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Lithological classification using multi-sensor data and Convolutional Neural Networks

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Deep learning has been used successfully for computer vision problems, e.g. image classification, target detection and many more. We use deep learning in conjunction with ArcGIS to implement a model with advanced Convolutional Neural Networks (CNNs) for lithological mapping in the Mount Isa region (Australia). The area is ideal for geological remote sensing as there is only sparse vegetation. Besides freely available Sentinel-2 and ASTER data, several geophysical datasets are available from exploration campaigns. There are first studies based on Sentinel-2 data for geological applications and ASTER has a long history in lithological mapping, however not in the field of deep learning. By fusing the datasets and thus covering a wide spectral range as well as capturing geophysical properties of rocks, we aim at improving classification accuracies. This approach can also be used for other applications that aim at classifying landcover.

We developed an end-to-end deep learning model with 2-D convolutional and deconvolutional layers using Tensorflow. Our model was inspired by the family of U-Net architectures, where low-level feature maps (encoders) are concatenated with high-level ones (decoders), which enables precise localization. This type of network architecture was especially designed to effectively solve pixel-wise classification problems as is the case for lithological classification. We spatially resampled, reprojected and fused the multi-sensor remote sensing data into an image cube as input for our model. The connection between ArcGIS and the deep learning libraries was achieved by using the Python API for ArcGIS and by implementing the training and testing workflow into Jupyter Notebooks. Our model classifies each pixel of the multiband imagery into different types of rocks according to a defined probability threshold.

After fitting our model on 50 million pixels, results show that the overall accuracy based on Sentinel-2 bands alone is around 73% and can be improved by adding ASTER bands to almost 75%. By including both, ASTER and geophysical data, results could not be improved.

In conclusion, by fusing Sentinel-2 and ASTER spectral bands that perfectly capture major absorption features of clay minerals and mafic minerals such as pyroxenes and carbonates, we achieve rather good classification results for the different lithologies, even though there are many labelling errors in the training data.