Transfer Learning for Hyperspectral Image Classification Using Pre-trained Model

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Hyperspectral images (HSI), acquired with spectrometers, can obtain images of surface objects with dozens or even hundreds of spectral bands. Compared with multispectral images, they not only reveal two-dimensional spatial information but also contain rich and fine spectral information. Therefore, HSI has been extensively applied to various fields such as surface object detection, disaster investigation, agricultural mapping, and land resource management.

In the past, HSI classification typically used band selection or feature extraction for dimensionality reduction prior to image classification. In addition, machine learning algorithms are also applied to HSI classification. Machine learning methods can use experience or input data to optimize or improve the trained models or functions through continuous learning. The common machine learning methods for HSI classification include support vector machine (SVM), random forest (RF), and so on. In more recent years, the convolutional neural network (ConvNet or CNN) is a popular and widely used approach in deep learning, including HSI processing and classification. However, deep learning methods for HSI classification still need a large amount of training data to evaluate the models. Usually, collecting training data in the real world is time-consuming and laborious, or the collected training data may become outdated or varied due to changes in time or environment. Therefore, how to reduce the need for training data and how to deal with the problem of outdated or variant data is also an important research issue. The concept of transfer learning is to apply learned knowledge to solve problems effectively. The new model does not need to be trained from scratch but uses a known model or some of its parameters with less training data. At the same time, the training time of models can be reduced.

There are also some researches that use the well-known image analysis CNN model to perform pre-training by ImageNet, and then perform HSI classification by transfer learning. Meanwhile, various algorithms such as 3D-CNN, 3D-2D CNN (HybridSN), 1DCNN, stacked autoencoder (SAE), and a deep belief network (DBN) have been proposed for HSI classification. In this study, aforementioned CNN models are used as the basic model and combined with transfer learning for multi-period or multi-scene HSI classification. The variables are tested for different circumstances in the experiment, such as which layer or parameter should be kept and how much training data should be used. According to the experiments, classifying new HSI by transfer learning can achieve good classification performance with less training data and computation time. Fine-tuning models can have better results for different transfer of model networks. Also, we can apply transfer learning to other scenes with different objects. As image content or CNN model structures become more complex, transfer learning can reduce computational complexity and quickly achieve reasonable classification results. Finally, a proper transfer learning procedure for multi-period or multi-scene hyperspectral image classification will be found.

Keywords: Hyperspectral Image, Classification, Convolutional Neural Network (CNN), Transfer Learning