ABSTRACT

Chi, Jun-Hwa Ph.D., Purdue University, December 2013. Manifold Learning Based Spectral Unmixing of Hyperspectral Remote Sensing Data. Major Professor: Melba M. Crawford.

Nonlinear mixing effects inherent in hyperspectral data are difficult to handle using linear spectral unmixing models. Although direct nonlinear unmixing models provide more capability to capture nonlinear phenomena, they are difficult to formulate and generalize the results since research has been conducted from different perspectives. Manifold learning based spectral unmixing accommodates nonlinear features in the feature extraction stage followed by linear mixing, thereby exploiting characteristics of both linear and nonlinear unmixing approaches. Since endmember selection is critical to successful spectral unmixing, it is important to select proper endmembers from the manifold space. However, excessive computational burden hinders developing manifolds for large-scale remote sensing data. This dissertation addresses the issues of high computational overhead of manifold learning for developing representative manifolds for the spectral unmixing task.

Manifold approximations using landmarks are popular for mitigating the high computational complexity of manifold learning. A new computationally effective landmark selection method that exploits spatial redundancy is proposed in Chapter 3. The robust, less costly landmark set with low spectral and spatial redundancy is successfully incorporated with a hybrid manifold which shares properties of both global and local manifolds.

In Chapter 4, active learning heuristics are introduced to increase the number of landmarks with the goal of developing more representative manifolds for spectral unmixing. By communicating between the landmark set and the query criteria relative to spectral unmixing, more representative and stable manifolds with less spectrally

and spatially redundant landmarks are developed. A new sampling method based on the pixels with locally high contrast within image subsets and convex-geometry finds a solution more quickly and precisely. Experiments were conducted to evaluate the proposed methods in Chapter 3 and Chapter 4 using the AVIRIS Cuprite hyperspectral reference dataset.

Finally, a case study of manifold learning based spectral unmixing in agricultural areas is presented in Chapter 5. Remotely sensed data collected by airborne or spaceborne sensors are utilized to effectively quantify crop residue cover over extended areas. Although remote sensing indices are popular for characterizing residue amounts, they are not effective with noisy Hyperion data because the effect of residual striping artifacts is amplified in ratios involving band differences. In this case study, spectral unmixing techniques are investigated for estimating crop residue as an alternative approach to the index based methods. The spectral unmixing techniques, and especially the manifold learning approaches, provide more robust, lower RMSE estimates for crop residue cover than the hyperspectral index based method for Hyperion data.