Decision Fusion for Supervised and Unsupervised Hyperspectral Image Classification

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Decision fusion has been used to increase classification accuracy of remotely sensed images beyond the level achieved by individual classifiers. The main reason for the use of multiple classifiers is that some classifiers may perform better in terms of accuracies for some classes, while others possibly provide better results for other classes. If the best classifier can be used for each pixel, the misclassified pixels in the final classification map are those that were wrongly classified by all methods. Many methods have been developed for the fusion of classifier decisions [1-2]. Widely applied voting concepts include majority voting and complete agreement. The linear opinion pool (LOP) and the logarithmic opinion pool (LOGP) employ the weighted sum and the weighted product, respectively, of the posterior probabilities obtained by the individual classifiers, where the weights are selected to reflect the goodness of the separate input data.

In this paper, we are more concerned with the individual classifiers that are to be combined. Our objective is to establish a connection between classifier types and the improvement in hyperspectral image classification accuracy caused by the combination of the classifiers. Due to the high data dimensionality of hyperspectral imagery, it is difficult to have enough training samples when implementing supervised classifiers; due to the existence of large number of mixed pixels, it is also difficult to have high quality of training samples for each class. Another problem when performing the classification of remotely sensed images is that it may be difficult to know the number of classes present in an image scene; when this information is unknown, a supervised classifier is prone to yield misclassifications. Sometimes, an unsupervised classifier may provide better result than a supervised classifier. Aiming at this situation, we will combine the results from supervised classifier and unsupervised classifier to improve the classification accuracy.

In some cases, we may know the information of foreground classes, i.e., the number of classes to be classified and their spectral signatures [3]. We have demonstrated that a semi-supervised classifier may be able to yield accurate foreground classification without knowing the number of background classes and their information. For example, constrained linear discriminant analysis (CLDA) employs a data whitening process to suppress background, followed by matched-filter-type class extraction and discrimination [4-5]. Such a semi-supervised classifier is particularly useful in practice. Thus, we will also investigate the performance improvement by fusing the result from a semi-supervised classifier.

The classifier selected in each category is the one with the best performance to our best knowledge: support vector machines (SVM) is the one for supervised classification, CLDA is the one for semi-supervised classification, and independent component analysis (ICA) is the one for unsupervised classification.

Three cases will be tested. In the first case, the number of classes to be classified is correct and training samples have good quality; in the second case, the number of classes to be classified is correct but training samples have errors; in the third case, the number of classes to be classified is incorrect and training samples have errors. Obviously, in the first case, SVM has good performance; in the second and third cases, the CLDA and ICA classifiers have better performance. Preliminary results show that a semi-supervised and unsupervised classifier can improve the performance of supervised classifier by decision fusion when complete class information is unavailable.

References:

[1] J. A. Benediktsson and I. Kanellopoulos, "Classification of multisource and hyperspectral data based on decision fusion," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37, no. 3, pp. 1367-1377, May 1999.

[2] M. Petrakos, J. A. Benediktsson, and I. Kanellopoulos, "The effect of classifier agreement on the accuracy of the combined classifier in decision level fusion," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 39, no. 11, pp. 2539-2546, Nov. 2001.

[3] Q. Du, "Modified Fisher's linear discriminant analysis for hyperspectral imagery," *IEEE Geoscience and Remote Sensing Letters*, vol. 4, no. 4, pp. 503-507, Oct. 2007.

[4] Q. Du and C.-I Chang, "Linear constrained distance-based discriminant analysis for hyperspectral image classification," *Pattern Recognition*, vol. 34, no. 2, pp. 361-373, Feb. 2001.

[5] Q. Du, H. Ren, and C.-I Chang, "A comparative study for orthogonal subspace projection and constrained energy minimization," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 41, no. 6. pp. 1525-1529, Jun. 2003.