terms, can be represented by production rules.

To construct the integral indicator it is necessary to translate the values of each parameter to a single scale [-1, 1]. The extreme values of the linguistic variable's ordinal scale are marked as -1 and +1, the point of "0" corresponds to the linguistic definition of the middle of the scale, according to the physical meaning of this indicator.

In accordance to the theory of experiment planning, to build the convolution matrix of indicators it is necessary to build an expert survey of extreme values of particular indicators that reflect the expert opinion in the form of production models (e.g. If indicator 1 is set to "high", indicator 2 is set to "low", ...indicator n has a value of "low", then the integral indicator is rated as "below average").

To determine the coefficients of the importance of the convolution of indicators, taking into account the impact of both individual performance and the impact of sets of two, three, and so on, indicators, an orthogonal expert survey plan is formed. The polynomial coefficients are calculated according to the rules adopted in the theory of experimental planning. Averaged scalar multiplications of the respective columns of the orthogonal matrix and vector values of the resulting indicator are calculated.

THE SIMULATION SYSTEM STRUCTURE OF INTEGRATED INTELLIGENT DECISION SUPPORT

One of the main subsystem of IIDSS is the simulation system (SiS) which permits to organize integrated modeling of CO. We propose the possible shim of SiS. The multiple-model description of CO structure-dynamics control processes is the base of comprehensive simulation technologies and of simulation systems. We assume the simulation system to be a specially organized complex. This complex consists of the following elements: simulation models (the hierarchy of models); analytical models (the hierarchy of models) for a simplified (aggregated) description of objects being studied; informational subsystem that is a system of data bases (known ledge bases); control-and-coordination system for interrelation and joint use of previous elements and interaction with the user (decision-maker).

The components of the simulation system were the main parts of the developed program prototypes during our investigation. The processes of CO structure-dynamics control are hierarchical, multi-stage and multi-task ones. The structure of simulation system (SIS) models conforms the features of control processes. There are three groups of models in SIS: models of CO CS and OS functioning (subsystem I of SIS); models of evaluation (observation) and analysis of structural states and CO CS structure-dynamics (subsystem II of SIS); decision-making models for control processes in CO CS (subsystem III of SIS).

SiS includes also the system of control, coordination and interpretation containing user interface and general control subsystem, local systems of control and coordination, subsystem of data processing, analysis, and interpretation for planning, control and modeling, subsystem of modeling scenarios formalization, subsystem of software parametric and structural adaptation, subsystem of recommendations producing for decision-making and modeling.

The data-ware includes data bases for CO states, for CO CS states and general situation, for SO states, and data bases for analytical and simulation models of decision-making and of CO CS functioning.

The main feature of comprehensive modeling is the coordination of different models constructed via formal or non-formal decomposition of tasks. Various approaches, methods, algorithms and procedures of coordinated choice through complexes of heterogeneous models are developed by now [7, 8].

CONCLUSION

The general structure of an Integrated Intelligent Decision Support Systems (IIDSS) and SiS were presented for a wide range of tasks for territory management. The proposed architecture of an IIDSS allows: 1) to execute all developed software modules with incompatible runtime requirements under various virtual machines within a single hardware server to overcome the problems of heterogeneity on one hand, and the convenience of deploying an

IIDSS on the other; 2) to provide an interaction between modules through network communication, taking into account the prospects for further development of the IIDSS towards geographically distributed architectures. We propose to create a software “wrapper” that consolidates a private system for input-output of each module as a standardized data exchange interface. There are advantages of using the intelligent technology for support: 1) use a combination of quantitative and qualitative(fuzzy) information about the management effectiveness of the territory, which will significantly improve the quality of decisions and conclusions; 2) formalization of expert information provided to the expert in a natural language by introducing linguistic variables, which allow an adequate display of the approximate verbal description of objects and phenomena, even in cases where there is no deterministic description; 3) the proposed method in a fuzzy environment with a synthesized theory of experiments design, and a fuzzy-logic linguistic description of statements, allows us to carry out the formalization of a constructive level of expert experience(an expert group) in the form of predictive models in a multidimensional space of linguistic performance. The proposed method minimizes the number of calls to the expert sand takes into account the complex non-linear nature of the influence of efficiency indicators on a Objects (CO) indicator.

ACKNOWLEDGMENTS

The research is partially supported by the Russian Foundation for Basic Research (grants 13-07-00279, 13-08-00702, 13-08-01250, 13-06-00877, 13-07-12120-ofi-m, 15-29-01294-ofi-m, 15-07-08391, 15-08-08459); grant 074-U01 supported by Government of Russian Federation; Program “5-100-2020” supported by Government of Russian Federation, Department of nanotechnologies and information technologies of the RAS (project 2.11); by the Ministry of Education, Youth and Sports of CR within the National Sustainability Program I (NPU I) (grant number LO1415); by ESTLATRUS projects 1.2./ELRI-121/2011/13 «Baltic ICT Platform» and 2.1/ELRI-184/2011/14 «Integrated Intelligent Platform for Monitoring the Cross-Border Natural-Technological Systems».

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