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ABSTRACT

Recently, due to the advancement of remote sensors, optical remote sensing has been a significant increase in the number of spectral bands in acquired data, going from multispectral to hyperspectral. Hyperspectral imagery with hundreds of bands offers high spectral resolution and provides the potential accuracy in detection and classification of targets unresolved in multispectral images. However, higher spectral resolution increases the computation complexity in image processing. Thus, how to improve the accuracy with less computation complexity is the main challenge for hyperspectral image classification.

A common issue in hyperspectral image classification is to improve the class separability with a reduction of dimensionality of hyperspectral data. Several approaches have been proposed to reduce the dimensionality. Principal components analysis (PCA) has been widely applied for band selection, which extracts the feature based on the eigenvalues of the image correlation matrix. Recently, there are some classifiers using subspace-based techniques, such as the orthogonal subspace projection (OSP), noise subspace projection (NSP) and signal subspace projection (SSP) [1], which project the undesired pixels onto some orthogonal subspaces, noise or signal subspaces, to achieve dimensionality reduction. The above classifiers, trained by images with known ground truth data, are employed in human supervision. However, in some situations, when the ground truth data is not available, it is necessary to develop an unsupervised classification as a useful step toward defining spectral classes. Some existing unsupervised classifiers for multispectral images, such as eigen-region-based segmentation technique [2], require multidimensional search and intensive computation complexity to do the image classification. Thus, it is unappropriate to directly employ these methods for hyperspectral image classification.

In this study, we propose an efficiet hierarchical classifier shown in Fig. 1 for hyperspectral images, which exploits high degree correlations in spectral and spatial domains. To reduce the dimensionality of hyperspectral data, we first examine the spectral correlations between hyperspectral image bands. Bands with highly correlated features are grouped together by using a recursive algorithm which searches the group centers and reorders the original image bands. Thus, each group contains a set of highly correlated bands, and the image correlation matrix can approximate to be a sparse matrix, $R \approx R_t = diag[R_i]$, where $\boldsymbol{R_i}$ is the correlation matrix of the ith image group. Next, the image feature of each group is extracted by the transformation $z_i = \mathbf{\Phi}_i^T \mathbf{x}_i$, where $\mathbf{\Phi}_i$ is composed of the principal eigenvectors of $\boldsymbol{R_i}$. As shown in Fig. 1, the dimensionality of hyperspectral data $x_i, i = 1,...,L,$ is reduced to K after the transformation. Based on the extracted features, our classifier partitions the image using a binary quaternion- moment-preserving (BQMP) thresholding

technique [4]. As we know from [3] and simulation results, spectrum of normal AVIRIS images can be divided into four major groups according to the spectral correlation. In the first stage of the proposed classifier, we choose four principal features $z_i, i = 1,..,4$, which correspond to four major groups, respectively, and express the hyperspectral data as the quaternion $\hat{\mathbf{z}} = z_1 + z_2.i + z_3.j + z_4.k$. By keeping the quaternion moments invariant during the BQMP thresholding process, the image is partitioned into some proper regions. Afterwards, we examine the variance of each image region and select one with large variance which can be further partitioned by the principal features extraction and the BQMP thresholding. To get more accurate classification results, we may perform the above partition procedures in spectral and spatial domains, recursively. Generally, the proposed classifier requires only $1/\boldsymbol{K}^2$ computations of conventional PCA in feature extraction, if image is partitioned into K groups. And the computation in the BQMP thresholding is of order of data size N.

We have conducted the experiments on the AVIRIS images to validate the efficiency of the proposed schemes. According to the hierarchical BQMP method, the AVIRIS image is partitioned into 3 regions. Simulation results in Fig.2 validate the efficiency of the proposed scheme which can identify the target (building area) more accurate than other existing methods.

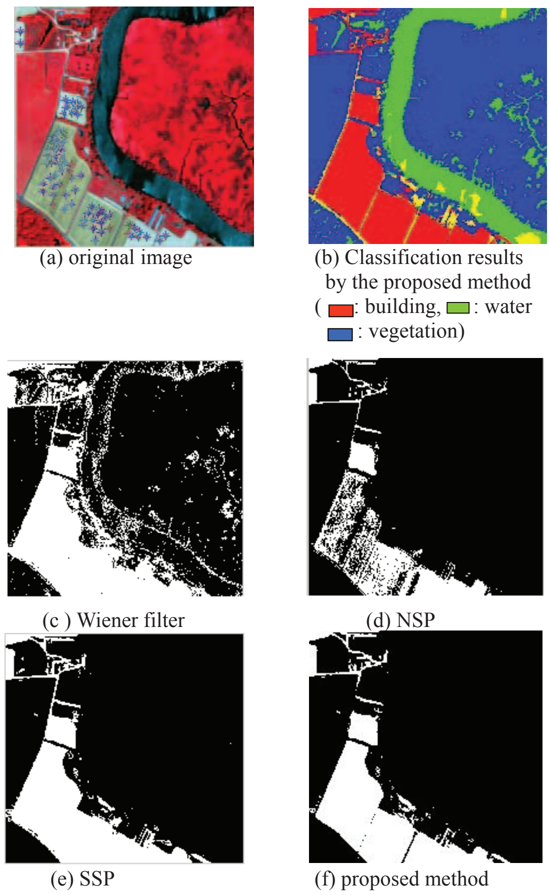

Fig. 2 Simulation results. (b) : classification results by the proposed method, (c)~(e) : detection results of some supervised classifiers with training data marked '*' in (a). (f) : detection results of the proposed method. (Target signature is building represented by white color)

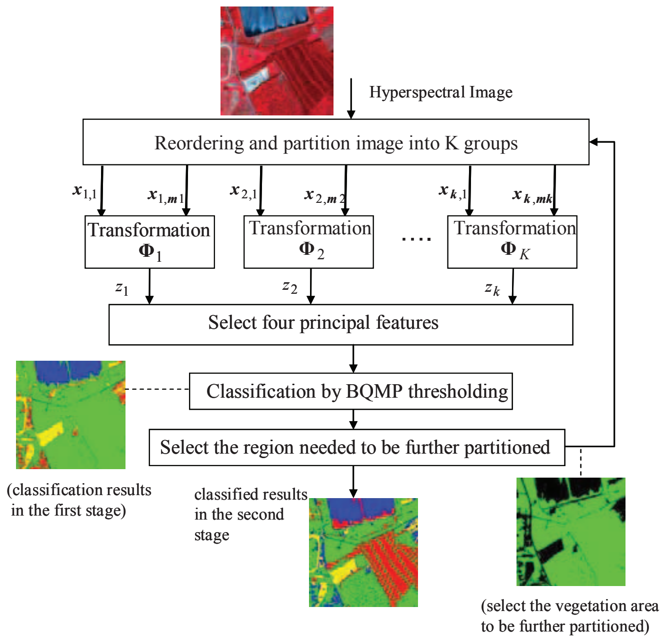

Fig. 1 Block diagram of the hierarchical BQMP classifier

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