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Extracting structural and lithological data from Digital Outcrop Models of cave chambers

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Acquiring and building Digital Outcrop Models becomes an essential tool in geosciences, while standing out as a complementary approach to traditional geological field surveys. Most of all, it allows: (ii) to survey field data from inaccessible outcrops, quantify volumes and large amounts of discrete measurements, (ii) to get a continuous representation of the area of interest and a means to gain quantitative data, (iii) to monitor 4D evolution of the topographical surface model and (iv) to integrate realistic digital outcrop models into virtual environments for geosciences training, teaching and geocommunication. More specifically, the use of drone (or Unmanned Aerial Vehicles) and field cameras combined to Structure from Motion (SfM) photogrammetric technology is becoming a robust alternative to Light Detection And Ranging (LIDAR) scans, due to its low-cost and flexible implementation in different kind of environments as well as the rise of many affordable software packages producing Digital Surface Models (e.g., Agisoft Photoscan, MicMac, VisualSFM).

We present here a challenging study in Lorette Cave (South Belgium). The main chamber of this cave system ($\sim$ 10000 m^3) is the principal target of the study as its roof exhibits an imposing sedimentary pile being inaccessible for direct measurements of geological structures. We built a high resolution 3D model (396 M points and 40 M polygons) using SfM photogrammetry, combining DSLR field and UAV pictures. This communication will focus on the optimized workflow for pre-, syn- and post-processing of such high resolution models in confined caves and/or lowlights environments, which includes:

• Acquiring the field pictures. This goes through the optimization of the amounts and positions of spotlights, the number of ground control points, the number of photographs, overlap and points of view, etc.

• Building the model, i.e. using preliminary treatments of digital field pictures (mask, highlights/shadows and halogen light color corrections), optimizing parameters for 3D points cloud and 3D mesh computation.

• Georeferencing the model, i.e. calculating the transformation matrix to transform the outcrop model (leveling, azimuth to-the-north, scaling, translating) from photogrammetric to real-world coordinate systems.

• Extracting geological data via building a detailed lithostratigraphic log of the underground outcrops, quantifying the orientation of inaccessible geological structures (e.g. faults, joints, sedimentary beddings), comparing them to accessible structures measured on the field, defining the tectonic kinematics of faulted structures.

• Sharing 3D data, i.e. integrating digital outcrop models into a virtual world using Unity software framework and a smartphone-based VR headset.