Hyperspectral Image Classification using Support Vector Machines (SVM)

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1. Introduction

Due to the curse of dimensionality of Hyperspectral data, as number of dimensions is increased, the predictive power of a classifier or regressor first increases but then decreases with a fixed number of training samples. In this project, we studied the class-dependent subspace-based Support Vector Machine (SVM*sub*) for hyperspectral image classification. With 10-fold cross validation, we evaluated the predictive accuracy of SVM*sub*. The average accuracy of SVM*sub* in cross validation turned out to be around 70%. For comparative analysis, PCA-based nonlinear SVM was also conducted, which achieved 75% predictive accuracy after fine tuning of the parameters.

2. Datasets

The hyperspectral image (HSI) used in our project is a scene acquired by the AVIRIS sensor over the Indian Pines test site in North-western Indiana, consisting of 145×145 pixels and 224 spectral reflectance bands in the wavelength range 0.4-2.5 × 10^{-6} meters.

3. Methods

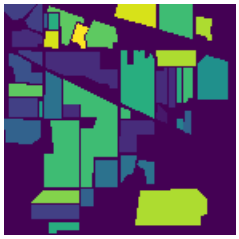
We used class-indexed subspace-projection-based method for HSI classification. Specifically, the high dimensional HSI pixel vector will be non-linearly projected onto a lower dimensional feature space, where each dimension of the feature space is a subspace corresponding to a class and spanned by a set of orthonormal basis vectors. After subspace projection of original pixel vectors in HSI, we would feed these new feature vectors into the linear multi-class SVMs. In addition, we also used PCA to extract the first five principal components of raw HSI and then feed the transformed spectral vector into non-linear SVMs.

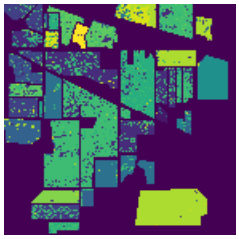
4. Experiments and Results

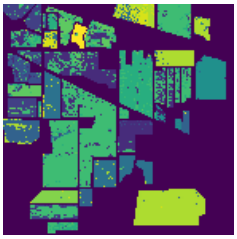
10-fold cross validation of SVM*sub*

Fold	1	2	3	4	5	6	7	8	9	10
Accuracy	0.6673	0.6953	0.6972	0.7155	0.6962	0.7078	0.7114	0.6979	0.7133	0.6979


Hyperspectral image


Ground truth


Prediction-SVM*sub*


Prediction-PCA_SVM

In this project, subspace projection and PCA was used to transform the original high dimensional spectral vectors into lower dimensional feature vectors. Most useful information for multi-class classification was retained after transformation. PCA based methods performed slightly better than SVM*sub* in terms of the predictive accuracy. However, SVM*sub* does not need any non-linear mapping after subspace projection whereas PCA-based SVM still requires non-linear kernels for classification, indicating that SVM*sub* should perform more robust than PCA-based SVM.