Convolutional Neural Network Models for Ordinary Chondrite Petrologic Type Classification

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Rationale
- Explore the role of deep learning models in the planetary/exploratory sciences.
- Broadly: develop statistical models and tools that can assist scientists with material identification in exploratory contexts.
- Specifically: develop models to aid in ordinary chondrite identification and classification.

Training Data
- Training images selected from mosaic image at random (Figure 1.)
- Training data set currently contains 35,000 images
- Training images are 256px x 256px or 512px x 512px grayscale images
- Meteorites used: ALH 77221 (H4), ALH77288 (H6), ALH 78109 (LL5), ALH 78119 (LL3.5), ALH 81017 (LL5), ALH 84081 (LL6), ALH 85017 (L6), ALH 85033 (L4), ALH 85070 (L3.6), DAV 92302 (LL3.6), GRO 95658 (LL3.3), QUE 93050 (LL4), WSG 95300 (H3.3)
- Image labels based on sampled meteorite’s petrologic type: Type 3 = [1 0 0 0], Type 4 = [0 1 0 0], Type 5 = [0 0 1 0] and Type 6 = [0 0 0 1]. Currently model cannot distinguish Type3 subtypes.

Results
- Model 4C4D shows a training accuracy of ~83% and a validation accuracy of ~78%. The disparity between these accuracies suggests that the model is ‘overfitting’ or memorizing the data set rather than learning feature-label associations.
- Conversely, model 4C5D shows a training accuracy of ~90% with a nearly identical validation accuracy.
- Model 4C6D has training and validation accuracies of ~85%. While there is parity between training and accuracy values, this model has significantly worse results than 4C5D. This suggests continual addition of dense perceptron layers does not necessarily increase model accuracy.

Convolutional Neural Network

Figure 2. Schematic of image convolution. (left inset) Filter matrix (enlarged for illustration) of size nxn sweeps over image in a path similar to that shown by red arrows. (right inset) pixel values of the feature map output are generated by taking the dot product of the nxn filter matrix and an nxn section of the original image that lies within the filters path.

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Current models architectures were discovered through trial and error, we plan to uncover more architectures of high accuracy through genetic algorithm searches.

References and Acknowledgements
US Antarctic meteorite samples are recovered by the Antarctic Search for Meteors (ANSMET) program, which has been funded by NSF and NASA, and characterized and curated by the Department of Mineral Science of the Smithsonian institution and Astromaterials Acquisition and Curation Office at NASA Johnson Space Center. This work was supported by the RISE2 node (T. D. Glotch, PI) of NASA’s Solar System Exploration Research Virtual Institute.