Hyperspectral Image Analysis
CIS 4930 / 6930
Fall 2012

Instructor: Dr. Paul Gader
Office 301 CSE Bldg
Office Hrs: Monday, Tuesday, Wednesday 9th period (4:05-4:55)

Subject Matter.
The course will focus on algorithms for processing hyperspectral images and the pixels in those images. Hyperspectral imagery is rapidly become more available and is used for research and applications in many fields. The primary field has been remote sensing of the earth, which is used for measuring climate change indicators, terrestial and aquatic resource management, agriculture, search and rescue, disaster assistance, and military and intelligence observations. Other fields include medicine, biometrics, food safety, planetary exploration, and mining.

Hyperspectral images are characterized by having high spectral resolution measurements of light at each pixel. These measurements are referred to as spectra and are related to the light reflected or emitted from materials and objects in the scene. The spectrum at each pixel, which we refer to as spectral pixels, may consist of anywhere from around fifty to hundreds of measurements. The measurements are made in consecutive bands that can be anywere from one nanometer (nm) to tens of nanometers wide. They can cover the Ultra-Violet, Visible, as well as Near, Short Wave, Medium Wave, and Long Wave Infra-Red regions of the electro-magnetic spectrum. The spatial extent of individual pixels can range from centimeters, to meters, and even to tens of meters from spacecraft.

Hyperspectral image processing differs from almost all standard digital image processing and computer vision processing in that spectral pixels can be used to identify individual materials in a scene. Methodologies that identify materials from their spectral response to light are part of the area of spectroscopy, a common tool in chemistry. Therefore, the act of processing hyperspectral image data to identify materials in a scene is referred to as imaging spectroscopy. Although chemists achieve great precision in the laboratory, it is more difficult to achieve such precision with image spectroscopy. Indeed, the limits of applicability of imaging spectroscopy are not known at this time.

The unique goals of imaging spectroscopy are determining what materials are present in a scene and detecting and classifying materials in a scene at the sub-pixel level. A consequence of the fact that pixels are often spatially large means is that the observed spectrum at a pixel is often a mixture of the spectral response from multiple materials. Imaging spectroscopy requires analyzing pixel spectra using algorithms derived from a combination of optimization, probability and statistics, inverse problem theory, linear algebra, signal processing, pattern recognition, graph theory, manifold theory, and physical models.

Topics

The course will begin with a brief overview of hyperspectral images. Methods of displaying and visualizing hyperspectral images will then be covered. The visualization process will lead to a discussion of dimensionality reduction. The focus will then turn to unmixing, which is a major course topic. The physics of light and the interaction of light with matter will considered more deeply in the context of studying unmixing. This will include the interaction of light with the atmosphere. Sub-pixel detection and aspects of pattern classification that are specific to imaging spectroscopy will be covered after unmixing. The course will conclude with a look at combining spatial information with spectral information.

Course materials

Information sources will include technical articles and course notes.

Grading

The class will involve homework assignments and 2 tests. Homework assignments will consist of solving math problems and writing programs to process hyperspectral images. MATLAB is the preferred processing environment. The first test will be mid-semester. The second test will be the final day of classes. Both tests will be in class. Class participation will be very important.

Class Participation:	30%
Homework:	40%
Tests:	30%