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Semi-automatic characterization of fractured rock masses using 3D point clouds: discontinuity orientation, spacing and SMR geomechanical classification

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Investigation of fractured rock masses for different geological applications (e.g. fractured reservoir exploitation, rock slope instability, rock engineering, etc.) requires a deep geometric understanding of the discontinuity sets affecting rock exposures. Recent advances in 3D data acquisition using photogrammetric and/or LiDAR techniques currently allow a quick and an accurate characterization of rock mass discontinuities.

This contribution presents a methodology for: (a) use of 3D point clouds for the identification and analysis of planar surfaces outcropping in a rocky slope; (b) calculation of the spacing between different discontinuity sets; (c) semi-automatic calculation of the parameters that play a capital role in the Slope Mass Rating geomechanical classification.

As for the part a) (discontinuity orientation), our proposal identifies and defines the algebraic equations of the different discontinuity sets of the rock slope surface by applying an analysis based on a neighbouring points coplanarity test. Additionally, the procedure finds principal orientations by Kernel Density Estimation and identifies clusters (Riquelme et al., 2014). As a result of this analysis, each point is classified with a discontinuity set and with an outcrop plane (cluster).

Regarding the part b) (discontinuity spacing) our proposal utilises the previously classified point cloud to investigate how different outcropping planes are linked in space. Discontinuity spacing is calculated for each pair of linked clusters within the same discontinuity set, and then spacing values are analysed calculating their statistic values.

Finally, as for the part c) the previous results are used to calculate parameters F_1, F_2 and F_3 of the Slope Mass Rating geomechanical classification. This analysis is carried out for each discontinuity set using their respective orientation extracted in part a). The open access tool SMRTool (Riquelme et al., 2014) is then used to calculate F_1 to F_3 correction factors introducing the slope and the analysed discontinuity set dip directions and dips.

In order to illustrate the proposed methodology, we present a slope placed in the National route N-332 in El Campello (Alicante, SE Spain), in the named Flysch sequence of Alicante, which corresponds to sediments of pelagic domain that constitute rythmite predominated by marls, In order to illustrate the proposed methodology, we present a slope placed in the National route N-332 in El Campello (Alicante, SE Spain), in the named Flysch sequence of Alicante, which corresponds to sediments of pelagic domain that constitute rythmite predominated by marls, on which frequently overlaps calcareous deposits [1]. The studied rock mass is composed of thick bedded blocky calcarenites with an extremely high competence, well interlocked and undisturbed, consisting of parallelepipedic blocks formed by three intersecting discontinuity sets (decimetric thickness with the other two dimensions from decimetric to metric). The studied rock slope was modelled by two 3D point clouds. The first one was acquired by means of a Leica C10 Laser Scanner and the second one was generated using the photogrammetry technique Structure from Motion (SfM) using Agisoft PhotoScan.