

Abstract

Spectroscopy is the study of light as a function of wavelength that has been emitted, reflected or scattered from a solid, liquid, or gas. Each material has its own spectral signature, and hence can be identified using spectral analysis.

Hyperspectral imaging (HSI) -also called *Imaging Spectroscopy*- sensors observe hundreds or thousands of contiguous spectral bands as well as spatial locality. A hyperspectral image cube (two spatial dimensions and the third is the wavelength) contains a large amount of information about the imaged scenario. Thus the automated analysis of such image cubes is an important asset.

Spatial analysis in HSI is rather difficult due to the fact that HSI taken by a satellite or an airborne camera has low ground sampling distance (GSD). This means that many targets of interest can be located within one pixel. Another related problem is the availability of materials in nature as mixtures. As a result, spectral analysis is of great interest specially sub-pixel detection algorithms and spectral unmixing.

This thesis discusses a fully automated HSI analysis system. The target is to achieve a system with reliable performance. A suggested pre-clustering step has shown improvement of the known algorithms for (1) endmember count estimation i.e. identifying the number of materials in a given cube, (2) endmember extraction i.e. identifying the signatures of the materials in a given cube, and (3) calculating the abundances of each material in every pixel of the cube.

Experiments are conducted on synthetic and real image cubes. The clustering step shows improvements in both cases. The algorithms used for that step are k-means, fuzzy c-means, and self-organizing maps.

Another approach for performance enhancement is to divide and conquer. Breaking the spectral signatures into basic units allows better representation (feature extraction) of the acquired signals, and hence better analysis. For this step, several algorithms have been used, namely: principal components analysis (PCA), independent components analysis (ICA), restricted Boltzmann machines (RBMs), and learning dictionary (LD) algorithms.