DEVELOPING AN EXPERT SYSTEM FOR SITUATIONAL ANALYSIS OF AVALANCHE DANGER

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Introduction

Conducting of constant monitoring and building of interpretation models for prediction of such situations initiation can be considered as one of emergency situations risk monitoring and, in particular, situations caused by avalanches. Hereinafter, such models make the basis of the decision-making support system; this is favorable for development of recommendations for timely performance of preventive measures directed to emergencies prevention [4].

Shortages of the traditional approaches application

Patterns similarity method and regression analysis [1, 2] are the most often chosen when considering methods and models for avalanches prediction. But the prediction results obtained with these methods are not always applicable and demonstrate a number of shortages: they require appreciable computational resources; they don't cover existing diversity of causes leading to an avalanche formation. Impossibility to define the avalanche danger degree, avalanches number and dimensions are also among shortages [3].

Avalanche danger initiation microsituations classes

Representation of diversity of their initiation factors in the form microsituations set help to increase faithfulness of analysis and avalanches slip prediction. Every such microsituation corresponds to a definite combination of the avalanche initiation medium factors. At the same time such a representation makes it possible to divide the whole set of causes acting on the avalanche initiation into two subclasses of situations. One of subclasses characterizes a set of microsituations representing the avalanche initiation and the other subclass is characteristic for avalanche non-dangerous situation in general. Then the emergency avalanche situations risks management can be presented the generalized description of the system with the set of different microsituations. Reasoning from such an interpretation the logic rules for generalization of the analyzed set o data for their further division into classes of the avalanche-dangerous and avalanche-non-dangerous situations were derived:

$$\text{“avalanche-dangerous”}=\left(\{F_{\text{л}}^{\text{л}}(X)\}/\{F_{\text{н}}^{\text{н}}(X)\}\right)\cup\left(\{F_{\text{н}}^{\text{н}}(X)\}/\{F_{\text{л}}^{\text{л}}(X)\}\cup\right)$$
$$\cup\left(\{F_{\text{л}}^{\text{н}}(X)\}/\{F_{\text{н}}^{\text{л}}(X)\}\right)\cup\left(\{F_{\text{н}}^{\text{л}}(X)\}/\{F_{\text{л}}^{\text{н}}(X)\}\right)\cup\left(\{F_{\text{л}}^{\text{н}}(X)\}/\{F_{\text{н}}^{\text{н}}(X)\}\right),$$

$$\text{“avalanche-non-dangerous”}=\cup\left(\{F_{\text{л}}^{\text{н}}(X)\}\cap\{F_{\text{н}}^{\text{л}}(X)\}\right)\cup\left(\{F_{\text{н}}^{\text{н}}(X)\}/\{F_{\text{л}}^{\text{л}}(X)\}\right),$$

where $F_{\text{л}}^{\text{л}}(X)$ $\left(F_{\text{л}}^{\text{н}}(X)\right)$, $F_{\text{н}}^{\text{л}}(X)$ $\left(F_{\text{н}}^{\text{н}}(X)\right)$ is a probability function of referring the avalanche-dangerous (avalanche-non-dangerous) microsituation to the avalanche- dangerous (avalanche-non-dangerous) class, respectively, with a set of the avalanche danger initiation medium factors X.

Further development of the analyzed data division into classes of the avalanche –dangerous and avalanche non-dangerous situations is an introduction of the integral measure of proximity between microsituations based on

Wilcoxon test value; this makes it possible to obtain reasonable results using real data for the avalanche-dangerous Itagar Chychkan region of Kyrgyz Republic (Fig. 1).

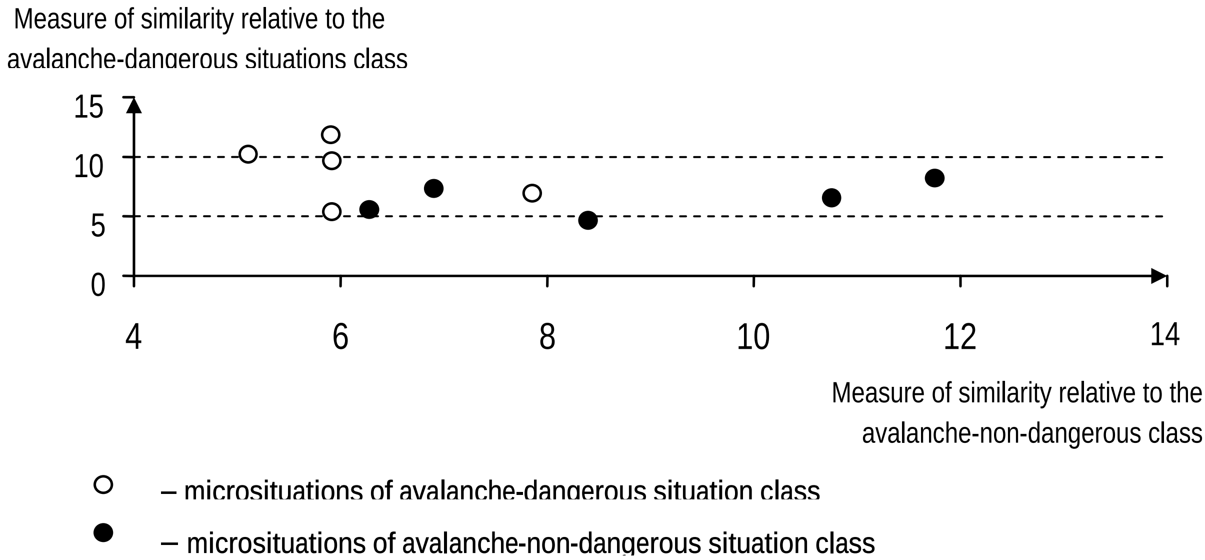

Fig.1. Distribution of microsituations in the space of features describing their relation to the avalanche-dangerous and avalanche-non-dangerous situations classes

Yet, in the conceptual plan the essence of the probabilistic aspect of analysis of the avalanche-dangerous initiation medium can be reduced to definition of the probability reference of some point as current characteristics of the considered medium either to the field of the avalanche-dangerous situation initiation or to the field of the avalanche-non-dangerous situation consideration. The given approach can be treated also as a correspondence of the current characteristics of the avalanche climate initiation medium, whose parameters define some region, to the preceding probabilistic distributions of the avalanche-dangerous and avalanche-non-dangerous situations. Consequently, we may speak about the probability of correspondence of the investigated characteristics of the avalanche-dangerous climate initiation medium to the probabilistic distributions of the avalanche-dangerous and avalanche-non-dangerous situations.

Representation of the avalanche danger factors as the microsituations classes made it possible to obtain the objective correspondence between the probabilistic estimates of the avalanches slip and the degrees of the avalanche danger scale.

Starting from the analysis of the presented micrositations classes the positive result was obtained relative to correction of the prediction system response time to a possible avalanche slip. The essence of such an estimate consists in construction and analysis based on the fuzzy sets theory of the corresponding functions of the prediction time correction $\mu(X)$ (Fig. 2).

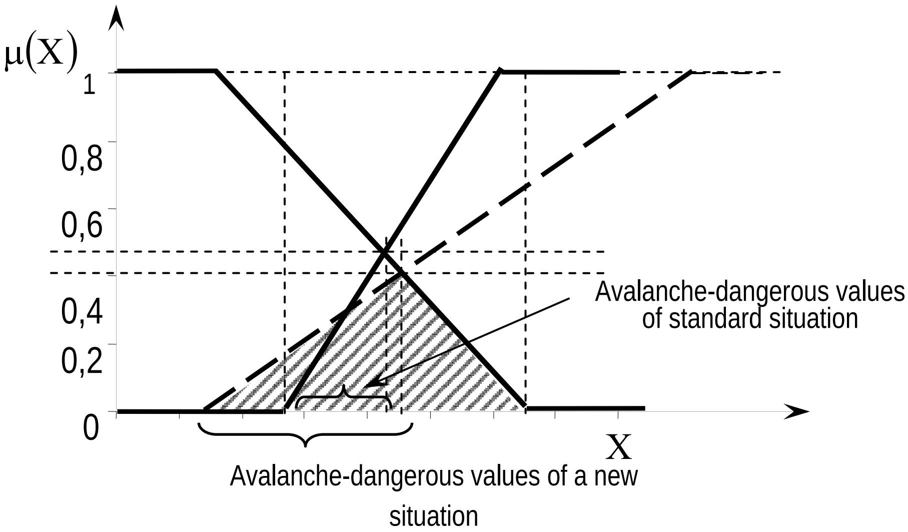

Fig.2. Methods of the theory of fuzzy sets as a basis for correction of the prediction system response time to a possible avalanche slip

Such analysis allow to make first steps in development of intelligent expert system which is able to analyze micrositations, predict possible avalance-dangerous events and track list of activites took in such situations. According to results system can propose a list of activites, which were used in previous situations alike this, helping an experts to quickly react on possible danger (see Fig. 3).

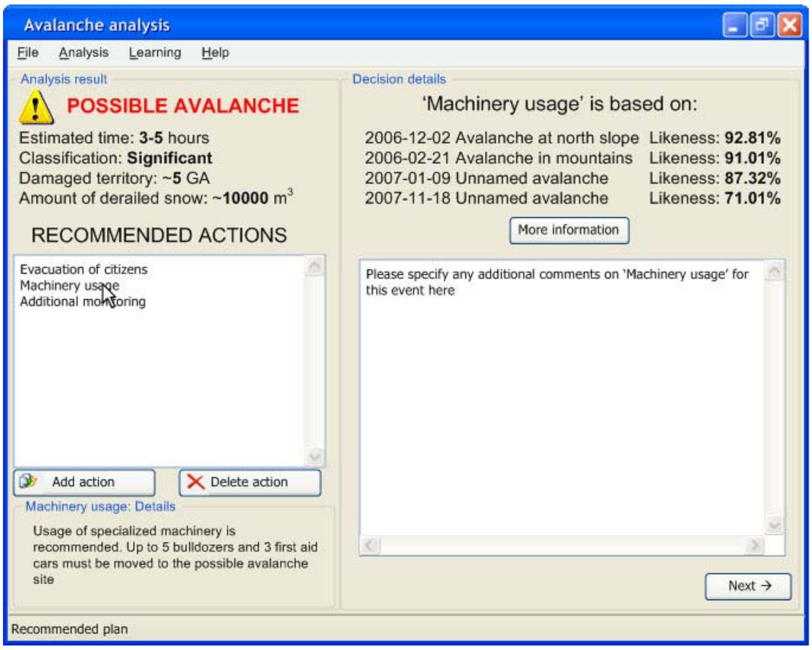

Fig 3. Analysis of possible avalanche situation

Such results can be achieved by constantly learning system. Each measurement is recorded during 'Learning mode' of the system. Special attention should be paid to each avalanche, forecasted by system or not. After each avalanche the data should be specified, defining more accurate terms of avalanche situations for this station/region (see Fig. 4.)

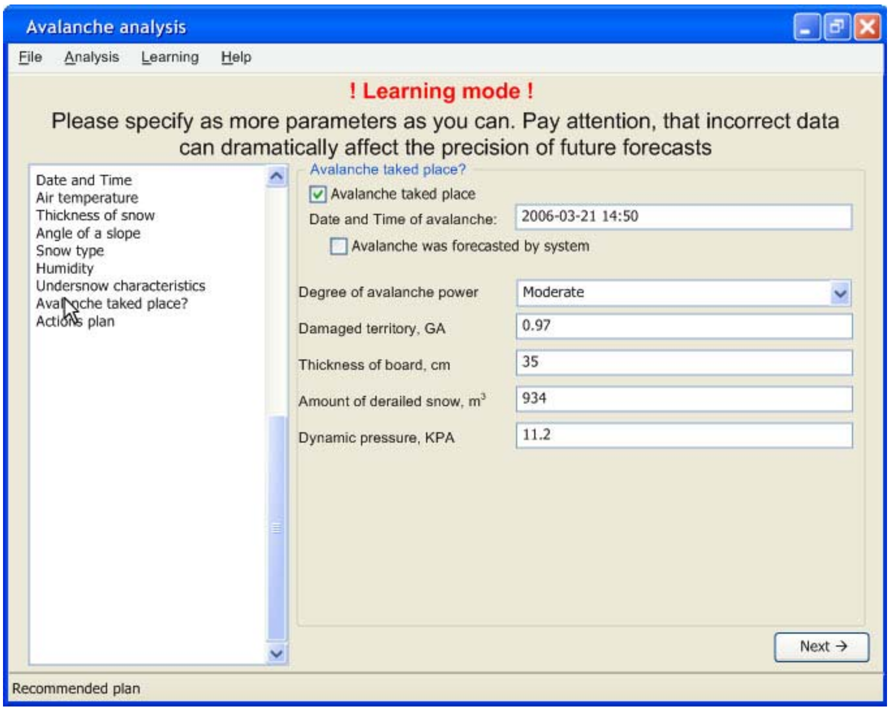

Fig 4. Learning mode of the system

The effectiveness of this system was checked using statistic of avalanches provided by meteorological stations at Itagar, Chichkan district, Kyrgyz republic.

Conclusion

The approach presented in this work makes it possible to receive an adequate description of the avalanche-dangerous medium initiation using a set of the corresponding micrositutations and, as a result, to increase the analysis precision and prevent arising natural calamities in the form of the avalanches slip.

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