MATHEMATICAL MODELLING IN ENGINEERING

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Annotation: In this text the bibliography is reviewed whose theme is the application of mathematical modeling (MM) in teaching, specifically, in some subjects of the engineering career. Throughout the exposition, it reflect on the results that several researches have obtained on the subject, rescuing those proposals that have rethought the conception of the teaching of mathematics and the strategies in which it should be explored to achieve, among the students, an integral professional training, reflective and able to solve problems in the exercise of engineering. To gather the bibliographic information on the subject, it was tracked systematically and extensively with the Google search engine. The contributions of some leading researchers in the field of educational mathematics were considered, whose research results have been published and disseminated in articles from specialized journals, scientific congresses, books and other dissemination products.

Key words: Google search engine, quantity of one or another dimension, experiment began to be carried

Introduction

Mathematical modeling is successfully used in solving various practical issues in Exact Sciences. The method of mathematical modeling gives an opportunity to learn how to represent a quantity of one or another dimension that characterizes the issue, and then connect it.

On the basis of the method lies the concept of a mathematical model.

The object studied as a mathematical model is said to be a functional link between the characteristics expressed in the form of a mathematical formula or algorithm.

After the invention of the computer, the importance of mathematical modeling sharply increased. There was a real opportunity to create complex technical, economic and social systems, and then apply them with the help of computers. Now the experiment began to be carried out not on the object, that is, on the real system, but on the mathematical model that replaced it.

The computer-aided execution of enormous calculations associated with the movement train of spacecraft, the creation of complex engineering structures, the design of transport Highways, the development of economy, etc., confirms the effectiveness of the mathematical modeling method.

As a rule, the conduct of computational experiments on a mathematical model is carried out in cases where it is impossible to research an actual object in an experiment or when it is not purposeful from an economic point of view. It should also be taken into account that the results of such a calculation experiment are not very accurate compared to the experience conducted on a real object. But such examples can be cited that the computing experience conducted on a computer serves as the only source of reliable information about the process or phenomenon under study. For example, it is possible to predict the consequences of the nuclear war on the climate only by mathematical modeling and conducting computational experiments on the computer. The computer shows that there is no absolute victory in the nuclear armed war. Computer-based experience shows that as a result of such a war on earth, environmental changes, that is, a sharp change in temperature, pollination of the atmosphere, melting of glaciers at the poles, even the earth can leave its axis.

Mathematical expressions of physical processes given in mathematical modeling are modeled. The mathematical model is a approximate description of the class of some phenomena expressed by mathematical signs of the outside world. The mathematical model is a powerful method of knowing the outside world, as well as for predicting and controlling.

The analysis of the mathematical model gives the opportunity to be integrated into the essence of the phenomenon under study. The study of phenomena using a mathematical model is carried out in four stages.

The first stage is the expression of laws that connect the main objects of the model. The second stage is to check the mathematical issues in the model.

The third stage is to determine whether the model satisfies the accepted practice criteria. In other words, to determine the issue of whether the results of observation of an object obtained by theoretical results from a model are compatible.

Materials And Methods

The fourth stage is the transfer of the sequential analysis of the model and its development, clarification by summing up the data on the studied phenomenon.

Thus, the main content of modeling is based on the initial study of the object by means of experiment and (or) theoretical analysis of the model, comparing the results with the data on the object, correcting (improving) the model, etc.

To draw up a mathematical model, initially the issue is formalized. In accordance with the content of the issue, the necessary characters are entered. Then a functional link is formed between the dimensions, written in the form of a formula or algorithm.

Modeling depending on the texture and characteristics of the object is different conducted in different ways. In the modeling of objects in subsequent times, mainly it is widely used in two different analytical and experimental methods.

When the object is modeled in an analytical way, the main texture of the same object and properties mathematical relations (equation, inequality, integral, differential, it is expressed using integral differential equations or their systems), that is, the texture and properties of the object are transferred to mathematical formulas. In this way mathematical relations contained all the basic properties of this object it is also required to be in simple form. Analytical method of modeling it requires a specialist to have in-depth knowledge of his field, as well as sufficient knowledge of the subjects of computational mathematics and programming in algorithmic language.

Usually the mathematical model of engineering issues algebraic equations, ordinary or private derivative differential equations, integrals or their if in the form of their systems, then the mathematical model of economic issues is expressed mainly in the form of inequality, logical expression or their systems.

For example, the mathematical model of the issue of bending an elastic band the given boundary conditions of a simple differential equation of the fourth order transport, which is an economic issue if brought to find a satisfactory solution and the mathematical model of the problem is simple linear algebraic inequality system, which satisfies and maximizes the target function variables are brought to find their values.

Experiments on model objects built in experimental method, that is, it is a model built on the basis of the results obtained by observations. The construction of an experimental model of an object is an extremely complex process. Because some in order to build an experimental model of objects, it is necessary to conduct several observations over a long period of time, under different conditions. Mathematical models are usually composed of relationships and *variables*. Relationships can be described by *operators*, such as algebraic operators, functions, differential operators, etc. Variables are abstractions of system parameters of interest, that can be quantified. Several classification criteria can be used for mathematical models according to their structure:

Linear vs. nonlinear: If all the operators in a mathematical model exhibit linearity, the resulting mathematical model is defined as linear. A model is considered to be nonlinear otherwise. The definition of linearity and nonlinearity is dependent on context, and linear models may have nonlinear expressions in them. For example, in a statistical linear model, it is assumed that a relationship is linear in the parameters, but it may be nonlinear in the predictor variables. Similarly, a differential equation is said to be linear if it can be written with linear differential operators, but it can still have nonlinear expressions in it. In a mathematical programming model, if the objective functions and constraints are represented entirely by linear equations, then the model is regarded as a linear model. If one or more of the objective functions or constraints are represented with a nonlinear equation, then the model is known as a nonlinear model.

Linear structure implies that a problem can be decomposed into simpler parts that can be treated independently and/or analyzed at a different scale and the results obtained will remain valid for the initial problem when recomposed and rescaled.

Nonlinearity, even in fairly simple systems, is often associated with phenomena such as chaos and irreversibility. Although there are exceptions, nonlinear systems and models tend to be more difficult to study than linear ones. A common approach to nonlinear problems is linearization, but this can be problematic if one is trying to study aspects such as irreversibility, which are strongly tied to nonlinearity.

Static vs. dynamic: A *dynamic* model accounts for time-dependent changes in the state of the system, while a *static* (or steady-state) model calculates the system in equilibrium, and thus is time-invariant. Dynamic models typically are represented by differential equations or difference equations.

- **Explicit vs. implicit:** If all of the input parameters of the overall model are known, and the output parameters can be calculated by a finite series of computations, the model is said to be *explicit*. But sometimes it is the *output* parameters which are known, and the corresponding inputs must be solved for by an iterative procedure, such as Newton's method or Broyden's method. In such a case the model is said to be *implicit*. For example, a jet engine's physical properties such as turbine and nozzle throat areas can be explicitly calculated given a design thermodynamic cycle (air and fuel flow rates, pressures, and temperatures) at a specific flight condition and power setting, but the engine's operating cycles at other flight conditions and power settings cannot be explicitly calculated from the constant physical properties.

Discrete vs. continuous: A discrete model treats objects as discrete, such as the particles in a molecular model or the states in a statistical model; while a continuous model represents the objects in a continuous manner, such as the velocity field of fluid in pipe flows, temperatures and stresses in a solid, and electric field that applies continuously over the entire model due to a point charge

- **Deterministic vs. probabilistic (stochastic):** A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables; therefore, a deterministic model always performs the same way for a given set of initial conditions. Conversely, in a stochastic model—usually called a "statistical model"—randomness is present, and variable states are not described by unique values, but rather by probability distributions.
- **Deductive, inductive, or floating:** A deductive model is a logical structure based on a theory. An inductive model arises from empirical findings and generalization from them. The floating model rests on neither theory nor observation, but is merely the invocation of expected structure. Application of mathematics in social sciences outside of economics has been criticized for unfounded models. Application of catastrophe theory in science has been characterized as a floating model.

  Strategic and non-strategic Models used in game theory are different in a sense that they model agents with incompatible incentives, such as competing species or bidders in an auction. Strategic models assume that players are autonomous decision makers who rationally choose actions that maximize their objective function. A key challenge of using strategic models is defining and computing solution concepts such as Nash equilibrium. An interesting property of strategic models is that they separate reasoning about rules of the game from reasoning about behavior of the players.

Results And Discussions

In business and engineering, mathematical models may be used to maximize a certain output. The system under consideration will require certain inputs. The system relating inputs to outputs depends on other variables too: decision variables, state variables, exogenous variables, and random variables.

Decision variables are sometimes known as independent variables. Exogenous variables are sometimes known as parameters or constants. The variables are not independent of each other as the state variables are dependent on the decision, input, random, and exogenous variables. Furthermore, the output variables are dependent on the state of the system (represented by the state variables).

Objectives and constraints of the system and its users can be represented as functions of the output variables or state variables. The objective functions will depend on the perspective of the model's user. Depending on the context, an objective function is also known as an *index of performance*, as it is some measure of interest to the user. Although there is no limit to the number of objective functions and constraints a model can have, using or optimizing the model becomes more involved (computationally) as the number increases.

For example, economists often apply linear algebra when using input-output models. Complicated mathematical models that have many variables may be consolidated by use of vectors where one symbol represents several variables.

Engineering mathematics is a branch of applied mathematics concerning mathematical methods and techniques that are typically used in engineering and industry. Along with fields like engineering physics and engineering geology, both of which may belong in the wider category engineering science, engineering mathematics is an interdisciplinary subject motivated by engineers' needs both for practical, theoretical and other considerations out with their specialization, and to deal with constraints to be effective in their work.

Successful applications of mathematical modeling techniques in engineering sciences have led the way to extend the techniques to more exotic areas of inquiry, like nanotechnology, nuclear-reactor engineering, material science, environment, weather prediction, biological processes, space sciences, cosmology, and also social sciences. Although the general philosophy of modeling in these new areas remains the same as discussed in this article, the simulation procedures and validation criteria are different and dependent on the types of models and the disciplines they belong to.

Mathematical modeling is a vast, multidisciplinary field that pleads to engage the interest and dedication of engineers, scientists and mathematicians to solve the problems facing the humankind. A significant development in the mathematical modeling activity is the availability of very-high-speed computers, which can solve a variety of complex models. In spite of all the advances in empirical knowledge, solution techniques, and computer assistance, it must be noted that human intelligence, experience, and intuition still play a significant role in mathematical modeling.

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modeling. Mathematical models are used in the natural sciences (such as physics, biology, earth science, chemistry) and engineering disciplines (such as computer science, electrical engineering), as well as in non-physical systems such as the social sciences (such as economics, psychology, sociology, political science). Mathematical models are also used in music, linguistics and philosophy (for example, intensively in analytic philosophy).

A model may help to explain a system and to study the effects of different components, and to make predictions about behavior.

The priorities of modern technological education, guaranteeing, its high quality, become the main howling the material of academic disciplines through immersion in activity ability and mastery of competencies, educational and professional communication identification, as well as the implementation of the principle complementarity as complementary understandability of humanitarian and technical preparation.

If humanitarization expresses activity content reversal engineer to environmental (including not meaning human ecology), aesthetic, and sociocommunicative etc. meanings, while strengthening historical and special.

Components preparation and deriving from historical given factors and conditions for achieving multilateral efficiency in action of the modern specialist techno sphere, then mathematization and modeling of engineering and technical education involves the formation future engineers have an effective technical apparatus for solving engineering tasks. Mathematization means bringing teaching the content of the discipline "Magmatic "to the needs of engineering specialists, and not just disclosure mathematical knowledge by itself, which greatly reduces the value to students and complicates them understanding.

Mathematization involves co-building of mathematical training, co- uniting fundamental mathematics technical knowledge with types of engineering tasks and revealing the possibilities of their solutions. This greatly enhances practical orientation of mathematics training and brings the foundation mental mathematical base under training within the actual engineering uneven component.

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