Hyperspectral

HYPERSPECTRAL

The Hyperspectral module is designed for processing and analyzing images acquired with airborne and satellite-borne imaging spectrometers. It consists of a set of hyperspectral-specific application programs, a set of visualization programs, and spectral libraries (*splib04a* and *splib04b*) from the United States Geological Service (USGS).

Also available are hyperspectral image compression and MODTRAN4-based atmospheric correction.

MODULE PREREQUISITES

Hyperspectral is an add-on to Geomatica Core.

Hyperspectral Image Compressor and Hyperspectral Atmospheric Correction are available as add-ons to the Hyperspectral module.

IMAGE METADATA SUPPORT

Included within the Hyperspectral module is support for image metadata, which has been designed to accommodate the needs of hyperspectral processing and analysis.

Importing Metadata

- METAIN – Reads metadata from XML and reformats and stores it in a GDB file, allowing you to view Global and Band-Specific Metadata
- If the data and metadata are provided in an ENVI-format header/data file pair, then Geomatica programs can read the metadata directly from the header file
- METAOUT – Exports metadata to an XML file

DATA PREPROCESSING

Preprocessing tasks, which prepare data for visual interpretation, removal of atmospheric effects, or automated analysis can be divided into sensor-related calibration, geometric correction, and noise removal.

Sensor–Related Calibration

- DRSUB – Dark Reference subtraction:
  - Obtains band-image values that are more closely proportional to at-sensor radiance
- SHFTCW – Shift-center wavelength value:
  - Directly changes the center wavelength values in band-response profiles

Geometric Correction

- ROLLCOR – Pushbroom scanner image roll correction:
  - Removes roll distortion without ancillary data
  - Shifts image lines by an integer number of pixels

Noise Removal

- STRPCOR – Remove periodic striping:
  - Multiplies pixel values in each bad row or column stripe by a gain value that is a function of neighboring rows or columns
- BRDFCOR – Reduce cross-swath brightness variation:
  - Reduces along-scanline tone variation without knowing the instantaneous view direction
- PCLT – Generate a principal components linear transformation:
  - Computes and applies parameters of band-wise linear data transformations and their inverses
  - Is computed from the band-vector covariance matrix
  - Results in bands being ordered in decreasing image quality
- MNFLT – Generate a maximum noise fraction linear transformation:
  - Computes and applies parameters of band-wise linear data transformations and their inverse values
  - Accepts explicit noise image or approximation for certain kinds of

  - noise (salt-and-pepper, image striping)
  - Results in bands being ordered in an increasing signal-to-noise ratio
- PRINTLT – Print linear transformation parameter values
- LINTRN – Linearly transform image channels:
  - Computes and applies parameters of band-wise linear data transformations and their inverse values
  - Transforms an image using the parameters read from a transformation parameters file
  - Applies either the forward or inverse transformation
- MNFNR – Maximum noise fraction noise removal:
  - Is used when an image band has significantly more noise than the other image bands
  - Transforms an image band so that its noise content is close to that of the other bands
  - Applies multiple times to the same image in order to reduce the noise in multiple bands

VISUALIZATION OPERATIONS

The Hypersepctral module includes a set of visualization operations accessible through Geomatica Focus. These include:

- Thumbnails – view all image bands in a tiled rectangular array
- 3-D Data Cube – displays a three-dimensional model of your data and allows you to:
  - Excavate Data Cube
  - Rotate Data Cube
- Band Cycling – chooses an optimal color composite
- Scatter and Spectral Plots
- Linkage of scatterplot and image displays

SIMPLE ATMOSPHERIC CORRECTION

The Hyperspectral module supports the following simple atmospheric correction.

Empirical Line Calibration

- EMPLINE – Empirical line calibration:
  - Computes parameters of band-specific radiometric transformations to transform multi-band image values to estimates of scene reflectance
  - Relies on ground or lab reflectance spectrum for surface types that can be localized in an image
  - Does not account for the effect of variations in atmospheric conditions over the full extent of image

Flat Field Correction

- FTLOC – Locate spectrally flat targets:
  - Generates reference spectrum by finding image locations where image spectra are best approximated by a polynomial function of wavelength
- SP2RT – Convert a spectrum to a radiometric transformation:
  - Converts reference spectrum (FTLOC) into a radiometric transformation
  - Stores transformation in the image file
  - Can be applied on-the-fly
- APPLRT – Apply radiometric transformation:
  - Applies transformation and creates new transformed image

LOCAL ANALYSIS

The Hyperspectral module supports the following local analysis.

Endmember Selection

- ENDMEMB – Select Endmembers:
  - Estimates a set of Endmember spectra for a specified image region using iterative error analysis (IEA)
  - Outputs endmembers to a file, used as input into SPUNMIX
  - Specifies the size of an endmember set

Spectral Unmixing

- SPUNMIX – Spectral Linear Unmixing:
  - Linearly unmixes a hyperspectral image
  - Estimates the contribution of each endmember to the spectrum at each image location
  - Computes a fraction map for each endmember
  - Provides a single map output for each endmember spectra
  - Provides a value at a given location as an estimated fractional contribution of a map's reference spectrum to image spectrum
  - Determines information on a "subpixel" scale
  - Extracts information from "mixed pixels"
  - Includes an RMS-error for each endmember in an output report

Spectral Angle Mapper Image Classification

- SAM – Perform a spectral angle mapper classification
  - Classifies hyperspectral data, using reference spectra that defines classes
  - Extracts lab-measured reflectance spectra
  - Computes the "spectral angle" between each band vector and each reference spectra
  - Results in a raster layer showing the smallest spectral angle (to reference spectra) for each pixel
  - Resamples input reference spectra to match image wavelength sampling if necessary
  - Prints a tabular summary of classification results

SPECTRA HANDLING

The Hyperspectral module supports the following spectra handling.

Spectra Handling

- I2SP – Derive spectra from an image
- SPCONVP – Concolve spectra with band response profiles
- SP2SP – Reformat a set of spectra

Scatter and Spectral Plots

Scatter and spectral plots provide tools that examine spectra and analyze the separability of classes, allowing you to:

- View spectra from regions of interest
- Open spectra from a spectral library to compare with spectra from your regions of interest
- Save spectra to a either an XML or to an SPL library
- Provide an Active Radiometric Quantity and Wavelength graph.
- Provide an Active Displayed Spectra table
- Include data controls
- Adjust Hyperspectral Images
- Set Plotting Ranges
- Provides reports
- Provides graph options and settings

HYPERSPECTRAL IMAGE COMPRESSOR

The Hyperspectral Image Compressor module supports vector quantization. Vector quantization provides a lossy image compression that is very effective with hyperspectral images. Not only does vector quantization save data storage space and bandwidth, but the input and processing of vector quantized image data reduces program execution time for large images.

Even though vector quantization is lossy, satisfactory analysis results may often be obtained with vector quantized images. Even if final analysis results must be obtained with the original image data, vector quantization may be used to speed up operations during intermediate experiment to determine parameter values.

Compressing Hyperspectral Data

- VQHSOC – Hierarchical self-organizing cluster vector quantization:
  - Provides lossy image compression

- Transforms an N-band image into a set of N-dimensional "codevectors," called a "codebook," plus an "index map"
- Achieves compression when the size of a set of codevectors and index map is less than the size of original image

HYPERSPECTRAL ATMOSPHERIC CORRECTION

A new atmospheric correction capability has been added for Geomatica 10. The advanced software employs the MODTRAN4 atmospheric radiative transfer model, and is augmented by software for deriving an atmospheric water vapor content map from the image data, and for spectral line curvature and correction. PCI Geomatics customers can obtain the MODTRAN4 executable and data files directly from PCI Geomatics. We have been licensed by the United States Department of the Air Force to provide this service. These new capabilities provide end-users with the capability to better analyze and view their hyperspectral data.

- GENTP5 – Generate a MODTRAN4 'tape5' files (Note: this is not a general `tape 5' file generation utility, but rather is limited to the parameters relevant to the atmospheric correction method)
- GENRLUT – Generate an at-sensor radiance look up table from a MODTRAN4 'tape7' output file
- RESRLUT – Resample at-sensor radiance to surface reflectance dataset
- ATRLUT – Transform at-sensor radiance to surface reflectance dataset
- GENAWC – Generate a water vapor colum map
- GENCLUT – Detect spectral line curvature correction
- SLCCOR – Apply a spectral line curvature correction
- SMSPEC – Smooth the dataset in the along-band dimension
- RLUTSP – Extract radiance spectra from a radiance look up table
- VIEWAZ – Evaluate the view zenith angle and azimuth
- SOLARAZ – Evaluate the solar zenith angle and azimuth

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