Comparison of lasergrammetry and photogrammetry for rock walls diagnosis and monitoring

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Gravitational instabilities are a major challenge in mountainous regions. Development of new trajectographic technics, lasergrammetric and photogrammetric 3D modeling, plays a significant role for the diagnosis and monitoring of landslides. They allow 3D surface investigation of hazardous areas, based on areas visible by the instruments.

Diagnosis and gravitational instabilities expertise:

When rock is not covered by vegetation or protective structures, Lasergrammetry and photogrammetry give a precise 3D Digital Elevation Model (DEM). They also provide a high definition photography, essential to the diagnosis. Nevertheless, most of the studied areas are partially vegetated, or covered with wire mesh. This can moderately or totally block the ground out. These elements must be removed, to do the protection studies.

Elimination of vegetation and existing surface works

The 3D laser scanner Lidar type (TOF) provides more information than photographic sources, thanks to advanced signal processing technics, called « online waveform processing ». Thanks to the rigorous multi-targets detection, this technology allows to extract the "off field points" from the true points corresponding to the field. Playing on the echoes of transmitted signals, enables to select points corresponding for instance to the vegetation or a wire mesh along a rock face.

Figure 1a shows a site where the vegetation totally covers the lower part of the rocky hillside even in winter. In this particular sector, the photogrammetric technic does not allow the realization of a digital elevation model of the entire rocky hillside of interest. Figure 2b shows the 3D colorized cloud point obtained by lasergrammetry after the elimination of vegetation. The processing of Lidar data allows the identification and characterization of the existing merlon construction which is completely covered and blocked out by vegetation. The lasergrammetric survey on the site enables the construction of a precise DEM of the whole slope. This DEM has been used for the trajectographic modeling taking into consideration the existing protection infrastructure.

Figure 2a shows the result of the elimination of various wire meshes on an instable rocky slope to be stabilized (Hospital Pasteur in Nice). Figure 2b and c display the automatic discrimination of the echoes generated by the meshes from those generated by the rocky slope. Nevertheless, even though the presence of a wire mesh does not cause trouble as for the data processing, the acquisition time on the other hand is much higher. It is capital to multiply the stations so that the laser beam arrives perpendicularly against the rock wall. Furthermore, it is necessary to increase the angular resolution (with respect to a classic survey) in order to obtain enough points on the rock face to create a fine meshing.

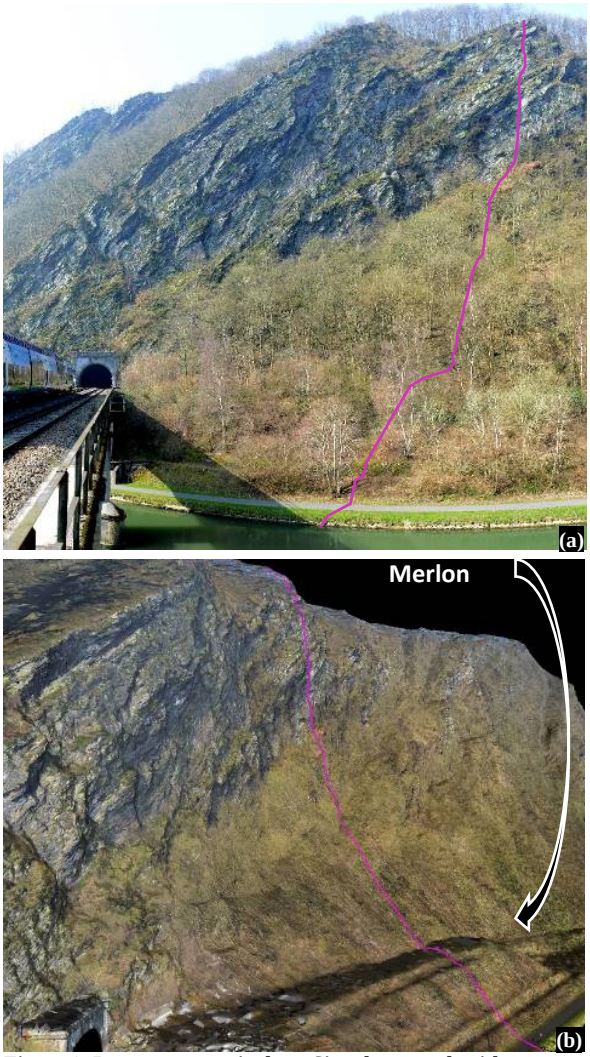

Figure 1: Lasergrammetric data: Site photograph with presence of vegetation (a) and textured DEM after processing (b), The violet line represents the realized trajectographic profile.

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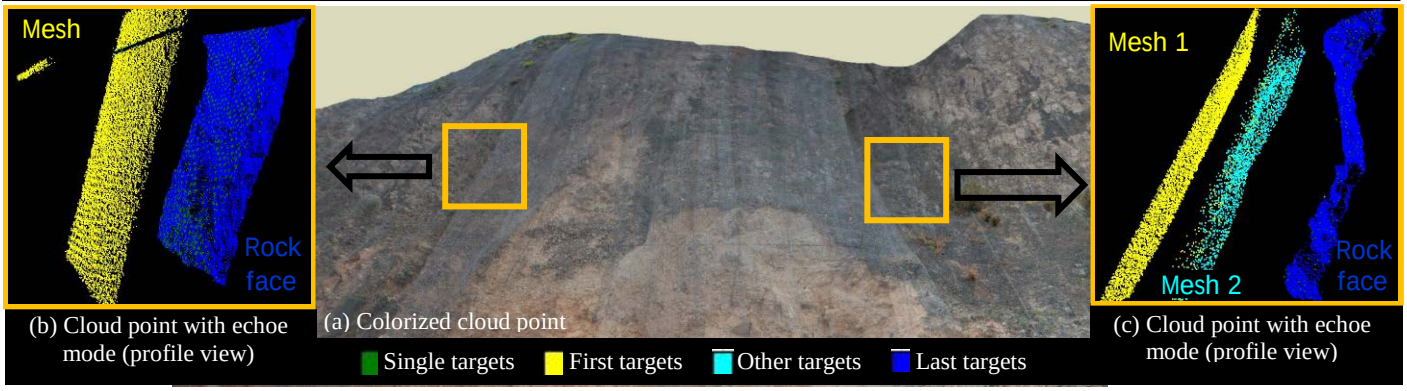

Figure 2: Lasergrammetric survey with colorized obtained cloud point (a) and discrimination of one (b) or two (c) hanged wire meshes

The elimination of vegetation and some hanged wire meshes allows a geo-structural analysis of the hidden rock wall. Figure 3 displays an example of result obtained by the automatic processing of lasergrammetric data.

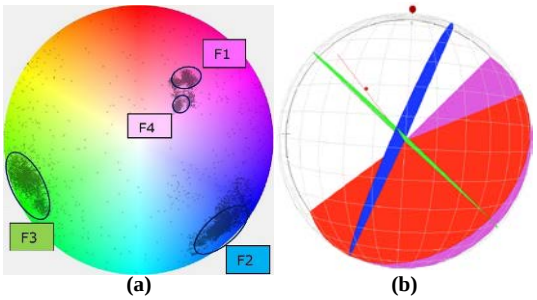

Figure 3: Geostructural analysis from lasergrammetric data: (a) Poles of different fractures families, HSV Diagram (Hue Saturation Value), (b) 3D Wülff diagram of surveyed discontinuities – lower hemisphere

Taking into account vegetation and existing protection structures in the trajectographic simulations

In order to implement and design the passive protection structures against rockfalls, it is advisable to take into account vegetation and existing protection structures in the trajectographic simulations.

Figure 4 demonstrates the capacity of the lasergrammetric technic to qualify and quantify those elements. The precise 3D localization of the areas of vegetation, the density and type of vegetation, the size and diameter of the trees are easily measurable. The localizations and dimensions of the structures are also designed with a very fine accuracy.

Auscultation and gravitational instabilities monitoring:

Both technics of lasergrammetry and photogrammetry enable to compare 3D models carried out at different dates in order to quantify and evaluate displacement of a high risk site which do not present vegetation nor surface protection structures.

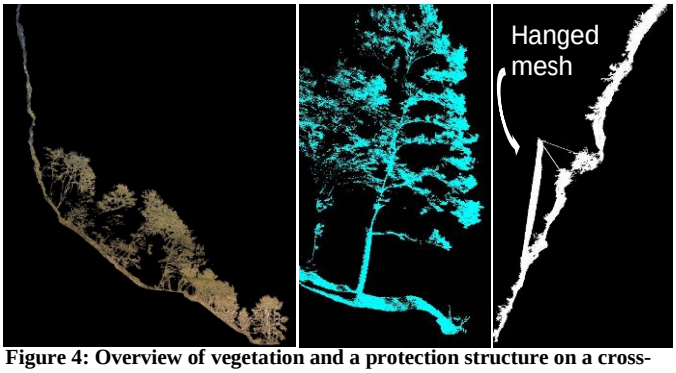

Figure 4: Overview of vegetation and a protection structure on a cross-section profile

Nevertheless in a natural hazards prevention objective, the monitoring tools should not depend on environmental and climatic conditions since these are major factors affecting rockfalls risks.

The Laser scanner is the topographic device allowing a high speed and contactless acquisition thanks to a laser beam and a quick scanning mechanism. Some atmospheric parameters are likely to disturb and consequently to distort the data. Indeed, the temperature, the pressure, the atmospheric gaseous composition, the climatic conditions and the presence of particles in the air are the elements which influence the measurements. However some of these elements can be taken into account and implemented into the device in order to minimize the errors.

On the other hand, photogrammetry offers less flexibility for the adjustment of a precision monitoring. Indeed, this technic is not working by night, in back-light conditions, or when the air humidity is high. Therefore, the data gathering must be carried out in optimal environmental conditions to obtain quality results in order to detect displacements in the range of 1-5 cm. The environmental conditions also influence directly the lasergrammetric data but not as much as they affect photogrammetric ones.

CONCLUSION

Lasergrammetry and photogrammetry give high quality data. But, contrary to photogrammetry, lasergrammetry allows to create a DEM, getting rid of vegetation and existing surface protection structures, and to integrate these very elements into the trajectographic simulations, lasergrammetry is more suitable for diagnosis and the monitoring of gravitational instabilities. Despite a merely superior cost price (acquisition and processing), the additional data provided by lasergrammetry over photogrammetry bring a non-negligible added value for the project.