Study Of Methods For Analysis Of The Complexity And Condition Of Objects Presented As A Data System

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***Abstract*—The study of information structures, the collection of data on the tasks of studying the behavior of objects as a data system, often occurs in conditions of uncertainty, insufficient information about the completeness of the statistical sample and therefore uncertainty about the model of the studied object and environment. The effective behavior of each object is a behavior in which the fulfillment of certain criteria for the quality of the functioning of the object is ensured, regardless of its type and purpose, i.e. it may be an object with a technical purpose or an economic, social or other purpose. Without studying the information processes, obtaining their evaluations, it is difficult to solve the problem of studying the state of objects and their behavior.**

Keywords—objects, information, complex system, modeling, mathematical model, cognitive maps.

I. INTRODUCTION

The main difficulty in studying and functioning of objects is the fulfillment of the requirement for adequate mathematical model, due to the functioning of objects in conditions of information uncertainty regarding the environment with incomplete data system for the structure of the object and analytical models of its subsystems and elements. These conditions are becoming more complicated and in developing their models we have to deal with an increasing degree of data uncertainty, which does not allow the use of analytical modeling. Analytical modeling is the presence of accurate and consistent knowledge, allowing to obtain rigorous logical-mathematical models, models of analysis of information processes in the observed objects. Analytical modeling is effective when the observed object has signs of stationarity, i.e. the lack of effect is linear. For real objects this is usually not possible.

There are objects with strong signs of stochasticity, for the modeling of which methods of probability theory and mathematical statistics are used in solving control problems. These methods work very well in the presence of statistics, but are quite difficult to obtain due to the relatively short periods of time during which the systems work, as well as the complexity of the experiments. Therefore, in the conditions of insufficient data and their poor structure, it is necessary to develop and implement tools for the presentation of knowledge that adequately reflect the dynamics of the processes in the subject area.

II. MODELING OF COMPLEX OBJECTS

There are different approaches to the problem of modeling complex objects. One of them is to create a model in the form of a set. The aggregated, unified model in its composition can contain any models, the application of which can be effective in those areas of the state space of the object for which the model will be adequate. The task is to determine the area of the partitions in the space state of the system, in which the analytical models will adequately describe the functioning of the observed object. By applying the necessary models in the relevant areas of the state space, one can successfully solve the problem of object modeling. The solution to this problem is related to the study of a data system for the functioning of the objects, assessment and forecast of the dynamics of the changes in this data.

The aspect of aggregation of information by complexes presupposes its aggregation by functional and synergistic features. The aggregation of indicators is performed either by simple summation or by calculating an average value in one or more aspects. The different degree of aggregation of indicators at different levels is carried out not only by including more indicators in the aggregation, but also at the expense of the number of aspects - with the transfer to higher levels, the information is usually aggregated into one, and in all aspects. Here are associated the levels of the system, the temporary - with the subsystems of planning in time (perspective, current, operational), the aspects of complexes - with groups of services needed for planning, reporting, management. The formal construction of the model of the studied object in the form of a set is formulated, but the application of this approach requires further development and testing, as each observed object may be in different states and with different degrees of uncertainty. For example, there are difficulties in defining the boundaries of the transition from one area to another, the choice of model types, and algorithmization. The characteristics of the use of model types are not taken in to account, but the result of the application of the model in the form of an aggregate, depending on their correct and timely application. Hence the aspect of application of the object model in the form of a set requires further study.There are different approaches to the problem of modeling complex objects. One of them is to create a model in the form of a set. The aggregated, unified model in its composition can contain any models, the application of which can be effective in those areas of the state space of the object for which the model will be adequate.

fig.1 System levels 1

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III. MODELING OF COMPLEX SYSTEMS

Of particular importance is the concept of complexity of an object according to the data system of that object. From the point of view of synergistic methodology, complex systems have the following main characteristics:

- very heterogeneous components;
- component activity;

- different, parallel manifestations of the connection between the components;

- the semiotic nature of the relationship;

- behavior, openness and distribution of a component;

- dynamism, ability to learn, evolutionary potential;

- uncertainty of environmental parameters.

The aspect of assessing the complexity of an object according to the data system is from the point of view of analysis of the properties and data for the functioning of the object. Complex systems have inherent properties: variability of individual parameters; systematic and stochastic behavior; uniqueness and unpredictability of the system behavior in specific conditions; ability to change their structure; maintaining the integrity and form of behavior; ability to withstand destructive systems trends; ability to adapt to changing conditions; ability and desire to form goals. They are open, self-organizing, information, memory systems. In complex systems, decision-making problems are poorly structured under conditions of different types of uncertainty. Problems and tasks of modeling complex systems is the application of techniques and methods that are subject-oriented and allow to solve problems with their description and explanation, forecasting the ways of their development, structure analysis, stability analysis, scenario analysis and several other system tasks. All this requires a complete solution to various problems in a single system.

The cognitive approach to the study of complex systems and cognitive modeling can be seen as a way of thinking about these systems, not just as a set of tools and manuals designed to understand the object. In the process of knowing the system, to reveal the uncertainty about the success of this process, the researcher needs appropriate tools and high professionalism, as well as understanding of their own cognitive process and modeling tools to allow the researcher to manage the learning process.

The process of cognitive structuring of expert knowledge can be understood as revealing the uncertainty of a complex system. In real systemic decisions, many people make decisions, and the subjective preferences of decision-makers can have a multidirectional focus. A coherent solution can be achieved in the process of cognitive modeling and to make sense of its results.

Management decisions are implemented in a real system. Computational experiments can detect existing inconsistencies in the thinking patterns of both one and a group of experts and reduce the risk of the human factor.

Given the above characteristics of complex systems, it is possible to justify different goals and their cognitive research. The main objectives of the study include the following: understanding, explanation, description of complex systems, forecasting, adapting or managing the development of complex systems, their improvement.

When making decisions in the implementation process, it is first necessary to simulate the properties, structure and behavior of a complex system, because a full-scale experiment on a living system (economic, social, political, etc.) to achieve such goals is unacceptable, impossible, expensive, dangerous or all together. To date, the direction of the simulation has been developed, but it does not pay direct attention to the process of knowledge of researchers (experts, decision makers) and their impact on the result of the simulation and subsequent conclusions and recommendations. Therein lies the risk of the human factor.

Basically, the developed cognitive modeling of complex systems is another area of simulation modeling, but with the ability to include and reflect the fact of the influence of the cognitive process on the final result. This is happening, including through the structuring and gradual restructuring of expertise in the and in connection with the research process. This can be solved by gradually formalizing the process of knowing various aspects of a complex system and solving it, if possible, with the help of special tools. This can be a combination of technologies and tools, cognitive sciences, expert, statistical and other methods for object identification and descriptions, methods of set theory and graph theory, control theory, catastrophe theory, systems theory, hierarchical theory systems, complexity theory, simplified connectivity analysis, optimization theory, solution theory and many more.

IV. Build the foundation of a research system

To build such a system, modeling of complex systems is used, theoretically given by the set of works M:

$$\mathbf{M = \{M_O, M_E, M_{OE}, M_D, M_{MO}, M_{ME}, Q, M_{PR}, M_U, M_H, A\}}, \quad (1)$$

where MO is the object model of the system, ME is the model of the environment, MOE is the model of interaction between the object and the environment, MD is the model of behavior of the system, MMO and MME are models for measuring the state of the system and environment, Q are disturbing influences, MPR is a decision-making model, MU is a control system model, MH is an observer model, and A are the rules for unifying models and selecting processes to change an object.

The mathematical models of MO, ME and MOE are cognitive models. They can be represented by systems of equations, in the language of probability theory and fuzzy sets. MD is a model of behavior in the system, including in the form of impulse processes, disturbing and controlling the influence on the model. MMO and MME are sets of rules, procedures, and measurement tools for the state of the site and the environment.

The methodology for research and decision making takes into account the development of the process of knowing the object in the mind of the researcher. The model of the observer is manifested in the process of knowing the object and the decisions made by it. The model of its perception, knowledge and understanding of the object is a cognitive model of a complex system. Building a mathematical model (1) for a specific system takes into account the objectives, research and decision-making, which allows to organize the process of research and build a research process in which objects can be modified.

The cognitive methodology of the study of complex systems is understood as the logical organization of the researcher's activity. The implementation of the model (1) consists in determining the purpose, object and subject of research, methods and information technology of cognitive modeling, allowing to understand and explain the mechanism of phenomena and processes in the object, to develop possible scenarios of its development and its adaptation to the environment. Cognitive modeling is a multi-stage process. For this purpose, a clear (G) or fuzzy (FCMs) cognitive map can be developed depending on the system properties and information about the object at that time. Mathematical cognitive map is a sign-oriented graph:

$$\mathbf{G = (V, E),} \qquad \mathbf{(2)}$$

The cognitive map shows the causal relationships in the system between the vertices V, vi∈V, i = 1,2, ..., k, which are elements of the studied system. E is the set of arcs, arcs eij∈E, i, j = 1,2, ..., n reflect the relationship between the vertices vi and vj. The cognitive map G can be represented by the square matrix of relations EG = (eij) h × h, and the element eij of the matrix EG at the intersection of the i-th row and the j-th column can take the values "1" if the influence at the peaks it is one-way, "-1" if the influence is multi-way, or "0". G0 is an initial model and is built on the basis of visualization of the initial ideas about the structure of the system, its external environment and the nature of the interaction between the vertices.

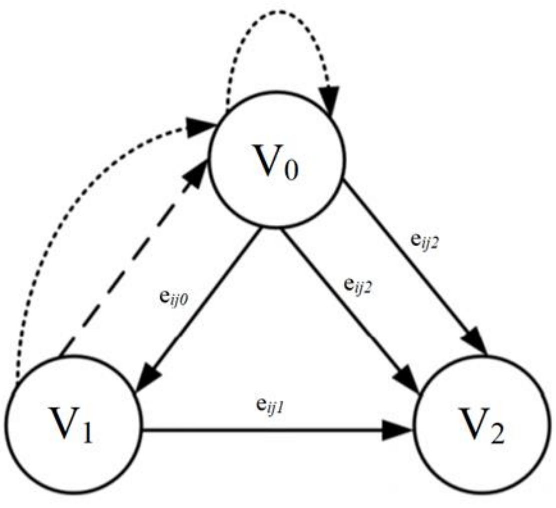

fig.2 Sign-oriented graph

The fuzzy cognitive map is in the form of a fuzzy oriented graph of the 1st and 2nd order.

The concept of FCMs (fuzzy cognitive map) is introduced - this is a digraph. Then FCMs means a set of sets:

$$\mathbf{G^{\sim}=(V,\tilde{U}),} \qquad \mathbf{(3)}$$

where V $\{v_i\}$, i∈I {1, 2, ..., n} is an even set of vertices (or concepts), and $\tilde{U}$= {<μ_u<υ_i, υ_k >/< υ_i, υ_k >>} is an odd number of ribs (or arcs) where, <υ_i, υ_k >∈V_2, a μ_u<υ_i, υ_k> is the degree of belonging of the oriented edge <υ_i, υ_k> to the odd set of oriented edges $\tilde{U}$. The initial model of the system in the form of a certain cognitive map can be sequentially transformed into a more complex mathematical model, the main types of which are vector functional graphics, digraph, weighted signed diagram and the simplest functional graphics.

Parametric vector functional graph has the following form:

$$\mathbf{F_P = (G, X, F, \theta),} \qquad \mathbf{(4)}$$

where F_P is a tuple in which: G is a sign digraph, X is a set of parameters of vertices of this graph, θ are spatial arameters of the vertices, and F = (X, E) = $f\left(x_{i,}x_j, e_{i,j}\right)$ is a function of arc transformation.

For the purposes of simulation modeling, it is recommended to outline the limits of the range of values [-1, + 1]. In the case of determining the F relationship through the membership function, it is a fuzzy cognitive model:

$$\mathbf{F^{\sim} = (G^{\sim}, X^{\sim}, F^{\sim}, \theta),} \qquad \mathbf{(5)}$$

where $G^{\sim}$=(V,$\tilde{U}$) is a fuzzy weighted, directed graph, whose vertices are characterized by fuzzy parameters $X^{\sim}$ and edges - fuzzy causal relationships between the parameters of $F^{\sim}$,.

Cognitive maps can be formed in a hierarchy:

$$\mathbf{IG = (G_{\kappa}, G_{\kappa+1}, E_{\kappa}),} \qquad \mathbf{(6)}$$

where G_{κ} and $G_{\kappa+1}$ ca are cognitive maps, respectively, at k and k+1 levels, some vertices of which are connected by arcs E_{κ}. If arc transformation functions are defined, then a hierarchical cognitive model is implemented. System management as well as the lower level can be a cognitive map that unfolds the peaks to the highest level.

The interaction according to certain rules of the systems can also be represented by a general model of the interaction hierarchy:

$$\mathbf{IGG=(I_{G1},\ I_{G2}, \ldots\ldots, I_{GK}, R),} \qquad \mathbf{(7)}$$

where R are the rules of interaction.

V. Conclusion

The role of information in control theory is crucial, because for the selection of adequate control solutions from a certain set X, the uncertainty will be greater the greater the power |X| of the set governing the decision. To reduce uncertainty, it is necessary to decrease |X|. The absolute and relative magnitude of the data being checked is a measure of information or the amount of uncertainty. The data after the verification becomes objective and becomes information, the evaluation of which allows to determine the uncertainty. The incompleteness of the reflection is radically inevitable due to the universal connection of all objects from the real world and the infinity of their development, i.e. there is a limit to information and uncertainty.

In the process of gaining some cognitive experience in modeling complex systems, there are problems that cannot be considered definitively solved. These are the problems in the decision-making process for developing a cognitive model. Therefore, different expert methods are more often applied in general.

For the development of cognitive models a composition of models and methods of system dynamics with cognitive maps, the development of methods for solving system problems, intertwining the results of solving individual problems and interpretation of the results was proposed. It is necessary to develop methods for analysis of different types of stability of the cognitive model itself and for the conclusions obtained for real systems.

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