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ORIGINAL ARTICLE

Automatic classification of volcanic rocks from thin section images using transfer learning networks

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Abstract
In this study, efficient deep transfer learning models are proposed to classify six types of volcanic rocks, and this paper has a novelty in classifying volcanic rock types for the first time using thin section images. Convolutional neural network-based DenseNet121 and ResNet50 networks, which are transfer learning methods, are used to extract the features from thin section images of rocks, and the classification process is carried out with a single-layer fully connected neural network. The proposed models are trained and tested on 1200 thin section images using four different optimizers (Adadelta, ADAM, RMSprop, SGD). AUC, accuracy, precision, recall and f1-score are used as performance metrics. Proposed models are run 10 times for each optimizer. DenseNet121 classifies volcanic rock types using RMSprop with an average accuracy of 99.50% and a maximum of 100.00%, and ResNet50 classifies using ADAM with an average accuracy of 98.80% and a maximum of 99.72%. Thus, the applied deep transfer learning is promising in geosciences and can be used to identify rock types quickly and accurately.

Keywords Rock classification · Volcanic rocks · Deep transfer learning · DenseNet121 · ResNet50 · Convolutional neural networks

1 Introduction

Rocks are one of the fundamental components of Earth. Identification or classification of the rock types is an important part of geological research and a difficult task due to the heterogeneous properties of rocks. Rock types can be traditionally determined by petrologist with different methods such as with the naked eye vision, microscope examination or chemical analysis. This is a time-consuming process and requires experienced specialists who know the petrographic classification criteria. Identification and classification of rocks can be done effectively and automatically using computer technologies.

In recent years, many researchers have done studies related to rocks such as textural identification and classification of rocks [8, 15, 25], the classification and identification minerals in rock types ([1, 11, 16], rock fragmentation [23], etc. in geoscience using machine learning methods. The classification of rock types, an important subject of geosciences, has been studied by many researchers using computer technologies and pattern recognition techniques. Młynarczuk et al. [19] made a study for classifying nine different types of rock. They applied four pattern recognition techniques: the nearest neighbor, k-nearest neighbor (KNN), nearest mode and optimal spherical neighborhood algorithms. Lepistö et al. [14] classified the rocks into four groups using KNN method as classifier. Patel and Chatterjee [20] studied a computer vision-based rock type classification using probabilistic neural networks. They classified only seven limestone rock types using nine color histogram features. Yin et al. [31] proposed an automatic rock structure classification system using image processing and pattern classification technologies. Sand rock classification was studied by Tian et al. [29]; they classified sand rocks into

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