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Terrestrial laser scanning point clouds time series for the monitoring of slope movements: displacement measurement using image correlation and 3D feature tracking

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Dense multi-temporal point clouds acquired with terrestrial laser scanning (TLS) have proved useful for the study of structure and kinematics of slope movements.
Most of the existing deformation analysis methods rely on the use of interpolated data. Approaches that use multi-scale image correlation provide a precise and robust estimation of the observed movements; however, for non-rigid motion patterns, these methods tend to underestimate all the components of the movement. Further, for rugged surface topography, interpolated data introduce a bias and a loss of information in some local places where the point cloud information is not sufficiently dense.
Those limits can be overcome by using deformation analysis exploiting directly the original 3D point clouds assuming some hypotheses on the deformation (e.g. the classic ICP algorithm requires an initial guess by the user of the expected displacement patterns).
The objective of this work is therefore to propose a deformation analysis method applied to a series of 20 3D point clouds covering the period October 2007 – October 2015 at the Super-Sauze landslide (South East French Alps). The dense point clouds have been acquired with a terrestrial long-range Optech ILRIS-3D laser scanning device from the same base station.
The time series are analyzed using two approaches: 1) a method of correlation of gradient images, and 2) a method of feature tracking in the raw 3D point clouds. The estimated surface displacements are then compared with GNSS surveys on reference targets.
Preliminary results tend to show that the image correlation method provides a good estimation of the displacement fields at first order, but shows limitations such as the inability to track some deformation patterns, and the use of a perspective projection that does not maintain original angles and distances in the correlated images. Results obtained with 3D point clouds comparison algorithms (C2C, ICP, M3C2) bring additional information on the displacement fields. Displacement fields derived from both approaches are then combined and provide a better understanding of the landslide kinematics.