# Utilization of local and global hyperspectral features via wavelet packets and multiclassifiers for robust target recognition

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The capabilities of hyperspectral sensors have proven attractive for highly precise ground cover mapping. These sensors have the ability to produce hundreds to thousands of spectral bands per pixel. However, small amounts of labeled training data coupled with the large dimensionality of the spectral data often causes hyperspectral classification systems to not generalize well and thus perform poorly. Many dimensionality reduction and feature extraction techniques have been investigated to account for the "curse of dimensionality" in hyperspectral target recognition systems [1-4]. More recently, spectral band grouping coupled with multiclassifiers and decision fusion (MCDF) has been investigated to account for small amounts of label training data and to address the concerns of generalizability [1,2,5,6].

Additionally, multiresolution analysis or wavelet analysis has become a basis for many feature extraction methods in the last couple of decades in signal processing. Two of the most efficient methods for implementing multiresolutional transformations are the Discrete Wavelet Transform (DWT) and the Wavelet Packet Decomposition (WPD) via the dyadic filter tree [7]. In current research, DWT and WPD have become leading methods in extracting local and global features in hyperspectral remotely sensed data. Hsu *et al.* used the WPD and DWT for feature extraction and optimization for hyperspectral target recognition in an agricultural application and found that the wavelet based features proved have superior results non-wavelet based features [8]. Bruce *et al*. investigated the use of the DWT in the dimensionality reduction of hyperspectral data and found that the local and global features were optimum in classification applications [4, 9]. Zhang *et al*. developed a remote sensing soil classification system employing the DWT as a feature extraction method, where the goal was the classification of three different pure soil textures [10].

This paper investigates the combination of the WPD and MCDF for a robust hyperspectral classification system. Specifically, we investigate the use of the WPD for multiresolution feature grouping and selection, forming groups of local and global spectral features, where each group is input to a classifier, resulting in local and global classifications. Then the decisions of the multiclassifier are fused to form a final class label. In previous work by the authors [11], the WPD tree was pruned using supervised metrics. In this paper, the WPD tree will be pruned using various unsupervised cost functions. The terminal nodes from the pruning are then viewed as feature vectors. These features vectors will then be preprocessed and passed to an unsupervised MCDF system. The primary advantage is that the proposed hyperspectral classification system will be unsupervised, thus negating the need for labeled training data, yet the system will take advantage of local and global spectral features. The resulting system will be accurate, robust, and highly generalizable. The proposed method is compared with current state-or-the-art hyperspectral analysis techniques to determine its comparative efficacy Conventional approaches, such as stepwise- linear discriminant analysis (LDA) or discriminant analysis feature extraction (DAFE), are conducted to determine a baseline of difficulty of the experimental dataset. In addition, the proposed system will be compared to other MCDF preprocessing schemes. Experimental analyses are conducted to determine quantitative accuracies of the proposed system. The analyses are conducted using hyperspectral data containing > 1000 spectral bands in the range of 350 to 2500 nm. This hyperspectral data is from an agricultural application, namely the early detection of a disease known as soybean rust (*Phakopsora pachyrhizi*) in soybean crops [12]. The ability to rapidly detect soybean rust onset is critical to the US economy, and agencies such as the U.S. Department of Agriculture (USDA) and Department of Homeland Security (DHS) are very interested in this particular application.

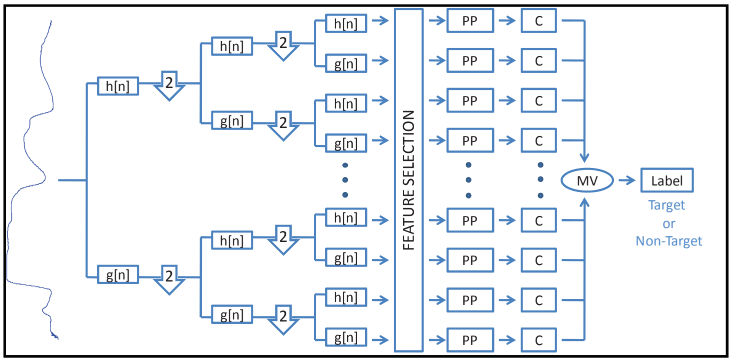


Figure 1. Block diagram representation of the Wavelet Packet Feature extraction method within MCDF framework.
(PP = preprocessing, C = Classifier, MV = Majority voting)

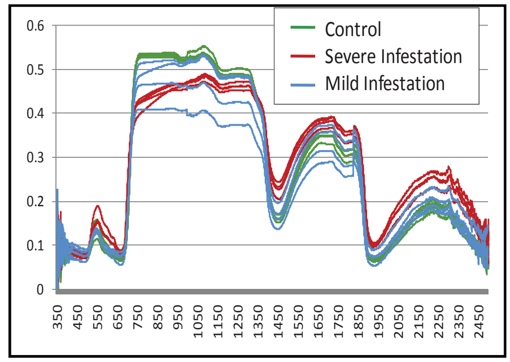


Figure 2. Example hyperspectral signatures for collected in field campaign, November 2008.


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