

Remote Sensing for Earth Observation: Practical – Geometric Correction

Aims and objectives

The aim of this practical is to introduce you to digital geometric correction.

Core tasks for this practical

1. Work with both raster and vector data in ENVI
2. Rectify a raw digital image using image to map rectification: reference points are obtained from digital line graph (DLG) co-ordinates.

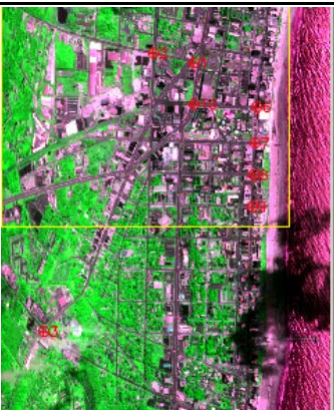
At the end of this practical you should have some understanding of the processes and issues associated with geometric correction, be familiar with vector data and be able to geometrically correct an image in ENVI .


Introduction

Data sets stored as images may have features such as roads and rivers that may allow you to associate the data with a geographic location. However, raw data do not represent locations on the surface of the Earth unless the data carry some reference to the ground location. Geometric correction (or georeferencing) is the process by which the geometry of an image area is made planimetric, thus allowing the data to be used to provide accurate map locations for features in the data. The process almost always involves relating GCPs (ground control points e.g., meters in northing and easting for the Transverse Mercator map projection) to pixel coordinates from the image (e.g., row and column values). This is necessary whenever accurate area, direction, and distance measurements are required. Most serious earth science remote sensing research is based on analysis of data that has been correctly rectified to a base map.

Locating Data For This Practical

You should find the following data available for download for use with this practical:

File name	Myrtle-beach_cams_1997-08-02	Quick look (RGB = 1,3,2)
Location	Myrtle Beach, SC	
Sensor	Calibrated Airborne Multispectral Scanner (CAMS)	
Spatial	3 × 3 m	
Temporal	August 2, 1997	
Spectral	Band 2 = Green (.52-.60) Band 4 = Red (.60-.63) Band 6 = NIR (.76-.90)	

File name	Myrtle_beach_roads.evf Myrtle_beach_bldgs.evf	Quick look (vector files)
Location	Myrtle Beach, SC	
Description	ENVI vector files displaying a digital line graph (DLG) of the road network and building coverage of Myrtle beach.	
Note	<i>The road coverage represents the centre of the streets either side of the road.</i>	

Two basic operations must be performed in order to geometrically rectify a remotely sensed image to a map coordinate system:

1. **Spatial Interpolation (or Warping)**, which defines the nature of the geometric coordinate transformation that must be applied to rectify or relocate every pixel in the original input image to its proper position in the rectified output image.
2. **Resampling**, which is the mechanism for determining the brightness value to be assigned to each pixel in the rectified output image.

For this task you will perform a simple rectification of a CAMS (Calibrated Airborne Multispectral Scanner) image of downtown Myrtle Beach, Sacramento to a UTM map projection. The procedure follows the general outline:

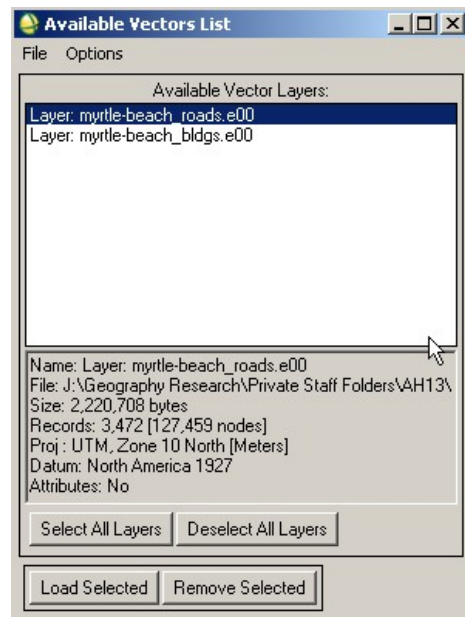
1. A series of ground control points (GCPs) are created, containing image (row and column values) that relate to map coordinates (UTM meters) for selected ground control points.
2. The GCPs are used to create a matrix containing the transformation coefficients.
3. A geometric model file is then created using the model properties and the original image file are input into a re-sampling program to produce a rectified image file

Task1: Displaying raster and vector data

Before we start the geometric correction procedure we will open and explore both the raster image and vector DLG files.

1. Load the Myrtle beach image into a new display
2. Now open each of the Myrtle beach vector files into a new vector display. From the main menu bar select **Vector/Open vector file** and navigate to **myrtle-**

beach_roads.evf Repeat to open **myrtle-beach_bldgs** file. Both files should now be visible in the **Available Vectors List**.



1. Select both layers and load the selected layers into a new vector window following the on screen instructions.
2. Layer properties (e.g. colour and thickness of lines) can be adjusted by selecting **Edit/Edit Layer Properties** from the vector display window.

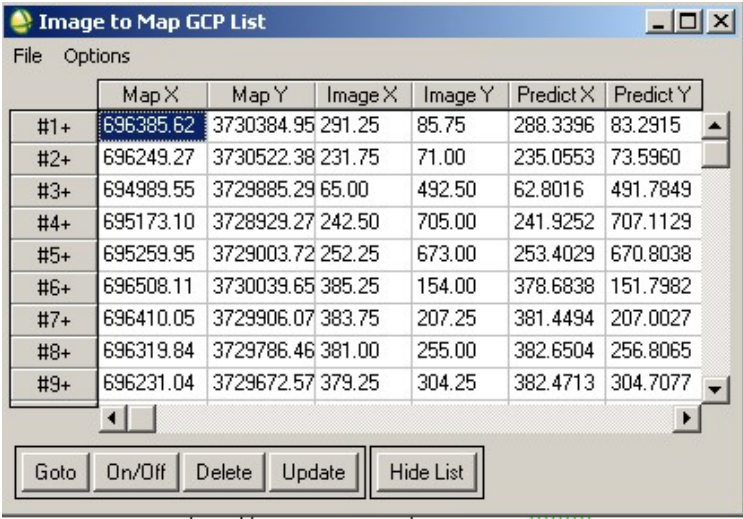
Task2: Selecting GCPs

Now we will select a set of ground control points (GCPs) which will be used to rectify our image.

1. From the main menu select **Map/Registration/Select GCPs: Image to Map**. Select the map projection that you wish to register the image to. In this case select **UTM, Zone 10** and set the output pixel size to match the resolution of the input CAMS image.
2. The **Ground Control Points Selection** dialogue will open. This is where you will collect your GCPs for image rectification. Now examine the road coverage vector file and the image closely. You should be able to recognise the similar road networks within your image. Notice that the UTM coordinates of the vector display are displayed in the lower left hand corner of the viewer. You will select GCPs using UTM co-ordinates for image rectification. You will remember that GCPs consist of two pairs of x, y coordinates
 - **Input coordinates**, which are usually data file coordinates in the image being rectified
 - **Reference co-ordinates**, which are coordinates of the map or reference image to which the source is being rectified.

When selecting GCPs, collect points evenly distributed throughout the entire area to be georeferenced. This will aid in a good rectification. Features like road intersections, corners of large building complexes, and land/water points etc. are good choices for finding locations on both images and topographic maps. A good number of GCPs for this exercise is 15-20 (in the real world the number could reach 60).

3. First we will collect the x, y location of a chosen GCP in the image. In the Main Image window, position the Zoom box over a good GCP area. Click the left mouse button on a specific pixel to position the cursor over that pixel or portion of that pixel. The coordinates of the selected location appear in the **Ground Control Points Selection** dialog in the fields labelled **Image X** and **Image Y**.
4. Now, find the corresponding location on the road/building coverage and right click. **Note that the cursor will automatically “snap” to the “active vector line” in the vector display window.** To toggle between the building layer and the road layer as active layers, select **Options/Select Active Layer** from the Vector display window. E.g. if you are using the road network to find certain GCPs then make that layer active and when using the building layer to locate GCPs make that layer active.
5. Once a point has been selected you will see the coordinates of the point appear in the bottom left hand corner of the window. To automatically enter the coordinates into the Ground Control Selection dialogue box, right click the mouse in the vector display window and select **Export/Map/Location**.
6. Having selected the same location in both windows (image and vector) click on **Add point** in the **Ground Control Points Selection** dialogue box. Symbols indicating GCP 1 will appear in both displays.
7. After you have placed approximately 3-4 GCPs, an RMS Error estimate appears. This is an indicator of the error between the file points and map points. For this exercise you will try to get the Root Mean Square (RMS) error to be less than 1.5. To view the error involved with each GCP select **Show List** on the **Ground Control Points Selection** dialogue box.



	Map X	Map Y	Image X	Image Y	Predict X	Predict Y
#1+	696385.62	3730384.95	291.25	85.75	288.3396	83.2915
#2+	696249.27	3730522.38	231.75	71.00	235.0553	73.5960
#3+	694989.55	3729885.29	65.00	492.50	62.8016	491.7849
#4+	695173.10	3728929.27	242.50	705.00	241.9252	707.1129
#5+	695259.95	3729003.72	252.25	673.00	253.4029	670.8038
#6+	696508.11	3730039.65	385.25	154.00	378.6838	151.7982
#7+	696410.05	3729906.07	383.75	207.25	381.4494	207.0027
#8+	696319.84	3729786.46	381.00	255.00	382.6504	256.8065
#9+	696231.04	3729672.57	379.25	304.25	382.4713	304.7077

8. Use the scroll bar at the bottom to move your view to the far right hand side of the table. Here are the listings of the error for each GCP. This can help you determine the GCPs you might wish to change. If the RMS error for ALL points is below one (as indicated in the Ground Controls Selection Dialogue), then congratulations, if not try to get the total as close to zero as possible. If the total RMS error is above 1.5 you will need to either delete a GCP to improve the RMS error or move the GCPs until the RMS error figure is more appropriate.

Instructions on how to edit GCPs:

- To **delete a GCP**, simple highlight the GCP in the table and select delete
- To see if deleting the GCP would improve the total RMS error **BEFORE** you actually delete the point. Select the point and click the **On/Off** button. You will see a – sign appear by the number when the GCP is effectively hidden. To un-hide the point, press the **On/Off** button again. See how the RMS error changes. Try not to delete too many GCPs, better to try and make them fit before removing.
- To **adjust a point**, select the relevant GCP in the table. The image cursor will automatically move to that location in the image. Place the cursor on the new location i.e. where you want to move the GCP to and then press update in the GCP table. The image x, y coordinates will now be updated.
NOTE: make sure the correct GCP is highlighted in the table before pressing update!

To save GCPs to add to or edit later select **File/Save GCPS w/map cords...** from the **Ground Control Points Selection** dialogue and enter a file name (*.pts files). GCPs can be restored from the same dialogue box at a later date **File/Restore GCPS from ASCII**.

Task3: Resampling and rectification

Once your RMS error is below 1.5 you are ready to resample the image.

1. Select **Options/Warp File** from the **Ground Control Points Selection** dialogue.
2. Select the file that you wish to rectify and click **OK**
3. In the Registration Parameters dialogue box, select “**nearest neighbour**” as the resampling method (it should be the default option). Chose where you wish to save your file and give the output image an appropriate name. Click **OK**. Your rectified image will be displayed in the available bands dialogue box.
4. Open the image in a new display and compare it with the un-rectified image. Overlay the vector layers onto your rectified image to see how well the vector layers fit by selecting the relevant layer from the **Available Vectors** dialogue box and loading it into the same display as your rectified image.

Question 1

Suppose that you selected a number of GCPs that were taken from both natural (river forks) and man-made (road intersections) features. Briefly summarise the reasons why some of your GCPs might have higher or lower initial RMS errors than others

Question 2: How might the attributes of images, like study area location, and resolutions of the sensor system used, lead to easier or more difficult rectifications of the images?

Question3

Note the dataset you used for ground truth (e.g. a digital line graph previously rectified image). What kind of error could be associated with your approach to GCP acquisition?

Question 4: Name two other sources of information that could be used to geometrically correct an image?

Question5

What are the key factors to consider when selecting GCPs to rectify an image? Give reasons for you answer

Question 6: A number of re-sampling schemes can be used in image rectification. Which re-sampling scheme would you use if (i) your overall goal was to produce a visually appealing thematic map and (ii) your overall goal was to extract quantitative information about vegetation health and vigour? Explain your an

