The Hyperspectral Image Interactive Helper / Analysis Toolkit (Hii-HAT) provides a rapid, robust means to create draft mineralogical maps, summarize novel detections, and generally draw attention to areas of interest for further investigation. It incorporates spatial reasoning to assist with rapid interpretation and summary of hyperspectral image catalogs.

Features / Overview

- The Hyperspectral Image Interactive Helper / Analysis Toolkit (Hii-HAT) provides a rapid, robust means to create draft mineralogical maps, summarize novel detections, and generally draw attention to areas of interest for further investigation.
- It incorporates spatial reasoning to assist with rapid interpretation and summary of hyperspectral image catalogs.
- Applicable to diverse instruments and hyperspectral datasets (case studies consider CRISM and AVIRIS).
- IDL/ENVI Plug-in for portability and multimission operations.
- Compatibility: Windows, Linux, OSX.

Test Dataset

We use data from the Compact Reconnaissance Imaging Spectrometer (CRISM) instrument orbiting Mars [1], specifically the 1000-2500nm wavelengths of images (frt00003)63, 8158, 8636, and 3R69. These four images are well-studied in the literature and offer a benchmark dataset for development.

1. Superpixel Segmentation

Superpixels are a spatial preprocessing step for noise reduction. They represent the image as contiguous regions of a few tens or hundreds of pixels in area. An oversegmentation of the image using the Felzenszwalb algorithm [2] reduces noise while preserving small signals evident in only a few contiguous image pixels. Measurement noise is reduced proportionally to the square root of the superpixel area.

2. Automatic Atmosphere Correction

Analysts commonly use “neutral” spectra to compensate for atmospheric effects and improve spectral contrast. Dividing a spectrum of interest by a bland, featureless spectrum can enhance features not present in the common background. Unfortunately, discovering neutral regions is a laborious manual process that must often be performed in the time-critical environment of mission planning. Additionally, sensitivity matching requires the same detectors (image columns) be used for both ROIs and associated neutral regions.

3. Endmember Detection

Endmember detection uses superpixel segmentation followed by Sequential Maximum Angle Convex Cone (SMACC) or N-FINDR endmember extraction. This process entails:
- Superpixel representations outperform pixels, reducing error scores by a factor of 2-5 in each of the four images we considered.
- Superpixels always capture as many or more distinct mineral classes. Finally, the resulting noise-reduced endmember spectra provide a better match to the expert’s minerals.

4. Probabilistic Mapping

Following endmember extraction, unmixing algorithms can compute the proportion that each pure constituent contributes to any image pixel. Hii-HAT includes tools for interactive real-time unmixing with Bayesian Positive Source Separation [3]. This avoids a problem of many least-squares algorithms where optimal solutions often entail a nonzero contribution from all constituents. Bayesian unmixing can encourage “sparse” mixtures by a prior distribution favoring zero-value coefficients.

Superpixel representations also permit more sophisticated and computationally complex analyses. Hii-HAT uses a Gibbs sampling algorithm for probabilistic unmixing that computes distributions over mixing coefficients. This reveals not just the most likely proportions of the endmembers but also the uncertainty associated with each proportion. The technique assists in interpreting features that one can explain by multiple constituents or combinations. The computational requirements of Gibbs sampling would be prohibitive if used on every pixel in a scene.


Hii-HAT automatically finds appropriate neutral regions for target ROIs in projected hyperspectral images. This process entails:
1. Transforming the target ROI back to the original, unprojected image, detecting a neutral region within the columns shared by the target ROI.
2. Reprojecting the resulting neutral region.

The detection step identifies spectrally bland regions by measuring the residual of the best-fitting line to each superpixel’s spectrum. The appearance of these spectra is comparable with expert-provided neutral regions.

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