ABSTRACT

Yang, Hsiu-han L. Ph.D., Purdue University, May 2014. Manifold Alignment for Classification of Multitemporal Hyperspectral Image Data. Major Professor: Melba Crawford.

Exploring remotely sensed images to obtain land cover classification maps is an effective approach to acquire information over landscapes for environmental studies that can be accomplished over extended areas with limited ground surveys. Further, with advances in remote sensing technology, spaceborne hyperspectral sensors provide the capability to acquire a set of images that have both high spectral and temporal resolution. These images are suitable for monitoring and analyzing environmental changes with subtle spectral characteristics. However, inherent characteristics of multitemporal hyperspectral images, including the high dimensionality, nonlinearity of hyperspectral data, and nonstationarity phenomena over time and across large areas, pose several challenges for classification.

This research addresses the issues of classification tasks in the presence of spectral shifts within multitemporal hyperspectral images by leveraging the concept of the data manifold. Although manifold learning has been applied successfully in single image hyperspectral data classification to address high dimensionality and nonlinear spectral responses, research related to manifold learning for multitemporal classification studies is limited. The proposed approaches utilize spectral signatures and spatial proximity to construct similar "local" geometries of temporal images. By aligning these underlying manifolds optimally, we are able to reduce the nonstationary effects and perform classification in a representative temporal data manifold. "Global" manifolds learned from temporal hyperspectral images are also discussed. The global approaches have a major advantage in faithful representation of the data in an image, such as retaining relationships among different classes. Local manifolds are favored in discriminating difficult classes and for computation efficiency. We further propose hybrid global-local manifold alignment methods that combine the advantages of global and local manifolds for effective multitemporal image classification.

Results show the effectiveness of utilizing common geometries of successive images in terms of classification results. The proposed manifold alignment methods are also demonstrated as a successful technique in some practical cases where the targeted geographical region may only have training samples for one time period, yet exploration of other temporal images is desired. The proposed methods are also demonstrated as feasible domain adaptation methods that can handle spatially disjoint data sets.