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Multidimensional Probabilistic Model for Representing Environmental Information

Irina Kameneva*

G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine, Ukraine

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***Corresponding author:** Irina Kameneva, G.E. Pukhov Institute for Modelling in Energy Engineering of NAS of Ukraine, 15 General Naumov Str., Kyiv, 03164, Ukraine

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Introduction

The probabilistic paradigm has taken a leading position in modern environmental research in recent years, both in the field of monitoring data analysis and in the decision-making process against the backdrop of numerous natural and man-made disasters. The cognitive approach discussed below combines data mining methods (probabilistic aspects) with a wide range of cognitive computer graphics capabilities. Cognitive modeling includes not only the methods of presenting and visualizing multidimensional information, but also the entire process of analyzing, structuring and integrating the data that precedes it. The main goal of our research is to identify the most valuable information contained in the analyzed data, for example, key parameters or factors by which you can create forecasts and make decisions [1,2].

An analogy is drawn between the process of an individual's subjective perception and data analysis in multidimensional statistics. From the set of individual features you need to go to a holistic view of the data structure (visual image or evaluation). For the selection and decision making it is proposed to use subjective probabilistic assessments.

Subjective Approach to Risk

In many applied environmental protection tasks, the semantic meaning of a complex situation can be defined as the presence or absence of danger. At the same time, our perception of danger is quite subjective. It is determined by the specifics of personal perception of specific situations, their assessment within the framework of acquired experience.

Referring to psychological research in the field of risk and safety, we can conclude that when assessing the degree of danger for making appropriate decisions, an important role is played by individual risk perception. On the one hand, each new situation requires making a decision taking into account the acquired experience. On the other hand, the choice of a solution (or rather, its consequences) affects the structure of the previously formed knowledge space, that is, each new step leads to the correction of this knowledge and has a certain impact on decision-making in the future.

Probabilistic Statement of the Problem

The risk space can be defined as follows. Each probabilistic model describes a certain set of observations X, where the partition E(X) is defined, which forms a set of random events [2,3]. On this set, a non-negative function P is given, which satisfies the known properties of the probability measure and determines the probability of random events from E(X). The set of observations X, the set of random events E(X) and the probability measure P, given on the set E(X), form a probabilistic risk space (X, E, P).

Risk factors can be factors of an arbitrary nature (physical, genetic, psychological, social, etc.) that affect the disruption of homeostasis of the system under study. For a numerical assessment of the reliability of the relationships established at the empirical level, it is possible to use well-known methods of mathematical statistics, which allow taking into account the uncertainties that arise both when measuring the impacts themselves and when assessing the dependence between the impact and the effect. If different consequences of the impact of a certain factor are considered as events A1, A2, ... , then the values of the probabilities for different cases act as characteristics of the risk caused by this factor.

Environmental risk is the risk caused by environmental pollution (in particular, atmospheric air, drinking water and food). In turn, each of these factors can be specified by specifying quantitative estimates of harmful impurities (concentrations in atmospheric air, water, soil, etc.).

In theoretical studies, the subjective risk space can be constructed "top down", that is, first select the most general risk factors, which are gradually developed in a sequence of individual indicators provided in the form of quantitative estimates. When studying experimental data, the modeling process occurs in reverse order, from specific measurements or estimates to a set of generalized probabilistic characteristics [3,4].

The set of quantitative indicators obtained as a result of systematization of monitoring data and expert assessments is collapsed into a small number of indices (risk factors), which form the coordinate axes of the probabilistic semantic space of knowledge.

Potential territorial risk is considered as the maximum possible risk value R (x, y) = max in the zone of influence of certain man-made objects. To rank a number of potentially dangerous objects, it is possible to construct a distribution of potential risk for each of them (taking into account different scenarios of events). In modern studies, the probabilistic distribution of risk (risk field) is usually built for the case of the most dangerous on the basis of already available statistical information, expert assessments and the ecological knowledge base.

Visualization of environmental data: Two directions of data visualization have been developed for the interpretation of ecological information: traditional means of visualization data for the studied areas (risk maps) and means of visualization of graphic images (templates) that display the distribution of situations (or events) in the space of informative features. Modern GIS technologies have been adapted to analyze the state of individual territories, which provide information in the form of maps of man-made loads or risk maps. Figure 1 presents example of probabilistic risk distribution of toxic effects for the population of different districts of Kyiv, built on the basis of monitoring data taking into account subjective expert assessments.

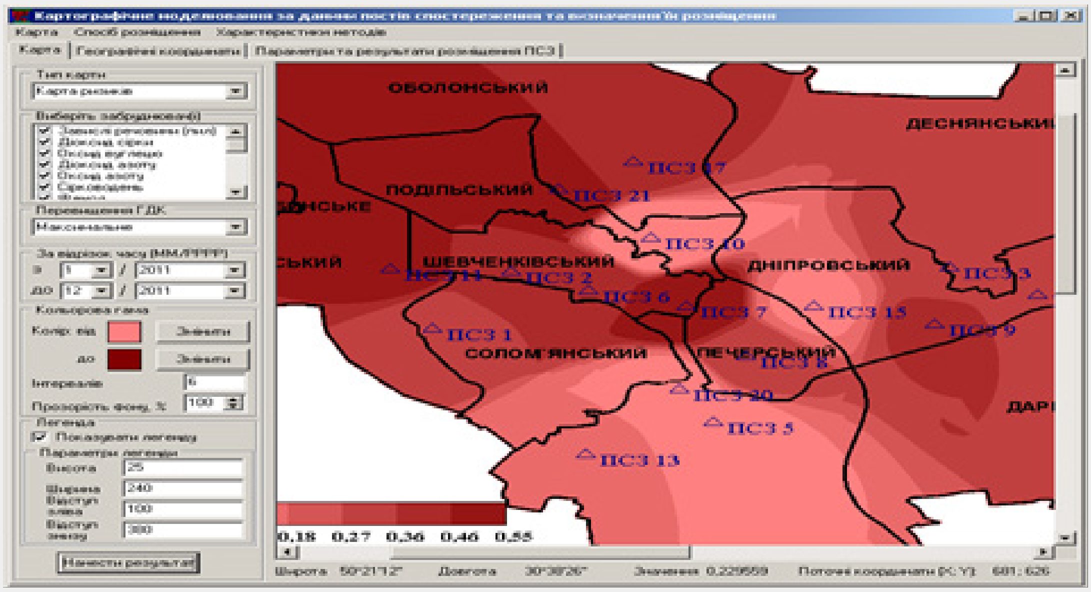

Figure 1: Risk distribution for the population of Kyiv.

Therefore, the probabilistic models of expert knowledge proposed on the basis of the above considerations have a dual nature: at the logical level they have a formal mathematical description, and at the same time receive the corresponding visual interpretation using modern means of cognitive computer graphics.

Conclusion

Based on multivariate analysis and appropriate software tools [3,4], it is possible to construct probability distributions for territorial systems during military conflicts, where the risks of possible destruction and damage increase depending on the location of important infrastructure facilities, military units

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or energy enterprises. For high-risk urbanized systems, we recommend to conduct additional research to determine the range of resistance of the studied systems to probable destruction due to terrorist acts, taking into account nearby critical infrastructure facilities.

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