2nd International Conference on Problems of Logistics, Management and Operation in The East-West Transport Corridor (PLMO 2023) Baku, Azerbaijan
DOI:10.54381/plmo2023.46

The role of modeling in emergency risk prediction

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Abstract. Prediction of emergency situations is the most important for the future in elimination of consequences of risks. From the scientifical side it is acceptable modeling such a situations. There are a lot of modeling methods to choose for solving suitable problems. In this article is dealed with mathematical-statistical modeling by means of simulation for the prediction of emergency situation risks. So, it is possible to predict by using statistical information which happened in past and by this way, it will afford to prevent emergencies which would be happened.

Keywords: *regression; correlation; Matlab/Simulink; simulation; simulation*

1. INTRODUCTION

In recent years, climate changes, developing of industrial, environmental damage and other such processes have turned into an urgent issue the management of emergency situations and the prediction of risks that may occur immediately. It is possible to predict emergency risks that may occur in the future through the models obtained by risk forecasting. Its algorithm should be known for optimal prediction of emergency risks. A risk prediction algorithm is a sequence of mathematical and logical operations. In this case, its optimal mode is determined on the basis of the information about the causes, situation and environment of the event that happened earlier. Obviously, such issues are impossible to investigate without a mathematical model to solve them.

2. PROPERTIES OF RISK MODELING

In the literatures of the modern era, it is possible to find many different methods of the predicted risk model. However, it is necessary to approach the solution of such issues using heuristic (logical), mathematical or combination methods.

The methods of modeling in the prediction of emergency risks depend on the type of predicted objects, as well as the methods of calculating the future values of the unknown parameters of the models and the predicted quantities. Based on this, modeling methods are divided into two main groups:

- risk modeling methods;
- methods of extrapolation (exclusion, transfer) of information about the incident, disaster; these are often called statistical methods.

Data obtained in the modeling method are extrapolated for forecasting. As a result, the distribution of models in predicting risks by classification is somewhat conditional. That is, based on the statistical data of emergency situations, we move probable events to the future period.

Taking into account that each expert's forecast is subjective during risk modeling, it is appropriate to apply an objective mathematical modeling method for predicting emergency situations that may occur.

The objectivity and accuracy of the received information, as well as the mechanization of the process of calculating forecasts using modern computers, are the main advantages of mathematical modeling using computers.

The stages of mathematical modeling in risk prediction are:

- selection and justification of the modeled process;
- calculation of the characteristics of the process investigated in the model;
- analysis of the statistical results of the modeled process and assessment of the accuracy of these results.

The type of the forecasted risk model and all its parameters are different from the known modeling method during statistical forecasting, not only a number of parameters of the model, but also in some cases, the type of process model is independent of experience but unknown a apriori based on experience.

In predicting the impact risks related to emergencies, relevant dependencies can be depicted using analytical, tabular or graphical methods. These dependencies are called impact models, which allow determining the strength of damaging factors or different types of emergency at the point under consideration (Figure 1).

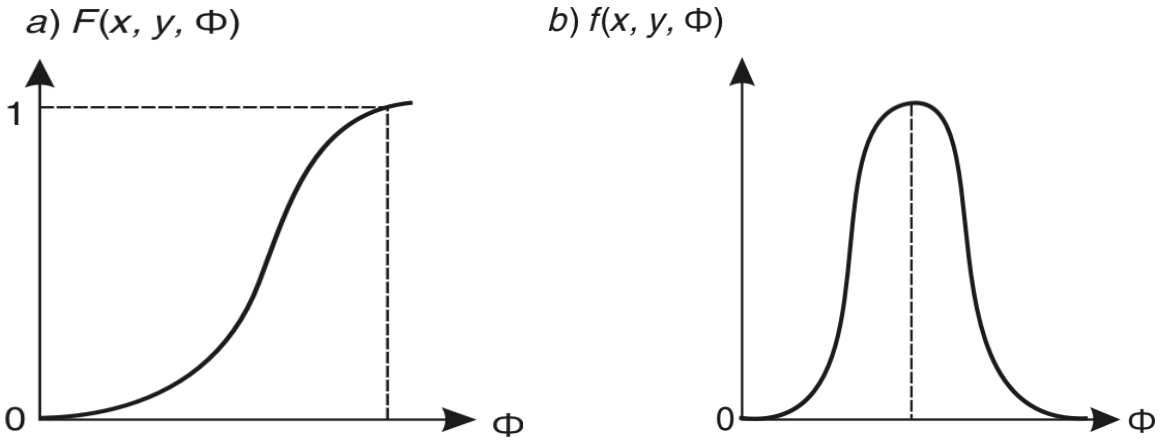

Fig. 1. Distribution law density plot

Influence models can be grouped into the following types:

- basic information about the occurrence of an emergency;
- the distribution function F(x, y, ϕ) of the random quantity ϕ, which is characteristic of the investigated emergency;
- function f called distribution density or probability density of random quantity ϕ-f(x, y, ϕ);
- the effect model can be characterized by statistical materials on the observed data.

Predicting the probability of occurrence of emergency situations is often observed with dynamic events. Since the parameters of dynamic phenomena change over time, the investigated functional equation, which includes the derivatives of the unknown, is called a differential equation. Derived or distributed differential equations are used for cases with special variables:

$$\frac{dy(t)}{dt} = f(y,t) \tag{1}$$

$$\frac{\partial y(x,t)}{\partial x} + \alpha \frac{\partial y(x,t)}{\partial t} = f(y,x,t) \tag{2}$$

The predicted unknown risk is modeled as the result of the equations y(t) or y(x,t). In applied matters, x represents the input variable (coordinate or quantity) of emergency risk, and y represents the output variable (Figure 2).

Fig. 2. Graphic for predicting risk modeling

In classical prediction theory, a mathematical model of an object is constructed between the inputs u(t), f(t) and the output y(t) (Figure 3). Such equations are called input-output model. [2] Implicitly, this model is given as follows:

$$F(y, y^2,...,y^{(n)}); (u, u^2,... u^{(m)}); (f, f^2,... f^{(r)}) \quad (3)$$

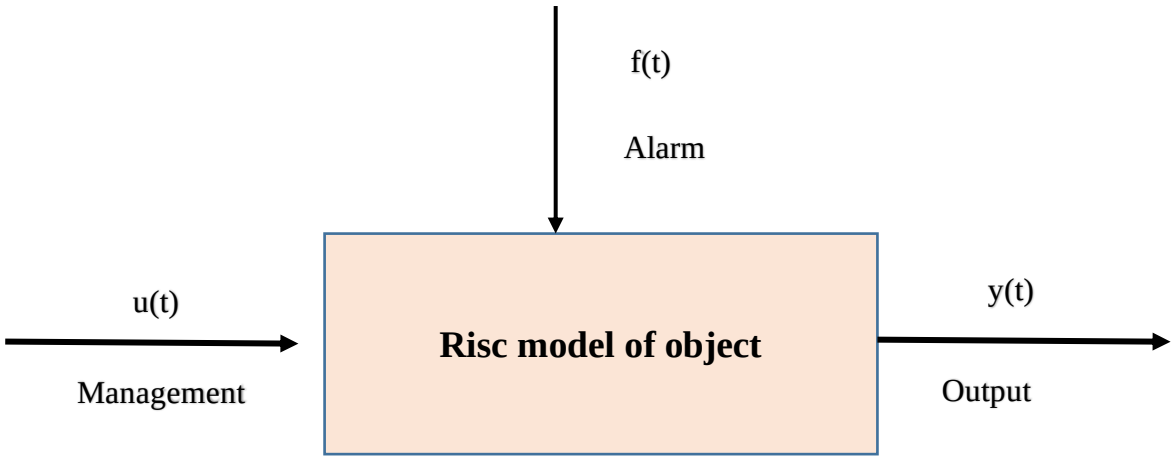

Fig. 3. Graphic for risk modeling of object

2.1. Types of risk modeling

Solving problems in the application of models in the prediction of many emergency risks can be written in nonlinear equations. Difficulties may arise in regulating such cases on the basis of the principle of variable structural forecasting, the characteristics of which are related to the following:

- the presence of multiple different types of risk points;
- presence of complex risk points;
- the presence of risks with the same structure in different regimes, etc.

Modeling for emergency situations is known like a visualization to explain, predict, or control an abstract representation of any real event. These types of models are divided into 3 places:

1. Physical models (for example, built under the influence of an earthquake);
2. Visual models (for example, maps showing the dynamics of emergency situations);
3. Theoretical models (for example, Monte-Carlo or the method of statistical tests).

Physical models show the object affected by any emergency. Visual models have great potential, are more widely used in scientific literature, and most of the graphs in emergency risk prediction are limited to the representation of data frequency distributions and time series rather than processes or systems. Theoretical models can be expressed in ordinary language, formal logical systems, mathematics, computer code, or diagrams. [3]

A model-based view does not draw a sharp distinction between models and theories. A small set of models used in a field can be called a theory.

When emergency situations occur, it is important to eliminate the consequences of those situations, as well as to carry out rescue operations in rescuing the victims. However, by predicting and assessing most events in advance, an effective result can be achieved in reducing the risks that may occur, as well as in preventing the risk of a predetermined disaster. As mentioned, there are various methods of forecasting, of which the most important for modern science is computer simulation of probable emergency situations.

The application of statistical data and mathematical methods is the basis of the construction of mathematical-statistical modeling. Statistical data serve to determine the nature, type and causes of occurrence of previously occurring events. It plays an important role in interfering with the course of events by using statistical data, in eliminating the consequences of emergency situations and in studying all these processes accordingly. For this, it is appropriate to apply it. regression analysis method, correlation analysis method, etc. are examples of statistical methods. [4]

In most cases, the construction of a risk prediction model consists in obtaining mathematical descriptions of processes using basic physical laws (Newton's, Maxwell's, Kirchhoff's laws, etc.). But in many cases it is difficult or impossible to study the physical nature of the processes. Then it is necessary to be satisfied with the empirical (statistical) information about the input and output parameters of the studied object. Building models of events consists of the following stages:

- choosing the structure of the model,
- evaluation of model parameters based on experimental data,
- diagnostic check and model validation,
- using the model for its purpose.

The description, study and prediction of all possible processes and events with the help of mathematical methods is considered one of the foundations of mathematical modeling. If the mathematical modeling of a possible emergency situation is considered, it requires testing the dependence of the characteristics of the event model on various internal parameters and even optimizing the construction. In addition, mathematical modeling allows in principle to simulate various undesirable situations.[5]

Today, computer modeling plays a major role in conducting excellent scientific research. It is not by chance that the need to use the computer arises in analytical research itself. Simulation modeling of complex systems implemented on a computer is shown in the form of a certain algorithm. As a result, simulation modeling is considered a fairly flexible modeling.

2.2. Computer modeling

As before mentioned, mathematical tools (equations, laws, etc.) and statistical data are used in mathematical-statistical modeling. Mathematical-statistical modeling and simulation cover almost all fields of science and technology. In addition, simulation tools consist of a wide range of software tools and various computer-implemented application systems. For example, the Matlab/Simulink software package (Figure 4).

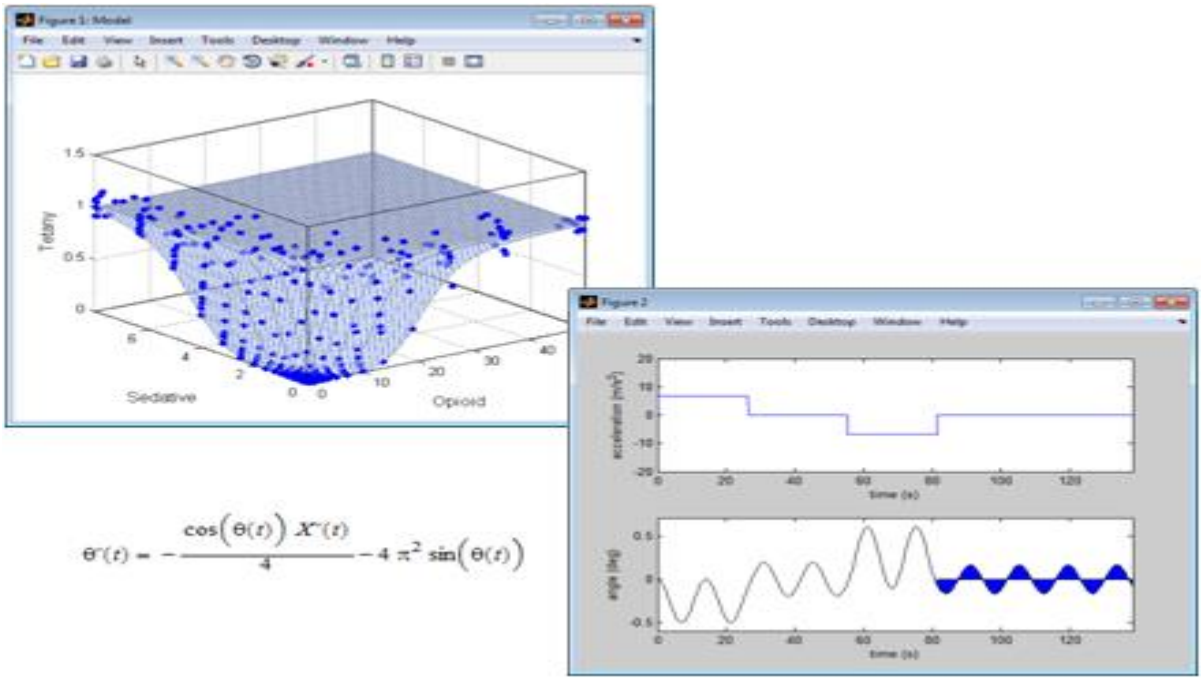

Fig. 4. Mathematical model in MATLAB/SIMULINK software package

By using Matlab software, it is possible to numerically solve mathematical models and systems of differential equations by describing the results obtained in risk assessment in table and graphic form.

One of the most widespread methods of simulation modeling is the Monte Carlo (1949) or statistical tests method. Although the theoretical foundations of the Monte-Carlo method were known long before the advent of computers, they did not find wide application. The main reason for this is that the manual calculation of random quantities is inefficient. Due to the rapid development of computers, the field of practical application of this method has expanded considerably. With the help of this numerical method, it is possible to solve the following problems approximately by means of a computer program:

- modeling of random quantities;
- calculation of areas and multiple integrals;
- solution of equations;
- acquisition of various characteristics based on well-known models of dynamic systems, etc. [6]

3. CONCLUSION

Taking into account the above, it can be said that statistic data has great role in prognozing future's situations. It affords to say or express any probabilities by using risk assessment. Making models by applying mathematical-statistical methods through the appropriate software in the prediction of emergency situations which are the current issues of the modern era will play a role by analyzing the relevant data in minimizing the damage caused by the consequences of emergency situations that may occur in the future

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