"Investigation of landslide phenomena with Artificial Neural Networks and Geographical Information System".

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Report

Natural processes occurring as a consequence of internal or external geodynamic processes lead to the preservation of balance on earth's surface. These processes may result in fatalities or casualties by destroying human settlements in urban and urbanizing areas. Landslides are frequently responsible for considerable losses and they are subsequently considered among the most serious geohazards, which plague many parts of the world and have serious socioeconomic significance.

Even though, a wealth of experience has been accumulated in recent years in assessing and treating landslide hazard, our knowledge still remains fragmentary. Consequently landslides and related instability phenomena in natural and manmade slopes remain an engineering geological problem to investigate and a geotechnical problem to solve.

The study of basic landslide processes and the rating of the importance of the critical parameters are crucial in order to carefully decide on the appropriate mitigation measures and finally predict future events.

In the present research program, both qualitative and quantitative parameters involved in the abolition of equilibrium of natural and manmade slopes are examined in terms of holistic approach of instability phenomena. Moreover, the rating of the dominance and interaction intensity of the parameters is examined. The impact of these parameters on the stability of slopes is investigated through the use of computational tools called artificial neural networks. The research was originally oriented at large scale (single slope), then on national scale and finally focused on certain study areas in terms of regional scale (Fig1).

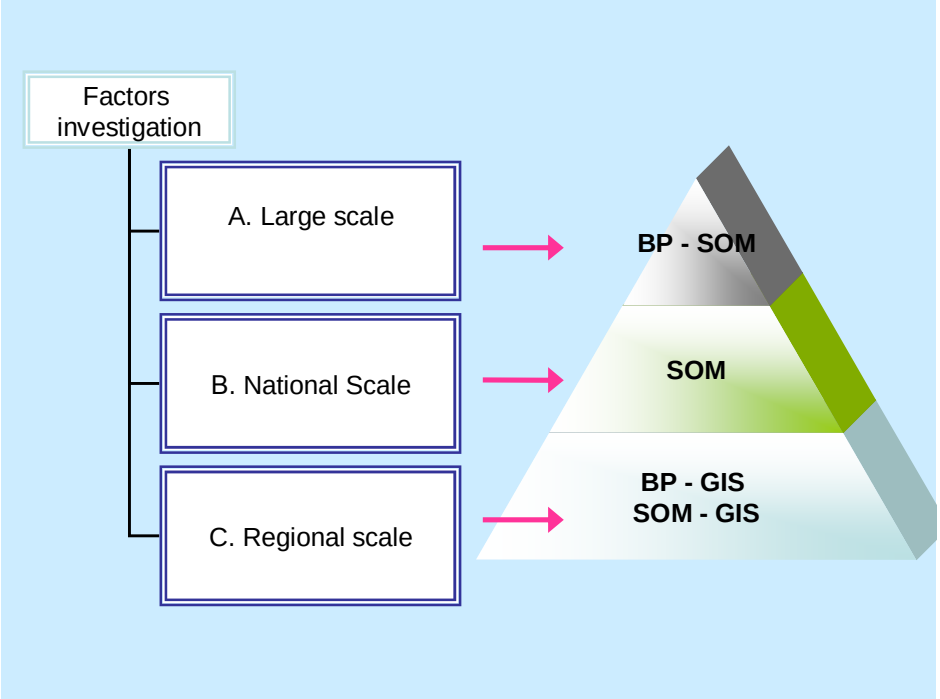

Fig1. Steps followed during the research using Back-propagation (BP), Self Organizing Maps (SOM) and GIS.

The proposed methodology was initially applied in a particular slope (large scale), using back-propagation algorithm. Safety factor and stability estimation were phrased as a supervised learning problem. Artificial neural networks were developed in order to estimate safety factor and status of stability for a soil or rock slope. They were proved of being capable to recognize different data sets within a whole data set.

The application of the method of partitioning of connection weights, adapted in order to study the sensitivity of the parameters, was found to give a reasonable and objective ranking of the most important ones.

The next step was to apply an algorithm of unsupervised learning (Self Organising Map - SOM) in the study of slope stability and try to discover information patterns (Fig. 2).In terms of holistic approach of the problem, it was attempted to implement in the model qualitative parameters such as status of stability or mechanism of failure. Artificial networks were developed in order to detect the trend of the data to clustering, according to mechanism of failure and status of stability. Parameter interaction intensity and parameter dominance was also evaluated using a coupled model of neural networks and interaction matrix methodology.

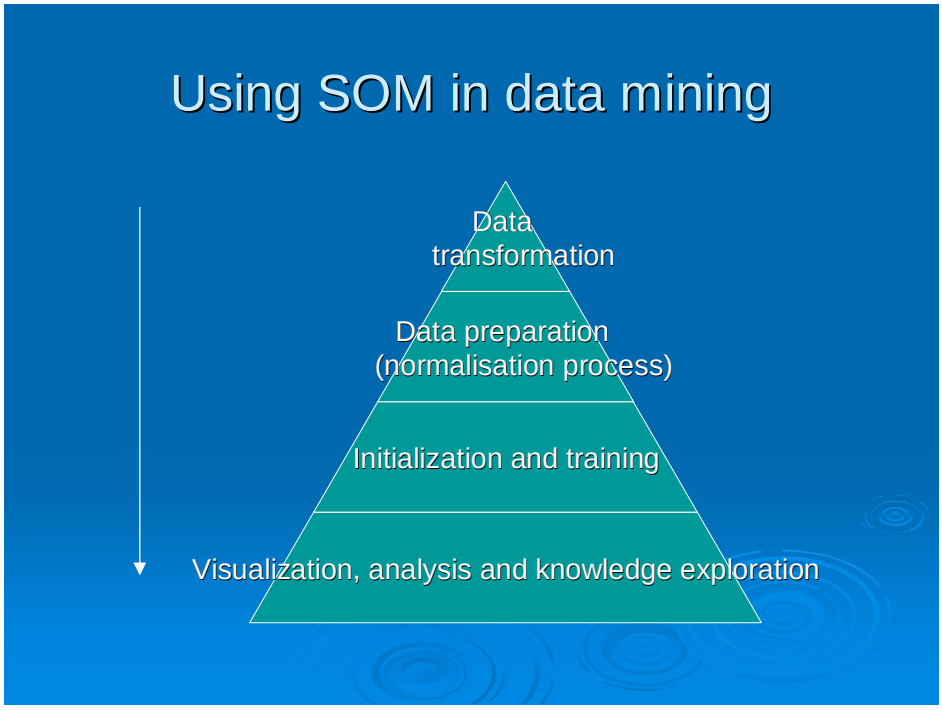

Fig2. Steps followed using Self Organizing Maps (SOM) in data mining.

In terms of national scale a database of landslide events from the Greek territory was studied. Artificial neural networks were developed in order to discover knowledge through the investigation of qualitative parameters, which describe the causal factors of landslides, (geological formation, altitude, aspect, and human processes, number of soil rapture etc). The research focused in the examination of the importance of the related factors, interrelations and interaction intensity.

Self organizing maps were found to illustrate structures in the data in a different manner than more traditional multivariate analysis methodologies. SOM algorithm concentrates on preserving the neighborhood relations in the data instead of trying to preserve the distances between the data items. There is the tendency to create clusters around the factors the most important (best matching unit) which characterize the cluster and these particular clusters have a distinct physical meaning (Fig. 3).

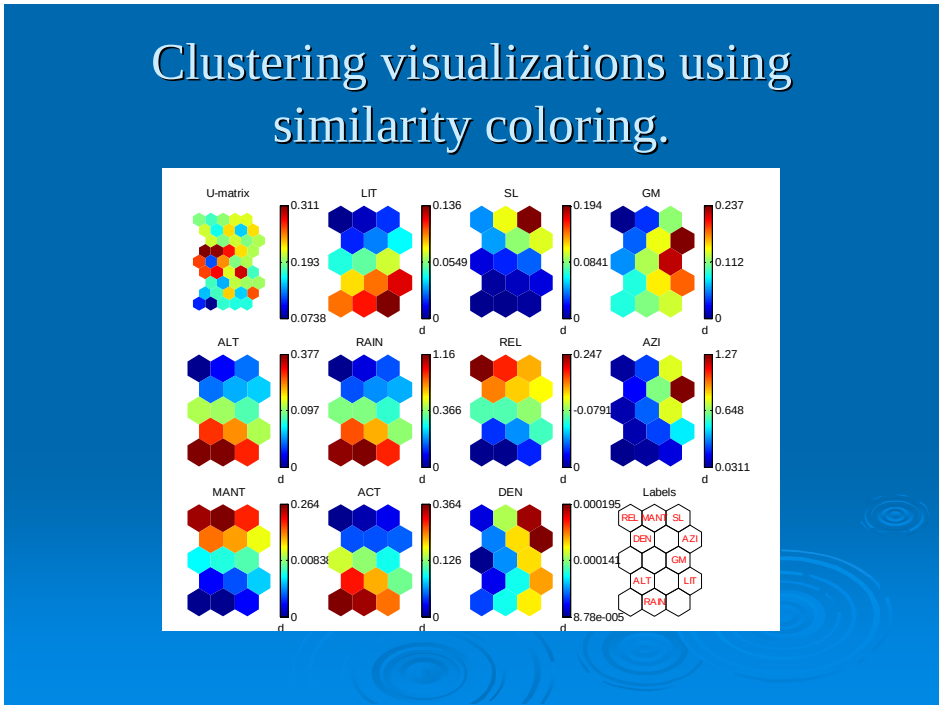

Fig3. Clustering tendency around the best matching units.

Finally a landslide hazard assessment methodology is introduced, which couples both geographical information system technology and artificial neural networks. In terms of a geotechnical model of landslide hazard assessment the selected study area is an area of high seismicity near the city of Aigio. In this model failure criteria under static or dynamic conditions for soil or rock slopes were implemented through suitable algorithms. In terms of a qualitative approach of landslide hazard assessment model the study area is an area in Evrytania district which depicts high landslide frequency.

According to the results stemming from this thesis, GIS were proved to be an indispensable tool for managing geological geotechnical, seismic and climate information. Moreover, they offer the potential of a complete analysis, using tools of spatial analysis, as well as the implemented algorithms in order to produce landslide hazard assessment models (Fig.4).

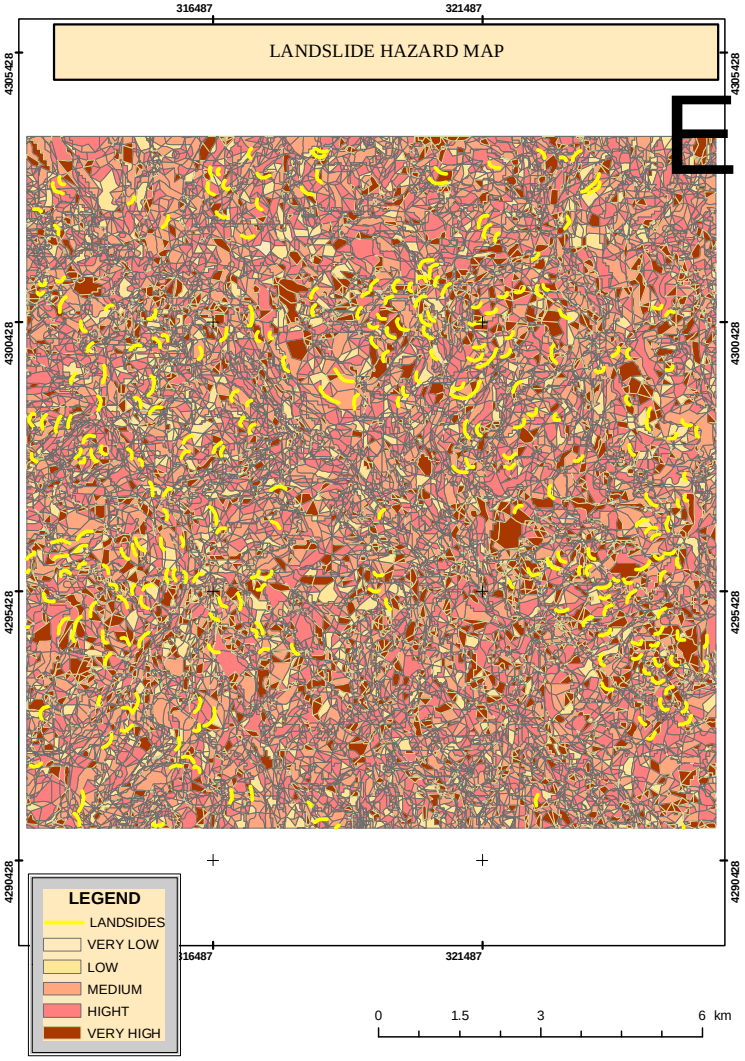

Fig. 4. Landslide hazard map in Evrytania district.

The main results arising from the research are the following:

- Artificial neural networks were developed in order to estimate the value of safety factor (F) and the status of stability (S) for a soil or rock slope using the algorithm of back-propagation.
- There was a better convergence between (F) value estimated from neural networks and the value calculated from analytical methods, than the convergence between the value coming from least square approximation method and analytical methods.
- Another very important result stemming from the above study is that artificial neural networks can recognize trends and folds in data sets.
- An objective and quantified rating was attributed to the weights of the parameters involved in the calculation of safety factor. The application of the method of partitioning of connection weights, adapted in this thesis in order to study the dominance of the parameters, was found to give a reasonable ranking which is in accordance with preexisting knowledge.
- Holistic approach of the problem of slope stability was held, integrating in the analysis qualitative parameters such as status of stability and mechanism of failure.
- Unsupervised artificial neural networks were developed which use knowledge discovery methods in order to detect the trend of the data to cluster according to the mechanism of failure and the status of stability.
- The importance and the interaction intensity of the factors contributing to landsliding procedures were investigated, in an objective and quantified approach using a coupled model of artificial neural networks and interaction matrix, the results were again reasonable.
- Self Organising Maps detect clusters in a data set in a different approach than multidimensional statistical analysis techniques. There is a tendency of the data to preserve their neighborhood distances than the distances between the items of the data base and create clusters around the most important factors, which portray a clear physical meaning.
- Geographical information systems offer the prospect of an integrated analysis and they are also the necessary tools in order to organize data coming from neural networks, in order to produce landslide hazard models.