



Monitoring the spatial and temporal evolution of slope instability with Digital Image Correlation

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The identification and monitoring of ground deformation is important for an appropriate analysis and interpretation of unstable slopes. Displacements are usually monitored with in-situ techniques (e.g., extensometers, inclinometers, geodetic leveling, tachymeters and D-GPS), and/or active remote sensing methods (e.g., LiDAR and radar interferometry). In particular situations, however, the choice of the appropriate monitoring system is constrained by site-specific conditions. Slope areas can be very remote and/or affected by rapid surface changes, thus hardly accessible, often unsafe, for field installations. In many cases the use of remote sensing approaches might be also hindered because of unsuitable acquisition geometries, poor spatial resolution and revisit times, and/or high costs. The increasing availability of digital imagery acquired from terrestrial photo and video cameras allows us nowadays for an additional source of data. The latter can be exploited to visually identify changes of the scene occurring over time, but also to quantify the evolution of surface displacements. Image processing analyses, such as Digital Image Correlation (known also as pixel-offset or feature-tracking), have demonstrated to provide a suitable alternative to detect and monitor surface deformation at high spatial and temporal resolutions. However, a number of intrinsic limitations have to be considered when dealing with optical imagery acquisition and processing, including the effects of light conditions, shadowing, and/or meteorological variables.

Here we propose an algorithm to automatically select and process images acquired from time-lapse cameras. We aim at maximizing the results obtainable from large datasets of digital images acquired with different light and meteorological conditions, and at retrieving accurate information on the evolution of surface deformation. We show a successful example of application of our approach in the Swiss Alps, more specifically in the Great Aletsch area, where slope instability was recently reactivated due to the progressive glacier retreat. At this location, time-lapse cameras have been installed during the last two years, ranging from low-cost and low-resolution webcams to more expensive high-resolution reflex cameras. Our results confirm that time-lapse cameras provide quantitative and accurate measurements of surface deformation evolution over space and time, especially in situations when other monitoring instruments fail.