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APPLICATION OF CONVOLUTIONAL NEURAL NETWORKS FOR CLASSIFICATION OF LUNAR SAMPLE PETROGRAPHIC THIN SECTIONS

Abstract

The ability to carry out in-situ geologic sample analysis without sending samples to laboratories on earth can be considered an exploration enabling ability in terms of crew autonomy. Sample Return is often technically challenging, or impossible, and the lead time for receiving results would limit astronauts ability to be autonomous within an exploration scenario. With renewed interest in the crewed exploration of the Moon, there is a need for tools that would provide astronauts with instant knowledge about the samples they are collecting. This would let them make decisions while on EVA and potentially increase overall situational awareness and science output of the mission.

In pursuit of this goal, we have developed a Machine Learning method to build a model capable of classifying samples collected over the course of Apollo missions. Generally, in order to differentiate rock type in a sample, the petrographic thin section is prepared, photographed under a microscope and annotated by trained geologists. Our model replaces human annotator and is capable of differentiating between two primary rock types present in Apollo samples – Basalts and Breccia – that consist of 96

The model is a Convoluted Neural Network architecture based on VGG 16 layers using pre-trained weights and with the top layer replaced with Global Average Pooling layer. The model input is a 250x250 image of a thin section and output is a category of Basalt or Breccia. It was trained on a dataset of 13,106 images from 512 Apollo samples. 115 samples were randomly isolated to serve as a testing dataset, the rest was used for training and validation. The resulting model has an average accuracy of 90.51

These proof of concept results show great promise in the application of Machine Learning technologies for sample classification. Additionally, evaluation of trained neural networks is very fast and relatively easy computationally and it can be performed on the computers on the moon or integrated into equipment. The next step in the research would be to develop similar methods that do not require thin sections but can be performed with a surface photo of the sample, potentially combined with other fast metrology techniques (such as spectroscopy).