Spectroscopy and machine vision – a replacement for manual gravel analysis?

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Petrographic gravel analysis is usually carried our manually, making it time-consuming, subjective and not perfectly reproducible. For automated gravel analysis, the Geological Survey of Austria operates a petroscope which uses spectrometric (Hofer, 2011) and laser triangulation (Lee et al., 2005) techniques to determine rock type and geometric properties of each individual grain within a sediment sample.

A feeder system separates the sample and forwards the particles onto a conveyor belt where they are scanned individually by a spectrometer and by two laser cameras. Due to the resolution of the cameras, the minimum detectable particle size is 2 mm. Geometric properties include the length of the three main axes and derived parameters such as elongation, flatness, angularity and sphericity as well as the shape and flakiness index of each particle. For the entire sample, the grain size distribution is also calculated. Reflectance spectra are interpreted in terms of rock type using multivariate functional regression analysis which allows to estimate the percentages of rock types present in the lithological spectrum.

While the determination of particle geometry is well tested and provides reliable results (Hofer & Bach, 2015), the determination of rock type is currently limited by the spectrometer which only measures in the visible and near-infrared light spectrum (380 – 930 nm). Algorithms are trained so far on crushed rock samples of andesite, basalt, chert, dacite, dolomite, gabbro, gneiss, granite, greywacke, limestone, rhyolite and serpentinite. Rock types in these samples are classified with an accuracy of 96 %.

To improve rock type identification, ongoing work focuses on collecting more samples including all major rock types occurring in Austria and on using an additional spectrometer measuring at wavelengths of 1300 – 2500 nm. Furthermore, adaptive techniques such as novelty detection are being developed for automatic extension of the classification model. The aim is to increase the number of recognizable rock types and to quantify statistically the heterogeneity within rock types.

Results will be used to forecast technical material properties of sediment samples (attrition, resistance to fragmentation, friction angle), to derive their aggregates resource potential (e.g. suitability for concrete, railway ballast) but also to study their sedimentary context (provenance, transport mode and distance, depositional environment). With its improved functionality, the petroscope can be used in quality control systems for aggregates by producers (gravel pit operators) and customers (construction sites, concrete plants).

References:

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