Feature Extraction using ENVI
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Abstract
Feature extraction is a complex image processing problem that can be approached from different directions. In this article we will show the semi-automatic approach provided by ENVI's Feature Extraction module. This module is based on a powerful, fast and simple segmentation algorithm that uses just two parameters and generates a deterministic result (different executions on the same dataset with the same parameters generate the same result). The feature extraction workflow is guided by an interactive wizard that allows previewing results at each step making easier the choice of parameters. Once the parameters have been fixed to extract a specific feature, the module can be run in batch mode to process multiple datasets. Final results can be provided as raster or vector fully integrated with ArcGIS.

Introduction
Feature extraction is a complex task in image processing which is closely linked to other problems as image segmentation or image classification. It consists of identifying, in a digital image, groups of pixels belonging to the same entity from the real world (feature).

This extraction can be automatic to a certain level. Fully automatic feature extraction algorithms exist, but they are very limited (they are designed for a very specific type of image and for a very specific feature). The semi-automatic approach tries to extract as much as possible from the image using a few parameters provided by the user, who will choose them depending on the target feature.

ITT Visual Information Solutions ENVI software provides some semi-automatic tools to extract features from digital images. Apart from the huge set of basic image processing operations, they contain also some user friendly tools aimed to extract features:

- ENVI's SPEAR tools
- ENVI's Feature Extraction module
ENVI’s SPEAR tools

They are a set of workflows to accomplish specific image processing tasks. Every workflow has its own wizard that guides the user through the process. Among all the available tools, the most interesting ones for feature extraction are:

- **Anomaly Detection**: This tool computes an image that highlights pixels that are spectrally different from his surrounding pixels. Usually these anomalies are related to man-made structures.
- **LOC (Lines Of Communication) - Roads**: This tool computes an image that highlights roads in order to help the user to digitize them.
- **LOC (Lines Of Communication) - Water**: This tool perform the same task as the previous one but for water bodies.
- **Vegetation delineation**: This tool performs the same task as the previous one but for vegetation.
- **TERCAT (Terrain Categorization)**: This tool helps the user to perform multiple classifications and compute a land-coverage / land-use image.
- **Watercraft Finder**: This tool searches for watercrafts in open water.

ENVI’s Feature Extraction module

This module works with ENVI EX, which is a new product aimed to provide image processing capabilities to GIS users. It allows the user to perform some tasks using a user-friendly GUI and to generate vector information that can be directly exported to an ESRI shapefile or a geodatabase.

One of the workflows available in ENVI EX is the object oriented feature extraction one. This workflow is composed of two main tasks:

- **Segmentation**: the image gets separated in groups of adjoining pixels with similar values. This task needs just two parameters:
  - **Scale Level**: a number between 0 and 100 to decide the level of complexity for the first segmentation.
  - **Merge Level**: a number between 0 and 100 to regroup adjoining segments and avoid over-segmentation.
- **Classification**: after some attributes get computed for each segment they are classified using one of these techniques:
  - **Rules**: we impose some conditions over the attributes to be fulfilled.
  - **Examples**: we choose some segments to teach the software about the features we are looking for.

The main advantage of this workflow is that it is highly interactive and that the user can always preview the result of each step, seeing the impact of the chosen values in real time.
Target Features

The aim of this benchmark is to extract from a reference data set these features:

- Water Bodies
- Roads
- Buildings
- Vegetation

Reference Data Set

The reference data set to use for our feature extraction test contains 3 images of the same region captured by the Quickbird sensors:

- `qb_06apr2009_ms.tif`: multispectral image (visible and near infrared) at 3 meters of resolution.

![Figure 1. True color composition of the reference multispectral image](image)
Figure 2. Infrared color composition of the reference multispectral image

- qb_06apr2009_pan.tif: panchromatic image at 0.6 meters of resolution.

Figure 3. Reference panchromatic image

- qb_06apr2009_pan_sharpened.tif: pan sharpened version of the two previous images.
Our workflow

Our workflow is composed of two steps:

- Pan Sharpening
- Feature Extraction

Pan Sharpening

The reference data set contained already a pan sharpened image, but only visible bands were available. Near infrared can give us important information, especially to extract vegetation and water bodies, so we decide to perform our own pan sharpening.

To sharpen our image we only need to set two parameters:

- **Sensor**: Quickbird
- **Resampling method**: Cubic convolution

![Figure 4. Detail from panchromatic image](image)
Figure 5. Detail from true color image

Figure 6. Detail from infrared image

Figure 7. Detail from true color sharpened image

Figure 8. Detail from infrared sharpened image
**Feature Extraction**

This step is performed using ENVI EX. We start the feature extraction workflow and provide the pan sharpened image obtained from the previous step. The feature extraction workflow follows these steps:

![Feature extraction workflow diagram](image)

**Segment**

At this step the software starts image segmentation and asks us a Scale Level parameter to do it. This parameter is a numerical value between 0 and 100 that controls the size and the complexity of the resulting segments. Values close to 0 produce more and smaller segments, and values close to 100 produce less and bigger segments. In order to choose the right value, the software gives you the possibility of previewing the result.
Merge

Next step is to merge the current segmentation. This is done to avoid over-segmentation that may happen in previous step. This merge is also controlled by a numerical value between 0 and 100, where 0 means no merge at all and 100 means merge all. Of course, the result can be previewed.
Refine

Once segmentation is finished we can apply a simple threshold to a band of our segments to get rid of all the segments that are not useful for us. This is only used when there is a clear difference between target features and background, and it can reduce the computing load.

Compute Attributes

At this step attributes are computed for each segment. These attributes can be:

- **Spectral**: minimum, maximum, mean and standard deviation for each channel.
- **Spatial**: area, length, shape of the segment…
- **Texture**: range, mean, variance and entropy of the segment.
- **Custom**: band ratio, hue, saturation and intensity.

Classification

In order to assign our segments to some target feature we need to perform a classification. This classification can be done in two different ways: by rules or by examples.

Classification by rules is done by giving specific conditions for segment attributes. The user has to select an attribute and range of values we consider valid for our class. Several rules can be combined by logical operators.

In the classification by examples the software creates his own rules from a set of training data given by the user. For each feature we are looking for, the user has to click on several segments on image to provide a sample to train our classification algorithm. Two classification algorithms are available: K-Nearest Neighbors and Support Vector Machines.

A preview of the classification is available to check classification parameters.

Export Features

Finally, the classification result can be exported as an image, or as a vector file. In this last case we have the option to export our attributes to the vector file, which can be a Shapefile or a Geodatabase.

This step provides also an option to smooth our vector and avoid the pixel look.

Results

After several tests we have checked that it is difficult to find global parameters to segmentate our target features in the whole image at the same time. Segmentation results depend on image statistics, which suffer from great changes in different regions. Best segmentation results are get by separating image in thematic areas: mountain, urban, etc…
With this report we provide also results for 3 subsets, including segmentation parameters. As our algorithm has no random initialization, results can be reproduced using these parameters.

**Subset 1**

This subset contains an image of some facilities.

![Figure 12. Subset 1](image_url)

Segmentation has been done using 30 as Scale Level and 87 as Merge Level. No thresholding has been performed. Classification by rules has been used. Rules can be found as an XML file in data directory.

![Figure 13. Result for subset 1](image_url)
**Subset 2**

This subset contains an image with different types of vegetation and soil. It does not contain any human made structure.

![Subset 2](image)

**Figure 14. Subset 2**

Segmentation has been done using 30 as Scale Level and 92 as Merge Level. No thresholding has been performed. Classification by rules has been used. Rules can be found as an XML file in data directory.

![Result for subset 2](image)

**Figure 15. Result for subset 2**
**Subset 3**

This subset contains an image with part of a river, a road and a village.

![Figure 16. Subset 3](image)

Segmentation has been done using 25 as Scale Level and 95 as Merge Level. No thresholding has been performed. Classification by rules has been used. Rules can be found as an XML file in data directory.

![Figure 17. Result for subset 3](image)
Conclusion

ENVI provide powerful and simple tools to extract features from digital images. These tools are easy-to-use due to their friendly GUI that guides you through the workflow. That makes ENVI the ideal software for any kind of user, not only for image scientists.

Feature extraction is still a complex problem that needs human work to be done in the right way. Our feature extraction workflow has been designed as a tool to help users to avoid fully manual extraction and to provide an initial estimation to start from. His wizard and his preview functionality make it a perfect tool for people without experience in image processing.

Feature extraction results could be improved adding new information to our image, by example a DEM. This kind of information allows us to correct illumination problems and to have new attributes (elevation, orientation, slope…) for our classifications.