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Stacked sparse autoencoder in hyperspectral data classification using spectral-spatial, higher order statistics and multifractal spectrum features

Xiaoqing Wan[a], Chunhui Zhao[a,] *, Yanchun Wang[b] and Wu Liu[a]

[a] *College of Information and Communication Engineering, Harbin Engineering University, Harbin 150000, China*
[b] *College of Communication and Electronic Engineering, Qiqihar University, Qiqihar 161000, China*
* *Correspondence: lilikaixn@sina.com*

ABSTRACT: This paper proposes a novel classification paradigm for hyperspectral image (HSI) using feature-level fusion and deep learning-based methodologies. Operation is carried out in three main steps. First, during a pre-processing stage, wave atoms are introduced into bilateral filter to smooth HSI, and this strategy can effectively attenuate noise and restore texture information. Meanwhile, high quality spectral-spatial features can be extracted from HSI by taking geometric closeness and photometric similarity among pixels into consideration simultaneously. Second, higher order statistics techniques are firstly introduced into hyperspectral data classification to characterize the phase correlations of spectral curves. Third, multifractal spectrum features are extracted to characterize the singularities the self-similarities of spectra shapes. To this end, a feature-level fusion is applied to the extracted spectral-spatial features along with higher order statistics and multifractal spectrum features. Finally, stacked sparse autoencoder is utilized to learn more abstract and invariant high-level features from the multiple feature sets, and then random forest classifier is employed to perform supervised fine-tuning and classification. Experimental results on two real hyperspectral data sets demonstrate that the proposed method outperforms some traditional alternatives.

Keywords: classification; hyperspectral imagery; feature-level fusion (FLF); stacked sparse autoencoder (SSA); random forest (RF)

1. Introduction

Recent advance in remote-sensing imaging technology has made the hyperspectral image (HSI) with several hundred narrow bands much easier to be obtained and more widely available. Such HSI provides both detailed spectral and structural information and gives the possibility to identify land cover objects by revealing subtle differences in the spectral signatures [1]. Therefore, the use of hyperspectral image has been an active area of research in many practical applications, such as scientific remote sensing, environmental monitoring, and military surveillance [2,3]. Hyperspectral classification is a hot topic in these applications, which has received a growing interest among researchers. During the last decade, there have been a number of classification methodologies to build appropriate classifiers for hyperspectral images [4-6]. Specially, support vector machine (SVM) is one of the most popular machine learning algorithms that has been demonstrated to be very powerful in classifying high-dimensional HSI [7,8]. Basically, the SVM classifier focuses only on spectral information without taking into account the spatial relationship between adjacent pixels; nevertheless, those pixels within a local region usually belong to the same material and show approximate spectral characteristics. Hence, to improve the classification accuracy, integrating spatial information to build a spectral-spatial classifier is necessary. In recent