Machine learning for grain images of volcanic ash based on grain shape and transparency

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Volcanic ash consists of a variety of components such as juvenile and/or old magma fragments, minerals, and fragments of surroundings. The component of volcanic ash varies with magma composition, eruption style, fragmentation/transportation mechanism, and surrounding geological units. In other word, the component of volcanic ash would be a key to infer characteristics of volcanic activity, though its classification has no universally standardized criteria and is time consuming and complex even for professional people.
One of the most parametrizable information of volcanic ash grains is shape. Previous studies have tried to characterize and classify ash grains by statistical analysis using shape parameters such as circularity, aspect ratio, and shape factor (e.g., Maria and Carey, 2007; Liu et al., 2015). Miwa et al., 2015 used not only shape but also luminance consists of red, green, and blue tones to characterize properties of volcanic ash.
Image classification using machine learning techniques can be applied to volcanic ash. Calculating mixing ratio of four learned grain types using a convolutional neural network (CNN), Shoji et al., 2018 tried to classify and characterize volcanic ash samples which were generated in different eruption styles: magmatic, phreatomagmatic, and rootless (explosive and continuous lava-water interaction) eruptions.
In this study, we try to distinguish eruption style from the component of volcanic ash, which its grain images were automatically collected using an automatic grain analyzer and were classified by a commercial machine learning software. We used same volcanic ash samples with Shoji et al., 2018 which were produced by three types of eruption style, magmatic (scoria cones in Izu Peninsula and 1983 products in Miyakejima, Japan), phreatomagmatic (Nippana tuff ring, Miyakejima, Japan), and rootless (rootless cones in Myvatn, Iceland) eruptions. Images of volcanic ash grains of these samples were obtained by Morphologi G3S (Malvern Instruments) at the Geological Survey of Japan, AIST. In the machine learning performed by Shoji et al., 2018, the training data was prepared so that classify grain images by shape: blocky, vesicular, elongated, and rounded. To identify glass fragments and transparent crystals, we prepared eight types of training images based on not only shape but also whether transparent or not. The training data consists of typical basal grains, does not include ambiguous grains. To increase number of images, we rotated, flipped, and shifted images. We used Rapid Machine Learning Image Analysis software (NEC Advanced Analytics) while Shoji et al., 2018 used the Keras package to structure CNN. This software has been applied to identification of micro fossils (Hoshino et al., 2018). The training was performed under CNN structure with 30 epochs. Using the trained network, we automatically classified volcanic ash grains which also include ambiguous ash grains. This software calculates the probabilities for each of the eight grain type for every grain. Integrating this probabilities within each sample, we can obtain the component of volcanic ash automatically. In this presentation, we will show preliminary results of training and classification and discuss its relation with eruption styles. Such grain analysis method can be applied to various types of grains such as fluvial sediments and returned samples from extraterrestrial regions (e.g., Itokawa and Ryugu).

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