Hyperspectral Image Classification

Abstract:

Research on image classification has become a big challenging issue for the remote sensing community. With a rapid growth of remote sensing technology and increasing number of satellites, the availability of hyperspectral images (HSI) is growing exponentially. High spectral dimensionality of HSI makes them useful data inputs for many remote sensing applications; environmental, military, mining and medical fields. Image spectrometers are installed to capture the HSI, which can image in many continuous and very narrow bands. HSI images have high spectral resolution and it contains many information which leads to the need for highly accurate processing methods for hyperspectral images. The processing methods of hyperspectral remote sensing images mainly include image correction, noise reduction, transformation, dimensionality reduction, and classification.

Objectives:

- To identify the different methods for hyperspectral image classification.
- To arrive at an optimal algorithm for HSI classification.
- To find the best performing classifier after combining the spatial and spectral information.

Problem Definition:

1) The high dimensionality of hyperspectral images may lead to the spectral information dimension up to hundreds of dimensions.
2) Affected by factors such as atmospheric conditions, sensors, composition and distribution of ground features, and surrounding environment, the spectral information of hyperspectral images changes in the spatial dimension, resulting in that the ground feature corresponding to each pixel are not single.
3) During the acquisition of hyperspectral images, the interference of noise and background factors seriously affects the quality of the collected data. The image quality directly affects the classification accuracy of hyperspectral images.

Literature survey:

Hyperspectral image classification methods are classified into supervised classification, unsupervised classification, and semi supervised classification.

In supervised classification, based on the known sample category and prior knowledge, we have to determine the discriminant criteria to calculate the discriminant function. Commonly used supervised classification methods include support vector machine method, artificial neural network classification method, decision tree classification method, and maximum likelihood classification method. The unsupervised classification method, without any prior knowledge, the classification is done based on the spectral similarity of the hyperspectral data, that is, the clustering method. Since no prior knowledge is used, unsupervised classification can only assume initial parameters, form clusters through pre classification processing, and then iterate to make the relevant parameters reach the allowable range. The main disadvantage of the supervised method is that the classification model and classification accuracy mainly depend on the number of training data sets of label points, and obtaining a large number of hyperspectral image class labels is a time-consuming and cost-intensive task. Although unsupervised methods are not sensitive to labelled samples, due to the lack of prior knowledge, the relationship between clustering categories and real categories is uncertain. Semi Supervised classification uses both labelled and unlabelled data to train the classifier. It makes up for the lack of unsupervised and supervised learning. This classification method is based on the same type of labelled and unlabelled samples on the feature space [1]

To reduce the HSI challenges, different dimensionality methods were proposed to transform the HSI from the original space into a low-dimensional space in which the new feature space has less redundant information.[6]. For extracting the spatial features and to improve the spatial resolution by reducing the high dimensionality by Principal Component Analysis (PCA) and computing the profiles on the first principal components, leading to the definition of extended MPs (EMPs) (Morphological Profiles). But there are many limitations while performing PCA leads to Independent Component Analysis (ICA) before the computation of the MPs [6]

Another classification is based on the deep learning method which requires a large number of training samples for classification, and the training time is long. If there are enough training samples, the deep learning method is a good choice. If sufficient labelled samples are provided, then the deep learning classifiers will give best performance for hyperspectral image classification. But if there are not many sufficient data samples available, it may fail. But active learning endows deep learning classifiers with the ability to alleviate this deficiency. However, existing active deep learning methods tend to underestimate the feature variability of hyperspectral images when querying informative unlabelled samples subject to certain acquisition heuristics. To address this limitation, we developed a feature-oriented adversarial active learning (FAAL) strategy, which exploits the high-level features from one intermediate layer of a deep learning classifier for establishing an acquisition heuristic based on a generative adversarial network (GAN).[2]

Spectral–spatial method is the other classification technique for classification of hyperspectral images (HSIs) by modifying traditional Auto-Encoder based on Majorization Minimization (MM) technique. In this, firstly construct weights of Auto-Encoder, similarity angle map (SAM) criterion is used as regularization term. It is useful to extract spectral similarity of initial features. Then to enhance the classification accuracy, fuzzy mode is used to estimate parameters. These modifications lead to create an extended Auto-Encoder based on MM (EAEMM). Also, to improve the performance of Auto-Encoder, multi-scale features (MSF) are extracted. Among these, MSF-EAEMM shows that the classification accuracy can be improved a lot.[6]

Another major challenge in remote sensing images is its inherent large scale and complex structures which leads to the difficulties such as spatial object distribution diversity and spectral information extraction when existing models are directly applied for image classification. A new system developed an attention-based pyramid network for segmentation and classification of remote sensing datasets. Attention mechanisms are used to develop (i) a novel and robust attention-based multi-scale fusion method effectively fuses useful spatial or spectral information at different and same scales; (ii) a region pyramid attention mechanism using region-based attention addresses the target geometric size diversity in large-scale remote sensing images; and (iii) cross-scale attention in our adaptive atrous spatial pyramid pooling network adapts to varied contents in a feature-embedded space.[3]

The neural network-based hyperspectral images (HSI) classification model also has a deep structure, which leads to the increase of training parameters, long training time, and excessive computational cost. The deepened network models are likely to cause the problem of gradient disappearance, which limits further improvement for its classification accuracy.[4]

References

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