

Feature Extraction in ENVI EX using DigitalGlobe Multispectral Imagery

Introduction

Feature Extraction is a module for extracting information from high-resolution panchromatic or multispectral imagery based on spatial, spectral, and texture characteristics. One can extract multiple features at a time, including vehicles, buildings, roads, bridges, rivers, lakes, and fields. Feature Extraction works well with DigitalGlobe image data in an optimized, user-friendly, and reproducible fashion so users can spend less time with processing details and more time interpreting results.

Feature Extraction in ENVI EX uses an **object-based** approach to classify imagery. An object is a region of interest with spatial, spectral (brightness and color), and/or texture characteristics that describe the region. Traditional remote sensing classification techniques are pixel-based, meaning that spectral information in each pixel is used to classify imagery. While a pixel-based method works well in some situations, there are instances in which the object-based approach may be the best method. This tutorial focuses on the Object based approach. With high-resolution panchromatic or multispectral imagery, such as DigitalGlobe's QuickBird, WorldView-1, and WorldView-2* satellites, an object-based method offers more flexibility in the types of features to be extracted.

The Feature Extraction Workflow

Feature Extraction is the combined process of segmenting an image into regions of pixels, computing attributes for each region to create objects, and classifying the objects (with rule-based or supervised classification) based on attributes to extract features.

Extracting Impervious Features with Supervised Classification

This tutorial simulates the workflow of a city planner who must identify all of the impervious surfaces in a neighborhood. Impervious surfaces include paved surfaces, rooftops, and other structures that replace naturally pervious soil with impervious materials. The total coverage by impervious surfaces in a given area affects urban air and water resources. City government officials often use the area of impervious surface on a given property as input into assessing its property tax. You will learn how to use Feature Extraction to extract impervious surfaces using supervised classification and save it to a polygon shapefile.

Supervised classification in Feature Extraction is an iterative process. Best results are obtained by collecting a wide range of training samples, modifying classification parameters, and modifying computed attributes, all while previewing results on-the-fly. The process is not meant to be a quick-and-dirty, simple, linear workflow when the imagery is highly textured and consists of many spatially and spectrally heterogeneous features.

**The eight (8) spectral bands of WorldView-2 provide greater accuracy in multispectral analysis applications. Since more of the visible spectrum is detected, more information is present in the imagery that comes from this sensor. For more information on WorldView-2's eight spectral bands please refer to <http://www.digitalglobe.com/downloads/white-papers/DG-8SPECTRAL-WP.pdf>*

Opening and Displaying the Image

1. Start ENVI EX.
2. Double-click **Feature Extraction** in the Toolbox, which is the lower-left corner of the ENVI EX interface.

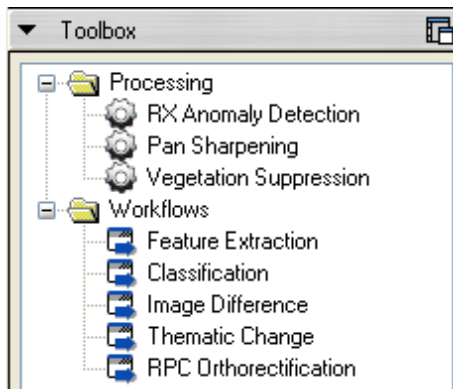


Fig.1. ENVI EX Toolbox

The Select **Fx Input Files** dialog appears.

3. Click **Open File**. The Open dialog appears.
4. Navigate to the folder where your DigitalGlobe Multispectral image resides. In this example, we select an image file named *qb_colorado*, and click **Open**. This image is a QuickBird, 4 band pan-sharpened, 0.6-m spatial resolution, subset saved to ENVI raster format. You can create spectral and spatial subsets for use with Feature Extraction, but we will not do those steps in this exercise.
5. Click **OK** in the Select Fx Input files dialog. **The Find Objects:** Segment panel appears. You can drag this panel outside of the ENVI EX interface if it's obscuring the image.

Segmenting the Image

1. In the **Find Objects: Segment** panel, enable the **Preview** option to display a Preview Portal. ENVI EX segments the image into regions of pixels based on their spatial, spectral, and texture information. The Preview Portal shows the current segmentation results for a portion of the image.

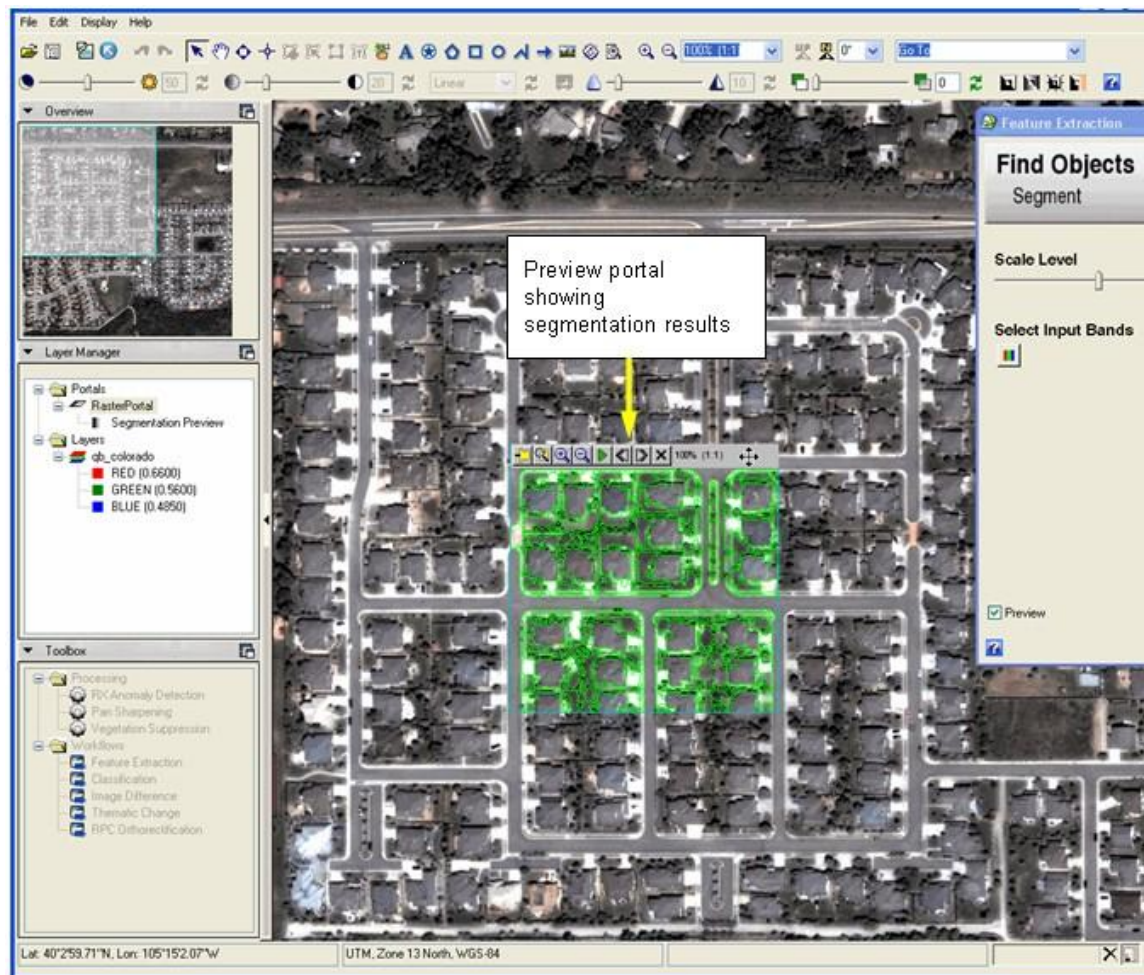


Fig.2. Find Objects Segment Panel

If you move your cursor to the top of the Portal, the Portal toolbar appears. You can use the Blend, Flicker, and Swipe tools on the Preview Portal toolbar to view the underlying layer. You can also use the Pan, Zoom, and Transparency tools on the main toolbar, although these are for display purposes only; they do not affect Feature Extraction results. You cannot adjust the Contrast, Brightness, Stretch, or Sharpen values in a

Preview Portal. You can move the Preview Portal around the image or resize it to look at different areas.

2. Type **30.0** in the **Scale Level** field, and click **Next** to segment the entire image using this value.

ENVI EX creates a Region Means image, adds it to the Layer Manager, and displays it in the Image window. The new layer name is qb_coloradoRegionMeans. The Region Means image is a raster file that shows the results of the segmentation process. Each segment is assigned the mean band values of all the pixels that belong to that region. Feature Extraction proceeds to the Find Objects: Merge panel.

3. Merging allows you to group similar adjacent segments by re-assembling over-segmented or highly textured results. Type **90.0** in the **Merge Level** field, and press **Enter**. The Preview Portal updates to show how the new **Merge Level** affects the segments.

Values of **30** for **Scale Level** and **90** for **Merge Level** effectively delineate the boundaries of impervious surfaces such as roads, sidewalks, and rooftops.



Fig.3. Merge Level Preview Portal

4. Click **Next**. Feature Extraction proceeds to the Find Objects: Refine panel.

5. The Refine step is an optional, advanced step that uses a technique called *thresholding* to further adjust the segmentation of objects. Thresholding works best with point objects that have a high contrast relative to their background (for example, bright aircraft against a dark tarmac). You do not need to perform any thresholding on the image to extract impervious surfaces. Accept the default selection of **No Thresholding**, and click **Next**. Feature Extraction proceeds to the Find Objects: Compute Attributes panel.

6. For this exercise, we will compute all available attributes. Ensure that all attribute categories are selected under both the Attributes and Advanced tabs, and click **Next**. ENVI EX computes the attributes; this process takes a few minutes to complete. These attributes will be available for supervised classification. If you choose not to compute selected attributes when using Feature Extraction, you will save time in this step but will be unable to use those attributes for classification.

7. Feature Extraction proceeds to the **Extract Features**: Classify or Export panel. Select **Choose by Selecting Examples**, and click **next**.

Supervised Classification

Supervised classification is the process of using training data to assign objects of unknown identity to one or more known features. The more features and training samples you select, the better the results from supervised classification. Training data consist of objects that you select as representative samples of known features.

The Extract Features: Supervised Classification panel begins with one undefined feature (Feature_1, see figure below). As you move the mouse around the Region Means image, the objects underlying your cursor are highlighted with the color assigned to that feature. You may need to click once in the Image window to activate this function. This is normally how you would begin the process of collecting training data

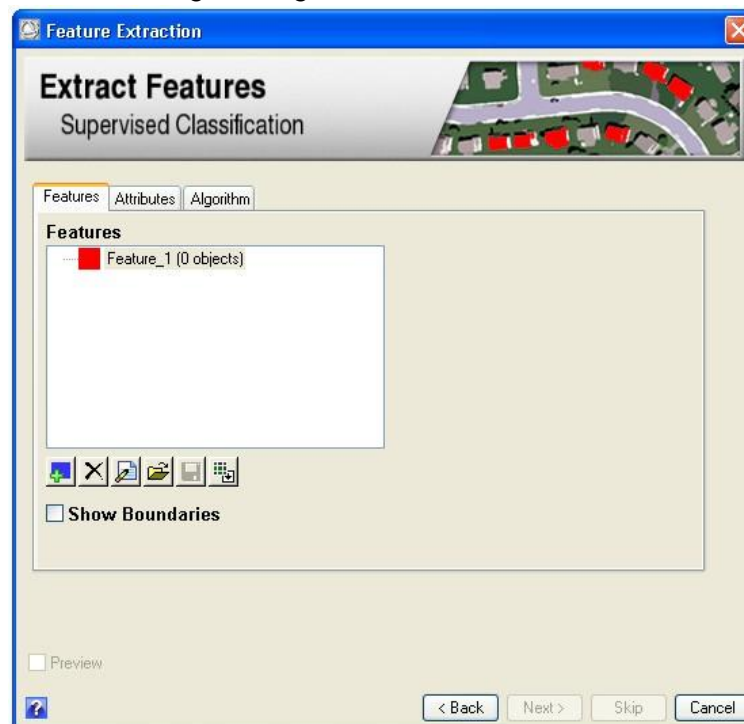



Fig.4. Extract Features Panel

Adding a New Feature and Collecting Training Data

1. In the Supervised Classification panel, click the **Add Feature** button . A new feature called "Feature_4" is added to the list. It contains no objects because you have not yet collected training data for this feature.
2. Right-click on **Feature_4** and select **Properties**. The Properties dialog appears.
3. In this example we'll change the **Feature Name** to **Dirt Road**, and click **OK**. You can also change the color if you wish. The Feature List should look similar to the following:

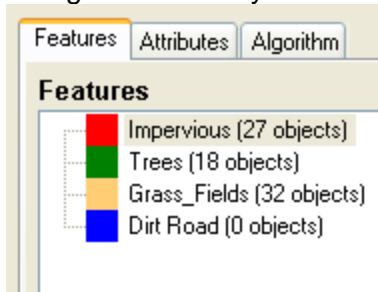


Fig.5. Feature List

4. In this example we go back to the upper part of this particular image with a dirt road
5. The Dirt Road feature is selected by default. If the Preview Portal is still open, move it out of the way before continuing since you cannot select training data through the Preview Portal. Click once in the Image window to activate the process of collecting training data for this feature. As you move around the image, the objects underlying the cursor are highlighted with the color assigned to the Dirt Road Feature.
6. Click to select objects representing the dirt road, as shown in the following figure. The color of the objects change to the feature color, and the feature name updates to show the number of objects you added. Move around the entire image and choose a variety of different objects that represent dirt roads.



Fig.6. Dirt Road Objects example

Here are a few more tips for selecting objects as training data:

- To select multiple objects at once, click and drag the cursor to draw a box around the objects. ENVI EX assigns all of the segments that are completely enclosed within the selection box to the feature. **Ctrl-Z** undoes the box selection. Be careful using the selection box because you can easily select too many features, which will slow the performance of the Preview Portal.
- To remove an individual object from the selection, click on the object. The feature name updates to show one less object.
- To see the boundaries of the individual objects, enable the **Show Boundaries** option in the Feature Extraction dialog.


Notice how the Preview Portal updates to show the new classification results in other parts of the image each time you select a new object and add to the training data set.

7. In the Feature Extraction dialog, select the **Impervious** feature.

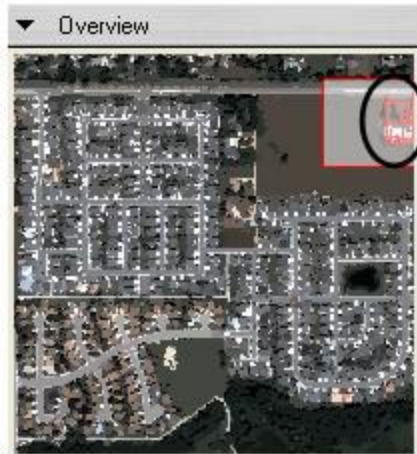
8. Experiment with selecting more training data for the impervious feature, and possibly adding a new feature of your choice. Evaluate how these changes affect the classification of impervious surfaces.

Importing Ground Truth Data

If you have access to Ground Truth Data for your data set you can optionally import this in the form of point and polygon shapefiles, when performing supervised classification. **Ground truth** data represent locations that researchers have visited and verified known feature types, thus it represents a true classification for specific areas of the image. In this exercise, we will open a sample ground truth file. If you do not have ground truth you may by-pass this section.

1. Click the **Import Truth Data from Shapefile** button . The Select Vector Data for Import dialog appears.
2. Click **Open File**. A file selection dialog appears.
3. Navigate to the folder where your ground truth shapefiles reside, in this case we'll select a shapefile named qb_colorado_groundtruth.shp, and click **Open**.
4. Click **OK** in the Select Shapefile for Import dialog.

The shapefile appears in the Image window (in the upper-right portion of the scene, outlined with a red box) and in the Layer Manager. The shapefile will remain in the Layer Manager throughout the rest of the Feature Extraction workflow.



Location of ground truth shapefile in the image

Fig.7. Overview Window with ground truth shapefile

5. In the Image window, we'll pan to the area of the shapefile (pixel coordinates for this example are approximately 1248,218) and zoom in so we can better see the individual records.



Red outline defining the shapefile boundary

Individual records within the shapefile (there are 10 total)

Fig.8. Ground Truth Shapefile

This shapefile is a fictional example of ground truth data that represents a GPS survey of different surface features on a single property.

An Import Attributes dialog also appears, when you open the shapefile. This dialog is similar to the Vector Attributes dialog in ENVI EX. In the next step, we will use the Import Attributes dialog to associate shapefile records to the features you have defined in the Supervised Classification dialog.

6. You first need to indicate which feature you will associate a shapefile record with. In this example, we select the **Dirt Road** feature in the Supervised Classification dialog.

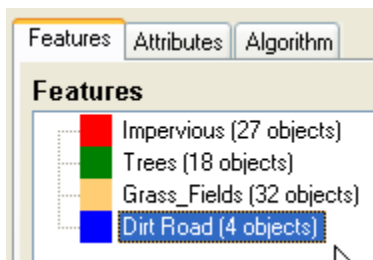


Fig.9. Features List Dirt Road Selection

7. In the Import Attributes dialog, use the **Shift** key to select rows **7-10**, which both contain records named “dirt road.” The associated points are highlighted with a cyan color in the Image window.

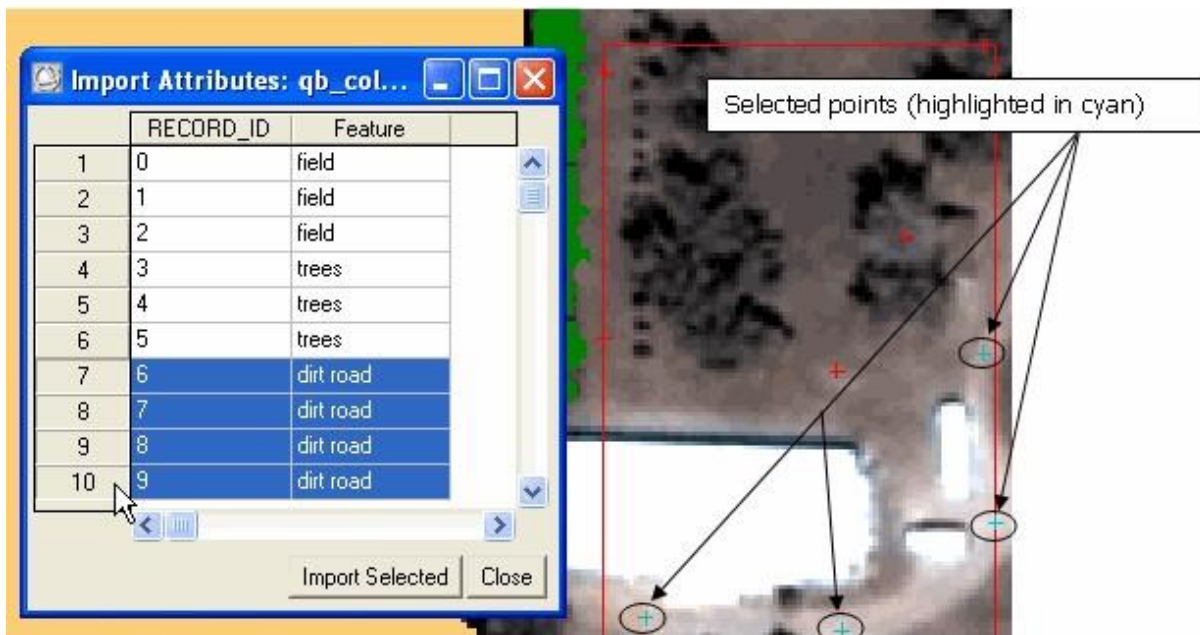


Fig.10. Import Attributes Dialog

8. In the Import Attributes dialog, click **Import Selected**. ENVI EX adds the selected vector records to the Dirt Road feature by matching the points' spatial locations with specific objects in the Region Means image (which is still available through the Layer Manager).

Note that three new objects were selected and colored dark blue, which is the color currently assigned to the Dirt Road feature. The feature name in the Supervised Classification dialog also updates to show the number of new objects added.

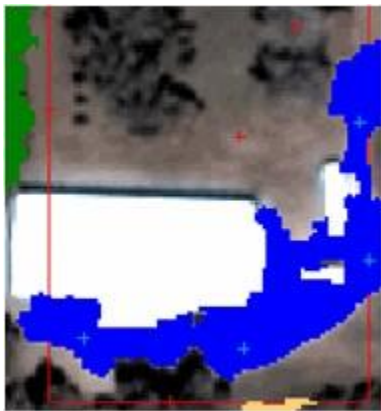


Fig.11. Dirt Roads Selection

If you find that ENVI EX adds some unwanted or incorrect objects to a given feature, you can correct it with one of the following options:


- You can remove an unwanted object from the Dirt Road feature by clicking on it, which removes the blue color. You can also continue with manually adding and deleting training samples for the feature, as described in "Adding a New Feature and Collecting Training Data" on pages 6 and 7.
- We will not complete this step in this tutorial, but another option is to go back to the Segment step and experiment with a lower **Merge Level** value, which will result in more segments/objects.

9. Try selecting different records in the Import Attribute dialog (such as "field") and importing them into a different feature (such as Fields_Grasses). Remember, you first have to select the Fields_ Grasses feature in the Supervised Classification dialog so that ENVI EX will associate the selected records with that feature.


Modifying Attributes



1. Click the **Attributes** tab in the Supervised Classification panel. The attributes you computed earlier in the Compute Attribute step are used to further classify features. The training data file

that you restored was created using all computed attributes (shown in the Selected Attributes list). Some attributes are more useful than others when differentiating objects. Classification results may not be as accurate when you use all attributes equally because the irrelevant attributes can introduce noise into the results.

2. Click the **Auto Select Attributes** button . ENVI EX selects the best attributes to use for classifying features.

Did this improve the classification of impervious surfaces? Remember that this is an iterative process and if you are not happy with your results you can try experimenting with your own set of attributes by following these steps:

3. Select one or more attributes from the **Selected Attributes** list, then click the **Unselect** button  to remove them from consideration. Again, the Preview Portal updates to show the changes to the classification.

4. To select individual attributes for classification, expand the Spectral, Texture, and Spatial folders to see their respective attributes. Each attribute is shown with an  icon. (The “Customized” folder contains the Color Space and Band Ratio attributes.) Click the **Select** button  to add the attribute to the Selected Attribute list.

5. Experiment with different combinations of spatial, spectral, texture, and customized attributes to determine the best results for classifying impervious surfaces. If you do not have time to select your own attributes, the **Auto Select Attributes** button often provides good results.

Modifying Classification Parameters

1. In the Supervised Classification panel, click the **Algorithm** tab.

2. From the **Classification Algorithm** drop-down list, select **K Nearest Neighbor**.


3. Click the **Update** button and examine the classification results in the Preview Portal. How did changing the supervised classification algorithm affect the classification of impervious surfaces?

4. Experiment with the two classification algorithms and try different values for each of their associated parameters. Evaluate how these changes affect the classification of impervious surfaces, by clicking the **Update** button to update the Preview Portal. Following are some tips on using the parameters.

5. To restore the default values for all of the parameters, click the **Reset** button.

Saving Your Changes to a New Training Data File

If you significantly improved the delineation of impervious surface boundaries by adding features, selecting more training data, importing ground truth data, experimenting with different attributes, and modifying classification parameters, you can choose to save your updated training data set to a new training data file.

1. In the Feature Extraction dialog, click the **Features** tab.
2. Click the **Save Training Data As** button . The Training Data dialog appears.
3. Select an output location and a new file name. Do not overwrite the training data file you restored earlier. This allows you to save an “iteration” of a training data set that you like in case you want to make further changes later. Click **OK**.

If you ever want to revert back to the classification results from the original training data file, you can click the **Restore Training Data** button and select your training data. In this case we would select qb_colorado_supervised.xml.

Creating a Shapefile of Impervious Surfaces

1. Click **Next** in the Supervised Classification panel. ENVI EX classifies the entire image. Feature Extraction proceeds to the Export Features panel.
2. The Export Vector Results option is selected by default so that you can output each feature to separate shapefiles. Because you are only interested in extracting impervious surfaces, leave the **Impervious** option checked and un-select all of the other features. (Use the small scroll bar to see the other features.)
3. Feature Extraction provides an option to smooth your vector shapefiles using the Douglas-Peucker line-simplification algorithm*. This Line simplification works best with highly curved features such as rivers and roads. In this example we select the **Smoothing** option and leave the default **Smoothing Threshold** value of 1.
4. Select an output directory to save your shapefile. By default, the shapefile will be named according to the associated Feature name.
5. Ensure the **Display Datasets After Export** option is enabled.

**More information may be found online by simply doing a search for “Douglas Peucker line-simplification algorithm”*

6. Click **Next**. ENVI EX creates a shapefile of the impervious feature, adds it as a new vector layer to the Layer Manager, and displays it in the Image window.



Fig.12. Impervious features shapefile

7. In the Layer Manager, right-click on **Impervious.shp** (or whatever you named the output shapefile) and select **Properties**. The Properties dialog appears.

8. Double-click inside the **Fill Interior** field, and select **True**.

9. Choose a **Fill Color**, and close the dialog. The polygon shapefile is filled with color, which makes the boundaries of impervious surfaces easier to discern.

Exiting Feature Extraction

After you export your classification results, you are presented with a summary of the processing options and settings you used throughout the Feature Extraction workflow. The Report tab lists the details of your settings, and the Statistics tab gives a summary of your feature name, feature count, and area statistics for the polygon shapefile you created. You can save this information to a text file by clicking the **Save Text Report** button.

After viewing the processing summary, you can click **Finish** to exit the Feature Extraction workflow. Or, click **Back to** go back to the Export Features panel and change the output options for classification results.

If you click **Back**, any output that you created is removed from the Data Manager and Layer Manager. If you click **Next** from the Export Features panel without making any changes, Feature Extraction will not re-create the output. You must make at least one change in the Export Features panel for Feature Extraction to create new shapefiles and/or classification images.

For more information on ExelisVis ENVI EX product please visit <http://www.exelisvis.com/ProductsServices/ENVI/Capabilities.aspx>

For more technical information on DigitalGlobe Products and Services please visit <http://www.digitalglobe.com/resources>

Additional Documents and Imagery Product Samples may be downloaded from here