EXELIS

Visual Information Solutions

ENVI Classic Tutorial: Image Georeferencing and Registration

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Image Georeferencing and Registration

This tutorial provides basic information about georeferenced images in ENVI® Classic and provides a starting point for conducting image-to-image and image-to-map registration using ENVI Classic. It assumes that you are already familiar with general image-registration and resampling concepts. This tutorial is designed to be completed in about 1 to 2 hours.

Files Used in this Tutorial

Download data files from the Exelis website.

File	Description
bldr_sp.img (.hdr)	Boulder SPOT georeferenced image subset
bldr_tm.img (.hdr)	Non-georeferenced Boulder TM data
bldr_tm.pts	GCPs for TM-SPOT image-to-image registration
bldrtm_m.pts	GCPs for TM-Map registration
bldr_rd.dlg	Boulder roads DLG

File	Description
bldr_tm1.wrp (.hdr)	Image-to-image result using RST and nearest neighbor
bldr_tm2.wrp (.hdr)	Image-to-image result using RST and bilinear interpolation
bldr_tm3.wrp (.hdr)	Image-to-image result using RST and cubic convolution
bldr_tm4.wrp (.hdr)	Image-to-image result using 1st degree polynomial and cubic convolution
bldr_tm5.wrp (.hdr)	Image-to-image result using Delaunay triangulation and cubic convolution
bldrtm_m.img (.hdr)	Image-to-map result using RST and cubic convolution for the Boulder TM data
bldrtmsp.img (.hdr)	Boulder TM/SPOT sharpening result using HSV sharpening, 10 meter pixels

Background

ENVI Classic provides full support for georeferenced images in numerous predefined map projections including UTM and State Plane. In addition, ENVI Classic's user-configurable map projections allow construction of custom map projections utilizing 30 standard projection types. In addition to the projections listed in Table D-8, ENVI Classic also reads any projection type from a geodatabase or Esri® layer file. See ArcGIS® Help for a full list of supported projections, or refer to the Tech Tip "Esri® Projection Engine Reference v1.0" on the Exelis website.

ENVI Classic map projection parameters are stored in an ASCII text file `map_proj.txt` that you can edit or modify using ENVI Classic map projection utilities. The information in this file is used in the ENVI header files associated with each image and allows simple association of a reference pixel location with known map projection coordinates. Selected ENVI Classic functions can then use this information to work with the image in georeferenced data space.

ENVI Classic's image registration and geometric correction utilities allow you to reference pixel-based images to geographic coordinates and/or correct them to match base image geometry. Ground control points (GCPs) are selected using the Image and Zoom windows for both image-to-image and image-to-map registration. Coordinates are displayed for both base and uncorrected image GCPs, along with error terms for specific warping algorithms. Next GCP point prediction allows simplified selection of GCPs.

Warping is performed using resampling, scaling and translation (RST), polynomial functions (of order 1 through n), or Delaunay triangulation. Resampling methods supported include nearest-neighbor, bilinear interpolation, and cubic convolution. Comparison of the base and warped images using ENVI Classic's multiple dynamic overlay capabilities allows quick assessment of registration accuracy.

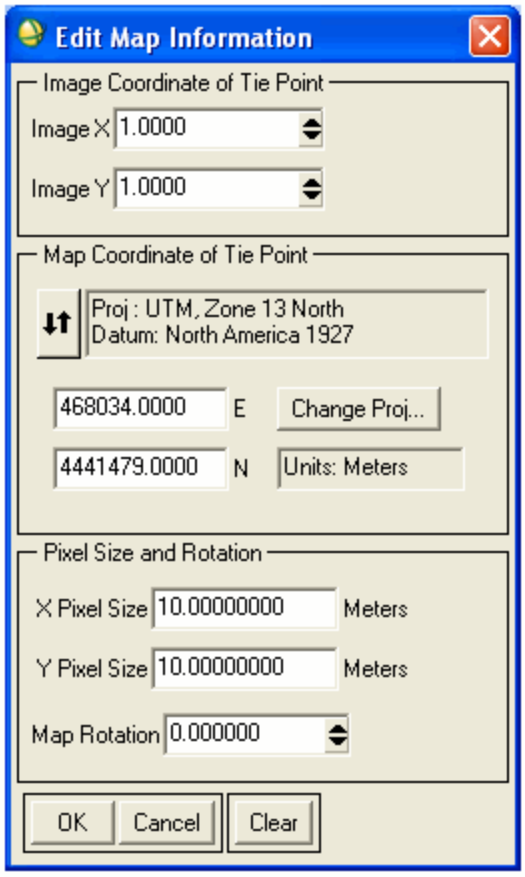
The following sections provide examples of some of the map-based capabilities built into ENVI Classic. For more detailed information, see the ENVI Classic Help.

Opening and Displaying Georeferenced Data

1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `bldr_sp.img` and click **Open**. The Available Bands List appears.
3. From the Available Bands List, select the **Georeferenced SPOT** band and click **Load Band** to load the image into a new display group.

Viewing Map Info in the ENVI header

1. In the Available Bands List, right click on the **Map Info** icon and select **Edit Map Information**. The Edit Map Information dialog appears.



This dialog lists the basic map information used by ENVI Classic in georeferencing. The image coordinates correspond to a reference pixel used by ENVI Classic as the starting point for the map coordinate system. Because ENVI Classic knows the map projection, pixel size, and map projection parameters based on this header information and the map projection text file, it can calculate the geographic coordinates of any pixel in the image. You can enter coordinates in either map coordinates or geographic (latitude/longitude) coordinates.

2. Click on the projection field toggle button  to display the latitude/longitude coordinates for the UTM Zone 13 North map projection. Note that ENVI Classic makes this conversion on-the-fly.
3. Click the **DDEG** button then click the **DMS** button to toggle between degrees-minutes-seconds, and decimal degrees, respectively.
4. Click **Cancel** to exit the Edit Map Information dialog.

Displaying the Cursor Location and Value

You can choose to display the location of your mouse cursor, screen value (RGB color), and the data value of the pixel underneath the crosshair cursor using the Cursor Location/Value dialog. When several display groups are open, this dialog specifies which display group's location and value are being reported.

1. To display the cursor location and value, select **Window > Cursor Location/Value** from either the ENVI Classic main menu bar or the Display group menu bar. You can also double-click inside the Image window.
2. Move the mouse cursor over the Image, Scroll, or Zoom windows to display location and value information in the Cursor Location/Value dialog. Note that the coordinates are given in both pixels and georeferenced coordinates for this georeferenced image. Also note the relation between map coordinates and latitude/longitude.
3. From the Cursor Location/Value menu bar, select **File > Cancel** to close the dialog.
4. Keep the display group open for the next exercise.

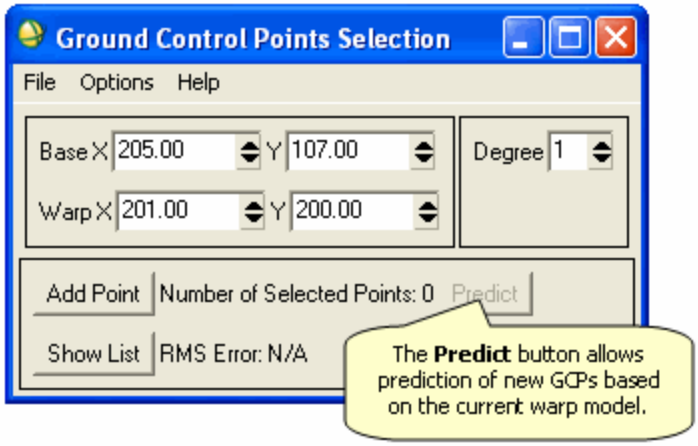
Image to Image Registration

This section of the tutorial takes you step-by-step through Image to Image Registration. The georeferenced SPOT image will be used as the base image, and a pixel-based Landsat TM image will be warped to match the SPOT.

1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `bldr_tm.img` and click **Open**. The Available Bands List appears and the RGB image is automatically loaded into a new display group.
3. Double-click in the Image window to display the Cursor Location/Value tool.
4. Move the mouse cursor over the Image, Scroll, or Zoom windows to display location and value information in the Cursor Location/Value dialog. Note that the coordinates are given in pixels since this is a pixel-based image rather than a georeferenced image like the SPOT data you used in the previous exercise.
5. From the Cursor Location/Value menu bar, select **File > Cancel** to close the dialog.

Starting Image Registration and Loading Ground Control Points

1. From the ENVI Classic main menu bar, select **Map > Registration > Select GCPs: Image to Image**. The Image to Image Registration dialog appears.
2. In the **Base Image** field, select **Display #1** (the SPOT image). In the **Warp Image** field, select **Display #2** (the TM image)
3. Click **OK** to start the registration. The Ground Control Points Selection dialog appears.

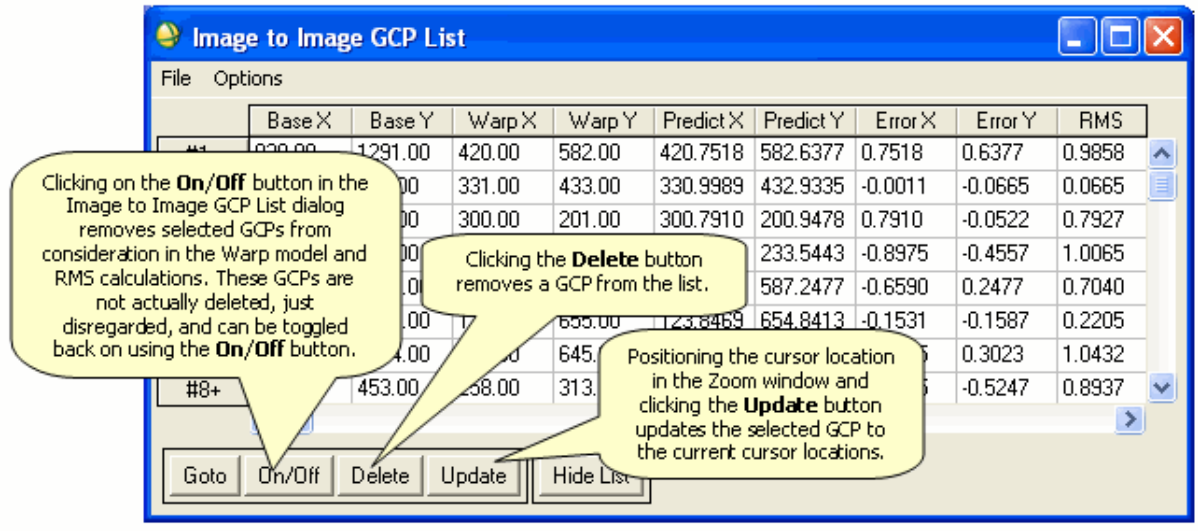


4. You can add individual ground control points (GCPs) by positioning the cursor in the two images to the same ground location. In the **Base** field, type **753** for the x location and **826** for the y location. Press the **Enter** key after typing each value, to move the cursor in the SPOT image. In the **Warp** field, type **331** for the x location and **433** for the y location to move the cursor in the TM image.

5. Examine the locations in the two Zoom windows and adjust the locations if necessary by clicking the left mouse button in each Zoom window at the desired locations. Note that sub-pixel positioning is supported in the Zoom windows. The larger the zoom factor, the finer the positioning capabilities.
6. In the Ground Control Points Selection dialog, click **Add Point** to add the GCP to the list. Click **Show List** to view the GCP list. Try this for a few points to get a feel for selecting GCPs. Note the list of actual and predicted points in the dialog. Once you have at least four points, the RMS error is reported.
7. From the Ground Control Points Selection dialog menu bar, select **Options > Clear All Points** to clear all of your points.
8. From the Ground Control Points Selection dialog menu bar, select **File > Restore GCPs from ASCII**.
9. Select `bldr_tm.pts` and click **Open**. Previously saved GCP parameters are loaded into the dialog.
10. Try positioning the cursor at a new location in the Image window containing the SPOT image. Click the **Predict** button to move the cursor position in the TM image to match its predicted location based on the warp model.
11. The exact position can now be interactively refined by moving the pixel location slightly in the TM data.
12. Click **Add Point** in the Ground Control Points Selection dialog to add the new GCP to the list.

Working With GCPs

The following image provides descriptions of the features and functions available in the Image to Image GCP List. Click **Show List** to view the GCP list. Click on individual GCPs in the Image to Image GCP List dialog and examine the locations of the points in the two images, the actual and predicted coordinates, and the RMS error. Resize the dialog to observe the total RMS Error listed in the Ground Control Points Selection dialog.



Warping Images

Images can be warped from the displayed band, or multiband images can be warped all bands at once. For this exercise you will warp only the displayed band.

1. From the Ground Control Points Selection dialog menu bar, select **Options > Warp Displayed Band**. The Registration Parameters dialog appears.
2. Click the **Method** drop-down list and select **RST**.
3. Ensure the **Resampling** drop-down list has the **Nearest Neighbor** option selected.
4. In the **Enter Output Filename** field, type `bldr_tm1.wrp` as the new filename and click **OK**. The warped image is listed in the Available Bands List when the warp is completed.
5. From the Ground Control Points Selection dialog menu bar, select **Options > Warp Displayed Band**. The Registration Parameters dialog appears.
6. Click the **Method** drop-down list and select **RST**.
7. Click the **Resampling** drop-down list and select **Bilinear**.
8. In the **Enter Output Filename** field, type `bldr_tm2.wrp` as the new filename and click **OK**. The warped image is listed in the Available Bands List when the warp is completed.
9. Repeat steps 5 – 8 using the **RST** method and **Cubic Convolution** resampling, then name the output file `bldr_tm3.wrp`.
10. Repeat steps 5 – 8 using the **Polynomial** method and **Cubic Convolution** resampling, then name the output file `bldr_tm4.wrp`.
11. Repeat steps 5 – 8 using the **Triangulation** method and **Cubic Convolution** resampling, then name the output file `bldr_tm5.wrp`.

Comparing Warp Results

Now you will use dynamic overlays to compare your warp results:

1. In the Available Bands List, click once to select the `bldr_tm.img` file, then select **File > Close Selected File** from the menu bar. In the subsequent ENVI Classic warning dialog, click **Yes** to close the associated display group.
2. In the Available Bands List, select the `bldr_tm1.wrp` file, click the **Display #** drop-down button, select **New Display**, then click **Load Band** to load the file into the new display.
3. Right-click in the Image window and select **Link Displays**. The Link Displays dialog appears.
4. Click **OK** in the Link Displays dialog to link the SPOT and the registered TM image.
5. Compare the SPOT and the TM images using the dynamic overlay by clicking the left mouse button in the Image window of the TM image.
6. Load `bldr_tm2.wrp` and `bldr_tm3.wrp` into new display groups and use the image linking and dynamic overlays to compare the effect of the three different resampling methods: nearest neighbor, bilinear interpolation, and cubic convolution. Note how jagged the pixels appear in the nearest neighbor resampled image. The bilinear interpolation image looks much smoother, but the cubic convolution image is the best result, smoother, but retaining fine detail.
7. Close the `bldr_tm1.wrp` and `bldr_tm2.wrp` display groups (select **File > Cancel** from the associated Display group menu bars).
8. Load `bldr_tm4.wrp` and `bldr_tm5.wrp` into new display groups, and use the image linking and dynamic overlays to compare to `bldr_tm3.wrp` (RST Warp).
9. Note the effect of the three different warping methods: RST, 1st degree Polynomial, and Delaunay Triangulation on the image geometry.
10. Use dynamic overlay to compare to the georeferenced SPOT data.
11. To display the Cursor Location/Value tool, double-click in the Image window.
12. Browse the georeferenced datasets and note the effect of the different resampling and warp methods on the data values.
13. From the Display group menu bar, select **File > Cancel** to close the dialog.
14. From the ENVI Classic main menu bar, select **File > Close All Files** to close all of the data files. Click **Yes** on the corresponding warning dialog.

Image to Map Registration

This section of the tutorial will take you step-by-step through an Image to Map registration. Many of the procedures are similar to Image to Image registration and will not be discussed in detail. The map coordinates picked from the georeferenced SPOT image and a vector Digital Line Graph (DLG) will be used as the base image, and the pixel-based Landsat TM image will be warped to match the map data.

Opening and Displaying a SPOT Image File

1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `bldr_sp.img` and click **Open**. The Available Bands List appears.
3. Select **Georeferenced SPOT** under `bldr_sp.img`, and click **Load Band**. The georeferenced SPOT image appears in a new display group.

Opening and Displaying a Landsat TM Image File

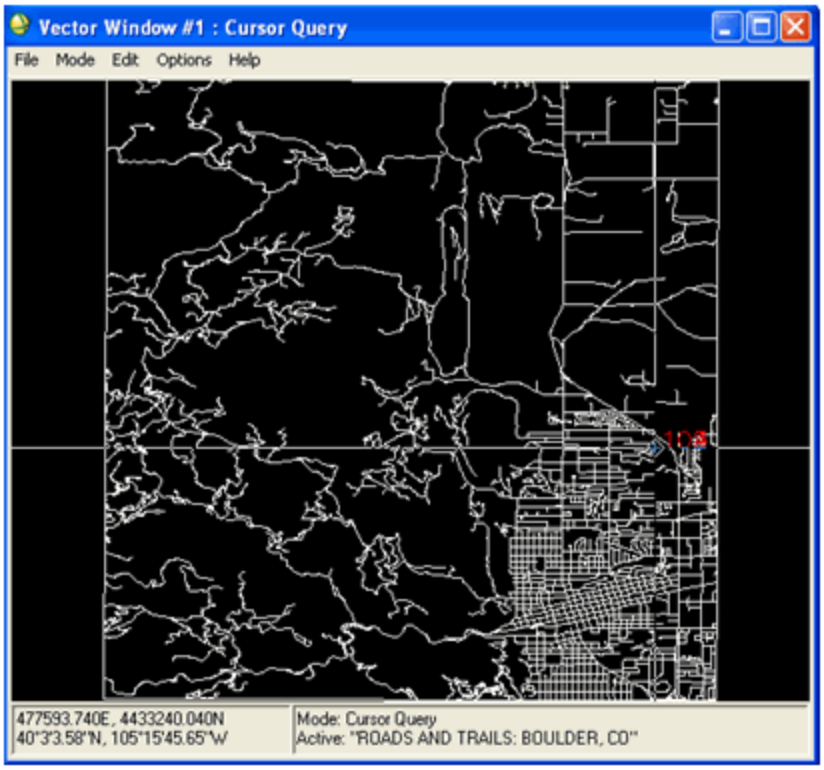
1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `bldr_tm.img` and click **Open**. A Landsat TM RGB image is automatically loaded into a new display group.

Selecting Image-to-Map Registration and Restoring GCPs

1. From the ENVI Classic main menu bar, select **Map > Registration > Select GCPs: Image to Map**. The Image to Map Registration dialog appears.
2. From the **Display #1** drop-down menu, select **Display #2**. You will warp the Landsat TM image (in Display #2) to match the georeferenced SPOT image.
3. Ensure **UTM** is selected as the projection.
4. Type **13** in the **Zone** field.
5. Enter **10.0** in the **X/Y Pixel Size** fields. SPOT data have a spatial resolution of 10m.
6. Click **OK** to start the registration. The Ground Control Points Selection dialog appears.
7. From the Ground Control Points Selection dialog menu bar, select **File > Restore GCPs from ASCII**.
8. Select `bldrtm_m.pts` and click **Open**. Previously saved ground control point parameters are loaded into the dialog.
9. In the Ground Control Points Selection dialog, click **Show List**. The Image to Map GCP List dialog appears. Examine the base map coordinates, the actual and predicted image coordinates, and the RMS error.

Adding Map GCPs Using Vector Display of DLGs

1. From the ENVI Classic main menu bar, select **File > Open Vector File**.
2. From the Files of type drop-down list, select **USGS DLG**.
3. Select `bldr_rd.dlg`, and click **Open**. The Import Vector Files Parameters dialog appears.
4. In the Import Vector Files Parameters dialog, click the **Memory** radio button, then click **OK** to read the DLG data. The Available Vectors List dialog appears.
5. Select the **ROADS AND TRAILS: BOULDER, CO** file, then click **Load Selected**.
6. Select **Display #1** and click **OK**. The Vector Parameters: Cursor Query dialog appears.
7. Return to the Load Vector dialog. From The Available Vectors List dialog, select the **ROADS AND TRAILS: BOULDER, CO** file, then click **Load Selected**.
8. Select **New Vector Window**, and click **OK**. This loads the vectors into a new vector window.



9. Click and drag the mouse in the vector window to activate a crosshair cursor. The map coordinates of the cursor will be listed at the bottom of the vector window.
10. From the Display group menu bar in the TM image, select **Tools > Pixel Locator**.

11. Type **402** in the **Sample** field and **418** in the **Line** field, then click **Apply** to place the cursor on the road intersection. Note that sub-pixel positioning accuracy is again available in the Zoom window.
12. In the Vector window, position the vector cursor at the road intersection at approximately 477593.74, 4433240.0 (40° 3' 3" N, -105° 15' 45" W) by clicking and dragging with the left mouse button and releasing when the circle at the crosshair intersection overlays the intersection of interest.
13. Right-click in the vector window and select **Export Map Location**. The new map coordinates will appear in the Ground Control Points Selection dialog.
14. In the Ground Control Points Selection dialog, click **Add Point** to add the map-coordinate/image pixel pair and observe the change in RMS error.

RST and Cubic Convolution Warping

1. From the Ground Control Points Selection dialog menu bar, select **Options > Warp File**. The Input Warp Image dialog appears.
2. Select the `bldr_tm.img` file, and click **OK** to select all six TM bands for warping. The Registration Parameters dialog appears.
3. Click the **Method** drop-down list, and select **RST**.
4. Click the **Resampling** drop-down list, and select **Cubic Convolution**.
5. In the **Background** field, type **255**.
6. In the **Enter Output Filename** field, type `bldrtm_m.img` as the new filename, and click **OK**. The warped image is listed in the Available Bands List and automatically loaded into a new display group when the warp is completed.
7. Note the skew of the image resulting from removal of the Landsat TM orbit direction. This image is georeferenced, but at 30 meter resolution versus the 10 meter resolution provided by the SPOT image.

Displaying and Evaluating Results

1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `bldr_sp.img` and click **Open**. The Available Bands List appears.
3. From the Available Bands List, select the **Georeferenced SPOT** band, click the **Display #** drop-down button, and select **New Display**.
4. Click **Load Band** to load the SPOT image into a new display group.
5. Compare the image geometries and scale.
6. From the Ground Control Points Selection dialog menu bar, select **File > Cancel** to close that dialog. Save the GCPs if desired. Now that you have learned how to perform image-to-image and

image-to-map registration, refer to the tutorial "Map Composition" on page 2 for guidance on adding grid lines and creating image maps in ENVI Classic.

7. You can quit your ENVI Classic session by selecting **File > Exit** from the ENVI Classic main menu bar.