THE SPECTRAL IMAGE PROCESSING SYSTEM (SIPS) - SOFTWARE FOR INTEGRATED ANALYSIS OF AVIRIS DATA

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1. INTRODUCTION

The Spectral Image Processing System (SIPS) is a software package developed by the Center for the Study of Earth from Space (CSES) at the University of Colorado, Boulder, in response to a perceived need to provide integrated tools for analysis of imaging spectrometer data both spectrally and spatially (Kruse et al., 1992a). SIPS was specifically designed to deal with data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and the High Resolution Imaging Spectrometer (HIRIS), but has been tested with other datasets including the Geophysical and Environmental Research Imaging Spectrometer (GERIS), GEOSCAN images, and Landsat TM. SIPS was developed using the "Interactive Data Language" (IDL) (Research Systems, 1991). It takes advantage of high speed disk access and fast processors running under the UNIX operating system to provide rapid analysis of entire imaging spectrometer datasets. SIPS allows analysis of single or multiple imaging spectrometer data segments at full spatial and spectral resolution. It also allows visualization and interactive analysis of image cubes derived from quantitative analysis procedures such as absorption band characterization and spectral unmixing. SIPS consists of three modules: SIPS Utilities, SIPS_View, and SIPS Analysis. SIPS version 1.1 is described below.

2. SIPS UTILITIES

The SIPS utilities module contains tools that prepare data for input to SIPS_View, the analysis programs, and other image processing software. These tools are written in IDL and C. Utilities are provided for reading AVIRIS tapes to band sequential (BSQ), band interleaved by pixel (BIP), or band interleaved by line (BIL) format files; creating a wavelength file and a histogram file; calibrating to reflectance; creating spectral libraries; and converting to various output file formats. The utilities all have command line interfaces, and some also have interactive graphical interfaces. A complete list of tools and detailed usage instructions are given in the SIPS User's Guide (CSES 1992).

3. SIPS_VIEW

3.1 GENERAL

SIPS_View is an interactive IDL program that allows the user to visualize and work with imaging spectrometer data both spectrally and spatially. It uses "widgets" such as menus, buttons, and slider-bars along with mouse and keyboard input to create a user-

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friendly interface. Interaction by the user with a given widget produces an "event" to which the software is able to respond by performing a specific function.

SIPS_View requires a minimum of one image file in any storage order; BSQ, BIP, or BIL. If the same image data is present in more than one storage order, SIPS_View chooses the best file for efficient data extraction. Additional files including wavelength, histogram, bad-bands, and spectral libraries enhance the performance and utility of the program.

3.2 SIPS_VIEW DISPLAY FUNCTIONS

The display functions operate on the image data in its spatial format. The "Image Window" displays the full resolution image in a 512 line x 614 sample window with a default 2% linear contrast stretch applied. The displayed image can be a gray-scale or density-sliced image of a specific band, or a color composite image of three bands. If the image is larger than 512 x 614, SIPS_View displays part of the image at full resolution, and allows scrolling to other parts of the image. Possible actions associated with the Image Window include selecting which band is displayed, selecting the color mode, and saving the current image to a data file or a color PostScript file.

In addition to the main window, SIPS_View creates and manages many other windows throughout its execution. The "Status Window" displays useful information about the current processing status of SIPS_View. The "Zoom Window" contains a subset of the image zoomed from 1 to 16 times. The "Current Spectrum Window" and "Saved Spectra Window" are used for viewing, extracting and saving spectra. Other windows such as "Contrast Stretch", "View Spectra", "Spectral Profiles" and the "SAM Viewer" are created only when accessed by the menu functions.

3.3 SIPS_VIEW SPECTRAL FUNCTIONS

SIPS_View spectral functions are those items that deal with imaging spectrometer data primarily in its spectral format. Spectral functions include browsing, region-of-interest extraction, profile extraction, viewing, and spectral matching.

The browse spectra capability allows the user to roam around the Image window displaying the current spectrum in real-time. The "Class Extraction" function allows the user to interactively define and extract spectral characteristics for user-defined groups of spectra for regions of interest. The mean, standard deviation, minimum, and maximum spectra for each class are displayed in the Saved Spectra window. View Spectra is a utility used for spectral display and analysis. When the View Spectra function is selected, SIPS_View creates a separate window to plot the spectra currently in the Saved Spectra Window as well as access and plot other ASCII and binary library spectra. The user can then manipulate this plot in a number of different ways, produce a PostScript output file of the plot, or import the plotted spectra back into the Saved Spectra Window for subsequent use in other SIPS functions. The "Spectral Angle Mapper" (SAM) is an analysis tool that permits rapid mapping of the spectral similarity of image spectra to reference spectra (Boardman 1992a). The algorithm determines the spectral similarity between two spectra by calculating the "angle" between the spectra, treating them as vectors in a space with dimensionality equal to the number of bands.

4. SIPS ANALYSIS PROGRAMS

The analysis module provides tools that perform complex calculations on an entire image and are too time consuming for interactive use. Currently, only the *unmix* analysis tool which performs linear spectral unmixing is available in this module. A knowledge-based, expert system analysis utility is presently undergoing testing and

revision (Kruse et al., 1992b) and will be released in the next version of SIPS. Other analysis modules are being developed and will be added at a later date.

The SIPS unmixing program, written in IDL, uses a simple linear mixing model. This model assumes that observed spectra can be modeled as linear combinations of endmembers contained in a spectral mixing library (Boardman 1992b). The unmixing approach seeks to determine the fractional abundance of each endmember within each pixel.

5. SOFTWARE AVAILABILITY

SIPS is provided free of charge or royalties. CSES plans, however, to continue development of these programs and retains the title and copyright to the software, documentation, and supporting materials. Recipients of this software are required to execute a Memorandum of Understanding (MOU) provided by CSES that specifies in detail all of the associated conditions. Send requests for an MOU to:

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6. ACKNOWLEDGMENTS

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