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DOMstudio: an integrated workflow for Digital Outcrop Model reconstruction and interpretation

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Different Remote Sensing technologies, including photogrammetry and LIDAR, allow collecting 3D dataset that can be used to create 3D digital representations of outcrop surfaces, called Digital Outcrop Models (DOM), or sometimes Virtual Outcrop Models (VOM). Irrespective of the Remote Sensing technique used, DOMs can be represented either by photorealistic point clouds (PC-DOM) or textured surfaces (TS-DOM). The first are datasets composed of millions of points with XYZ coordinates and RGB colour, whilst the latter are triangulated surfaces onto which images of the outcrop have been mapped or "textured" (applying a tech-nology originally developed for movies and videogames).
Here we present a workflow that allows exploiting in an integrated and efficient, yet flexible way, both kinds of dataset: PC-DOMs and TS-DOMs. The workflow is composed of three main steps: (1) data collection and processing, (2) interpretation, and (3) modelling.
Data collection can be performed with photogrammetry, LIDAR, or other techniques. The quality of photogrammetric datasets obtained with Structure From Motion (SFM) techniques has shown a tremendous improvement over the past few years, and this is becoming the more effective way to collect DOM datasets. The main advantages of photogrammetry over LIDAR are represented by the very simple and lightweight field equipment (a digital camera), and by the arbitrary spatial resolution, that can be increased simply getting closer to the out-crop or by using a different lens. It must be noted that concerns about the precision of close-range photogrammetric surveys, that were justified in the past, are no more a problem if modern software and acquisition schemas are applied. In any case, LIDAR is a well-tested technology and it is still very common.
Irrespective of the data collection technology, the output will be a photorealistic point cloud and a collection of oriented photos, plus additional imagery in special projects (e.g. infrared images). This dataset can be used as-is (PC-DOM), or a 3D triangulated surface can be interpolated from the point cloud, and images can be used to associate a texture to this surface (TS-DOM). In the DOMstudio workflow we use both PC-DOMs and TS-DOMs. Particularly, the latter are obtained projecting the original images onto the triangulated surface, without any downsampling, thus retaining the original resolution and quality of images collected in the field.
In the DOMstudio interpretation step, PC-DOM is considered the best option for fracture analysis in outcrops where facets corresponding to fractures are present. This allows obtaining orientation statistics (e.g. stereoplots, Fisher statistics, etc.) directly from a point cloud where, for each point, the unit vector normal to the outcrop surface has been calculated. A recent development in this kind of processing is represented by the possibility to automatically select (segment) subset point clouds representing single fracture surfaces, which can be used for studies on fracture length, spacing, etc., allowing to obtain parameters like the frequency-length distribution, P21, etc.
PC-DOM interpretation can be combined or complemented, depending on the outcrop morphology, with an interpretation carried out on a TS-DOM in terms of traces, which are the linear intersection of "geological" surfaces (fractures, faults, bedding, etc.) with the outcrop surface. This kind of interpretation is very well suited for outcrops with smooth surfaces, and can be performed either by manual picking, or by applying image analysis techniques on the images associated with the DOM. In this case, a huge mass of data, with very high resolution, can be collected very effectively. If we consider applications like lithological or mineral map-ping, TS-DOM datasets are the only suitable support.
Finally, the DOMstudio workflow produces output in formats that are compatible with all common geomodelling packages (e.g. Gocad/Skua, Petrel, Move), allowing to directly use the quantitative data collected on DOMs to generate and calibrate geological, structural, or geostatistical models. I will present examples of applications including hydrocarbon reservoir analogue studies, studies on fault zone architecture, lithological mapping on sedimentary and metamorphic rocks, and studies on the surface of planets and small bodies in the Solar System.