Satellite based Hyperspectral Imaging Techniques for Identification of Iron and Bauxite Ore Minerals

Abstract

This dissertation examines the capability of satellite based hyperspectral imaging technique as tool for mineral identification by conducting studies over two proven ore deposits. The design and implementation of several techniques for hypespectral image processing have been carried out in this study. Specifically, this thesis addresses the integration of ground based bulk minerals derived laboratory spectra with the satellite based hyperspectral image in a synergistic fashion with the ultimate goal of improving the analysis and interpretation of hyperspectral image based mineral identification. Hyperspectral image has been processed and endmember are extracted from it using MNF transformation and PPI analysis. Extracted endmembers are classified into appropriate mineral groups using a specially designed feature based neural network modeling technique, which is trained using modified Gaussian model (MGM) derived absorption features extracted from laboratory spectra of bulk minerals. One of the conspicuous parts of this thesis work is to use MGM for characterization and identification of absorption bands from the mineral spectra.

While endmember identification is an important aspect of hyperspectral image processing, mixture problem is very relevant issue in hyperspectral imaging mainly due to the fact that the spatial resolution often cannot separate between different materials participating in a pixel which results in a predominance of mixed pixels in this kind of images. As a result, hyperspectral images are dominated by mixed pixels and unmixing techniques are crucial for a correct interpretation and exploitation of the data. In this regard, a linear unmixing algorithm (LUM) is applied to estimate mineral abundances from the mixed pixels of hyperspectral image. In order to assess the ability of LUM to explain the mixed spectral behavior, the model is applied to analyse mixture spectra of synthetically generated powder samples of two-component mono-mineral mixtures mixed with different proportions. An experimental study is undertaken to generate laboratory based mixture spectra by preparing powder samples of minerals collected from the field. This study reveals that mixed spectral property is governed by the proportional presence of individual minerals in the mixture samples. Both the continuum and absorption components of mixed spectra are altered by mixing of pure materials. The linear model is able to explain the spectral variability of both the continuum and absorption components reasonably well with average R^2values for iron ore 0.87 and 0.89; and for bauxite mines are 0.91 and 0.93 respectively. The same linear model is then applied for spectral unmixing of mixed spectra for proportion (abundance) estimate of pure materials from the mixed one. It has been seen that the abundance estimate is done by a fair degree of accuracy with an average model R^2 of 0.88 and 0.92 for iron and bauxite ores respectively. Finally, abundance maps of minerals estimated from the hyperspectral images for both the deposits are prepared.

Keywords: Modified Gaussian Model, Linear Unmixing Model, Mixed Spectra, Feature based ANN Model, Abundance estimation.