Abstract

The recent advancement in the field of electronics has led to the development of sensors that capture the image of an area or object in spectral-domain with spatial information. Spectral signatures of these images provides reflectance, texture, moisture content, and other external quality characteristics of diverse samples far beyond human vision. Hyperspectral Image (HSI) finds its applications in many domains such as agriculture, astronomy, biomedical imaging, Earth observation, track military movements & operations, molecular biology, mineral identification, monitoring natural disasters, identification of disease in the medical industry, physics, and surveillance. The rate of production of hyperspectral data is increasing rapidly due to increment in the acquisition capacity of such devices and success of specialized missions by various space organizations. The large size and high scale acquisition of HSIs has increased the demand for a more efficient compression strategy that is effective against multidimensional data and different from traditional algorithms.

In this work, we categorized state of the art algorithms into eight broad categories namely transform based, prediction based, vector quantization based, compressive sensing based, tensor decomposition based, sparse representation based, multi-temporal based, and learning based algorithms. The main purpose of this thesis is to study and implement existing compression methods, thus mentioning their merits and demerits through close analysis. An in-depth analysis of the existing techniques deduced the need for a system that can eliminate redundant information as much as possible to reach ideal compression, improve the performance of existing compression techniques, and reduce the execution time of compression for real-time streaming.

This research endeavors developing an optimized compression scheme addressing three different problems of HSI compression. A lossless prediction-based compression technique for multitemporal images is developed. It removes temporal correlations along with spatial and spectral correlation, reduces the size of time-lapse hyperspectral images significantly. Prediction-based techniques suffer from high complexity and high run time due to pixel-wise operations. We propose a parallelization scheme to reduce the runtime in a high performance computing environment. It consists of a general framework of multilevel parallelism for lossless compression techniques. The results justify the efficiency of proposed work upon increasing number of cores of supercomputer having negligible impact on the compression performance.

This work also utilizes deep learning algorithms for the compression of HSIs applications due to the flexibility of deep networks. More complex functions can be accomplished by adding more units in a layer or multiple layers within a network. The computational complexity of deep networks is a hurdle in its general acceptance besides high performance in most applications. We utilize the most popular solution to accelerate training using GPUs by exploiting the multilevel parallelism existing in the training process and massive floating-point operations. We propose a lossy hyperspectral image compression algorithm based on the concept of autoencoders.

Lastly, we propose a model that combines a traditional transform-based decorrelation method with a convolution network model to improve reconstructed image quality. It reduces the dimensions of the input image by a significant level utilizing the benefits of max-pooling and convolution layer. The effect of compression on classification has also been evaluated in these two experiments using a state-of-the-art classification algorithm. A negligible difference in classification accuracy was obtained that proves the effectiveness of the proposed algorithm.