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A LiDAR intensity correction model for vertical geological mapping

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Ground-based LiDAR has been traditionally used for surveying purposes via 3D point clouds. In addition to XYZ coordinates, an intensity attribute is also recorded by the LiDAR devices but this parameter is rarely used for geological applications. The intensity of the backscattered signal can be a significant source of information in different geological applications, such as geological remote mapping of vertical surfaces, mineral exploration, stratigraphy, engineering, etc. However, the Intensity value recorded by the LiDAR is a function of several external parameters, thus a correction of the raw intensity information is required prior to make use of this parameter.
This study proposes an intensity correction model which takes into account of the range, the incidence angle and the surface roughness based on Oren-Nayar reflectance model (Oren and Nayar, 1994). The Oren-Nayar reflectance model is based on the idea that a surface is composed of micro-facets of various slope angles. The simplified version of this model requires only one parameter to characterize a surface, the standard deviation of the slope angle of the facets.
Different discrete pulse laser scanners of Optech's ILRIS category were used to understand how the back-scattered intensity evolves in function of range and incidence angle. This was performed by carrying out different indoor and outdoor experiments, using the following targets: 1) mobile 2m2 board covered by black/white paper, 2) white plaster corridor walls and 3) finally on natural outcrops.
First of all, we carried out a simple experiment by placing the mobile board at different distances ranging from 10 to 1000 meters. The analysis of the datasets revealed that the intensity of the backscattered signal decreases with the square of the range to the target, as was expected. However, both for the wall and the natural outcrops, the influence of the incidence angle appears to be more complex than the classical cosine law due to the roughness of the scanned surface. Thus, we propose to use a simplified Oren-Nayar reflectance model instead of the commonly used approach (cosine law). Using the Oren-Nayar model and varying the standard deviation of the roughness distribution, it is possible to apply a correction for each lithological class. As a result, a new intensity value in relative values is obtained for every point of the scan.