Low-cost terrestrial photogrammetry for rock cliff monitoring

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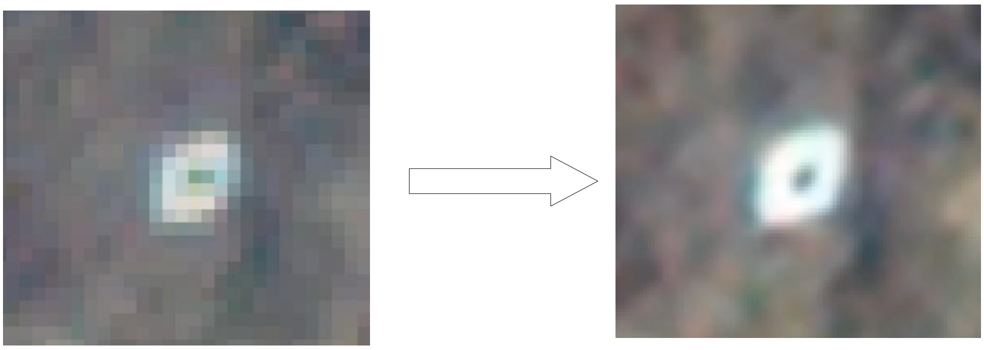
The use of a single camera is a good low-cost alternative for rock wall survey and rockfall detection. Unlike laser scanners, the mono-photogrammetry (or monoplotting) only provides 2-D displacement measurements. However, 3-D change detection remains essential for the study of gravity movements and the understanding of their failure mechanisms. Modern Structure-from-Motion (SfM) photogrammetry techniques allow to generate at low-cost precise measures useful for remote instability detection.

In recent years, various photogrammetric rock cliffs monitoring systems have been published. They are based on systems installed close to the unstable area and make daily measurements. This kind of survey is very promising because it can in some cases avoid the installation of extensometers sometimes delicate to set up and expensive. However, if the objective is to avoid the use of high-cost cameras, the major drawback of this method is that the camera must be positioned close enough to the hazard area to obtain a sufficient image resolution to measure the movements accurately.

This project experiments the possibility of monitoring a rock cliff using two industrial cameras positioned at several hundred meters apart. To meet the challenge, we propose to use a super-resolution method and to take advantage of the stacking of images taken consecutively. This technique increases the resolution of the images in post-processing (Figure 1) in order to identify potential movements of the rock face while being positioned at a high distance from the hazard area. Image stacking would also allow to reduce atmospheric and scintillation effects.

To test our system, we focused on an unstable granitic flake located above the commune of Salvan (Canton of Valais, Switzerland). This rock sheet of about 30 m^3 has been monitored since June 2018 using periodic ground-based laser scans and then with two high-precision extensometers (Figure 2), starting in June 2020. In the context of this study, nine photogrammetric targets were implemented over stable and moving parts (Figure 2), as well as two measuring stations composed of cameras fixed at 650 m from the rock sheet. Those cameras film continuously and send their images to a server via the GSM network. The data then goes through the processing chain for super-resolution and calculate the targets displacements using SfM photogrammetry. Combined with targets, this new system would give the possibility to monitor in real time the movement of an unstable rock compartment.



Original **Super-resolution x4**

Figure 1. Result of the combined super-resolution and stacking of the images performed on a target fixed on an unstable rock sheet (see Fig. 2).

Figure 2. Overview of the monitored rock sheet (drone image). 9 targets (white squares) were installed on the moving (5) and stable (4) parts. The solar panel is used to power both extensometers (metal bars) visible along the back crack.