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Approaches to the Solution of Tasks on Decision Support by Managing the Environmental Safety of the Local Urban Areas

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Abstract: The study presents approaches to designing of the Automated Control Systems (ACS) for management of the environmental safety of the local urban areas (the natural environment of which has a significant effect on the human health and activities). The operation of such ACSs is based on the synthesis of the intelligent environmental monitoring and intelligent support of the decision-making process. There have been proposed the structural model of the ACS subsystem implementing the functions of the decision support and the method of performing the integrated (complex) assessment of the existing and forecast environmental situation on the territories under consideration. The implementation of such ACSs will promote to the development of the modern cities based on the principles of biospheric compatibility, increase in the efficiency of managerial decisions in the area of environmental safety and as a result to the improvement of the human life quality.

Key words: Automated control system, environmental safety of the local urban areas, environmental monitoring, data mining, integrated assessment

INTRODUCTION

The most important component of the national security of any modern state is the environmental safety of its territories. Particular emphasis should be made on the local urban areas the natural environment of which has a significant effect on the human health and activities.

Today there is no such a country where the due regard is not paid to the environmental issues. One of the principal directions: an active measure is the designing of the effective systems for the environmental safety monitoring and management the operation of which is based on the wide use of the automation tools and information technologies methods. However, even on the territories where such systems with the extensive network of the observing stations run using the geoinformational and aerospace technologies simulating the spreading of contamination no fundamental improvement of the environmental conditions is observed. Let's specify the causes that in researcher's opinion, impair their performance:

- In these systems the issues of the data collection, processing, storage and transmission, environmental data visualization are solved to the fullest extent possible while the decision support issues are solved piecewise only. It is needed to provide the adequate forecasts, construction of the information and situational models and what is of utmost importance to enable the direct transformation of the environmental monitoring data to the management scenarios (with the further evaluation and guidelines on the implementation thereof)
- The integrated (complex) assessment of the environmental situation as a whole is not performed. The models and methods used allow evaluating the changing of the particular environmental components only. This significantly affects the correctness of the selection and stability of the controlling action since the implementation of the same measure may improve the quality of one natural constituent while impairing the others
- Both the software and calculation tools are almost not used for assessment and forecasting of the environmental situation within the above-mentioned local urban areas

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The tasks are complicated by the complexity and high dynamics of interaction of the natural objects and man-made facilities, a faint possibility of formalization thereof, substantial spatial distribution of the items under monitoring and management entities.

A great number of the research works and practical studies allow solving issues in the area of the environmental safety management (development of methods, models and algorithms for estimates, forecasts, optimization, etc.) (Navas *et al*., 2012; Wainwright *et al*., 2007; Njemanze, 2002; Rochelle-Newall *et al*., 2007; Rios-Insua *et al*., 2006; Sokolov and Panarin, 2005; Zhang *et al*., 2011). However, the tasks assigned above have not been solved yet.

PROCEDURE

Researchers have set the task to simulate the Automated Control System for Environmental Safety management (ACS ES) to be applied within the local urban areas. The key requirement is supporting and implementing the objective, highly-effective (in terms of promptness, environmental and economic efficiency, resistance to the environment dynamics) managerial decisions. The main principles of construction of such ACS: priority of the human life and health over the other economic and social targets; model universality, completeness and adequacy of the data analyzed; system adaptability and mobility; detection of the cause-and-effect relationships; rapid making of managerial decisions; scientific validity (rational combination of the environmental and economic interests of the area based on the scientific research).

MAIN PART

The implementation of the system satisfying the specified requirements and construction principles can be performed on the basis of the approaches described by Ivashchuk and Konstantinov (2013) and Ivashchuk and Ivashchuk (2013). However, some fundamental changes have been introduced. Thus, in the proposed ACS ES Model for the local urban areas the environmental monitoring subsystem is an integral part of the system of intelligent decision-making support (SIPPR). The operation thereof is related not only to the collection of data but also to the mandatory analysis thereof for the purpose of transformation to the particular management scenarios.

Figure 1 represents the structural model of SIPPR (continuous arrows-interaction between the subsystems and other ACS components, dotted arrow-environmental

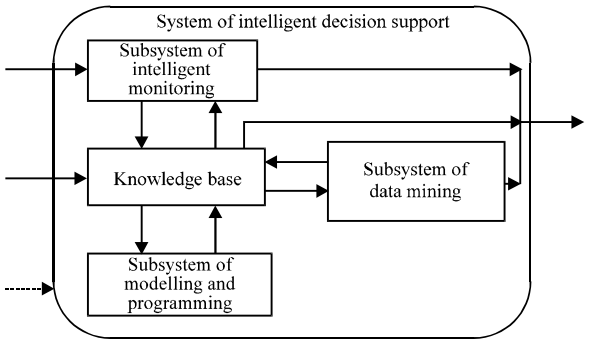

Fig. 1: SIPPR Structural Model

effect). According to the above mentioned, it includes: the intelligent monitoring subsystem (automated data collection and preprocessing; parameter estimation, integrated estimation of the established environmental situation; forecasting the changing thereof without implementing the controlling actions); knowledge base (accumulation and storage of data and models; establishing rules of the use of such data and models); subsystem of modelling and programming (building the mathematical, informational, situational models; development of the computer programs); subsystem of data mining (forecasting the development of the ecological situation upon implementation of controlling actions; integrated estimation; evaluation of effectiveness of the controlling actions; drawing up recommendations).

Particular emphasis should be put on the fact that a SIPPR features the functions of the integrated (complex) analysis of the ecological situation (both of the existing and forecast one). On the basis of analysis of the regulatory documents as well as results of interviewing of experts in the subject area, the parameters affecting the ecological situation within the local urban areas have been divided into two main groups. The first one includes the pollution index for example, concentration of pollutants in the atmosphere, the level of noise and electromagnetic fields, etc., the second one parameters determined by the regional infrastructure for example: the greening rate, insolation, street and road network specifications, etc.

The integrated (complex) analysis of the ecological situation is suggested to be performed in two stages. At the first one the similar integrated analysis is performed inside of each group of the specified parameters as the result: assessment of the environmental condition on the area under consideration and assessment of infrastructure in the context of the environmental safety. At the second stage the comprehensive assessment of the ecological situation (whether existing or forecast one) as a whole is

performed. In order to draw a conclusion at each stage the fuzzy logic tools are used. For the purpose of implementation of such approach the relevant models have been designed the solution of which is synthesized on the basis of the knowledge elements derived by performance of the experimental or model assessment of the quality indices of particular environmental parameters and regional infrastructure. The ecological situation is described by linguistic variable {EcSit, T, ES, G, H} where, T is the reference therm-set with the values: "normal", "troubling", "threatening", "critical", G is the rules allowing generating such values as "not dangerous", "very dangerous", "troubling or threatening", etc., H is mathematical rules determining the type of the membership function for each value formed with the use of G; EcSit is the composite linguistic variable:

$$EcSit = (ES_1, ES_2)$$

Where:

ES_1 = A linguistic variable describing the state of the natural environment

ES_2 = Linguistic variable describing the infrastructure of the local urban area with regard to the environmental safety

ES_1 and ES_2, in their turn, are composite ones:

$$ES_1 = (ES_{1j}),\ j = 1,\ldots, J$$

where, $ES_{1j}$is the "air pollution", "noise emission", «action of the alternating magnetic fields", etc.:

$$ES_2 = (ES_{2k}),\ k = 1,\ldots, K$$

where, ES_{2k} is the "insolation", "greening", etc.

The combinations of elements of these variables implemented on the basis of the specially developed rules ensure the synthesized model output.

Designing of the management scenarios aimed at reduction and prevention of environmental risks will be based on the results of synthetic assessment in particular.

SUMMARY

There has been developed the relevant software product and a user-friendly interface that makes it possible for an expert in the subject area without modeling and programming skills to make a rapid assessment of the current and/or forecast ecological situation.

CONCLUSION

Thus, the approaches to the design and organization of operation of the ACS ES for the local urban areas have been presented that will enable the effective solution of such tasks as increase in the environmental monitoring performance and the direct transformation of the outputs into managerial decisions by means of the real time data mining which includes the integrated analysis of the ecological situation.

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