NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696 Website: ijiert.org
VOLUME 7, ISSUE 11, Nov.-2020

SIMULATION MODELING

ORINOV NODIRBEK TOXIRJONOVICH
Teacher, Department of Information Technology, Andijan State University
+998888388844, nodirbekurinov1@gmail.com

MADAMINOV ZOXIDJON YUNUSOVICH,
Teacher, Department of Informatics Teaching Methods, Andijan State University
+998916070084, madaminovzahid@gmail.com

ALIYEVA GULZIRA ABARALIYEVNA
Teacher, Department of Informatics Teaching Methods, Andijan State University
+998 90 3877260, gulzira_aliyeva@bk.ru

ABSTRACT
Simulation solves real world problems safely and intelligently. It is a convenient analysis tool: it is visual, easy to understand and easy to check. In various areas of business and science, simulation helps to find optimal solutions and gives a clear understanding of complex systems. Bits Instead of Atoms: Simulation is an experiment to faithfully digitalize any system. Unlike physical modeling, such as creating a layout for a building, simulation is based on computer technology using algorithms and equations. The simulation model can be analyzed over time, and the animation can be viewed in 2D or 3D.

KEYWORDS: Simulation, model, method, statistical, Monte Carlo.

INTRODUCTION
Simulation modeling is the process of building and testing some modeling algorithm that mimics the behavior and interactions of the system under study, taking into account the effects of random input and the external environment. The imitation model has the most important features of models in general - it can be the object of an experiment, and the experiment is conducted with the model presented in the form of a computer program. The simulation model demonstrates the stochastic process of changing the discrete state of a system. When the model is implemented on a computer, statistics are collected on the model performance that is the subject of the study. At the end of the imitation, the collected statistical data are processed and the imitation results are obtained in the form of distribution of the studied quantities. Thus, mathematical statistics and probability theory are the mathematical basis of imitation.

Currently, there is no single point of view on what is meant by simulation. There are a large number of definitions of the term "simulation modeling" by now [1–2].

Simulation modeling is a method that allows you to build models that describe the processes as they would be in reality. Such a model can be “played” in time for both one test and a given set of them. In this case, the results will be determined by the random nature of the processes. Based on these data, one can obtain fairly stable statistics.

Another definition: simulation is a research method in which the system under study is replaced by a model that describes the real system with sufficient accuracy, and experiments are carried out with it in order to obtain information about this system.

There is a class of objects for which, for various reasons, analytical models have not been developed, or methods for solving the resulting model have not been developed. In this case, the mathematical model is replaced by a simulator or simulation model.

A simulation model is a logical and mathematical description of an object that can be used for experimenting on a computer for the purpose of designing, analyzing and evaluating the functioning of the object.

The simulation model can be considered as a set of rules (differential equations, state maps, automata, networks, etc.) that determine which state the system will go to in the future from a given current state.

Simulation is the process of "executing" a model, guiding it through (discrete or continuous) changes in state over time. Imitation, as a method for solving non-trivial problems, received its initial development in connection with the creation of computers in the 1950s - 1960s. The purpose of simulation is to reproduce the behavior of the system under study based on the results of the analysis of the most significant relationships between its elements, or, in other words, in the development of a simulator of the investigated subject area for various experiments.

Imitation modeling is used when:

- It is expensive or impossible to experiment on a real object;
- It is impossible to build an analytical model: the system has time, causal relationships, consequences, nonlinearities, stochastic (random) variables;
- It is necessary to simulate the behavior of the system over time.

Let's try to illustrate the simulation process by comparing it with a classical mathematical model. When constructing a mathematical model of a complex system, a number of difficulties can arise. The model, as a rule, contains a large number of parameters, many connections between elements and various nonlinear constraints, real systems are often influenced by random various factors, the accounting of which analytically presents very great difficulties, often insurmountable with a large number of them. These difficulties determine the use of simulation modeling. The main advantage of simulation over analytical modeling is the ability to solve more complex problems. Simulation models make it possible to quite simply take into account such factors as the presence of discrete and continuous elements, nonlinear characteristics of system elements, numerous random influences, and others, which often create difficulties in analytical studies. Currently, simulation is the most effective method for studying systems, and often the only practically available method for obtaining information about the behavior of a system, especially at the design stage.

In simulation modeling, two methods are distinguished:

- Statistical modeling method;
- Method of statistical tests (Monte Carlo).

The Monte Carlo method is a numerical method that is used to model random variables and functions whose probabilistic characteristics coincide with the solutions of analytical problems. It consists in multiple reproduction of processes that are realizations of random variables and functions, followed by information processing by methods of mathematical statistics.

If this technique is used for machine simulation in order to study the characteristics of the processes of functioning of systems subject to random influences, then this method is called the method of statistical modeling. The simulation method is used to assess the options for the structure of the system, the effectiveness of various algorithms for managing the system, the effect of changing various parameters of the system. Simulation modeling can be used as the basis for structural, algorithmic and parametric synthesis of systems when it is required to create a system with specified characteristics under certain constraints.

APPLICATION AREAS OF SIMULATION

- Physical processes;
- Materials science;
- Nano technologies;
- Business processes;
- Production;
- Information security, etc.

STATISTICAL MODELING

Statistical modeling is a numerical method for solving mathematical problems, in which the required values are represented by the probabilistic characteristics of some random phenomenon, this phenomenon is modeled, after which the required characteristics are approximately determined by statistical processing of the "observations" of the model [3]. In this method, the sought-for value is represented by the mathematical expectation of a numerical function of the random outcome of the phenomenon, that is, an integral over a probability measure. Conducting each "experiment" is divided into two parts: "drawing" a random outcome and the subsequent calculation of the function. When the space of all outcomes is a probability measure too complex, the rally is carried out sequentially in several stages. Random selection at each stage is carried out using random numbers, for example, generated by some physical sensor; their arithmetic imitation is also used - pseudo-random numbers. Similar random selection procedures are used in mathematical statistics and game theory.

Statistical modeling is widely used for solving integral equations on a computer, for example, in the study of large systems. They are convenient for their versatility, as a rule, they do not require a lot of memory. The disadvantage is large random errors, which decrease too slowly with an increase in the number of experiments. Therefore, methods have been developed for transforming models, which make it possible to reduce the scatter of the observed values and the volume of the model experiment.

MONTE CARLO METHOD

With the existence of a theoretical description of the method for a long period of time, the Monte Carlo method became widespread only with the advent of computers, that is, the problem of generating and using random variables in calculations is a rather laborious task.

Monte Carlo method is the general name for a group of numerical methods based on obtaining a large number of realizations of a stochastic (random) process, which is formed in such a way that its probabilistic characteristics coincide with similar values of the problem being solved [4-5]. The name of the method comes from the city of the same name in the principality of Monaco, where the gambling industry is developed, since the simplest mechanical device for generating random values is roulette.

HISTORY OF THE MONTE CARLO METHOD

The emergence of the idea of using random phenomena in the field of approximate calculations is usually attributed to 1878, when Hall's work appeared on the determination of the number p by randomly throwing a needle onto a paper ragged with parallel lines. The essence of the matter is to experimentally reproduce an event, the probability of which is expressed in terms of the number p, and to estimate this probability approximately. The Monte Carlo method was first proposed in 1949 by Metropolis and Ulam in the article "Monte Carlo Method" of the American Journal of the Association of Statisticians. J. Neiman and S. Ulam are considered the creators of the method. Domestic works using the Monte Carlo method appeared in 1955-1956. Since that time, an extensive bibliography on the Monte Carlo method has accumulated. Even a cursory glance at the titles of works allows us to conclude that the Monte Carlo method is applicable to solving applied problems from a large number of fields of science and technology.

Initially, the Monte Carlo method was used mainly for solving problems of neutron physics, where traditional numerical methods proved to be of little use. Further, his influence spread to a wide class of problems in statistical physics, very different in their content.

The Monte Carlo method has had and continues to have a significant impact on the development of methods of computational mathematics (for example, the development of methods of numerical integration) and in solving many problems it successfully combines with other computational methods and complements them. Its application is justified primarily in those problems that admit of a probabilistic description. This is explained both by the naturalness of obtaining an answer with a certain given probability in problems with probabilistic content, and by a significant simplification of the solution procedure.

Principles of obtaining random variables on a computer

The simplest mechanism for obtaining random values is a tape measure, where a stationary arrow at the moment of stopping a rotating disc with numbers indicates a specific value of a random variable.

The cyclic process of starting and stopping the roulette with the subsequent combining of the numbers obtained in each cycle into groups, you can create a table of random numbers. The largest such table contains over a million digits.

Getting tables of random numbers is a rather difficult task. To create such a table, it is necessary to check it, since the physical device generates random numbers other than a uniform distribution. When working with large tables of random numbers, a large amount of memory is required, which will be occupied by the corresponding file storing this table.

The simplest solution in this case would be to connect the roulette to a computer. In this case, the speed of generating random numbers will be significantly reduced. In this regard, the most efficient generator of random variables will be the noise in the vacuum tubes when the following algorithm is implemented: when the threshold value of the noise level is exceeded, an even number of times per digit will be set to one, otherwise - to zero.

In practice, the number of generators is equal to the sum of the bits of the pseudo-random number in which zeros and ones are written. In this case, at each step, one full-bit number is formed, which has a uniform distribution in the interval [0, 1].

DISADVANTAGES OF THIS GENERATION METHOD

1) The probable absence is equal to the probabilities of zeros and ones due to a malfunction of electronic noise generators.
2) Impossibility of reproducibility of a random sequence of numbers in order to test the performance of the program.

PSEUDO-RANDOM NUMBERS

The use of the above sensors in a computer is rather expensive, since random numbers are rarely used in calculations. As a solution to this problem, it is possible to use pseudo-random numbers. Obtaining pseudo-random numbers is performed by a computer based on algorithms and functions inherent in the mathematical description. The specified algorithms and functions are constantly checked, therefore, the quality of the generation of pseudo-random numbers is usually ensured. However, since all actions of the computer are pre-programmed, the pseudo-random numbers obtained in this way can hardly be called random. In order to objectively apply pseudo-random sequences, it is necessary to understand their features. Let us first define what is called a pseudo-random number. These numbers include numbers calculated, as a rule, by a recursive formula and satisfying a number of requirements inherent in a random variable.

J. von Neumann in 1951 developed the first algorithm for creating a sequence of pseudo-random numbers, which is called the method of mid-squares, which consists in the following:

Let an arbitrary 4-digit integer number n1 = 5243 be given. When squaring it, an 8-digit number n12 = 27489049 is obtained. We take 4 middle digits from this number and denote them as n2 = 4890. Then we will square the new number n22 = 23912100 and take the next 4 middle numbers. The result is the number n3 = 9121. Continuing the indicated recurrent actions, we will have n4 = 1926; n5 = 7094; n6 = 3248, etc. Thus, the pseudo-random sequence of numbers is written in the following form: 0.5243; 0.4890; 0.9121; 0.1926; 0.7094; 0.3248, etc.

From the above simple algorithm, more complex ones were created. However, the mechanism for generating a sequence of pseudo-random numbers has not changed and consists in sequentially obtaining the next value from the previous one.

ADVANTAGES OF METHODS FOR OBTAINING PSEUDO-RANDOM NUMBERS

1) The speed of obtaining random numbers is proportional to the speed of the computer, since the minimum number of simple operations is required to obtain a pseudo-random number.
2) Algorithms and programs for generating pseudo-random numbers are very simple due to the use of recurrent formulas.
3) In the reducibility of a sequence of pseudo-random numbers.
4) Possibility of permanent use of a sequence of pseudo-random numbers in problems of the same type without additional procedures for their certification and description of parameter changes.

THE ESSENCE OF THE MONTE CARLO METHOD

The essence of the Monte Carlo method is as follows: it is required to find the value a of some studied quantity. To do this, choose a random variable X, the mathematical expectation of which is: M (X) = a.

In practice, they do this: they carry out n tests, as a result of which they get n

Possible values of X; calculate their arithmetic $\bar{x} = \frac{\sum x_i}{n}$ mean
and take x as an estimate (approximate value) a * of the required number a:

$$a \simeq a^{*} = \overline{x}. \quad (1)$$

Because the Monte Carlo method requires a large number of tests, it is often referred to as the statistical test method. The theory of this method indicates how it is most expedient to choose a random variable X, how to find possible values. In particular, methods are being developed to reduce the variance of the used random variables, as a result of which the error decreases.

The Monte Carlo method is used very often, sometimes in an uncritical and ineffective way. It has some obvious benefits:

1. It does not require any regularity statements, with the exception of square integrality. This can be useful because often a random variable is a very complex function whose regularity properties are difficult to establish.
2. It leads to an executable procedure even in the multidimensional case when numerical integration is not applicable, for example, when the number of dimensions is greater than 10.
3. It is easy to apply under small constraints or without preliminary analysis of the problem.

IT HAS, HOWEVER, SOME DISADVANTAGES, NAMELY

1. The margin of error is not precisely defined, but includes some randomness. This, however, is more psychological than real difficulty.
2. The static error decreases slowly.
3. The need to have random numbers.

Application of the Monte Carlo method to modeling physical processes

The essence of solving physical problems by the Monte Carlo method is that a physical phenomenon is associated with an imitating probabilistic process that reflects its dynamics (in other words, each elementary act of the process is associated with a certain probability of its implementation). This process is then implemented using a set of random numbers. The values of physical quantities of interest to us are found by averaging over the set of realizations of the modeled process.

The main advantage of the Monte Carlo method in comparison with classical numerical methods is that it can be used to study physical phenomena of almost any complexity that cannot be solved otherwise. For example, it will be relatively easy to solve equations describing the interaction of two atoms, but it is no longer realistic to solve the same problem for hundreds of atoms. Moreover, the Monte Carlo method is often characterized by a simple structure of the computational algorithm. As a rule, a program is drawn up to carry out one random test (model step). Then this test is repeated the required number of times, with each subsequent step independent of all others.

The Monte Carlo method can also be called a "theoretical experiment". Indeed, if the laws of elementary acts are precisely known, and with them the probabilities of elementary events, the results obtained by this method would be are similar to experimental data.

CONCLUSION

In conclusion, it can be said that an imitation model can represent an object of almost any complexity. The limitations may be not only the lack of skill of the executor, but also the requirement of the adequacy of the model and the achievement of a very high accuracy of the result. And this is due to the large-scale statistical sampling, which leads to the need to obtain a large number of models and therefore high-performance computers.

REFERENCES

1) Строгалев, В. П. Имитационное моделирование : учеб. пособие для вузов / В. П. Строгалев, И. О. Толкачева. — Москва : Изд‑во МГТУ им. Н. Э. Баумана, 2008. — 276 с.
2) Хемди А. Таха. Введение в исследование операций / Таха А. Хемди. — Москва : «Вильямс», 2007. — 912 с.

3) Метод статистических испытаний (метод Монте–Карло) / Н. П. Бусленко [и др.]. — Москва : ГИФМЛ, 1962. — 244 с.
4) Ермаков, С. М. Методы Монте–Карло и смежные вопросы / С. М. Ермаков. — Москва : Наука, 1971.
5) Гмурман, В. Е. Теория вероятностей и математическая статистика : учеб. пособие для втузов / В. Е. Гмурман. — Москва : «Высш. школа», 1977.