A method for the detection and description of changes of clusters in snapshots of a vector field

Eva Nuhn

Geoinformatics Research Group (AGIS), University of the Bundeswehr Munich, D-85577 Neubiberg, eva.nuhn@unibw.de

INTRODUCTION

Many applications in GI-science deal with large vector fields. A current challenge is therefore to provide effective methods to handle them in such a way that they are easy to analyze, interpret and compare. In Nuhn et al. (2010) an extended version of the *single linkage clustering algorithm* (Sneath, 1957) is proposed for the processing of vector fields in landslide applications. While clustering of vector fields provides important information for the analysis and the interpretation, the changes in the clusters in different vector fields over time are often even more meaningful in many applications.

In this paper some preliminary work on methods for detecting and describing changes in clusters in different snapshots of a 2D vector field is presented. The applicability of the developed method is demonstrated using vector fields of a Finite Element slope stability simulation.

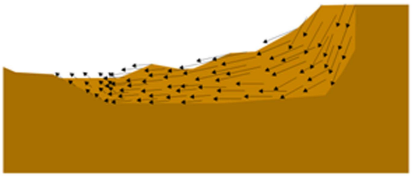

Figure 1: Vector field of a simulation result.

The simulation result is a bulky field of vectors (see figure 1) (Trauner et al., 2008). For the change detection process at least two snapshots (SN1 and SN2) of a vector field are needed. Consider two vector fields from different landslide simulations for the same area of a slope, which were performed for different time steps. After the simulation both vector fields are processed with the extended cluster algorithm, which was introduced by Nuhn et al. (2010). The results are clusters, which present different probabilities of occurrence of a landslide, with a corresponding deformation vector representing the degree of probability (figure 2, red areas indicate a high, yellow ones a medium and green ones a low probability).

Figure 2: Two clustered simulation results, with different probabilities of occurrence of a landslide.

COMPARISON OF SNAPSHOTS OF CLUSTERED VECTOR FIELDS

In this section first considerations for a method for the detection and description of changes of clusters of a vector field are made. The method should identify clusters, which change from one snapshot to the other. Further, clusters should be revealed, which do not change, that means clusters, which remain stable over time. Additionally, both disappearing and new emerging clusters should be revealed by the method. The method mainly consists of two steps, which are described in the following sections.

Cluster matching

Consider a cluster *X* in SN1. To detect if and how *X* has changed, it must be first checked in SN2 if it is still existent. It is assumed that a cluster *X* from SN1 is still existent in SN2 if:

1. There exists a cluster *Y* in SN2, which is overlapping *X AND*
2. Y has the same degree of probability of occurrence of a landslide as *X*.

If both conditions are fulfilled, then *Y* is supposed to be the same cluster as *X*. If there is no such cluster *Y*, then it is assumed that the cluster *X* has *disappeared.* If there is more than one cluster *Y* it cannot be uniquely identified, if *X* has split or if *new* clusters with the same degree of probability emerged in SN2. Therefore, for the initial studies in this paper it is assumed, that there is at most one cluster *Y* in SN2 for each cluster *X* in SN1. Further, new emerging clusters are not treated within this paper.

In the example of the clustered landslide simulations (figure 2) for all clusters *X* exist a cluster *Y*, which is overlapping *X* and which has the same degree of probability. Therefore all clusters from SN1 have an equivalent in SN2 and can be matched correctly.

Change detection and description

After the identification of a cluster in both snapshots, its type of change can be specified. Within this paper each cluster is processed independently without considering the changes of the other clusters. Although a cluster can change in many ways, in this paper only three cases are considered:

Case 1: A cluster changes its location – that means the center of the cluster changes its position.

Case 2: A cluster changes its size – change in size contains growing and shrinking, depending on the increase or decrease of the clusters size.

Case 3: A cluster does not change.

Combined cases are not discussed in this paper. To be able to identify which case is valid, a method proposed by Wilmsen (2006) can be adapted. The method analyzes topological states of objects in snapshots and derives types of change for the specific configuration of data. In table 1 the changes, which can be derived from topological relations, are summarized. To be able to detect the clusters which change between the two snapshots, the topological relation between the cluster from SN1 and from SN2 must be investigated.

Table 1: Types of change and their correlation with topological relations.

Topological Relations for Cluster from SN1 and Cluster from SN2	Type of Change
equal	No change
overlap, meet, disjoint	moving
contains, covers	growing
inside, coveredby	shrinking

In case of the example of the landslide simulation, the topological relation of the clusters 1, 4, 5, 6, 7, 8 is *equal* (see figure 3). This means, these clusters did not change between SN1 and SN2 hence case 3 is valid. The topological relation of cluster 3 between SN1 and SN2 is *covers.* That means the cluster was *growing* between the two snapshots. For cluster 2 the topological relation is *coveredby*, which represents a *shrinking* of the cluster. Therefore case 2 is valid for both clusters.

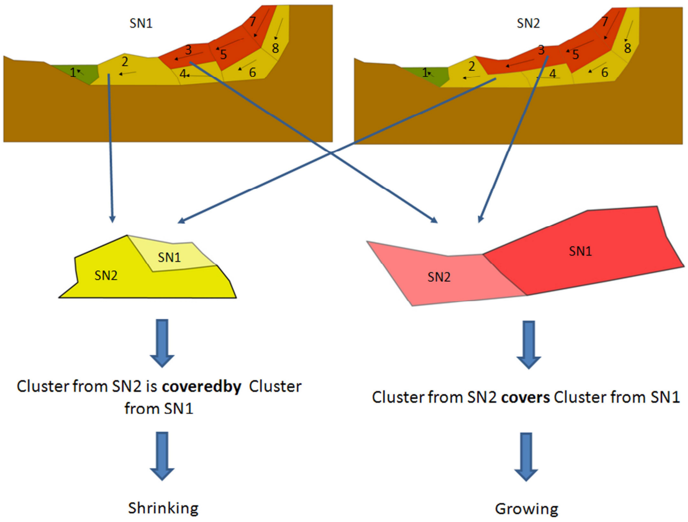

Figure 3: Topological relation of the clusters in SN1 and SN2.

OUTLOOK

In this paper the clusters have been processed independently without considering the changes of the other clusters. In reality the change of a cluster is the result of the interaction of all other clusters within the vector field. Thus, in a next step, all clusters have to be considered in order to describe the change of a specific cluster.

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