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# Towards robots with geologist eyes? Computer vision and Deep Learning approaches to field samples analysis

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Automation and robotics raise growing interests in the mining industry. If not already a reality, it is no more science fiction to imagine autonomous robots routinely participating in the exploration and extraction of mineral raw materials in the near future. Among the various scientific and technical issues to be addressed towards this objective, this study focuses on the automation of real-time characterisation of rock images captured on the field, either to discriminate rock types and mineral species or to detect small elements such as mineral grains or metallic nuggets. To do so, we investigate the potential of methods from the Computer Vision community, a subfield of Artificial Intelligence dedicated to image processing. In particular, we aim at assessing the potential of Deep Learning approaches and convolutional neuronal networks (CNN) for the analysis of field samples pictures, highlighting key challenges before an industrial use in operational contexts.

In a first initiative, we appraise Deep Learning methods to classify photographs of macroscopic rock samples between 12 lithological families. Using the architecture of reference CNN and a collection of 2700 images, we achieve a prediction accuracy above 90% for new pictures of good photographic quality. Nonetheless we then seek to improve the robustness of the method for on-the-fly field photographs. To do so, we train an additional CNN to automatically separate the rock sample from the background, with a detection algorithm. We also introduce a more sophisticated classification method combining a set of several CNN with a decision tree. The CNN are specifically trained to recognise petrological features such as textures, structures or mineral species, while the decision tree mimics the naturalist methodology for lithological identification.

In a second initiative, we evaluate Deep Learning techniques to spot and delimitate specific elements in finer-scale images. We use a data set of carbonate thin sections with various species of microfossils. The data comes from a sedimentology study but analogies can be drawn with igneous geology use cases. We train four state-of-the-art Deep Learning methods for object detection with a limited data set of 15 annotated images. The results on 130 other thin section images are then qualitatively assessed by expert geologists, and precisions and inference times quantitatively measured. The four models show good capabilities in detecting and categorising the

microfossils. However differences in accuracy and performance are underlined, leading to recommendations for comparable projects in a mining context.

Altogether, this study illustrates the power of Computer Vision and Deep Learning approaches to automate rock image analysis. However, to make the most of these technologies in mining activities, stimulating research opportunities lies in adapting the algorithms to the geological use cases, embedding as much geological knowledge as possible in the statistical models, and mitigating the number of training data to be manually interpreted beforehand.