PHOTOGRAMMETRIC 3D MODELS FROM DRONE IMAGERY FOR IMPROVED ROCK MASS CHARACTERIZATION

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ABSTRACT

The application relates to an innovative technology (drone plus software) introduced to current rock engineering problems that reduces time and cost while simultaneously increases safety. In particular, it covers the use of aerial imagery from drones for generating highly detailed 3D models from rock fall areas and how to use the 3D models to determine parameters on the rock mass that support on rating the situation and deciding on measures in quick and comprehensive manner.

INTRODUCTION / PROBLEM STATEMENT

There are several rock fall areas in Alpine regions in Austria. Some hazardous areas are close to infrastructure such as roads or railway lines, some even close to residential areas. After an incident, the situation needs to be assessed in order to decide on appropriate measures to prevent from further incidents and harms. In most cases, the areas are not accessible safely, so a direct determination of geometric rock mass parameters becomes difficult.

Using UAVs (drones) allows capturing inaccessible areas from a safe location. In doing so with highly redundant imagery and applying modern photogrammetry algorithms, comprehensive, accurate and particularly realistic 3D models are gained. They do not only provide comprehensive documentation of the area of interest but also serve as basis for mapping geological features and taking geometric measurements.

Figure 1: Photograph of a rock fall area (left); drone while capturing the area of interest (right)

PHOTOGRAMMETRIC 3D MODELS

Photogrammetry enables the generation of three-dimensional models from a series of overlapping photographs. The introduction of the so-called 'structure from motion' concept as well the broad availability of drones brought a kind of renaissance of this long-standing technology, not least because modern approaches work in a fully automatic manner.

Structure from motion includes a series of processing steps that allows computing a comprehensive set of 3D surface points that combine to a surface description (i.e. a mesh) in photo-realistic style. Due to high redundant information, geometric deviations that are present in any camera (lens distortion) are compensated while generating the 3D model. This *auto-calibration* ability makes modern photogrammetry algorithms capable of producing accurate 3D models even from low-grade cameras. So even low cost, off-the-shelf drones are eligible to generate 3D models at sufficient high accuracy.

In order to get reference to a superior co-ordinate system and cardinal directions, usually several ground control points (i.e. surveyed points) are used. The presented system is capable to generate 3D models at sufficient accuracy without any ground control points just by using the on-board GPS that is available in any drone beyond pure toys. This eases and speeds up field procedure tremendously.

Figure 2: 3D model of a rock fall area in Austria captured close after an incident in the center part; overall size of the captured area:750x250 m; vertical height: 200 m; flight time: 1 hour.

ROCK MASS CHARACTERIZATION FROM 3D MODELS

Once a 3D model is ready, several measurements/assessments from it are available including:

- Geometric measurements, such as volumes, areas, distances, cross sections,
- Geologic mapping features, such as orientation of traces or areas,
- Derived geological parameters, such as discontinuity sets and their spatial orientations or discontinuity spacing

The presented software allows direct interactive analysis of geometric entities and geologically relevant features but also provides automated analyses. Interactive measurements include orientation measurements (see *Figure 3*) without access restrictions or compromising safety. However, planar areas are identified automatically and more recently linear features have been included into the automatic analysis. The found features group to sets by automatic clustering leading to reproducible and statistically admissible assessments due to the high number of individual measurements (see *Figure 4*).

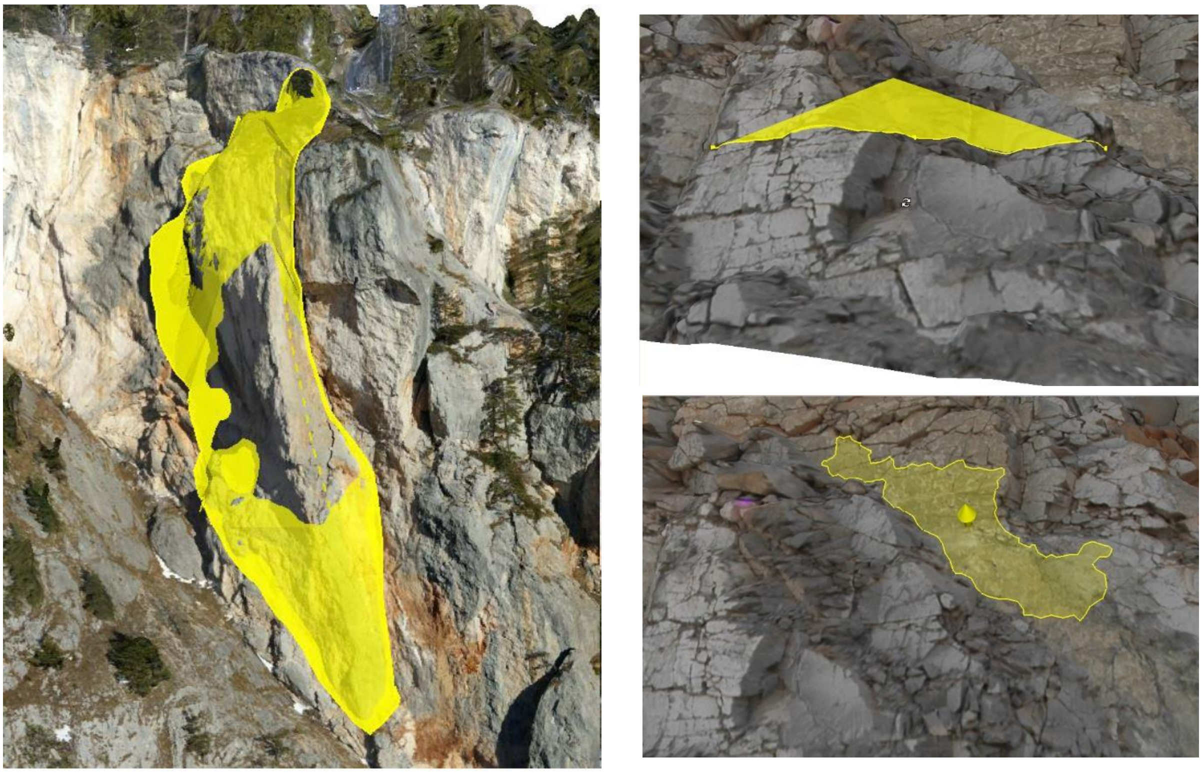

Figure 3: Quantification of a potentially detachable block with a volume of 2.350 m^3 (left) and exemplary orientation measurements from a trace (top right) and from an area (bottom right).

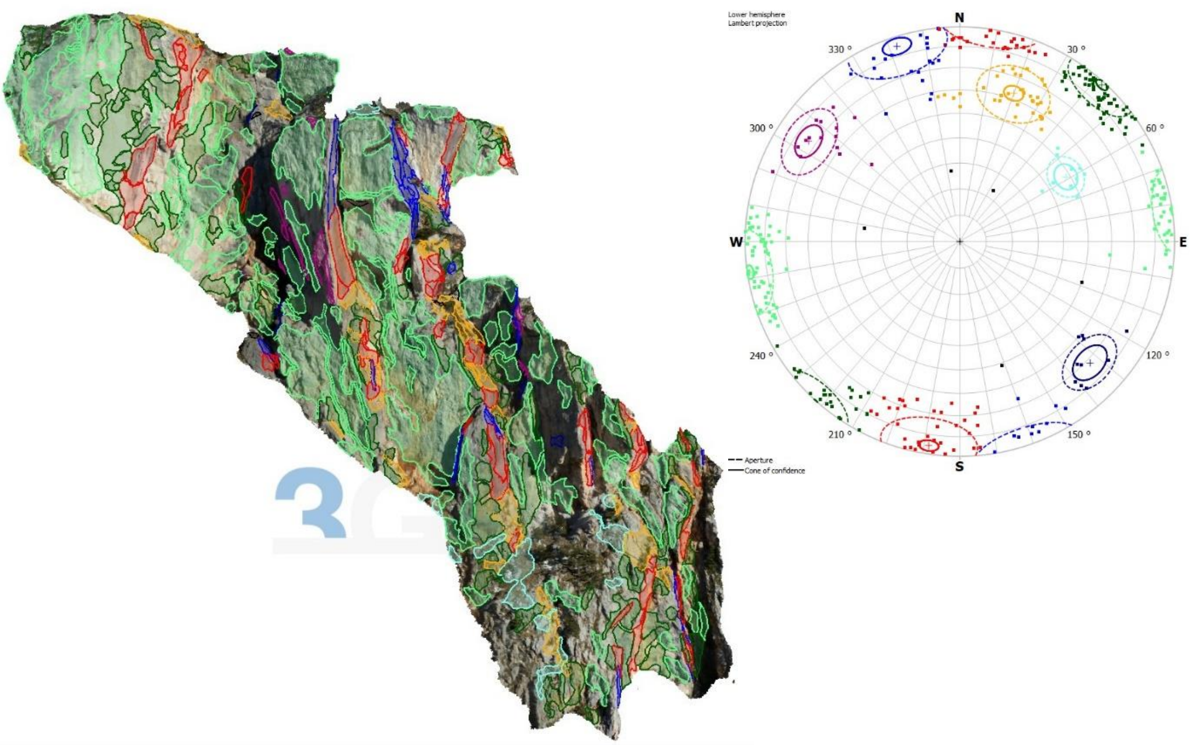

Figure 4: Automatic analysis of the hazardous area: identified structures (left) and discontinuity sets (right)

TIME CONSIDERATIONS

Besides the objective and comprehensive documentation by aerial 3D models, they also reduce time for the analyses significantly. The shown example of a rock fall area was inaccessible due to recent incidents. Consequently, no conventional ground characterization was possible. Using the suggested system, the time requirements for the entire procedure (flying the drone, processing the images, analyzing the 3D model) is less than a working day even for large areas that need to be assessed.

Table 3: Time requirements per task (exemplary)

Task	Time requirements (hours)	Comments
Drone flight	1	About 750 x 250 m No Ground control points 740 photos Ground Sample Distance (GSD) = 1 cm/px
3D model generation	3	Mobile work station
Model assessment	1	Depending on level of detail