ON THE MATHEMATICAL METHODS IN THE PROBLEMS OF FORECASTING AND DECISION MAKING IN THE CONDITIONS OF INCOMPLETENESS OF INFORMATION

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Abstract: The role of the method of mathematical modeling in the research of modern complex control systems and decision making problems is noted. The importance of mathematical methods for predicting and evaluating solutions in the development of digital technologies is emphasized. Models are indicated in the form of a maximum (minimum) function and differential inclusions intended for applying mathematical methods to systems under informational constraints.

Key words: mathematical modeling, decision making, informational constraints, differential inclusions, forecast methods.

1. Introduction

The process of its digitalization is deepening in the world economy, the leading role of information and communication technologies (ICT) in the services, management, business and education sectors is growing. The development of the digital economy is one of the priority areas for most economically developed countries. All developed countries of the world community make strategic investments in the development of ICT, information infrastructure, in the study of economic and social features of the new economic system.

Modern ICT, as the "core" of the digital economy, provides the basis for the development of new business models, digital platforms and services that allow for new types of economic activities. Digital technologies contribute to the growth of labor productivity, the opening of new channels of access to foreign markets, lower production costs, the creation of new jobs, the effectiveness of public administration and an increase in the standard of living of the population.

By now, it has become clear that qualitative economic growth is possible with the availability of technologies that make it possible to accurately assess the current state of markets and industries, as well as effectively forecast their development and respond quickly to changes in the national and world markets.

The synthesis of various areas of basic and applied scientific research is the main component of scientific and technological progress, which allows using modern technologies to create modern technical systems. By now it has become clear that the key and connecting link in the research of natural and technical sciences is the method of mathematical and computer modeling[1,2,5,12].

2. A problems of forecasting and decision making under informational constraints

The methodological basis for the study of the problems of effective management of complex technical and economic systems is a system analysis. This method in all well-structured models of applied problems is implemented as mathematical methods of decision making. These methods allow you to make informed decisions of a particular problem depending on its formulation. Currently, the most relevant decision-making problems in the face of risk and uncertainty (inaccurate data, incomplete information) [1,5]. By now, in connection with the development of information technologies, the possibility of applying such areas of mathematics as mathematical programming, game theory, statistical decision theory, optimal control theory, fuzzy set theory, fuzzy logic and neural computing, etc., has expanded.

Forecasting is a private form of modeling, as the basis of knowledge and control. Forecasting is a look into the future, an assessment of possible development paths, the consequences of certain decisions. Of great importance are forecasting issues related to the future market situation in the region (country).

Various forecasting methods have been developed. If we consider a situation in which events can develop according to several fundamentally different variants, then the method of decomposition of the forecasting problem is applied, which provides for the selection of a set of individual variants of the development of events (scenarios), which together cover all possible development options.

For forecasting, econometric and economic-mathematical models can also be used, as well as special computer systems can be created that make it possible to jointly use all of the above methods. The goal is to take into account all possible factors by which there is hope to improve the forecast.

The problems of forecasting are closely related to the issue of decision-making in planning. Planning is the development of a sequence of actions to achieve what is desired,

culminating in the adoption of a managerial decision. Planning is applied to important decisions that determine the further development of the economic structure (enterprises, firms).

It is clear that the planning technologies actually used by firms are quite complex. At the same time, mathematical planning methods (mathematical programming, dynamic programming, game models) are useful.

Very useful are computational experiments based on mathematical models in the economy, including standardization and product quality management. Econometric and statistical methods allow the construction of simulation econometric models in order to study forecasting and optimal control. The tasks of ensuring industrial and environmental safety can be solved using the theory of risk analysis, using econometric methods and expert assessments.

The mobilization of reserves, the optimal allocation of resources are the main and prerequisites for production efficiency in a market economy. One of the models of conflict of great practical importance is the model of matrix games. However, as a rule, the set of acceptable resource allocation options is infinite and, therefore, the game model goes into a more complex class of infinite games. Therefore, the study of the possibility of game-theoretic optimization of resource allocation based on the apparatus of matrix games and their mixed expansion is an urgent task.

In modern financial and banking operations, for the analysis and calculation of the characteristics of payment flows, it is necessary to precisely specify all flow parameters - payment sizes, interest rates, etc. When solving many practical problems, as a rule, these parameters are not exactly known, but you can always set the intervals in which they lie with a sufficient degree of certainty. In this case, interval analysis methods can serve as an adequate mathematical apparatus for the quantitative analysis of payment flows.

3. A mathematical methods in the nonsmooth control problems

Mathematical modeling of various problems of economics and technology, such as making the best decisions in economic planning and organization of production, in the design of technical devices and process control lead to special problems of mathematical programming with non-smooth objective functions.

Functions such as maximum and minimum make up a wide class of non-smooth functions. They can have a different structure and limitations on which their extreme properties depend. From this point of view, non-smooth functions of the maximum and minimum types of the following form are of interest:

$$f_1(x)=\max_{u\in U}\sum_{i=1}^{m_1}\varphi_i(u)g_i(x),\qquad f_2(x)=\min_{v\in V}\sum_{j=1}^{m_2}\psi_j(v)p_j(x), \qquad (1)$$

where $x\in R^n$, $\varphi_i(u)$, $\psi_j(v)$ $i=\overline{1,m_1}$, $j=\overline{1,m_2}$ – limited on compact $U\subset R^s, V\subset R^k$ functions, R^n – Euclidean space of vectors $x=(x_1,\ldots,x_n)$.

The effectiveness of the methods for solving each nonsmooth problem, presented as optimization of functions such as maximum and minimum, significantly depends on the properties of the objective functions and the specificity of restrictions on their parameters.

For functions of the form of maximum or minimum, it is of particular interest to study the properties associated with the question of their extremum. Also of interest is their relationship with a wide class of so-called quasi-differentiable functions and questions of applying the studied properties to the optimization problem of this type of function. These questions for the id functions (1) were considered in [14, 16]. Note that in order to develop numerical methods for optimizing the functions under consideration, it is necessary to learn how to construct the descent directions of such functions. Here you can use the methods of quasi-differentiable calculus [2,5,7].

With the increasing complexity of the structure of objects and their functions, it becomes increasingly difficult to use classical control methods. Management and optimization issues under conditions of uncertainty (informational constraints) [1,5], as well as differential games lead to models described by differential inclusions with a control parameter [3,4,8,13]

$$\frac{dx}{dt}\in F(t,x,u), u\in U\ . \qquad (2)$$

The relevance of control tasks in conditions of incomplete data leads to the need to study differential inclusions with delays of the form [9]

$$\dot{x}\in F(t,x(t),x(t-h_1(t)),\ldots,x(t-h_k(t)),u),\quad u\in U\ . \qquad (3)$$

It should be noted that the deviation-delay factor in the studied system is often the cause of phenomena that significantly affect the course of the process.

One of the important problems of the theory of controlled differential inclusions is the controllability problem of the ensemble of trajectories from the initial state to the terminal state. In real control systems, the problem of the fastest achievement of the terminal state along the trajectories of the control system is also relevant. In this regard, the time optimal control problem for controlled differential inclusions is of particular interest, understood as the problem of optimizing the time that the ensemble reaches the trajectories of a given terminal set.

One of the important criteria for controlling a system under uncertainty is the minimax problem for controlled differential inclusions. This task is one of the non-smooth control problems, and characteristic of it is the construction of optimal control, which guarantees a certain quality of the process.

The task of controlling a dynamic system by feedback is the main task of control theory. This task covers a wide range of issues related to the choice of a mathematical model of a controlled process, the definition of a control goal, and the control synthesis method. Each of these questions falls into a number of theoretical and applied problems of independent significance. These include, in particular: the task of stabilizing control systems in the face of incomplete data and lagging information; the observability problem of the ensemble of trajectories of differential inclusions; the task of minimax estimation of the projection (component) of a controlled process according to the results of observation . These problems are relatively little studied for models (2) - (3). Separate results were obtained in [3,4,10,12,13,15].

Given the increased role of the theory of fuzzy sets and fuzzy logic in the development of control methods for systems under conditions of uncertainty (incompleteness of information), we note that it is of great interest to study models described by controlled differential inclusions with a fuzzy right-hand side [6, 11].

4. Conclusion

The current stage of ICT development is characterized by the relevance of the introduction of information systems and digital technologies designed for forecasting problems. At the stage of development of these systems, several complex scientific and technical problems must be solved: reengineering and optimization of business processes; the choice of the rational structure of the information system; query optimization and computer network topology, etc.
In conclusion, we note that in connection with the development of ICT and innovative technologies in education, an important problem remains the training of highly qualified specialists in artificial intelligence technologies and the organization of targeted comprehensive studies of forecasting and decision-making models in conflict situations and in conditions of limited information.

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