Geophysical Research Abstracts, Vol. 7, 03955, 2005
SRef-ID: 1607-7962/gra/EGU05-A-03955

Analysis and interpretation of geodetic landslide monitoring data based on Fuzzy Systems

M. Haberler

Institute of Geodesy and Geophysics, Vienna University of Technology, Austria
(Michaela.Haberler@tuwien.ac.at)

Geodetic deformation measurements and the statistical deformation analysis are an important field of work within engineering geodesy. The basics for the evaluation of quasi-static monitoring networks are well-known: the landslide has to be represented by measuring points in such a way that the deformation of the sliding area can be reconstructed by the measured displacements of discrete points. To carry out a deformation analysis geodetic measurements of at least two epochs have to be provided. The interval between those epochs depends on the properties of the landslide, mostly on the deformation velocity. The geodetic deformation analysis assesses the displacements of the object points with statistical methods. So it can be stated, which points have statistically significant displacements.

To carry out a more detailed interpretation of the calculated displacements, further investigations are necessary. E.g. for a better monitoring of landslides, it is important to know the boundaries between the stable and the unstable or between unstable areas moving with different velocities in different directions. Based on this information, geotechnical sensors can be installed across block boundaries, which are the areas of interest. These sensors give permanently precise information on the deformation condition of the sliding area, which feeds a knowledge based system acting as a backbone of an intelligent alert system.

The work presented here is focussed on the first part of the project, the determination of blocks.

The assignment of the monitored points to the several blocks up to now has been performed in a purely visual way, which means that the investigator distinguishes matching points - out of a graphical representation of their displacement vectors -

based on their pattern of movement. So, similar vectors are combined to one block in a purely intuitive way, assessing the similarity of the length and the direction of the vectors.

This property of intuitive human thinking can be used to implement an automated detection of consistent point movement. To copy the human thinking process, some modern techniques like knowledge based systems, artificial neural networks and fuzzy systems are available. For the actual problem fuzzy systems are well suited, because the human language with its inherent fuzziness can be mapped to model terms like “similar length” or “similar azimuth”. The decision finding is done in a rule-based inference system; here again, the rules of everyday life can directly be used.

Additionally to this “visual” parameters of course some geodetic indicators exist to assess the movement of an object based on the displacement vectors of the monitored points.

The idea is to use an over-determined affine coordinate transformation to assess displacements between two subsequent epochs of measurements. Thus, the coordinates of the points of epoch n are mapped onto the coordinates of the same points of epoch n+1. A group of points moving in the same direction (assuming that they are lying on one common block) is characterized by small residuals and a small standard deviation within an over-determined affine transformation. In case points of different blocks were considered simultaneously the standard deviation and other indicators will be significantly larger.

Here, the strain analysis, which is mathematically analogous to the affine coordinate transformation, is used to describe the inner distortions of the object by means of the strain parameters e_{xx}, e_{xy}, e_{yy}. To avoid the dependency of the strain parameters on the coordinate system, the parameters are transformed into the principal strain axes system, represented by the strain ellipse (Tissot indicatrix), which delivers valuable indicators for the block detection algorithm. The modelling of these and other parameters used in the fuzzy decision system as well as an example showing the processing of the displacement information in the fuzzy system will be given.