ENVI

ENVI Tutorial: Near-Shore Marine Hyperspectral Analysis

Near-Shore Marine Hyperspectral Analysis

This tutorial presents a case history for using hyperspectral techniques to extract reflectance signatures for water, vegetation, urban areas, and minerals, using 1994 AVIRIS data from Moffett Field, California, USA. It quickly guides you through ENVI's end-to-end hyperspectral tools (EFFORT → MNF → PPI → n-D Visualization → Spectral Mapping → GLT georeferencing) to produce image-derived endmember spectra and image maps. For more detail and step-by-step procedures on performing a complete hyperspectral analysis, refer to the series of ENVI hyperspectral tutorials (introductory through advanced) before attempting this tutorial, and refer to ENVI Help when necessary.

Objectives

- Apply ENVI end-to-end hyperspectral processing methodology to a near-shore marine case study
- Gain hands-on experience running the procedures rather than reviewing preprocessed results (althrough preprocessed results are provided for comparison)
- Perform data exploration in a loosely structured framework
- Compare analysis results with known ground information

Files Used in this Tutorial

All files are on the ENVI Resource DVD.

`Data\spec_lib\veg_lib`

File	Description
`usgs_veg.sli (.hdr)`	USGS vegetation spectral library

`Data\spec_lib\usgs_min`

File	Description
`usgs_min.sli (.hdr)`	USGS mineral spectral library

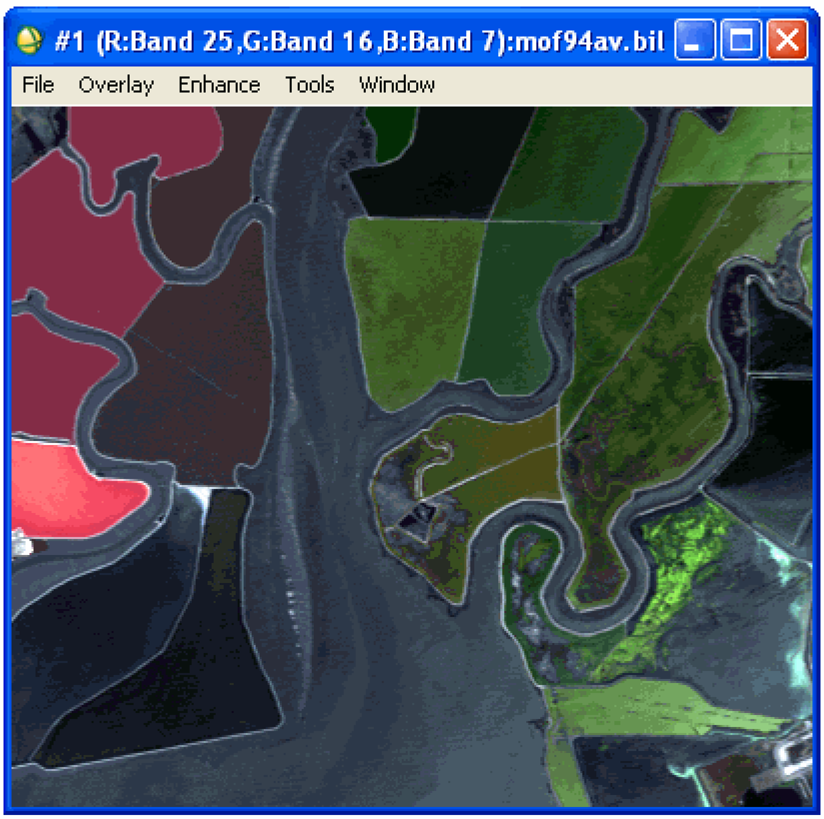
`Data\m94avsub`

File	Description
`mof94av.bil (.hdr)`	AVIRIS apparent reflectance data, 500 x 350 x 56 bands
`m94mnf.img (.hdr)`	VNIR MNF-transformed data
`m94mnf.asc`	VNIR eigenvalue plot data
`m94ppi.img (.hdr)`	VNIR PPI image
`m94ppi.roi`	ROI of VNIR PPI threshold
`m94_em.asc`	VNIR ASCII file of endmember spectra - all EM
`m94_em.roi`	VNIR ROI file of endmember spectra - all EM

File	Description
m94_ema.asc	VNIR ASCII file of endmember locations - selected EM
m94_sam1.img (.hdr)	VNIR SAM classes using m94_ema.asc
m94_rul1.img (.hdr)	VNIR SAM rule image
m94_unm1.img (.hdr)	VNIR unmixing image using m94_ema.asc

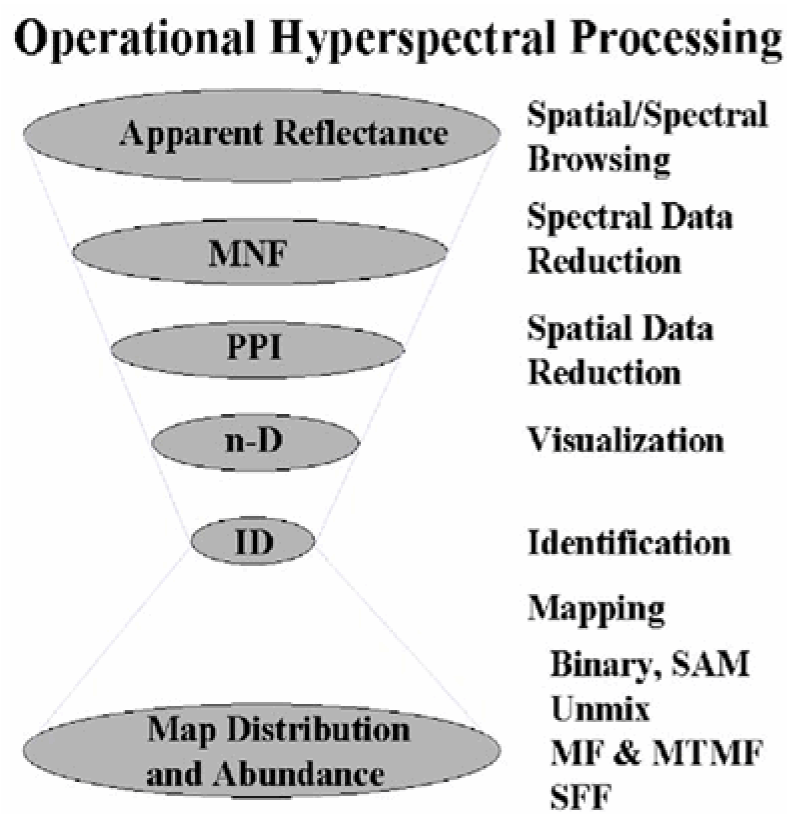
Moffett Field Site Background

Moffett Field was the launch site for the AVIRIS sensor in 1987, and it was used by NASA Jet Propulsion Laboratory (JPL) as a remote sensing test site. The region provides an ideal study area for water variability, urban studies, and vegetation. Much of the water variability is due to highly colored salt evaporation ponds containing a dense biomass of algae and/or photosynthetic bacteria (Richardson et al., 1994). Accessory bacterial pigments cause distinct spectral signatures that AVIRIS can detect. These include carotenoids, phycocyanin, and chlorophyll *a* and *b*. Application the standard AVIRIS analysis methods should lead to extracting endmembers from the data and mapping their spatial distribution and abundance. The data, however, contain some obvious mixing non-linearities, so you should learn to recognize these.



Processing Flow

The following figure shows the hyperspectral processing flow implemented in ENVI.



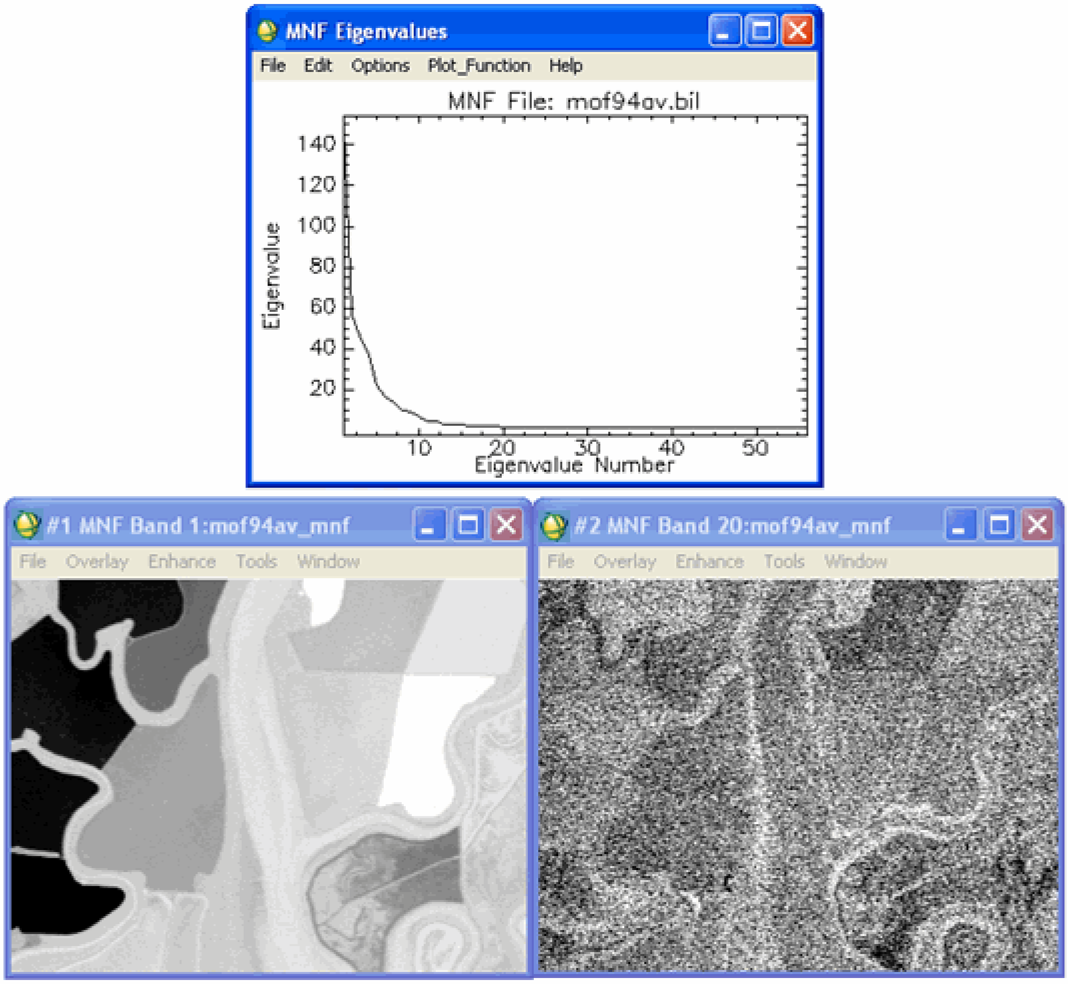
Hyperspectral Techniques for Near-Shore Marine Analysis

1. **Evaluate atmospherically corrected AVIRIS spectral radiance data:** Atmospheric correction removed most of the solar and atmospheric effects, transforming the data from radiance to apparent surface reflectance. Examine the data using spectral and spatial browsing, and use color composites to characterize spectral variability and to determine residual errors. Extract reflectance signatures for water, vegetation, urban areas, and geologic materials. Compare to spectral libraries.

File	Description
`mof94av.bil (.hdr)`	AVIRIS apparent reflectance data, 500 x 350 x 56 bands
`usgs_veg.sli (.hdr)`	USGS vegetation spectral library
`usgs_min.sli (.hdr)`	USGS mineral spectral library

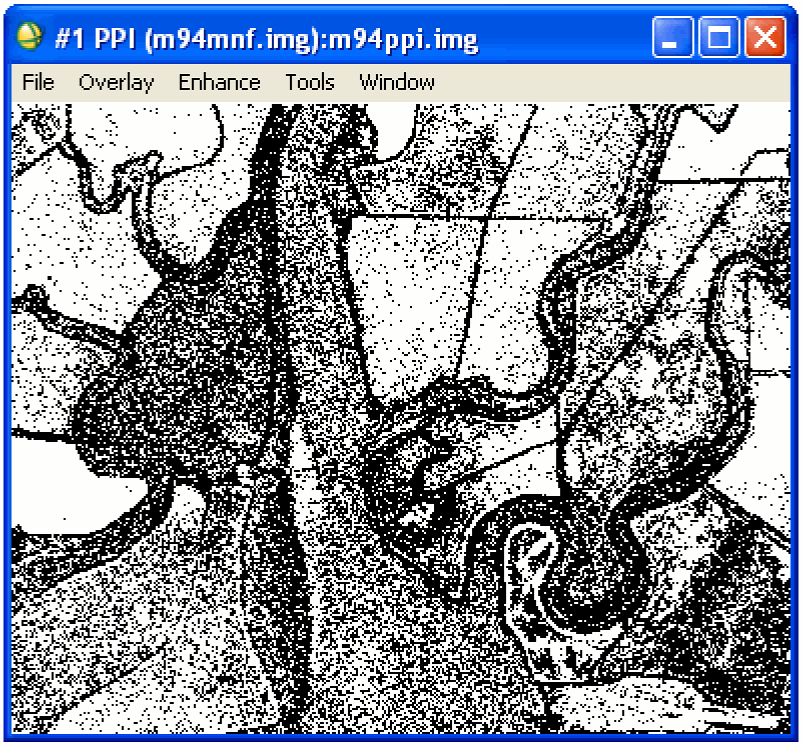
2. **Apply MNF transform and determine data dimensionality:** Review MNF eigenvalue plot to determine the break in slope and relate to spatial coherency in MNF eigenvalue images. Determine MNF cut-off between signal and noise for further analysis. Make your own MNF-transformed dataset or review the results in the files below.

File	Description
`m94mnf.img (.hdr)`	VNIR MNF-transformed data
`m94mnf.asc`	VNIR eigenvalue plot data
`m94mnf.sta`	MNF statistics
`m94ns.sta`	



3. **Apply PPI analysis to the MNF output:** Rank the pixels based on relative purity and spectral extremity. Use the FAST PPI option to perform calculations quickly in system memory, creating the PPI image. Display the PPI image, examine the histogram and threshold, and create a list of the purest pixels, spatially compressing the data. Generate your own PPI results and ROIs or review the results in the files below.

File	Description
`m94mnf.img (.hdr)`	VNIR MNF-transformed data
`m94ppi.img (.hdr)`	VNIR PPI image
`m94ppi.roi`	ROI of VNIR PPI threshold



4. **Perform n-D Visualization of the high PPI value pixels:** Use the high-signal MNF data bands to cluster the purest pixels into image-derived endmembers. Rotate the MNF data interactively in three dimensions, or spin in several dimensions and paint pixels that occur on the points (extremities) of the scatter plot. Use Z Profiles connected to the EFFORT apparent reflectance data and the n-D Visualizer to evaluate spectral classes. Use class collapsing to iteratively find all of the endmembers. Evaluate mixing and endmembers. Save your n-D results to a saved state file (.ndv). Export classes to ROIs and extract mean spectra. Compare mean spectra to spectral libraries. Use spectral/spatial browsing to compare image spectra to ROI means. Extract endmembers and make your own ROIs or review the results below:

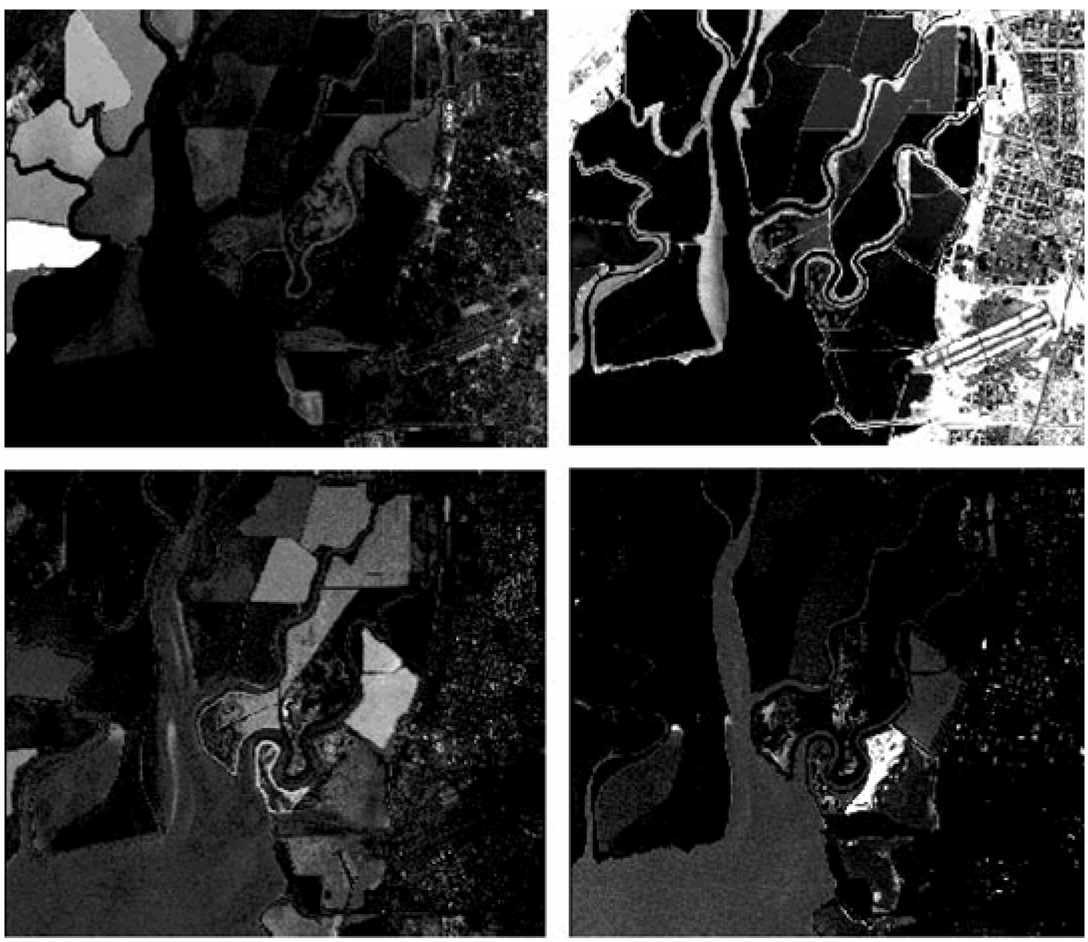
File	Description
`m94ppi.roi`	ROI of VNIR PPI threshold
`m94_em.asc`	VNIR ASCII file of endmember spectra - all EM
`m94_ema.asc`	VNIR ASCII file of endmember locations - selected EM
`m94_sam1.img (.hdr)`	VNIR SAM classes using `m94_ema.asc`
`m94ppi.ndv`	Saved n-D Visualizer state

5. **Use ENVI's mapping methods:** Map the spatial occurrence and abundance of materials in the Moffett Field scene. At a minimum, try the Spectral Angle Mapper (SAM) and Unconstrained Linear Mixing. Use SAM to determine spectral similarity to image endmember spectra. Perform your own SAM classification or review the results below. If time permits, try a SAM classification using spectral libraries. Be sure to evaluate the rule images. Use the Unconstrained Linear Unmixing to determine material abundances or review the results below. Be sure to examine the RMS error image and evaluate linearity, particularly whether the physical constraints

of non-negative and sum to unity (1) or less have been satisfied. Iterate if time permits. Compare abundance image results to the endmember spectra and spectral libraries using spatial and spectral browsing. If time permits, try running the Mixture Tuned Matched Filtering (MTMF) and/or Spectral Feature Fitting (SFF) methods.

File	Description
`m94_em.asc`	VNIR ASCII file of endmember spectra - all EM
`m94_ema.asc`	VNIR ASCII file of endmember locations - selected EM
`m94_sam1.img (.hdr)`	VNIR SAM classes using `m94_ema.asc`
`m94_rul1.img (.hdr)`	VNIR SAM rule image
`m94_unm1.img (.hdr)`	VNIR unmixing image using `m94_ema.asc`

The following figure shows spectral unmixing results: Red Pigment (upper-left), Green Pigment (lower-left), Vegetation 1 (upper-right), Vegetation 2 (lower-right).



References

Richardson, L.L., 1996, Remote Sensing of Algal Bloom Dynamics: BioScience, V. 46, No. 7, p. 492 - 501.

Richardson, L.L, D. Buison, C. J. Lui, and V. Ambrosia, 1994, The detection of algal photosynthetic accessory pigments using Airborne Visible-Infrared imaging Spectrometer (AVIRIS) Spectral Data: Marine Technology Society Journal, V. 28, p. 10-21.