Data mining in rock mining: predicting mechanical properties of carbonate rocks using hyperspectral remote sensing

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ABSTRACT

Determining the mechanical properties of rocks is important for various civil engineering fields, including the mining of raw materials for aggregates used in the construction and paving industries. Traditionally, the mechanical properties of rocks are obtained through in-situ and laboratory tests during geotechnical surveys. However, these time-consuming surveys involve many resources. In contrast, hyperspectral remote sensing methods make it possible to identify the mineralogical composition and crystallographic structure of the rock; properties that control the mechanical properties of the rocks. In this work, we characterize the mechanical properties of carbonate rocks by using a hyperspectral sensor in laboratory conditions.

We collected about 150 cylindrical samples of carbonate rock, with a wide range of strength values from several rock outcrops in Israel. We used a point spectrometer in the range of 0.4 – 2.5 μm and a spectral image sensor in the range of 3.0 – 12.0 μm, scanning the samples to obtain the signature of their light reflections and spectral emissivity. We then measured the samples' density, porosity, water absorption, and uniaxial compressive strength (UCS). We used sophisticated data mining to find statistical relationships between the hyperspectral signatures of the samples and their mechanical properties. We used this data to identify the most dominant wavelengths for predicting mechanical properties. We found that the density, porosity, and water absorption of carbonate rocks could be confidently predicted based on spectroscopy data, while the UCS of the rock could also be predicted, but less significantly.

The results of the study pave the way for the development of measuring tools for the mechanical properties of rock, based on non-destructive tests of quarrying materials.