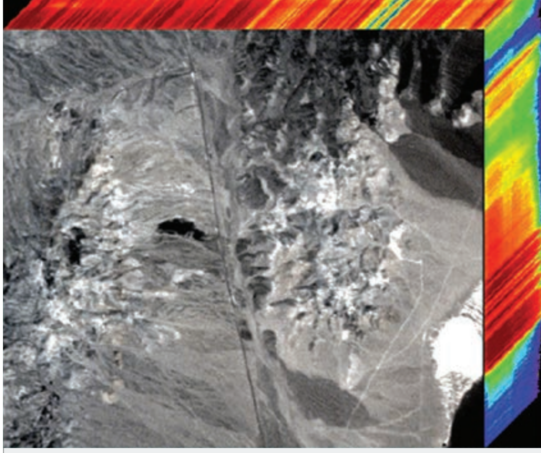


L3HARRIS™
FAST. FORWARD.

SPECTRAL ANALYSIS IN ENVI®

The Basics of Spectral Data

Every object or material – whether solid, liquid, or gas – reflects or emits electromagnetic energy in a distinctive way. Our eyes can only perceive electromagnetic energy in shades of red, green and blue (RGB) – this is called the visible spectrum. Spectral image analysis utilizes more bands from the electromagnetic spectrum to extract distinct spectral characteristics and derive valuable information.

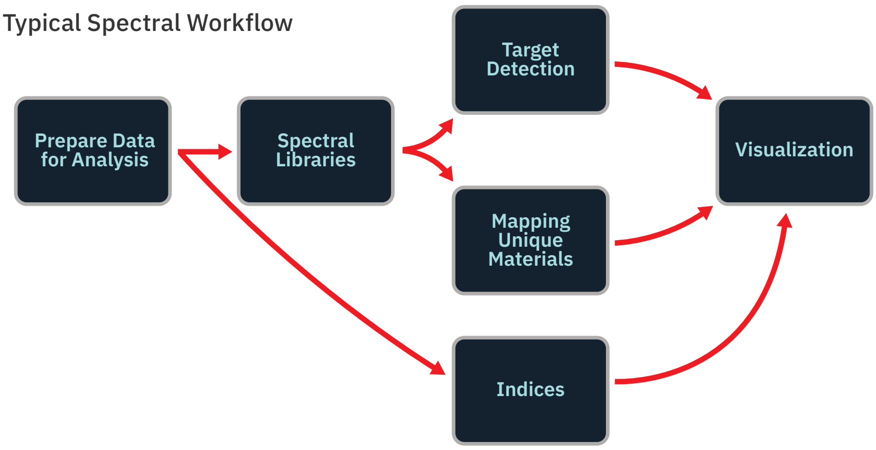
Spectral data is broken out into two categories, multispectral (MSI) and hyperspectral (HSI). Multispectral imagery generally has fewer, broader bands, while Hyperspectral imagery consists of more, narrower bands. Spectra from MSI imagery, like a Landsat or Sentinel-2 image, contains information that you can use to identify a material class like vegetation, soil and impervious surfaces. HSI can oftentimes give the exact material types such as weathered asphalt versus concrete.

Spectral data has been around for many years but until recently, compute power and storage capacity have struggled with the large size of the data. Having spectral data at your disposal is only the first step. In order to answer questions with the data, you need to be able to quickly preprocess it and easily and accurately extract information from it.

ENVI Spectral Analysis

ENVI was initially developed by imaging experts to process and analyze HSI data and it continues to be the definitive leader in spectral analysis. ENVI includes hundreds of spectral image processing tools to analyze MSI and HSI data and extensibility options to automate your workflows. These tools are based on established, scientific methods for spectral analysis – using pixel responses at different wavelengths to obtain information about the materials within each pixel. While initially developed with hyperspectral data in mind, most of the analysis tools in ENVI can be applied to multispectral data as well.

Typical Spectral Workflow



ENVI SPECTRAL TOOLS ARE THE INDUSTRY STANDARD

- Advanced data preprocessing, critical for producing accurate results
- Tested, proven and reliable to efficiently handle large datasets
- Beneficial to non-experts and experts alike

SPECTRAL ANALYSIS IN ENVI®

PREPARING DATA FOR ANALYSIS

A fair amount of preprocessing is needed to effectively use spectral data and extract meaningful information from it. This includes radiometric calibration and correction, atmospheric correction and geometric correction.

> **Radiometric Calibration and Correction**
ENVI provides tools to calibrate imagery from digital numbers to units of radiance. This is a precursor to being able to retrieve surface reflectance, which is vital when comparing data from different dates, times and sensors. Some imagery is delivered as "analysis-ready data," however, if you wish to control your image processing workflow, having the ability to work with Level 1 data is key. Radiometric correction can also remove certain kinds of noise that can be introduced in the imagery collection process.

> **Atmospheric Correction**
Atmospheric correction is necessary to clean up the diffusion and scattering of light present in a spectral image. ENVI corrects for atmospheric distortion to deliver a true, reliable representation of a specific image scene. ENVI offers either advanced, physics-based techniques or more of an on-the-fly method for real-time data processing and works with both multispectral and hyperspectral data. Analysis ready data from multiple sensors may have been processed using different atmospheric correction methods, which can introduce error. ENVI processes data from multiple sensors with a consistent methodology to ensure that what you see in an image was not artificially introduced.

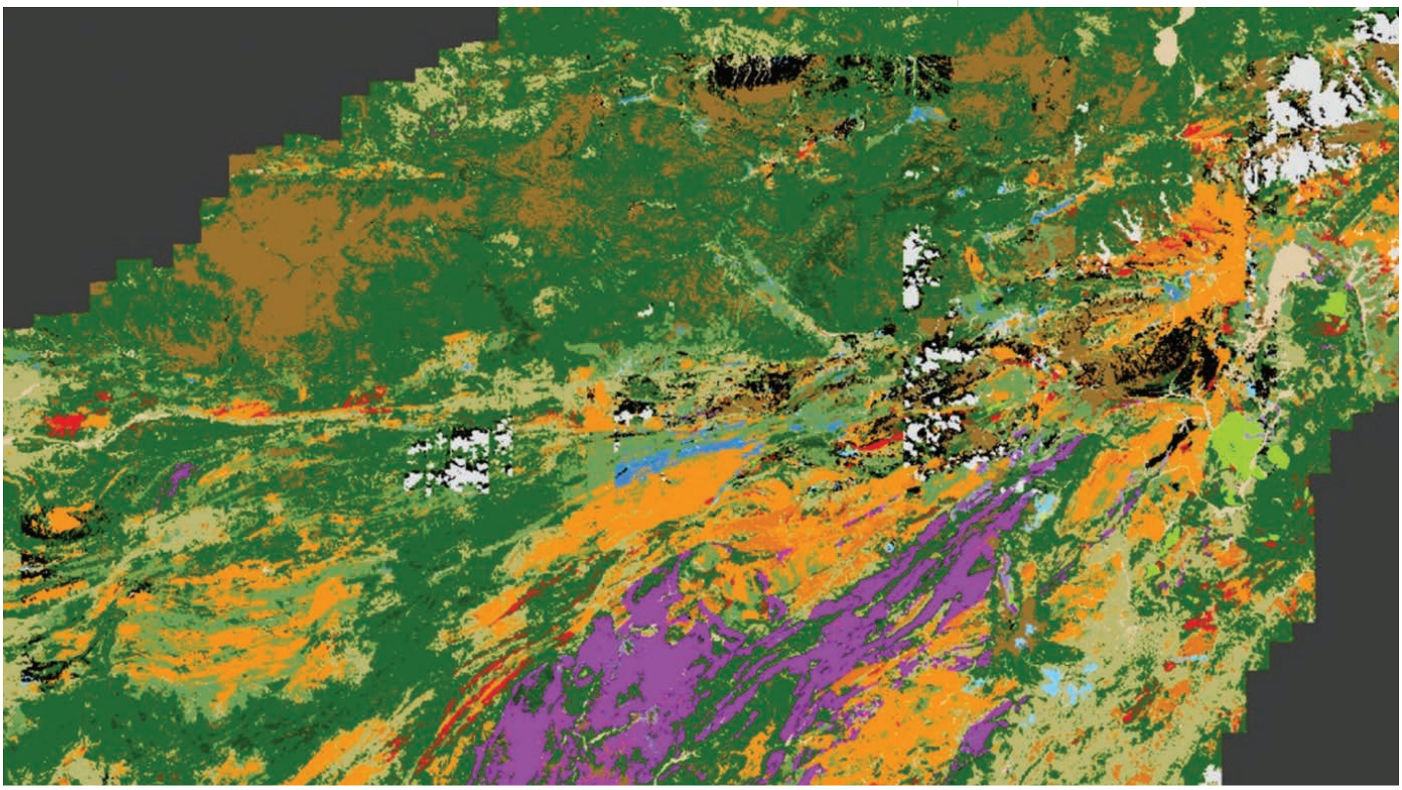
> **Geometric Correction**
ENVI can register one image to another or an image to a map projection to help maximize the data you can extract. Geometric correction is done by removing variations in sensor characteristics and orbital/airborne geometry. The result is the repositioning and resampling of pixels into a specified reference grid. This results in the ability to co-register and compare one image to another (i.e. change detection) or integrate multiple images together (i.e. analysis of multitemporal data for land use classification).

INDICES

Spectral indices are combinations of spectral reflectance from two or more wavelengths that indicate the relative abundance of features of interest. ENVI includes more than 50 indices to save users valuable time. Vegetation indices are the most popular type, but other indices are available for burned areas, man-made (built-up) features, water and geologic features. You can also write a script to compute spectral indices and write your own mathematical expressions for custom indices.

BELOW:

Spectral image processed in ENVI displaying material classes for minerals. Base from U.S. Geological Survey HyMap data of Afghanistan. Image courtesy of Kokaly, R.F. & Bahr,T. (2014).



SPECTRAL LIBRARIES

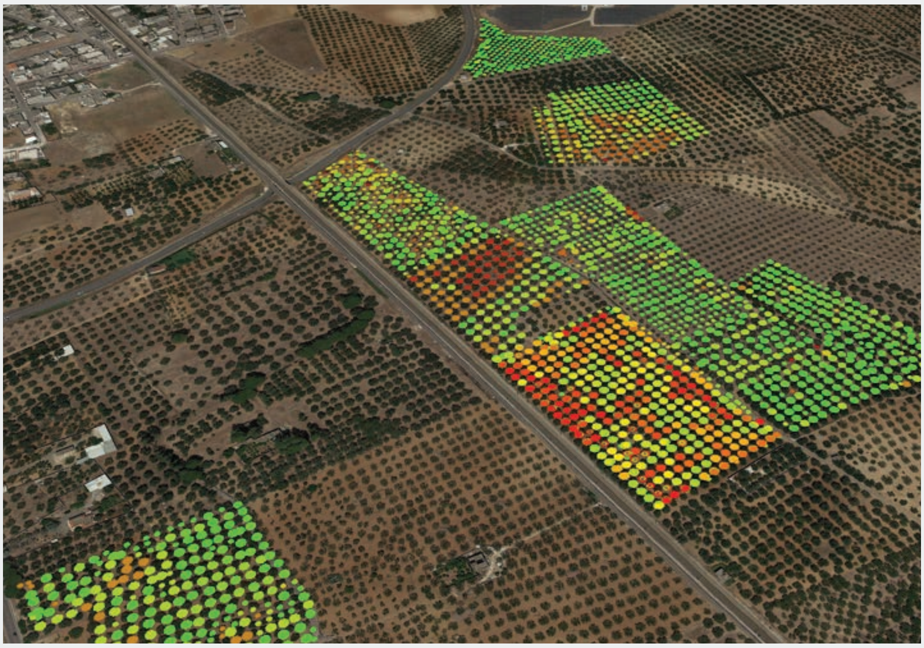
In ENVI, spectral libraries are used in many different spectrum identification, feature extraction, anomaly detection, target finding and material mapping workflows. ENVI includes a number of existing spectral libraries (i.e. from United States Geological Survey, Johns Hopkins University Applied Physics Laboratory, NASA Jet Propulsion Laboratory, etc.). Users can also build their own spectral libraries from a variety of spectra sources, including ASCII files, spectral files produced by spectrometers, other spectral libraries, user defined regions of interest, and spectral profiles and plots. Libraries can be resampled to other sensor wavelengths to make an exact reflectance comparison.

MAPPING UNIQUE MATERIALS

Spectral data users often want to map where materials are present in an image. For example, using ENVI you can map soil types to determine the trafficability of an area or if the location has been disturbed. Some classification routines in ENVI use a “fitting” approach, in which a measured spectrum is used to look for a combination of reference spectral data that resemble it.

TARGET DETECTION

ENVI utilizes many different spectral feature matching techniques to compare unknown spectral signatures to known reference spectra to find targets of interest. Targets may be a material or mineral of interest or they may be man-made objects such as vehicles. The tools in ENVI can also be linked to detect gaseous materials.



Olive trees in the Lecce Province, Apulia, Italy. Each circle represents an absolute NDVI value. The healthiest trees are colored green. The source image is from WorldView-2, processed using ENVI software.

VISUALIZATION

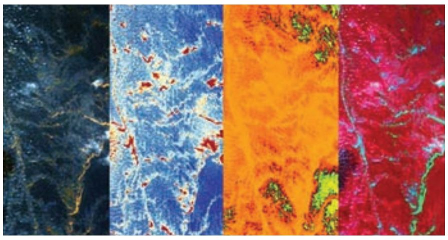
ENVI can be used to visualize complex spectral data so that you can interpret it and make informed decisions. The human eye can only see a limited number of spectral bands. Using ENVI, all spectral bands can be viewed in different combinations to highlight features of interest and create mapping products. ENVI supports hundreds of data sources, data types, file formats and file sizes.

Visualizing spectral data can be complex and time-consuming because it often requires you to re-order displayed bands, apply color tables, create layers, pan, zoom blend, integrate geographical data and more. ENVI has components for every step of this process from initially viewing imagery to map creation.

HYPERSPECTRAL IMAGING. SEEING IS BELIEVING.

The ability to get highly detailed information from spectral data is essential for many applications. This is especially true when complex chemical and physical interactions of things like vegetation, soil and mineral types, and even chemical analysis of items need to be understood. Here are several example applications of spectral data and ENVI spectral analysis.

OIL AND GAS

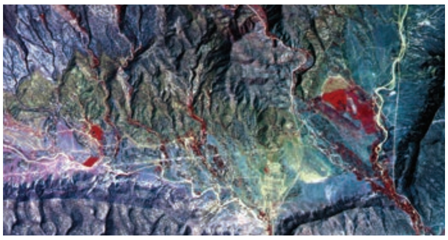


Visualize and understand the chemical seepage of oil even in areas of mixed land.

GEOLOGY

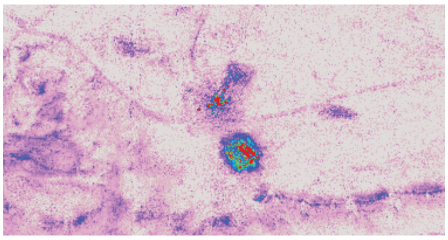
Measure the distribution and quantity of the content of drill cores and other geological samples.

MINING



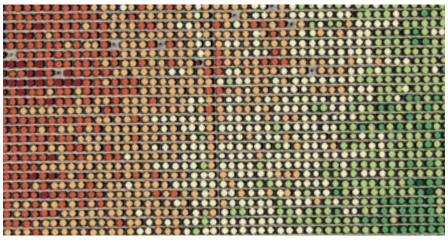
Identify and map mineral occurrences at the topographic surface, estimate mixtures and calculate abundances.

DEFENSE AND INTELLIGENCE



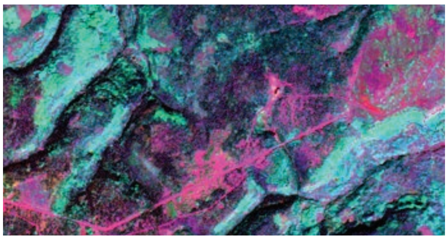
Detect camouflaged objects based on the spectral information related to the chemical makeup of materials.

PRECISION FARMING



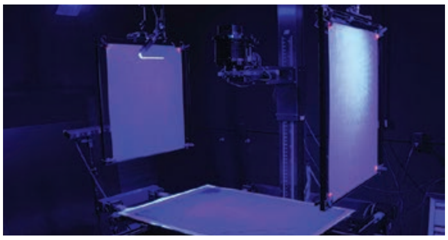
Map vegetation and crop diseases, detect stress, identify components in plants and detect impurities.

FORESTRY



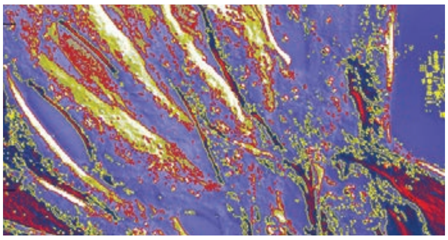
Classify individual tree species, discern foliar chemistry and detect pest and blight conditions.

CULTURAL HERITAGE



Use HSI as a noninvasive technique to monitor and preserve historical documents or canvas paintings.

MEDICINE



Quantify the diagnostic information available from reflected, fluorescent and transmitted light in tissue.

MICROSCOPY

Characterize the spectral properties of nanoscale samples for chemical-free monitoring of food products.

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