**Comparison of 3D point clouds produced by LIDAR and UAV photoscan in the Rochefort cave (Belgium)**

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**INTRODUCTION & PROBLEMATIC**

Amongst today’s techniques that are able to produce 3D point clouds, LIDAR and UAV (Unmanned Aerial Vehicle) photogrammetry are probably the most commonly used. Both methods have their own advantages and limitations. LIDAR scans create high resolution and high precision 3D point clouds, but such methods are generally costly, especially for sporadic surveys. Compared to LIDAR, UAV (e.g. drones) are cheap and flexible to use in different kind of environments. Moreover, the photogrammetric processing workflow of digital images taken with UAV becomes easier with the rise of many affordable software packages (e.g. Agisoft, PhotoModeler3D, VisualSFM).

**CLUSTERING 3D DATA**

The qFacets plug-in (T. Dewez, BRGM) of Cloud Compare allows to automatically merge neighbourd model polygons that have similar orientations (here, less than 10° between planes pole). This routine acts as a subsampling method on the basis of polygons geometry and spatial distribution. Comparison between structures measured on the field and those extracted from the 3D models is possible. This allows to investigate and spatialize structures that are inaccessible to the fieldworker and to run statistical spatial analyses over large amount of indirectly sampled structural data.

**Structural observations**

For in situ measurements, poles of joints and faults planes are spread along an average plane striking N069-SE41. This orientation is subparallel to sedimentation deposit orientation. Such a distribution of the joints suggests that the geometry of the strata pile strongly controlled their formation. Thus, they could be interpreted as a gravity consequence concomitant to the formation of the cave. Additional field 3D models investigations would be required to make further conclusions with this particular point. Variation have also been observed between the photoscan data from the surface area and the one surveyed in the cave, which may be interpreted as a large-scale folding structure.

**VOLUMES & MODELLING**

Computing volumes of underground cavities brings invaluable information to karst geologists. LIDAR data spatially cover a greater area of the surveyed chamber, which explain the greater volume computed compared to the photoscan mesh. Discretising the internal volume was also performed, using Teggen (F.), 2015). This helps modelling multiple problems such as, in our case, the effect of atmospheric pressure in the chamber on gravimetric measurements performed at the site.

**VOLUME**

$$V_{\text{areamesh}} = 9117 \, m^3$$

$$V_{\text{photoscan}} = 8403 \, m^3$$

**Conclusions and perspectives**

We illustrated via the Rochefort cave study case that using both sources of 3D information is applicable to quantify the orientation of inaccessible geological structures (e.g., faults, tectonic and gravitational joints, and sediments bedding), and compare these data to structural data surveyed on the field. An additional drone photoscan was also conducted in the surface sinkhole giving access to the surveyed underground cavity to seek geological bodies’ connections. Further analyses are still needed to improve the comparison of both information such as an extensive colorimetric/spectral analysis of the photoscan data. Rugsosity analyses would also be of interest on selected part of the 3D body.

**LIDAR scan vs UAV Photoscan**

Theodolite surveys and compass measurements were crucial for georeferencing both point clouds.

**LIDAR scan**

- Leica ScanStation 2
- Two ground stations
- ~3 hours of measurements
- 7 million points reconstructed

**UAV Photoscan**

- Drone Phantom 3 Pro
- ~2 hours of measurements for 305 UAV photos + 330 DSLR photos
- Photogrammetry processed with Agisoft
- 50 million points reconstructed

We combined the theodolite reference points with reference horizontal surfaces in the cave and known orientations between reference points (small cave conduits). Both LIDAR and photoscan point clouds were aligned on reference points. After this procedure the relative position of photoscan point cloud with regard to LIDAR point cloud was improved using the iterative fine registration method (ICP, via more than 500,000 common points), modifying the rotation and x,y,z scale object while conserving original scale ratios. The M3C2 method (Lague et al., 2013) was performed to compute distances between the two point clouds using the LIDAR point cloud as reference. This method evidenced that both point clouds match standard deviation of 0.03 m. In our case, the effect of atmospheric pressure in the chamber on gravimetric measurements performed at the site.

**Volumes**

$$V_{\text{areamesh}} = 9117 \, m^3$$

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**Facets around the center represent the ground**

- Faults orientation
- Faults strikes
- Joints strikes

**ROCHEFORT CAVE**

UAV Photoscan at surface

Theodolite survey

This large system is built within Devonian limestone units of the so-called Namurian (Variscan) fold-and-thrust-belt in Belgium. Ardenne is shown a well-developed karstic network (Cambebius, 2012) comprising large galleries with diameter of several meters separated by the sinuous directions of the stratigraphic unit (N070-75) and smaller galleries along the horizontal crosscutting the main ones. Its lithology is composed of alternating decametric-scales of well-consolidated limestones and weathered/poisoned limestones strata.