SPECTROSCOPIC ANALYSIS FOR MATERIAL IDENTIFICATION AND MAPPING USING PRISM, AN ENVI/IDL BASED SOFTWARE PACKAGE

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1. INTRODUCTION

The identification of materials by measuring and analyzing their reflectance spectra has been an important method used in analytical chemistry for decades. Now, airborne and space-based imaging spectrometers give scientists the opportunity to detect materials and map their distributions across the landscape. With new satellite-borne sensor planned for the future, for example HYSPIRI (HYPerspectral InfraRed Imager), robust methods are needed to fully exploit the information content in hyperspectral remote sensing data. Careful processing of laboratory, field, and remote sensing data is required to produce high quality spectra of materials of unknown composition which can be compared with spectral standards for identification. In this paper, an ENVI/IDL (ENvironment for Visualizing Images/Interactive Data Language) based software package called PRISM (Processing Routines in IDL for Spectroscopic Measurements) is described. Among its many functions, PRISM contains routines for the storage of spectra in database files, importation of field spectra, correction of field spectra to absolute reflectance, arithmetic operations on spectra, interactive continuum removal and comparison of absorption features, calibration of imaging spectrometer data to reflectance using field-measured spectra, identification and mapping of materials using spectral feature based analysis of reflectance data in an expert-system framework, and import/export of ENVI spectral library files. PRISM has been used to calibrate image cubes and map materials for the full-country coverage of HyMap data collected in 2007 over the country of Afghanistan. The PRISM software will be released to the general public by the U.S. Geological Survey (USGS).

2. BACKGROUND AND KEY CONCEPTS OF PRISM

PRISM draws on the legacies of a variety of USGS software that has been created to advance spectroscopy and spectroscopic remote sensing, including SPECPR [1] and Tetracorder [2]. Many capabilities of these programs are available in PRISM routines which are written in the IDL programming language to run within ENVI. Thus, PRISM is easily integrated with the image processing and GIS (Geographic Information Systems) capabilities of ENVI. The PRISM routines are grouped into four categories: 1) the ViewSPECPR module, 2) spectral analysis routines, 3) image processing routines, and 4) the Material Identification and Characterization Algorithm (MICA).

PRISM uses database files of SPECPR (SPECtrum Processing Routines) format; such files are used by terrestrial remote-sensing scientists and planetary scientists for storing spectra collected by laboratory, field, and remote sensing instruments. SPECPR files contain reflectance data and associated wavelength and spectral resolution data, as well as meta-data on the time and date of collection and spectrometer settings. The U.S. Geological Survey (USGS) spectral library is a SPECPR file that contains thousands of spectra of minerals, vegetation, and man-made materials [3]. PRISM has been written to use the meta-data fields in records to track changes to data through its "history" fields, allowing the user to trace the source data for any spectrum stored in a SPECPR file. For additional details on the format and content of SPECPR files, see Clark [1]. The USGS Spectral Library Version 6 (splib06) will be distributed with PRISM so that the user may immediately access high quality spectra in the library through the ViewSPECPR module. ViewSPECPR functions let the user plot spectra stored in the library and view web-browser formatted descriptions (HTML format) of materials in the library, which include spectral purity assessments and sample photos. ViewSPECPR also allows the user to apply continuum removal analysis to spectral features in reflectance spectra and to compare a spectral feature in one sample to another. An example comparison plot is shown in Figure 1 for the 2.1 μm feature of a spectrum of dry grass compared to the same feature in a spectrum of dry pine needles. Shape differences and shifts in band center positions of these absorption features are caused by their differing lignin and cellulose compositions [4].

Spectral feature analysis is the core application of PRISM. In particular, the user can compare the spectra of materials of unknown composition, either measured in the laboratory, field, or in a pixel of imaging spectrometer data, with the spectra of known materials. This spectroscopic analysis allows the composition of materials to be identified and characterized. This approach has been used for decades in the fields of analytical chemistry, geology, and astronomy. With recent technological advances that have produced airborne and space-based spectrometers, spectroscopic remote sensing using these same principles has been successfully extended to identify and detect the distribution of materials over large areas, including minerals [2] and vegetation [5].

MICA is the module of PRISM that gives the user the ability to identify and map materials by comparing spectra or an entire image cube to the spectra of reference materials. The MICA command file is a user created/edited document in which the user defines the spectra of materials they wish to include in a reference library against which to compare the spectra of unknown materials. In the MICA command file, the user defines continuum endpoints of diagnostic absorption features and constraints on feature fits, depths and continuum levels. The values in the MICA command file can be fine-tuned by the user to optimize material identification, discrimination between similar materials, and to complete detailed characterizations of mineral and vegetation compositions. As part of the analysis of images, MICA outputs fit and depth images for each material detected in

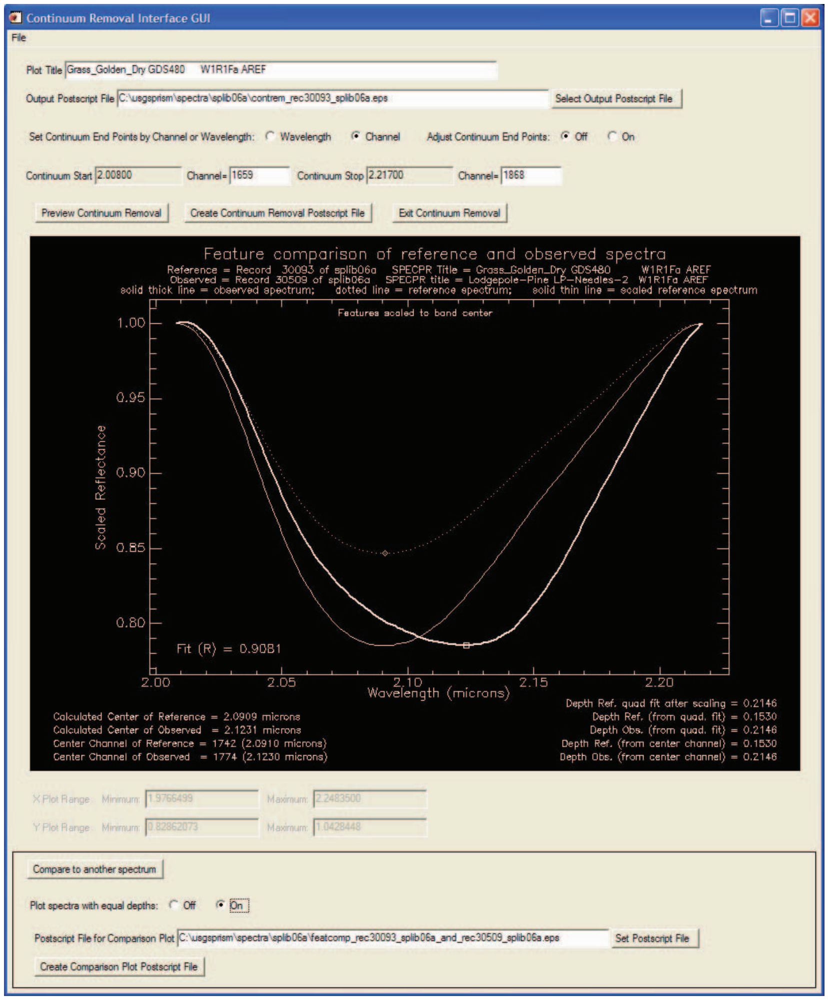

Fig. 1. Interactive spectral feature comparison accessed from the ViewSPECPR module of PRISM.

the scene. MICA also produces a summary of mapped materials as an ENVI classification image. Figure 2 shows a schematic of the program flow and key algorithms of MICA. With the PRISM software distribution, a generic command file to detect carbonates, phyllosilicates, sulfates, alteration-related minerals, and other materials absorbing in the 2 to 2.5 µm region will be included. This command file has been used to map materials in the full-country coverage of HyMap data collected in 2007 over Afghanistan.

3. SYSTEM REQUIREMENTS

PRISM Version 1.0 has been compiled using an ENVI 4.5/IDL7.0 full license operating on a Windows XP operating system and requires the installation of the iTools components of IDL7.0. The software has been tested extensively with a full licenses on a LINUX system and ENVI runtime leicenses on Windows XP and LINUX susyems This software has not been tested with ENVI licenses on Windows Vista or Apple Operating Systems.

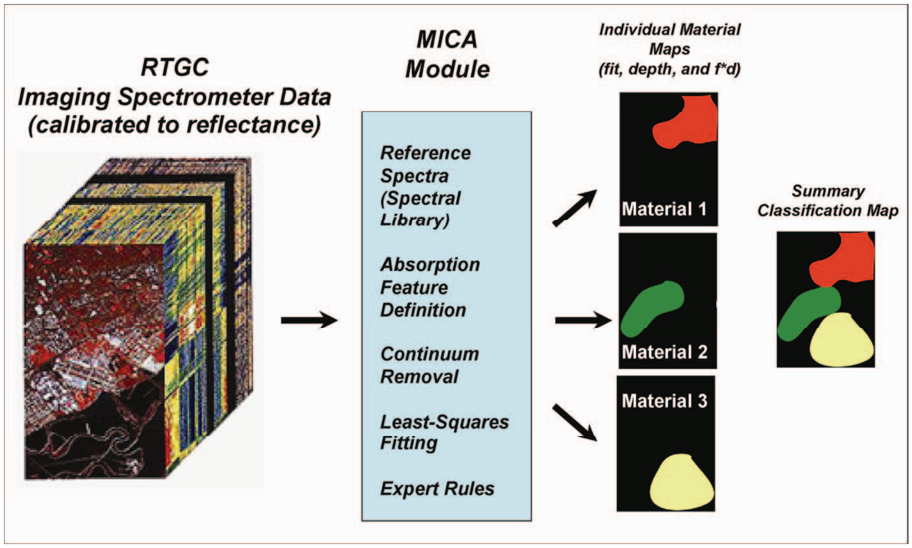

Fig. 2. Program flow and key algorithms of MICA module of PRISM.

4. REFERENCES

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