Object-Oriented and Cognitive Methods for Multi-Data Event-Based Landslide Detection and Monitoring[1]

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Landslides are a major hazard, in 2008 alone leading to more than 400 fatal disasters worldwide which killed over 32,000 people. Understanding the hazard, and subsequently the risk, requires accurate inventories of past slides, including their location, extent, type and triggering mechanism. Those inventories are difficult to obtain through field mapping, mainly due to access challenges and rapidly vanishing traces. Geoinformatics tools have proved to be of great value in disaster risk management, such as through remote sensing that allows accurate and timely acquisition of information on hazard processes, elements at risk or consequences of a hazardous event, which can be analysed or integrated with auxiliary information in GIS programmes or models. Landslides are one of those phenomena where geoinformatics developments have opened up new ways to build inventories of previous mass movements, but also to monitor potential or ongoing slides.

In the past, image-based mapping was primarily done by visual analysis of aerial photos or, increasingly, satellite imagery, and a number of automatic methods have been devel-oped. However, until recently only pixel-based methods, primarily employing different classi-fication or change detection techniques, were used. Those are beginning to be replaced by approaches based on objects or segments (BARLOW et al., 2003; MOINE et al., 2009). Object-oriented analysis (OOA) is inherently more suitable, as it can address the phenomena studied, landslides in this case, as what they really are – objects, not pixels – that have spectral, spatial and contextual characteristics (Figure 1). They thus allow limitations of pixel-based methods to be overcome, which are largely restricted to using spectral and texture information. Past landslide characterisations have identified a number of different landslide types and defined them, for example in terms of source material type, run-out length, failure plane curvature or crown shape. These characteristics also form the basis of cognitive, expert knowledge-driven visual landslide mapping. However, potentially any of these characteristics can also be employed in OOA, provided suitable data needed to calculate those parameters are available. The results can then be a (semi-)automatic and robust procedure that can identify landslides and determine their type, making use of the same expert knowledge that drives visual image analysis.

This was demonstrated in recent work that used multispectral 5.8 m IRS P6 LISS-IV imagery of parts of the High Himalayas in India, together with elevation information extracted from 2.5 m stereo-Cartosat1 data (MARTHA et al., 2010). These data were used for automatic mapping and discrimination of debris slides and flows, as well as translational or rotational rockslides. The approach developed is able to eliminate false positives that have proved difficult in previously reported research, such as clear-cuts, roads or riverbeds, and allows an effective integration of process knowledge, for example, the spatial relation of landslides with causative factors such as slope or road construction. Landslides mapped in an independent watershed of 53 km^2, using a process developed for a smaller area, were detected and correctly classified with accuracies of 76.4 % and 69.1 %, respectively, the smallest one meas-uring less than 800 m^2. This suggests that object-based automatic methods can well be used to substitute visual interpretation or field mapping, particularly when large areas need to be covered.

[1] Based in part on material by Tapas MARTHA (ITC [the Netherlands] and NRSC [India]).

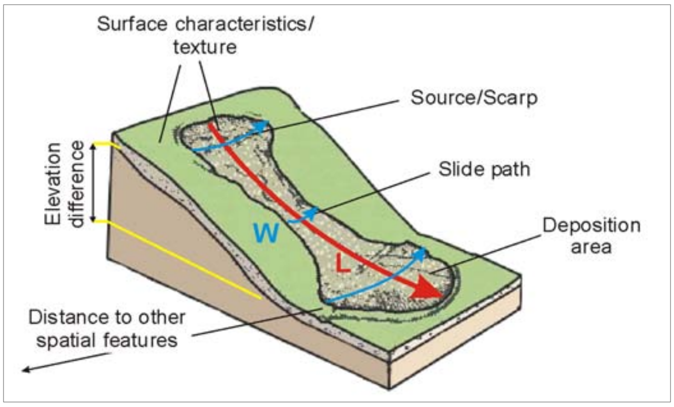

Fig. 1: Anatomical and contextual parameters that determine the type of landslide, and that can be used in OOA.

Using OOA efficiently also raises several problems. The actual analysis is reliant on proper image segmentation (Figure 2), the subjectivity and trial-and-error nature which has been the subject of years of research. Hence, research now focuses on how image statistics and intelligent object merging, rather than visual fine-tuning, can be used for an objective segmentation. Further work is also needed to develop OOA-based methods that include the mapping of other parameters needed in risk assessment, such as elements at risk. Segmentation-based analysis can also be applied to other data types often collected in landslide areas, such as laser scanning or airborne geophysical data, or to track changing features in slow-moving landslides. In the context of the SAFELAND project those, too, are explored.

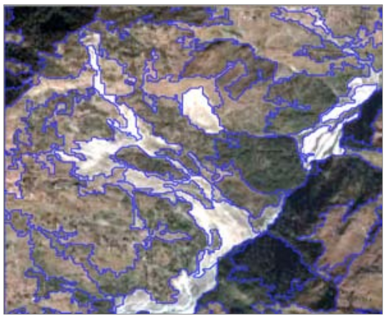

Fig. 2: The success of OOA relies heavily on proper delineation of the features of interest, hence on appropriate segmentation. Only then it is possible to make use of contextual parameters, such as length/width ratios of slides, or adjacency to specific source areas that supports landslide type determination.

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