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Comparison of LiDAR-derived directional topographic features with geologic field evidence: a case study of Doren landslide (Vorarlberg, Austria)

András Zámolyi (1,2), Balázs Székely (3,1), Gábor Molnár (3,1), Andreas Roncat (3), Peter Dorninger (3), Angelika Pocsai (4), Marek Wyszyński (5), and Peter Drexel (6)

(1) Department of Geophysics and Space Science, Eötvös University, Budapest, Hungary (andras@zamolyi.info), (2) Department of Geodynamics and Sedimentology, University of Vienna, Austria, (3) Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Austria, (4) Institute of Geography and Earth Sciences, Eötvös University, Budapest, Hungary, (5) Comarch S.A., Łódź, Poland, (6) Landesvermessungsamt Vorarlberg, Feldkirch, Austria

The study area, the Doren Landslide, is located northeast of Dornbirn (Vorarlberg, Austria) within the Molasse zone in the foreland of the Northern Calcareous Alps. It developed in a prominent morphologic position at the margin of a plateau that is formed by alternating ridges and valleys of Molasse sediments of various composition and glacial moraine sediments. The stream valleys of the area are showing rapid incision into the relatively erodible material; this sediment transport balance/imbalance influences the valley sides that at places develop landslides of various scale. Of them the Doren Landslide is the most prominent one that is already endangering real estate entities.

On-going research has focused on the repeated airborne and terrestrial laser scanning of the landslide in order to determine short-term volumetric and surface changes and the overall development of the phenomenon. Additionally, tectonic geomorphologic analysis using the digital terrain analysis approach was carried out by the authors aiming to document the geologic setting of the landslide and the adjacent areas in order to reveal possible relationship between the (micro)tectonic setting and the mass movement phenomena. In this study, linear and planar features derived from the LiDAR digital terrain model (DTM) by (i) visual lineament analysis and (ii) automated plane fitting are validated by the results of extensive field geological measurements.

For the automated plane fitting, we apply a segmentation approach, originally developed for building detection and roof landscape modeling from ALS data (Dorninger & Pfeifer 2008). It is based on global seed-cluster determination using a four-dimensional feature space defined by locally determined three-dimensional regression planes for each point. Starting from these seeds, all points defining a connected, planar segment are assigned. Due to the design of the algorithm, millions of input points can be processed at once with acceptable processing time on standard computer systems. This allows for processing geomorphologically representative areas at once. For each segment, numerous parameter are derived which can be used for further exploitation. These are, for example, location, area, aspect, slope, and roughness.

In the areas surrounding the recent landslide, the strike of geologically significant planes show a good correlation with the strike of lineaments mapped on the ALS-DTM. The mean strike direction that is prominent has an ENE – WSW orientation. However, within the area directly influenced by the recent landslide, observable differences between field geologic measurements and mapped lineaments occur. ESE – WNW striking linear features well mappable from the ALS-DTM are not recorded by field measurements of planar features (faults or bedding planes). This fact can be explained by several hypotheses. The orientation of patches derived by automated plane fitting also show distinct correlation with the field geologic measurements. Again, a good correlation between dip directions as well as dip values can be observed in areas surrounding the landslide. Detection of steep dipping fault surfaces within the landslide area shows promising results that can be further improved by adjusting the input parameters.

The good correlation of three different types of lineament analysis (field geologic measurements, ALS-DTM analysis, automated plane fitting) prove the accuracy of laser scanned data and the reliability of observations derived from ALS-data.

Dorninger, P., Pfeifer, N. (2008): A Comprehensive Automated 3D Approach for Building Extraction, Reconstruction, and Regularization from Airborne Laser Scanning Point Clouds. Sensors, 8, 11, 7323 - 7343.