DEVELOPMENT OF GENERALIZED NATURE ENVIRONMENT MODEL FOR EMERGENCY MONITORING

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Abstract: In the presented work the problem of generalized natural environment model of emergency monitoring is presented. The approach, based on using CASE-based technologies is proposed for methodology development in solving this problem. Usage of CASE-based technology and knowledge databases allow for quick and interactive monitoring of current natural environment state and allow to develop adequate model for just-in-time possible emergency modeling.

Keywords: emergency, monitoring, model, CASE, classification, clustering

ACM Classification Keywords: H.1.1 Systems and Information Theory

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Introduction

The analysis of emergency situations of natural and technogenic character in the different countries of the world for last five years, testifies to growth number of emergency situations average on 5 % per year. According to United Nations experts and large insurance companies for the last century has occurred more than 50 000 natural catastrophes in different countries of the world which has caused death of more than 4 million persons. Necessity of risks handling in extreme natural situations is called by global and national factors which render the negative influence safety of ability to live of world society.

This risks include [1]:

- rise of spontaneous natural phenomena risks, caused by global warming, growth of seismic activity, the extension of ozone gaps, etc., and also an intensification of technogenic influence on surrounding environment;
- rise of probability and scales of the spontaneous natural phenomena and catastrophes influence on human everyday live;

Managerial process by life safety should include modeling of an environment for risk factors revealing, a risk estimation at all development cycle, development of decision-making subsystem for monitoring, handling of risk and liquidations of emergency situation consequences.

Environment modeling for risk factors revealing provides research of possible threat sources, events initiating emergency situations occurrence, description of the object and existing protection frames, possible scenarios of event course and their ranking. Risk estimation is a process of emergency situation occurrence probability definition throughout the certain period and scale of consequences for health of people, property and a surrounding environment.

Development of such modeling system is main tasks of any research for support of natural safety. Let's remind that model represents a collection of objects and ratios between them which adequately describes only some properties of an environment. The model is only one of many possible emergency situation interpretation. This interpretation should suit the user in the present state of affairs, at present time. For model four properties are generally characteristic:

- The reduced scale (size) of model, more precisely, its complexity, which degree always is less, than for the original. At model construction simplifications are entered;
- Saving of key relations between different parts;
- Working capacity, i.e. possibility basically to work, as original-modeled emergency situation (anyway, similarly);
- Adequacy to the real properties of the original (a reliability degree)

Analysis of environment risks

The most part of earth surface are slopes. Sites of a surface concern slopes with the angles of slope exceeding 1 degree. They occupy not less than 3/4 of whole earth surface.

The more abruptly the slope is, the more considerably the gravity component, aspiring to overcome cohesive force of particles of breeds and to displace them downwards. To the Gravity help or stir features of slopes structure: durability of breeds, alternation of various structure layers and their inclination, ground waters weakening cohesive forces between particles of breeds. The slope collapse can be called subsidence — separation from a slope of a large-size block of breed. Subsidence is typical for the abrupt slopes added tight breeds (for example, limestones). Depending on a combination of these factors slope processes gain various shape. In order to correctly model such processes a bunch of various factors should be taken into account. Each factor should be estimated if it influence current situation in order to receive simplified model which still meets requirements described above.

Definition of risks estimation of states of natural complexes, etc., the statistical data about emergency situations, the spontaneous phenomena, and also on results of appropriate dangerous events modeling and situations should be grounded on results of the control of availability index of product of the dangerous technogenic objects, the given monitoring of dangerous geological and hydrometeorological processes. [2]

Presence of effective toolkit for quantitative estimation of safety level gives the chance to provide rationing of risks, levels definition of comprehensible risks for the population, a surrounding environment and economy objects, estimation of correspondence degree of current pace to European safety standards.

Handle of emergency situations risks provides the organization of constant danger level observation of natural processes, natural complexes, exogenous geological processes, etc. in a direction of their danger lowering. Regular monitoring of natural risks gives the chance to watch changes of safety level and to receive real estimations of a remainder resource which in the conditions of limited financial resources allows to optimise expenses on repair and a recovery work.

Proceeding from the analysis of existing methods and models for solution formulated above a problem of safety in emergency situations it is necessary to use a system approach which assumes following stages of problem solution:

- subject domain studying (inspection of objects of a surrounding environment);
- revealing and a formulation of emergency situation problem;
- mathematical (formal) setting of emergency situation occurrence problem;
- natural and/or mathematical modeling of researched objects and processes of surrounding environment;
- statistical processing of results of modeling,
- formulation of alternative solutions,
- estimation of alternative solutions,
- formulation of outputs and proposals on solution of emergency situation problem for objects of a surrounding environment.
- estimation of proposals according to knowledge base of experts
- adjustment of proposals and final decision taking

Problem statement

According to presented tasks of research, it is required to develop and investigate object-oriented methodology of specialized information-analytical system development, including components based on precedent knowledge, taking into account different points of view on current situations (modeling of monitoring methods of emergency situations). Such method must provide adaptation to different circumstances of current situation, must be easy extendable and fast enough to obtain result in required (limited) time before emergency situation occurs.

In general, such method can be divided in several parts:

- presentation of situations as logically connected chains;
- detection of most important nature parameters and transforming them to microsituations

- implementation of non-final estimation principle and taking into account expert linguistic estimations of currecnt situations

Such method should improve quality of emergency possibility estimation (time of estimation)

In general, the task of minimization risk of emergency appearance should be solved:

$$\Phi = \min_{j,i} \Re\left(X_{const}, x_j^K, x_i^M \right),$$

where X_{const} – set of constant parameters of nature environment (angle of slope, different plants and trees on the slope, type of inner structure and so on);

x_j^K – j-th numeral K – parameter of natural environment (air temperature, humidity, wind speed, etc.)

x_i^M – i-th quality M parameter of nature environment (expert estimation of emergency situations and possible risk of its occurrence, for example, verbal threat estimation – “big”, “average”, “low”, etc.)

Development of nature environment model and system for emergency prediction

As problem situation we will understand still controllable situation which can be classified as possible emergency. Developed method must provide [3]:

- system approach (different levels of situation description, support of decision takin lifecycle, differential point of view on analyzing emergency)
- variety of modeling methods $\{Mod\}$ and algorithms of solution taking $\{Alg\}$ both for automated system development and situation analysis for taking best solutions in case of emergency, which influence different aspects of subject (problem situation, taken solutions, additional resources required for estimation or controlling emergency)

In that case solving task of modeling automated system structure $\{Str\}$ and general conception of emergency modeling $M\left(Sit_i'\right)$ can be presented in such way:

$$\{Zad, Met, Mod, Alg, Prog, Pk\} \xrightarrow{\{Pr\}} \{Str\},\ Str_i \in Str,\ i = \overline{1, K}$$

$$M\left(Sit_i'\right) = \underset{Zad_\eta^e \in Zad}{extr}\ \underset{Zad_\eta^e \in Zad}{extr}\ \underset{Met^e \in Met}{extr}\ \underset{Mod_{\text{ПС}_i}^e \in Mod}{extr}\ \underset{Alg_j^e \in Alg}{extr}\ \underset{Prog_\varphi^e \in Prog}{extr}\ \min_{r \in \Re} M\begin{pmatrix} Zad, Met, Alg_j, \\ Prog_j, Mod_i, \Re \end{pmatrix},$$

where:

- Zad_η^e - η – th task of nature environment control and prognosis for e – th method of system development, $\eta = \overline{1, Z}$;
- Met^e - e – th method of model development, $e = \overline{1, E}$;
- $Mod_{\Pi C_i}^e$ - model of nature environment in e – th method of system development;
- Alg_j^e - j – th algorithm of system development for e – th method of system development; $j = \overline{1, J}$;
- $Prog_{\varphi_j}^e$ - φ – th program solution for implementing j – th algorithm in e – th method of system development, $\varphi = \overline{1, \Pi}$;
- Pk^e - estimation quality of result program complex

Structural analysis of emergency monitoring system should be considered as unity of complex system modeling methods and must be developed on the base of powerful informational support systems. Such systems are called

CASE-based (Computer Aided Software Engineering). Architecture of proposed CASE-system is based on paradigm “methodology-model-notation-methods”.

Let’s review process of development model of emergency situation model $\{Mod\}$ from CASE-based technologies point of view. During model $\{Mod\}$ development we should choose most effective variants of modeling, which provide receiving required adequate emergency risks estimations with minimal time for system development. And configuring. Model $\{Mod\}$ must provide connection of nature situation with search of control solutions $\Im$, which primary aim is prevention or liquidation of emergency consequences with minimal risk for human being R_e and use no more resources Σ, which are possible to use. In other words to solve the problem for situation i for current slope we must develop emergency model in such way:

$$Mod_i = \underset{r_e^i \in R_e}{extr}\, Mod\left\{X^i, \Sigma^i, \Im^i, r_e^i\right\} \text{ [4],}$$

where $i = \overline{1, N}$ – count of possible states of nature on current slope

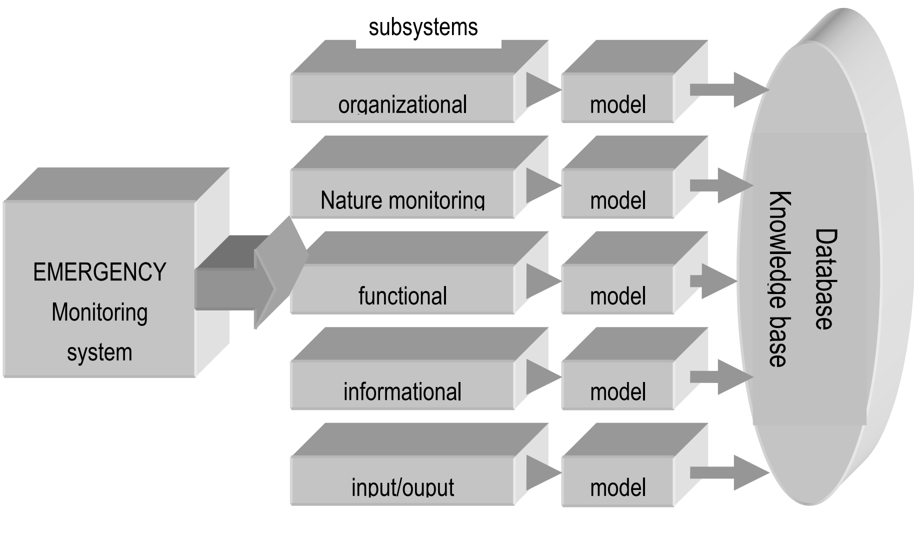
Integratiion in one model this element require to take into account next laws: A – associations; Posl – ordering; K – classification; $\mathrm{K}L$ – clustering.

Association takes place if current problematic nature state Sit_i^t, where t – current time, and situation Sit_i^{t-1}, happened before are connected with each other. This is expressed by equation $\mathrm{A{:}Sit}_i^t \to \mathrm{Sit}_i^{t-1}$

For Posl it is obvious that $\mathrm{Posl{:}Sit}_i^{t-1} \to \mathrm{Sit}_i^t$, because a chain of interconnected in time situations exists

Using classification $\mathrm{Sit}_i^t = \mathrm{K}\left\{(\mathrm{Sit}_i^t \in \mathrm{K}_{kr})\mathrm{or}(\mathrm{Sit}_i^t \in \mathrm{K}_{\overline{kr}})\right\}$, where K_{kr} – class of emergency and $K_{\overline{kr}}$ is class of non-emergency situations, group of most important nature parameters are revealed. In general clustering $\mathrm{Sit}_i^t = \mathrm{KL}\left\{(\mathrm{Sit}_i^t \in \mathrm{KL}_{kr})\mathrm{or}(\mathrm{Sit}_i^t \in \mathrm{KL}_{\overline{kr}})\right\}$ differs from general classification that classes are not determined at step of system creation. Using clustering homogeneous types of data are obtained automatically, reducing time for system development.

After obtaining classification position of current situation Sit_i^t it is possible to build required system using data from closest situations, happened in past which are homogeneous t current one:



Structure of emergency monitoring system

Such computer system of decision-making support grants to expert possibility to handle easily great volumes of the information in realtime a time scale, allowing it to obtain the objective data and make the value judgment. Using effective estimations expert can easily control many parameters during time, along with allowed changes in them:

Monitoring current nature parameters on slope and allowed differences

Conclusion

The offered approach to modeling nature environment allows quickly develop effective system for emergency prediction. Presented method is based on classification and clustering approach as theoretical backend and a strong use of CASE-based technologies as effective solution for quick development of system solving similar tasks (risk estimations in current case). Developed system can be easily implemented by means of any high-level programming language using database/knowledge base backend for storing micrositutional data. Effectiveness of such system allow to decrease risks on different slopes and effectively estimate running costs on living/manufacting in different areas.

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