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## **Airborne Laser Scanning (ALS) point cloud ground filtering for area of an active landslide (Doren, Western Austria)**

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Ground filtering of point cloud is the primary step required for Digital Terrain Model (DTM) generation. The procedure is especially interesting for forested areas, since LiDAR systems can measure terrain elevation under vegetation cover with a high level of penetration. This work analyzes the potential of ALS data ground filtering for area of an active landslide. The results of ALS filtering, for example, may improve geomorphological and motion-detection studies.

ALS data was collected during flight campaign 2011 under leaf-off conditions for Doren region, Vorarlberg, Western Austria. In this area, non-ground objects are mostly low vegetation such as shrubs, small trees etc. The vegetation is more dense in lower part of the landslide where erosion is smaller. Vegetation points can be removed based on the hypothesis that these are significantly higher than their neighboring points. However, in case of steep terrain, ground points may have the same heights as vegetation points, and thus, local slope should be considered. Also, if terrain roughness increases, the classification may become even more complex.

Software system OPALS (Orientation and Processing of Airborne Laser Scanning data, Vienna University of Technology) was used for processing the ALS data. Labeling ground points has been made using physical and geometrical attributes (parameters) of ALS points. Also additional attributes were calculated in order to improve extraction. Since bare ground surface is usually smooth and continuous unlike vegetation, standard deviation of local elevations was used as roughness measure to differentiate these surfaces. EchoRatio (ER) was adopted as a measure of surface penetrability, while number of echoes and differentiation between echoes (EchoNumber) were also deployed in filtering. Since the ground points are measurements from bare-earth that are usually the lowest surface features in a local area, normalized height was defined as a rank of neighboring points. Additionally, a so-called openness parameter was used as a convexity/concavity measure of surface. All of the mentioned point attributes have been combined in a decision tree in order to extract bare ground points.

Based on a preliminary analysis, it is noted that implemented filtering procedure has difficulties with surfaces with rough terrain or steep relief. There is an assumption for lack of ground points in areas with dense vegetation that reduced the penetration of laser beams to the ground (lower part of a landslide). Also, points representing low vegetation were often labeled as ground points. Procedure produced holes in point cloud which demanded appropriate interpolation methods to be applied.