GENERAL ANALYSIS AND PROBLEMS OF MATHEMATICAL MODELING THEORY

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ABSTRACT

This article provides a theoretical analysis of the history of modeling, model concept, model classes, design, mathematical model and its structure. In addition, theoretical and practical methods and recommendations for modeling, identification process, identification of stochastic objects, planning of experiments and construction of a system of mathematical models for analysis and forecasting are presented.

Keywords. Model, modeling, mathematical model, mathematical modeling, design, model classes, identification, stochastic objects, forecasting, etc.

INTRODUCTION

Model (lat. Modulus - dimension, norm) - an image or sample of an object or system of objects. For example, the model of the earth - the globe, the sky and the stars in it - the planetary screen, the photo in the passport can be called the model of the holder of this passport. Mankind has long been interested in the creation of conditions for a prosperous life, the prediction of natural disasters. Therefore, it is natural for mankind to study various phenomena of the external world.

A model - is a conditional image, an example of an object, event, process, and it develops and improves as a result of development. The model should reflect the main characteristics of the studied object, process and event. There are many similar examples from other fields.
Modeling *- is the study of objects of knowledge (physical phenomena and processes) using their models, the creation and study of models of existing objects and events.*

Let's take a look at the history of modeling. We know that one of the natural phenomena - the study of the motion of the planets - led to the creation of various models of the solar system. Examples include Ptolemy's geocentric model, Copernicus' geleocentric model, Kepler's and Newton's models.
Mathematical model - is an approximate example, a description of a class of mathematical symbols, symbols and events. It is not possible to build a mathematical model that fully reflects the phenomena of the objective world, but it is possible to build a mathematical model that accurately reflects the events of any objective. The mathematical model is divided into 4 stages: the formation of laws connecting the main objects of the model; Solve mathematical problems that lead to a mathematical model; determine the model's conformity to theory, analyze and improve the model.

Purpose

In general, there are theoretical and experimental methods of mathematical modeling of natural and social phenomena. For example, mathematical models constructed using the laws of the natural sciences, equations of balance, and equations of energy matching are called models based on the theoretical method.

Theoretical modeling methods are used in the design of new systems and processes, as well as in exploratory-type research.

The method of modeling processes and systems based on real data processing is called the experimental method.

Models are studied in classes. Based on the classification of the models, the degree of abstraction of the model from the original was obtained. Initially, all models can be divided into two groups, namely material (physical) and abstract (mathematical).

Scientific novelty of the article

A mathematical model is an expression of an object or process in the form of an equation, inequality, formula, table, or graph.

The main purpose of mathematical modeling:

- Systematic analysis of the interaction between complex object or process variables;
- Long-term forecasting of processes and events in terms of quality or quantity;
- Solves practical issues such as decision making, finding optimal solutions, planning.

In general, the modeling process is carried out in the following stages:

-Selection of the object of scientific research. This takes into account the need, relevance, cost-effectiveness and modeling capabilities of the object being studied;

-Study of the object of scientific research. At this stage, the structure of the object, the processes that take place in it are studied;

-Development of the structural scheme of the object. In this case, the object under study is conditionally divided into joints;

-Make a mathematical expression for the joints. In this case, the studied process is expressed in the form of general equations and tables corresponding to the joints. Algorithms for solving them are developed;

-Determine the parameters of the equations of the joints. In this case, a number of properties of the object under study, quality indicators are determined and algorithms for their measurement or calculation are developed;

-Building and analysis of mathematical models of objects or processes. At this stage, the joint models are interconnected and an algorithm for constructing an object model is developed, taking into account the boundary conditions, initial conditions, and possible variation intervals of the variables;

- Choice of solution methods. In this case, the method of modeling is used, taking into account the laws of nature of the object, its feasibility and purpose;

- The accuracy of the model is evaluated.

Building models of complex multi-factor processes or systems using experimental-statistical methods requires a large amount of computational work. Therefore, computer technology is widely used in mathematical modeling.

When processing the results of observations or experiments, the following work is done:

- Elimination of sharply differentiated observation results;

- Check the randomness and relevance of observation results;

- To determine the numerical properties of random variables, ie to determine the mean, variance, standard deviation, coefficients of variation, the appearance of the distribution of random quantities, and the error and reliability of these properties;

-Determine the appearance of the distribution of random functions, correlation function and spectral density;

- Check the occurrence of the process;

- Checking the stability of a process or system and determining whether there are hidden periodicity patterns in the data.

As far as we know, the results of observations contain data that are too large or too small for others. Such data is usually removed from the table.

Factors that are external to the modeled process are called exogenous, and factors that are specific to the modeled process are called endogenous.

So, modeling is the study of the properties of the original by studying the properties of the model by replacing one object (the original) with another (with the model).

Replacement allows you to speed up, simplify, and reduce the cost of learning the original features. In general, the object-original can be an arbitrary natural or artificial, real (real) or imaginary system.

RESULTS AND PRACTICAL APPLICATIONS

The article considers the object - the original system of training, which is the subject area of modeling.

The essence of knowing or studying any system is to create a model of it. It should be noted that the dynamics of the operation of systems of different physical nature is written using the same type of connections, that is, they can be described or expressed using the same type of models.

The deepening and expansion of the capabilities of modern computer and information technology has led to the further expansion and development of the use of modeling. In the current situation, as a result of the acceleration of scientific and technological progress, the conditions for achieving high efficiency in the use of limited material, financial, labor, labor, energy, time and other resources - the widespread use of mathematical modeling.

Optional mathematical tools - algebraic, differential and integral calculus, set theory, algorithm theory, etc. can be used to create mathematical models. The purpose of modeling and the characteristic features of the original determine the aspects of the models and the methods of studying them. For example, mathematical models can be divided into deterministic and probabilistic (stochastic) classes. The first determines the correspondence between the characteristics and parameters of the model, while the second determines the correspondence between the statistical values of these quantities.

The choice of this or that type of model is based on the degree to which random factors need to be taken into account.

In the development of mathematical models, different types of mathematical expressions are formed, taking into account the cause-and-effect relationships in each object or event.

If we denote the cause by X and the result by Y, the relationship between them can be conditionally written as:

$$Y = F(X)$$

where F represents the model operator.

The modeling problem is to find the operator F, and the operator F connects the inputs and outputs of the object. Suppose that $x_1, x_1, \ldots, x_n$ are observations of the input of the object, and $y_1, y_1, \ldots, y_n$ are observations of the output of $1,2,\ldots,n$ in discrete time minutes, respectively. These observations are associated with an unknown operator F_0 of the object, ie

$$Y_i = F_0(X_i) \ (i=1,2,\ldots,n)$$

The researcher is required to ensure that the model operator F is close to the object operator F_0 by some criteria, that is, let $F \approx F_0$. In other words, the issue of identification is raised.

The closeness between these operators is relative because the F_0 operators can have different structures, are formed in different languages, and have different number of input channels. Therefore, it is difficult or impossible to assess the proximity of operators. In most cases, there is not enough information about the object operator.

Therefore, the proximity of natural operators can be evaluated by N input factors X and object output vector $Y(t) = F_0\,[X, E(t)], Y^m = (y_1^M, \ldots\ldots, y_m^M)$ as well as the model output vector. The degree of closeness at each observation point can be estimated, for example, by the difference of the output vectors by the value of the square, ie

$$q(t) = \left|Y(t) - Y^M(t)\right|^2 = \sum_{i=1}^{m}[y_i(t) - y_i^M(t)]^2$$

In general, the proximity between the object and the model is estimated using the difference function p. This function consists of a scalar function with two vector arguments to the object and the model:

$$q(t) = p(Y(t), Y^M(t))$$

The identification process, that is, the model operator, must be defined in such a way that the difference between the object and the model is minimal.

Hence, the model operator F must be such that $Y^M \sim Y$ is appropriate, that is, the model and object outputs must be equivalent to the same input effects, in other words, the model operator must be defined in such a way that , the difference between the object and the model should be minimal [1,2].

The identification process does not always lead to the operation of finding the minimum of any function or functionality. If the object has a static property, the procedure for its identification is based on the solution of a system of linear or nonlinear equations in general. Therefore, the inclusion of objects in the procedure of minimization of identification is a matter of principle and importance.

Mathematical statistical methods are used to identify staghastic objects. There are two theories in this direction. Evaluation theory and experimental planning. The main task of the evaluation theory is to evaluate the unknown parameters of the object from observations in the presence of random effects and interferences.

The theory of experimental planning considers the processes of conducting active and passive experiments in order to determine the unknown parameters of stochastic objects.

We now turn our attention to the application of modeling methods in the education system. According to the functional scheme of the system of socio-economic relations between the education system, demography, labor market and sectors of the economy, the demographic block - demographic trends that underlie the social development of the country, sustainable development of social infrastructure, employment growth determines factors such as [6].

This block serves to calculate the forecast values of growth of labor resources in the Republic, including the total population, the number of able-bodied people, minors of working age, adults over working age.

The system of mathematical models, which represents the system of economy, labor market and vocational education, plays a key role in solving the problems of analysis and forecasting.

To build a system of mathematical models for analysis and forecasting, we introduce the following definitions:

By demographic block:

$$PR_t = f_1(t), \qquad N_t = f_2(PR_t), \qquad N_t^{MR} = f_3(N_t)$$

$$N_t^{nich} = f_4(N_t^{MR}, t), \quad N_t^{jb} = f_5(N_t^{MR}, t), \quad N_t^{bd} = \left(\frac{N_t^{nich}}{N_t^{jb}}\right) \cdot 100$$

Here $N_t - t$ - population per year - total,

$PR_t - t$ - annual population growth, thousand people,

$N_t^{MR} - t$ - Number of labor resources per year, thousand people,

$N_t^{nich} - t$ - Number of people employed in non-manufacturing sector, thousand people,

$N_t^{jb} - t$ - Total number of employees per year, thousand people,

$N_t^{bd} - t$ - annual employment rate, in percent.

Mathematical models were built on the basis of retrospective data on the given indicators, their statistical characteristics were analyzed, and those suitable for practice were selected. The forecast values of demographic indicators were calculated using the selected models. These values serve as the basis for making appropriate management decisions.

CONCLUSIONS AND SUGGESTIONS

Mathematical modeling has been successfully used to solve various practical problems in the exact sciences. The method of mathematical modeling allows you to quantify the quantity that characterizes the problem, and then study its dependence.

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