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THEORY OF MODELING

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Abstract: *The aim of this study is to provide a brief introduction to the theory of modeling, to classify the models and methods of modeling, to explore the most common tools for modeling and simulation. This is necessary to specify the main characteristics on which to compare the qualities of the means of modeling and simulation and to compare these tools based on specified characteristics. Results of the study can be applied to using simulation tools (the choice of situational model) for crisis management.*

Key words: *model, modeling, simulation*

Introduction

Experience shows that a good way to determine the properties of an object is the study of the properties and behavior of the object itself in real conditions. Sometimes the design of the object itself is difficult because it does not exist, and for its future interaction with the environment can not be taken into account many of the factors. For others hypothetical or insufficiently verified data is used. Major way to address this situation is modeling - creation of another object, called a "model" , and to study it (simulation) , instead to researching.

Studying and modeling of systems behavior is preceded by detailed observations and experimental studying. For this purpose, it is often necessary to carry out specific experiments, which requires considerable resources.

In recent years, widely is spread computer simulation as a supplement to, or replacement of modeling systems for which a simple closed form of analytical solutions is not possible.

1. Models and modeling

Fundamental concept in modeling is the concept of "model", which has many different definitions. In [4] there are over 25 meanings of the word. "Model" is a simplified representation or likeness (substitute) of real or abstract objects in the real world.

Model also means a prototype, pattern, scale model, a computer simulation. Models, even of the same object, can vary significantly depending on the purpose of their use [6].

Model is a subject of a different nature, able to substitute another

object through a certain correlation between their properties [1].

According to the IEEE "model" is an approximation, representation or idealization of selected aspects of structure, behavior, operation, or other characteristics of the real process, concept, or system [5]. Simulation is the process of using a model which, through algorithms and computational procedures processes the information for solving the mathematical equations of the model. This model has a behavior of the modeled system and it is called behavioral or simulation model.

Modeling is a method of scientifical research on a subject and brings together the stages of building a model, experimenting with the model and the transformation of data from the study information about the object (simulation).

Sokolov and Yusupov in [3] see modeling as one of the stages of cognitive activity of the subject, including self-selection model, conducting research on the model, obtaining and analyzing the results, displaying recommendations for further work on the subject and assessing the quality of the model for the problem, taking into account individual circumstances.

We can conclude that modeling is a replacement of one object with another in order to obtain information about the most important features of the original one. Object-substituent is called model. It is both a tool for the experiment, replacing the target object, and the object of the experiment. To justify the transfer of the properties of the original model, between the model and the original object there must be a certain similarity or likeness.

The term "modeling" refers to the process of development of the mathematical representation of the object of the model, while the term "simulation" refers more to the processing of information through the algorithms and calculation procedures for solving the mathematical equations derived from the model - i.e. the computer simulation of a system is the presentation by the activation of the model [6].

2. Modeling purposes:

- To forecast the effects of the system. Combining in a certain way the controllable and uncontrollable parameters of the system, we can perform a large number of simulations and thus to evaluate the behavior of the system.
- Easier explanation and better understanding of the object. Optimization and sensitivity analysis is performed.

Optimization is to provide the best quality of the system based on the criteria for achieving the objectives of the modeling system. Upon analysis of the sensitivity are selected the factors which values influence the operation of the modeled system the most.

3. Types of models and modeling

There are many classifications of models, depending on what, how and what is modeled. In practice, there are models that combine different

approaches and modeling techniques (hybrid models).

There are two main groups of models: physical models and mathematical models (Fig. 1).

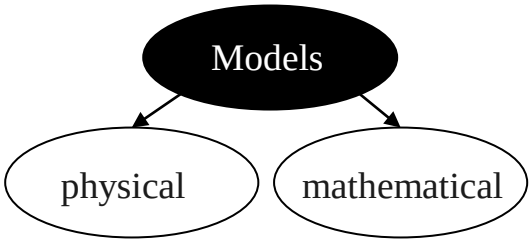

Fig. 1 Classification models

- Physical models are equivalent to the original or have another physical nature, but function as original.
- Mathematical models are formalized description of the object by mathematical relations, reflecting their functioning.

Another classification of Hristova (Fig. 2), divides the types of models as follows [2]:

- Physical models – small-scale versions of real objects (a model of the planets, etc.). They are designed to study, reproduct and predict behavior, and in many situations physical models have been replaced by the use of computer-aided design and testing.
- Theoretical models - used to explain the observed phenomena by creating a hypothetical mechanism or process.
- Logical models - they are part of mathematics and are based on definitions, axioms and standard rules of relationships through which lems and theorems are proved.
- Simulation (imitation) models - usually are computer programs that reflect a real system, which can change and test different assumptions about the system. To study the system, a model must be built and tested repeatedly.
- Mathematical models are abstract models of quantity description. They present a real existing object through systems of algebraic, differential and integral equations, logical conditions and others, so that theoretically, without laboratory tests and additional observations, to predict and manage the real object.

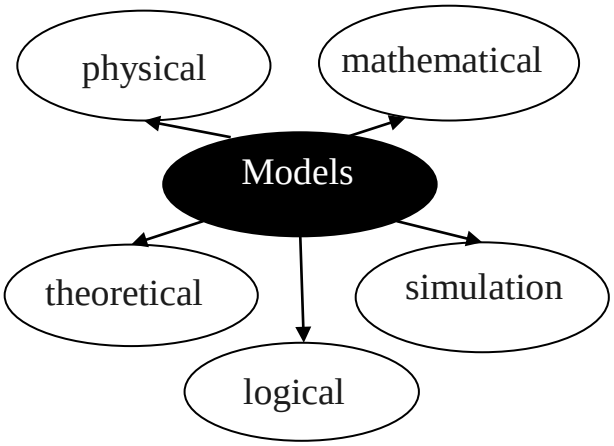

Fig. 2 Classification of models and modeling

According to whether the model is static or dynamic part of a system, the models are called static or dynamic.

If the functions and conditions used are represented entirely by linear equations, then the model is linear. If one or more of the connections is described by a nonlinear function, then the model is non-linear.

According to the way of modeling causality (causal links), the

models are deterministic and stochastic (probabilistic).

Numerical models use some kind of numerical procedure to describe the behavior of the system over the time, and are presented in tables or graphs. Analytical models use equations to describe relationships.

According to the way of modeling, models are discrete and continuous.

According to the type of modeling objects, the models are:

- Material - material - the model is implemented as a physical object (experimental system, device, machine, etc.);
- Abstract - logical - the models are represented by means of mathematics;

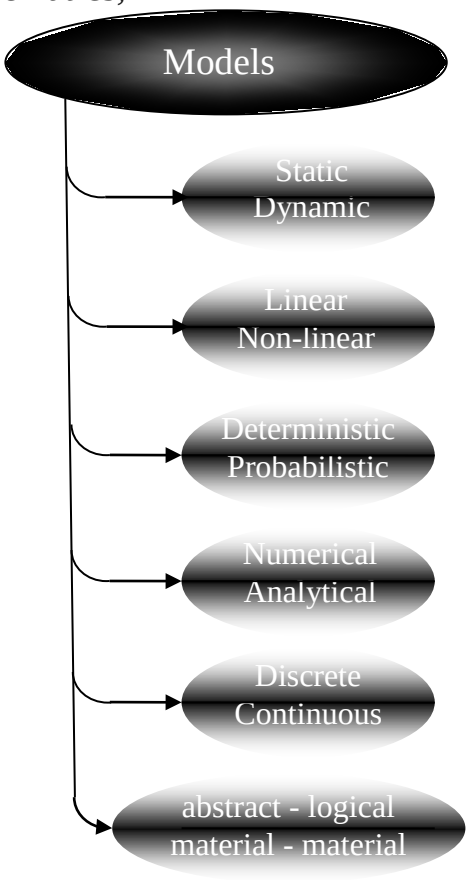

Fig. 3 Classification of mathematical models and modeling

The most common use of any mathematical model is to clarify the most important variables, determining the state and behavior of a system and quantitative regularities, i.e. the mathematical laws governing the change of these values. The success of the model depends on how easily the model can be used.

Mathematical modeling, wherein computer means are used, is called a computer modeling. Computer models are abstract descriptions of the tested system, by means of data objects through which may be carried out information operations.

Computer modeling has several advantages which may be summarized:

- The proper functioning of a given system can be determined at the stage of design and experimentation via computer model;
- Caracteristics of the system can be tested over a wide range of variation of the various external factors;
- The processes in the model proceed much faster than in the real system;
- The computer model may be tested in various combinations of input parameters;
- The computer model can easily adapt to changing conditions;
- In some complex systems, the computer model is the only one available for analysis and evaluation;

When, during the study of the subject, it is difficult to use only simulation or analytical modeling,

then a hybrid (combined) analytical and simulation modeling is used.

3. Methods of modeling

Modeling incorporates the following stages (Fig. 4):

- Formulation of tasks;
- Choosing and creating a model;
- Validation of the model;
- Verification of the model;
- Applying the model in practice.
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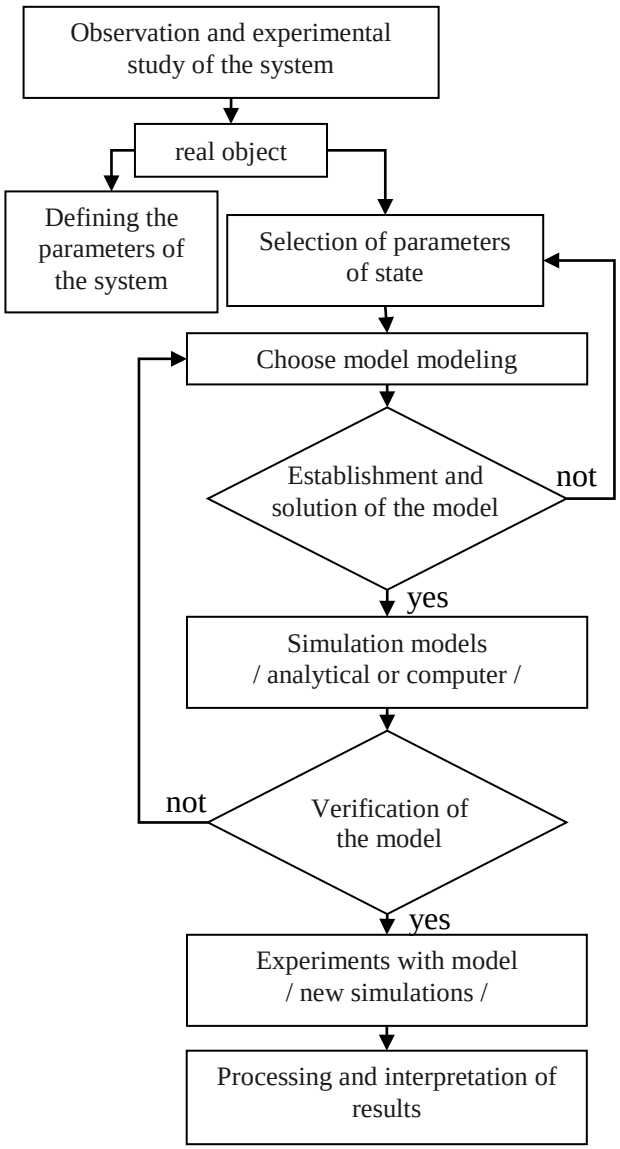

Fig.4 Methods of modeling

Formulation of tasks - defining the problem.

Modeling begins with the observation of the real object and predicting its future behavior. Therefore, we can not express in mathematical symbols and formulas all determinants of the studied problem, it is important to identify the main issues to study and make some restrictions. This decreases the number of the relevant factors. Determine the most significant variables and relationships between selected variables. Identify the factors having the greatest influence on the study behavior of real objects and ignore those factors that have relatively little influence on the study behavior of the real object.

Selecting and setting a model

Select the model that provides the best quality system based on the criterion for achieving the objectives of the modeling system. Relationships between selected variables are expressed mathematically as the real model becomes a mathematical model (the formalization of the object). It is possible for one and the same real object to have more than one mathematical model. The purpose of mathematical study is to obtain new information about the real-life situation. If we can not solve the model, we go back to the selection of a new model, and it is reduced to less unknown.

Validation of the model

Validation of the model is the degree of correspondence between the model and the modeled object, which is a probabilistic value in a range

between 0 and 1. This allows to study the object too, using the properties of the model.

Verification of the model

Verification is the extent to which the steps of the realization of the model correspond to each other. It is compared to the predicted results with observations and experimental data. If there is a match, the pattern is confirmed. If there is no match, the researcher returns to baseline data and chooses an appropriate model. Verification allows to outline the boundaries of applicability of the model.

Offering the model in practice and improvement.

One of the main objectives of the modeling is the model to be easily understood by consumers and to be easily used.

Conclusion

A study is made in which:

1. We studied modern understanding of the following concepts: models, modeling, simulation, verification and validation.

2. Examined are the most common classifications of the models, and basic properties of mathematical and computer models are compared.

3. Explored are the possibilities of the most popular tools for modeling and simulation.

4. Examined is the methodology of modeling.

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