Situational Center as an Intelligent Decision Support System Taking into Account the Uncertainty of the Source Information*

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Abstract. The article presents the structure of intelligent decision support systems based on situational center. The structural and functional diagram of the situational center is given, the module for accounting for uncertainty is supplemented. The intellectual subsystem of the situational center is described and the conclusion is done on the applicability of integrated software that allows solving various problems based on different sources of information, taking into account uncertainty. The block diagram of the algorithm for accounting for the uncertainty of the initial information is presented, for which it is necessary to calculate the following sample parameters: size, noise, and outliers, stationarity, type of distribution law. To implement such an algorithm, a software module was designed in the Python programming language, the results of the module are used in all subsystems of the intelligent situational center.

Keywords: situational center, intelligent decision support systems, the uncertainty of source information, software.

1 Introduction

The solution of applied problems requires the improvement of existing approaches to information and analytical support of management activities and the necessity for methodical software and hardware tools. An effective form of information and analytical systems that combining these tools are situational centers (SC), which are increasingly used as a tool to support management activities.

Situational centers, unlike traditional systems of automation of management, enable in real-time not only to provide the most complete and operatively information on the current and retrospective situation but also to calculate and analyze the consequences of management decisions [1, 2]. The traditional tasks standing before the situation center include the following:

- prediction of the state of the control object;
- modeling the consequences of management decisions;
- the solution of management tasks taking into account the constant change in the types of interaction with the external environment;
- the decision of administrative tasks at changing target functions and features of the object.

2 Theoretical part

To solve these problems, it is necessary to include in the SC a separate of relevant subsystems for monitoring, modeling, planning and forecasting, and decision-making. [3]. The structural-functional scheme of the SC is shown in Fig. 1.

A great place in the work of the situational center is occupied by solving tasks related to monitoring, analysis, and assessment of the situation:

- monitoring information of various formats, heterogeneous and fragmented in composition;
- operative tracking of a single information space, in which all the main services of the situational center work;
- control and operational impact based on timely information;
- identification of a set of factors that have the greatest impact on the development of the problem. [4]

The planning process at the Situation Center provides the optimal allocation of resources to achieve the set goals, to develop and define a system of quantitative and qualitative indicators to assist the selection of the most favorable ways to achieve the goals.

The following items relate to planning tasks within a situational center:

- the formulation and definition of a system of indicators that influencing the problematic situation or the decision process as a whole;
- justification of the indicators of the proposed strategies, goals, and tasks, which are planned in the coming period;
- definition of the requirement, planning of volumes, and structure of necessary resources[5].

The process of forecasting the development of facilities in various situations is an integral part of the work of any large system that is part of the situation centers, both state and commercial organizations. So, there arises the problem of choosing an acceptable control for large objects with a large number of significant parameters and connections between them. The main tasks to be solved in the forecasting process are the following:

- predicting indicators of different purposes and formats;

- formation of integrated integral estimates;
- fulfillment of target forecast calculations taking into account various parameters;
- justification of significance and assessment of the attainability of development goals [6, 7].

In the decision-making process, the main goal of the functioning of the situational center is to solve the set problem under conditions of uncertainty and heterogeneity of the information, and the following main tasks are considered:

- complex solution of the problem based on formal and informal decision support methods;
- generation of maximum possible solutions;
- selection, quantitative and qualitative evaluation of performance criteria;
- selection and optimization of the solution. [8, 9]

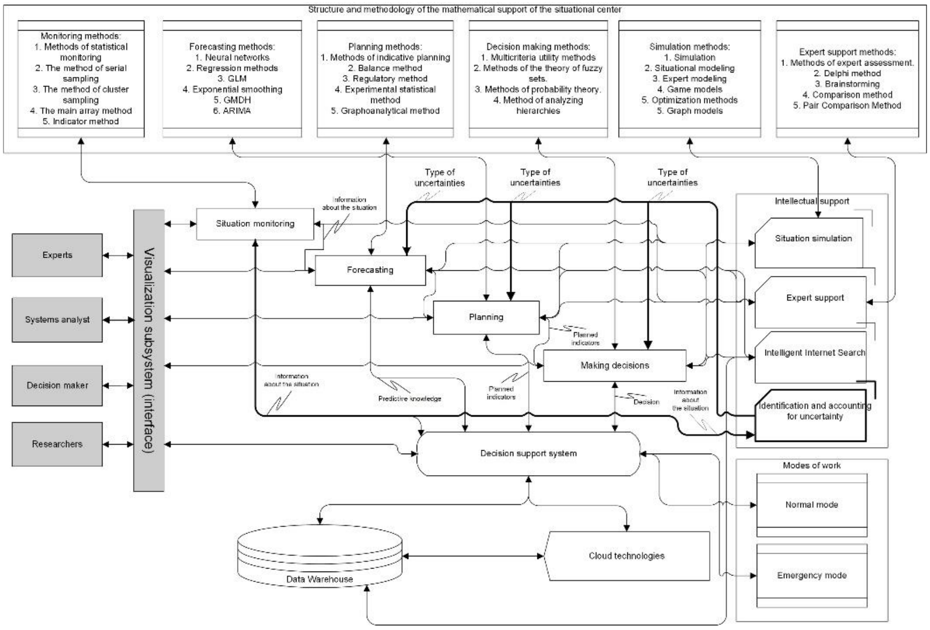

Fig. 1. Structural-functional diagram of the situational center

The Decision Support System is the basis for the functioning of the Situation Center, which allows automating the process of making management decisions to improve the efficiency and harmonization of information among participants in the decision-making process, and information, analytical and instrumental support to the decision-making processes of managers in the formation of management impacts.

These subsystems realize the solution of the tasks standing before the situational center. However, in addition to them, it is necessary to include information subsystems supporting the integration of software and hardware into the SO structure.

The situation center provides an opportunity to quickly respond to emerging problems and situations. At the same time, depending on the functions and tasks facing the SC, three operating modes can be distinguished: normal (development of scenarios for the development and functioning of the system), planning (allows you to find hidden cause-effect relationships of processes, predict), crisis (necessary for making decisions in complex or emergencies).

The analysis of literature sources allows us to correlate the operating modes of the situational center and its functions (table 1) [10, 11].

From Table 1 it can be seen that the forecasting problem is solved in each mode of operation of the situational center. The decision-maker uses the information obtained as a result to form effective decisions. A large number of different algorithms are used for forecasting, which must be selected depending on the operating mode of the SC, the degree of uncertainty of the source information, the requirements for the forecast and input data.

Table 1. SC FUNCTIONS IN DIFFERENT OPERATING MODES

Operating mode	Functions	Notes
Normal	• Simulation scenarios. • Collection and analysis of necessary information. • Final decision report.	There is no emphasis on achieving any goal. The situation is processed normally. The main limitation is the correctness of decisions by the decision-maker.
Planning	• Identification of hidden causal relationships of processes and phenomena. • Modeling various situations. • Prediction of the situation.	Used to effectively support pre-defined scenarios. The algorithms of planning, forecasting, information-reference interaction are actively used.
Crisis	• Analysis of the structure, parameters, and possible directions of development of crises. • Elimination of crises. • Crisis management with third-party resources.	Algorithms should provide the minimum time required to respond to a situation. The preliminary preparation of information is small, the composition and set of information are determined in the decision-making process. Information may be inaccurate, unreliable.

Forecasting is one of the basic functions of the SC. The decision-maker relies on the forecast to form effective solutions, which allows us to speak about the importance of this task. To implement it, a large number of different algorithms are used, including intellectual ones. The choice of a specific algorithm for solving this problem is required to be performed depending on the operating mode of the SC, the degree of uncertainty of the source information, the forecast requirements, and the input data. The prediction algorithms can be implemented as separate program modules. However, for the successful solution of the tasks in the SC it makes sense to implement a single module, in which it is possible to connect submodules that implement one or another algorithm. These submodules must be connected and used as needed and depending on the requirements of the decision-maker, the input data, the mode of operation of the situational center. Also, the existence of a single forecasting unit makes it possible to establish the process of transferring data to other modules, this is achieved through a single data format and processing of information.

A preliminary analysis of the available information is necessary during the operation of the SC to determine the type and degree of uncertainty present in it, to apply methods for its accounting and minimization. The need to account for uncertainty is justified by the following facts:

- study of poorly structured systems that use both quantitative and qualitative characteristics, with the latter prevailing;
- system management is carried out with incomplete, insufficient knowledge about the state and influence of the environment on the system, especially with large investments of resources;
- the presence of isolated or conflicting subsystems, while the search for a solution can be reduced to finding some compromise;
- when managing complex systems, it is more rational to generate proactive solutions than corrective ones.

Work with information is carried out at all stages of the SC. The operation of the subsystems of the SC is based on the work with data of different origin and structure. In this connection, the issue of storing heterogeneous sources of information used for analysis and decision-making is actual. To do this, we use a universal data warehouse, which allows us to combine a large number of information resources using both standard databases, and with the help of new cloud technologies.

To implement such an analysis, a methodology for accounting for the uncertainty of the initial information was proposed in [12-15], which can be implemented as a separate software module in the SC. The result of his work is the identified type of system uncertainty. The proposed methodology can be used in the subsystems of planning, forecasting, and decision making. The inclusion of such a module in the structure of the SC will take into account the specifics of the source data about the system under study, as well as automate the process of selecting the optimal mathematical methods for forecasting, modeling, and decision making. In particular, the proposed approach allows us to consider the forecasting process as an iterative procedure for reducing uncertainty in the decision-making management process.

From the point of view of the system approach, the decision-making process does not depend on the area in which the decision is made. At the same time, it is necessary to provide maximum support for monitoring, forecasting, planning, and decision-making processes from the point of view of mathematical methods capable of providing intellectualization of the stages of functioning of the situational center. For this purpose, a methodology for organizing and using mathematical methods and algorithms for rapid and effective analysis and solution search has been developed for the situational center [16]. It is based on accounting for the uncertainty of the available input information, the identification algorithm is presented in Fig. 2.

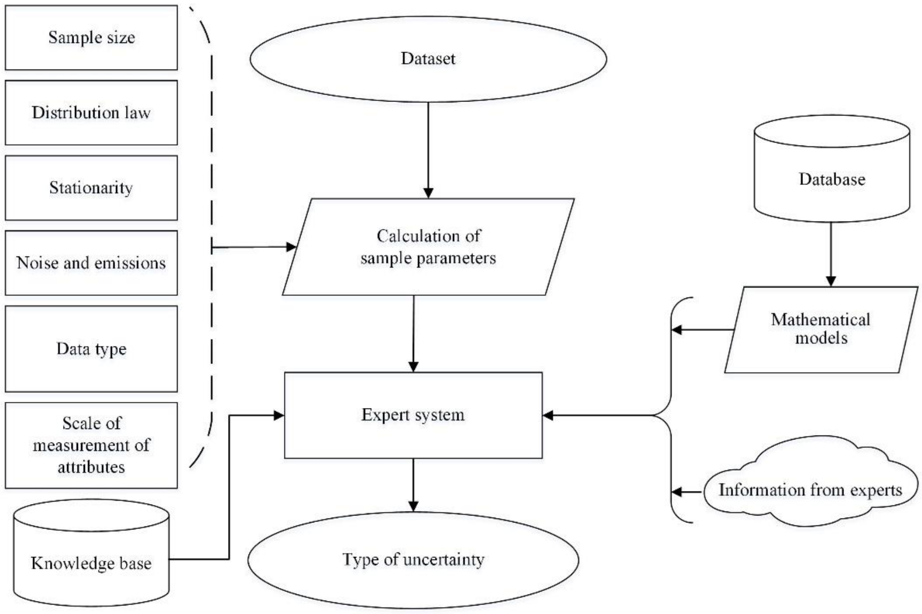

Fig. 2. Algorithm for identifying the type of uncertainty of the source information

The input receives a data sample characterizing this system. Then, the main sampling parameters are determined: sample size, data type (quantitative and qualitative data), the presence of noise and outliers, the scale of measurement of attributes, the type of distribution law, and the stationarity of the process. The calculated indicators, initial assumptions about the type of uncertainty present, information from experts, and previously saved models go to the input of the expert system, which concludes the type of uncertainty of the system. The expert system operates based on production rules. For example:

- in the conditions of a small sample, the accuracy and reliability when using deterministic and stochastic models will be small, which allows us to speak about the unsatisfactory quality of these models. Thus, with a small number of measurements, it is advisable to involve experts and use the fuzzy logic apparatus or use several mathematical methods of sample propagation (bootstrap methods).
- in the presence of qualitative or categorical data, it becomes difficult to use the traditional statistical apparatus for processing samples. In this case, you can use the fuzzy logic apparatus, namely, working with linguistic variables, neural networks to process the natural language, or recoding features (replacing with some numerical designation) [17, 18].

- in case of difficulty in determining the distribution law, stochastic methods are not applicable, due to inadequacy. To resolve this problem, there are several methods for approximating known distribution laws.
- under conditions of a nonstationary series, stochastic models do not process the presence of a relationship in the residuals of a series, which suggests that it is impossible to use, for example, a method such as the least squares method. In this case, preference should be given to fuzzy models and algorithms, for example, a fuzzy least-squares method.

The module is based on an algorithm that allows you to evaluate and determine the set of parameters of the source information, prepare data for further processing in an expert system that selects the most suitable type of uncertainty.

3 Practical part

The obtained type of uncertainty allows us to assume the preferred form of the mathematical model for describing the system; for this, it can be used both previously stored information and additional information about the problem received from the decision-maker.

The structural diagram of a software module for identifying and accounting for the uncertainty of the source information, taking into account the technologies used, is presented in Fig. 3.

Within this scheme, the following structural blocks can be noted:

- Sampling. In this block, a selection is obtained with information about the situation, object, or phenomenon. Data can come from various sources - from the user, from the Internet, etc. For their initial processing, external monitoring tools and intelligent search can be used.
- Interface. This unit can interact with the user through a graphical user interface (GUI), and an external application through standard data types. It should also be noted that it is necessary to provide for the functioning of the system in two modes:
  - Via the Internet. For this, in the Python programming language, there is a Django web framework. This framework is free and uses the Model-Presentation-Controller (MVC) design pattern, and allows to build a system from separate, plug-in modules.
  - In the form of an application program (native application), which is designed for a specific operating system. To create a GUI in this case, it is advisable to use PyQt. This solution has a large number of ready-made elements for creating a graphical interface, supports rapid prototyping tools.
- Data preparation. In this block, the input sample is read and converted to the internal data format. Here, the basic processes for sorting data, their initial processing are carried out. Numeric tables are also manipulated. For this, the Pandas library was chosen - a library in the Python programming language for processing input data. It provides the ability to interact with multidimensional structured data in CSV format.

There is the possibility of obtaining data slices (work not with the entire sample, but with its part).

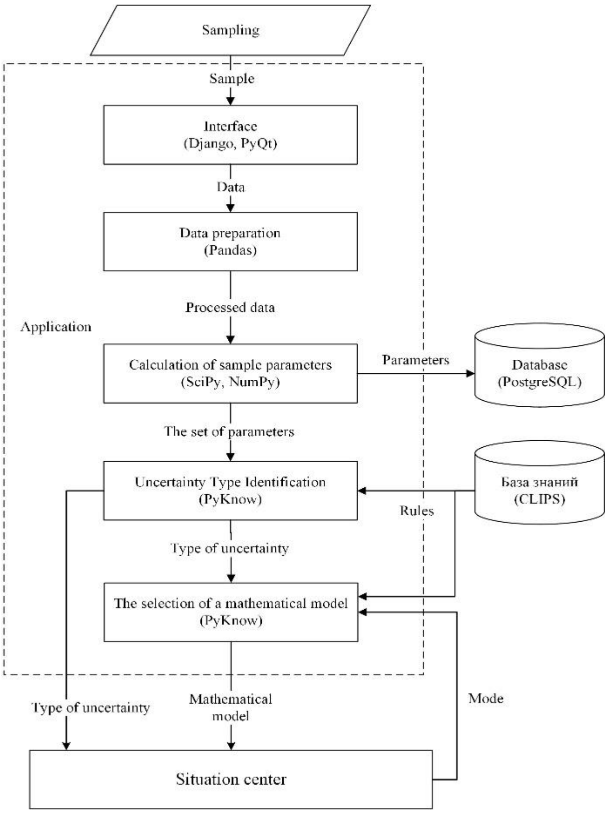

Fig. 3. Structural diagram of the module for identifying and accounting for the uncertainty of the source information

- In the unit for calculating the characteristics, the main parameters characterizing the uncertainty are determined: size, availability of qualitative data and dates, determination of the law of distribution of a random variable, identification of noise and emissions, calculation of the scale and scales of numerical data, as well as the determination of the stationarity of the process. The following libraries of the Python programming language were used to carry out these mathematical calculations: NumPy (for working with matrices and arrays) and SciPy (for basic mathematical calculations)[19]. The calculated characteristics are an array of parameters that characterizes the input data array. The generated array can be stored in the database for reuse. As a DBMS, a free object-relational database management system PostgreSQL was chosen. This DBMS is freely distributed and supports a large number of data formats.
- Identification of the type of uncertainty of the source information. In this block, the previously calculated array of sample parameters is input to the expert system. To

process the rules in production form, CLIPS is used - a software environment for developing expert systems. CLIPS is one of the most widely used environments due to its effectiveness. The implementation of the output is based on the effective Rete algorithm - the expert system constructs a special graph or prefix tree, the nodes of which correspond to part of the rule conditions. The path from the root to the leaf forms the complete condition of some production. PyKnow library exists to interact with CLIPS in Python [20].

- Selection of a mathematical model. The input of this block receives the calculated type of uncertainty and the mode of operation of the information system. Then, based on them, the expert system selects a suitable mathematical apparatus for the input sample, such as the uncertainty of the system (deterministic, stochastic, fuzzy) and the operating mode.

The calculated type of uncertainty of the initial information and the mathematical model is then used by other subsystems of the situational center. This approach can operate in an automated mode, which significantly speeds up the decision-making process and reduces the requirements for user qualifications.

As a platform for building an intellectual system of a situational center, it is advisable to use integrated software that can solve various tasks based on heterogeneous sources of information with full uncertainty.

The presented basic functional characteristics of systems, objects, and subjects of the decision-making process allow considering the complex approach to the realization of the intellectual system of the situational center. The use of such an approach makes it possible to provide the possibility of considering and solving the maximum number of tasks, reducing the time for analysis and preparing information for the solution, using an intellectual approach to the extraction and use of diverse knowledge. Also, it should be noted that the functioning of all structural components should be accompanied by mandatory consideration of the uncertainty of available information.

4 Conclusions

The use of different systems, including software and hardware systems, decision-making subjects, mathematical and heuristic decision-making methods within the single intellectual system of the situational center, will ensure the fulfillment of a large number of tasks involving a minimum amount of resources.

The proposed structural and functional scheme of the intellectual system of the situational center ensures the implementation of the most effective strategy for finding the optimal solution to the problem or task in question.

The use of such an approach will provide intellectual support for monitoring, planning, forecasting, and decision-making procedures for functioning in different modes at any stage of the SC operation. The developed intellectual decision support system based on the situational center is a set of interrelated software systems, mathematical and methodological apparatus, decision-making specialists that allow the intelligent system to be reconfigured to solve a different class of tasks and different subject areas in the shortest possible time.

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