HYPERSPECTRAL DATA COMPRESSION

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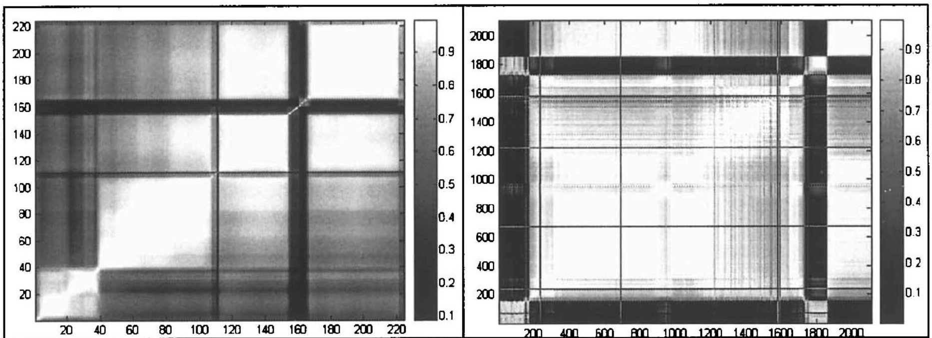
Preface

The interest in remote sensing applications and platforms (including airborne and spaceborne) has grown dramatically in recent years. Remote sensing technology has shifted from panchromatic data (a wide range of wavelengths merged into a single response), through multispectral (a few possibly overlapping bands in the visible and infrared range with spectral width of 100-200*nm* each), to hyperspectral imagers and ultraspectral sounders, with hundreds or thousands of bands. In addition, the availability of airborne and spaceborne sensors has increased considerably, followed by the widespread availability of remote sensed data in different research environments, including defense, academic, and commercial.

Remote sensed data present special challenges in the acquisition, transmission, analysis, and storage process. Perhaps most significant is the information extraction process. In most cases accurate analysis depends on high quality data, which comes with a price tag: increased data volume.

For example, the NASA JPL's *Airborne Visible/Infrared Imaging Spectrometer* (AVIRIS, http://aviris.jpl.nasa.gov) records the visible and the near-infrared spectrum of the reflected light of an area 2 to 12 kilometers wide and several kilometers long (depending on the duration of the flight) into hundreds of non overlapping bands. The resulting data volume typically exceeds 500 Megabytes per flight and it is mainly used for geological mapping, target recognition, and anomaly detection.

On the other hand, ultraspectral sounders such as the NASA JPL's *Atmospheric Infrared Sounder* (AIRS, http://www-airs.jpl.nasa.gov), which is recently becoming a reference in compression studies on this class of data, records thousands of bands covering the infrared spectrum and generates more than 12 Gigabytes of data daily. The major application of this sensor is the acquisition of atmospheric parameters such as temperature, moisture, clouds, gasses, dust concentrations, and other quantities to perform weather and climate forecast.



Absolute value of the correlation between spectral bands: AVIRIS, Moffett Field, scene 2 (left) and AIRS, Granule 9, Pacific Ocean, daytime (right).

Such volumes already exceed available transmission bandwidths. Efficient data compression allows real-time distribution of remote sensed data and reduces storage at the ground station. In many cases lossless compression is required at the archive level (e.g., for accurate climate monitoring in the case of ultraspectral sounders).

As in natural images, hyperspectral data present high correlation in the spatial dimension: adjacent locations have similar *spectral signatures*. Furthermore, there is a direct correspondence among bands or group of bands in the spectral dimension. For example, the figure above depicts the correlation coefficients (0 stands for no correlation, 1 for complete linear correlation) between spectral bands of two sample data volumes, one AVIRIS and one AIRS respectively.

This correlation seems to suggest that a simple extension of natural image compression algorithms to the hyperspectral data compression problem would suffice to achieve good performance. Unfortunately, the dynamic range of remote sensed data is much higher than natural images and statistics generally differ from one band to the other, and such extensions tend to lack effectiveness without further technical development.

This book provides a survey of recent results in the field of compression of remote sensed 3D data, with a particular interest in hyperspectral imagery. We expect this material to be of interest to researchers in a variety of areas, including multi dimensional data compression, remote sensing, military and aerospace image processing, homeland security, archival of large volumes of scientific and medical data, target detection, and image classification.

Chapter 1 addresses compression architecture and reviews and compares compression methods. Chapter 2 through 4 focus on lossless compression (where the decompressed image must be bit for bit identical to the original). Chapter 5 (contributed by the editors) describes a lossless algorithm based on vector quantization with extensions to near lossless and possibly lossy compression for efficient browsing and pure pixel classification. Chapters 6 deals with near lossless compression while Chapter 7 considers lossy techniques constrained by almost perfect classification. Chapters 8 through 12 address lossy compression of hyperspectral imagery, where there is a tradeoff between compression achieved and the quality of the decompressed image. Chapter 13 examines artifacts that can arise from lossy compression.

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