

Exercise #5b - Geometric Correction of Image Data

- 5.6 Geocoding or Registration of geometrically uncorrected image data
- 5.7 Resampling
- 5.8 The Ukrainian coordinate system
- 5.9 Selecting Ground Control Points

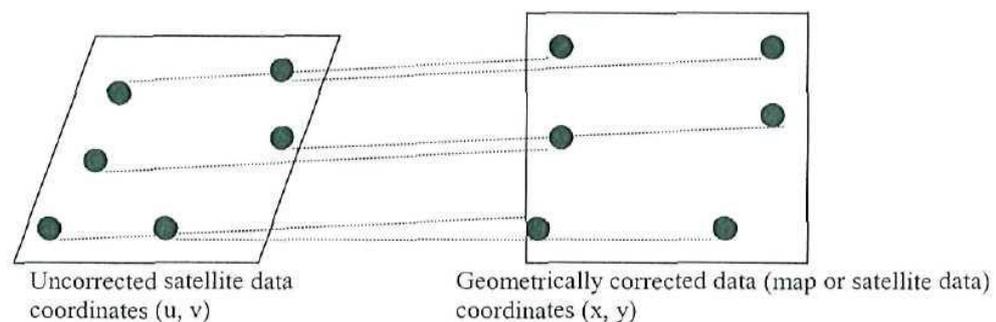
Objective: Learn about geometric correction of an unrectified satellite image, and do an image-to-image registration as one way to geometrically correct. You'll also use skills you learned in Exercise #5a, so instructions for those operations won't be explained again in this exercise.

Note: Make sure you read and do this exercise carefully. Not following instructions can lead to a completely wrong answer!

5.6 Geocoding or Registration of geometrically uncorrected image data



There are many sources of geometric distortion in a satellite image, many of which can be mathematically modeled and removed at the receiving station to produce a "system corrected image". However, there are still some geometric errors and the scene should be "geocoded" or "registered" to a map projection in order to be comparable to other scenes, or to use with other geographic data. A common way to do this is to develop a pair of polynomial equations that express the known geographic coordinates x and y in terms of the uncorrected image pixel positions u and v .



Polynomial equations (2nd order), used for correcting the image:

- $u = a_0 + a_1x + a_2y + a_3xy + a_4x^2 + a_5y^2$
- $v = b_0 + b_1x + b_2y + b_3xy + b_4x^2 + b_5y^2$

The coefficients a and b in these equations should be solved for, using the x and y of the coordinates in the geometrically corrected data, and the u and v of the uncorrected satellite data. The coordinate pairs x, y and u, v are called "Ground Control Points" or "GCPs".

5.7 Resampling

Once the polynomial equations have been solved, a new image is created by a process called "resampling". For each pixel in the new image, the pixel's DN must be determined by calculating the new position from the polynomials, and then looking up the original pixel values in the uncorrected image at the u, v coordinates. The need for resampling comes from the fact that the new coordinates will not fall evenly on the old pixel boundaries, and the DNs will need to be changed. You must decide how you will calculate the new pixel DNs. There are three common resampling methods available:

1. Nearest Neighbour: take the DN value of the spatially nearest pixel
2. Bilinear interpolation: Take a distance-weighted average of the surrounding 4 pixels.
3. Cubic convolution: Use the surrounding 16 pixels to calculate a weighted average for the new cell.

The method you choose depends on the type of image and your objectives. Nearest neighbour resampling has the advantage of not altering original data values, but it may lead to jagged edges in linear features. Bilinear interpolation generally smoothes the output image. Cubic convolution is the most computationally intensive, but often produces the highest visual quality.

There are a few different data sources that can be used to geocode an image, for example, map data, or a coordinate file of known coordinates, or an already geocoded image over the same area. In this exercise we will be using an already geocoded image as the "reference image", and doing an image-to-image registration.

The images you are **looking at**

- File name: tm95_fs.bil
 - Path/Row: A subset from 193/018
 - Sensor: Landsat 5 TM
 - Pixel size: 30m x 30m
 - Acquisition Date: June 6, 1995
 - Bands: 1,2,3,4,5,6,7
 - Correction level: System corrected Geographic area: Brattaker i Vasterbotten Lan
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- Filename: tm940705.img
 - Path/Row: A subset from 193/018
 - Sensor: Landsat 5 TM
 - Pixel size: 30m x 30m
 - Acquisition Date: July 5, 1994
 - Bands: 1,2,3,4,5,6, 7
 - Correction level: Geometrically corrected to Swedish RT90 Grid
 - Geographic area: Brattaker i Vasterbotlen Lan



Open a viewer (Viewer #1), and open the image tm95_fs.bil. Notice that the .bil extension means that this is a different format of image file than we used in Exercise #5a. The .bil extension stands for "Band Interleaved by Line". This particular tm95_fs.bil image has not been geometrically corrected. We will correct this image and give it coordinates in the Swedish RT90 coordinate system.

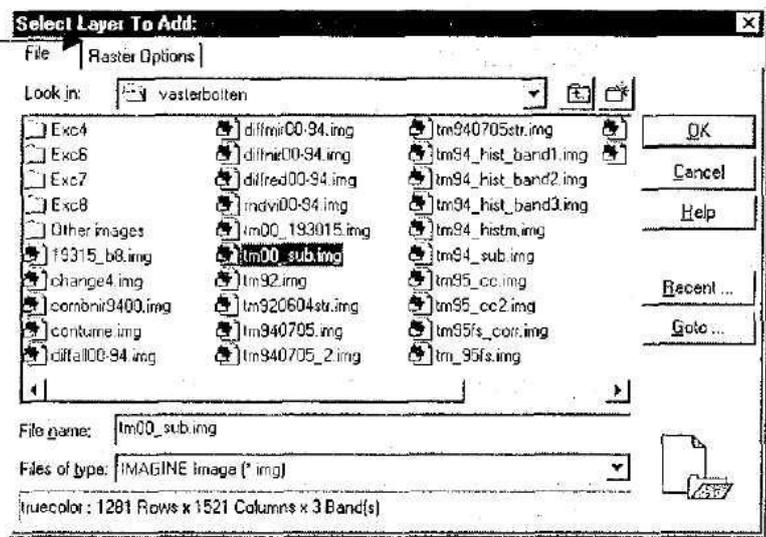
In order to do this and other operations using Erdas Imagine, we need to save this .bil file as an .img file. In the Viewer, go to File/Save/TopLayerAs, and save the file as tm95 fs.img.

Tip: Note that in Imagine, when you type a file name into a window, you have to press the Enter (or Return) key on your keyboard. This registers the information you have typed in, and then all the options in the window are available to use (they weren't before you pressed the Enter key).

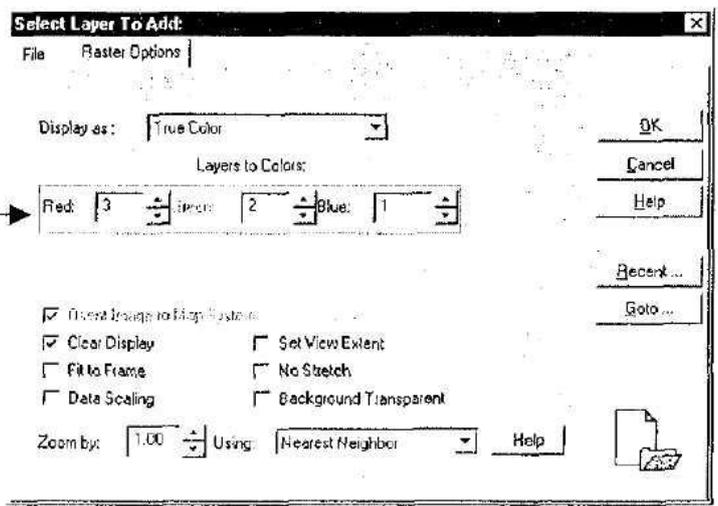
Then clear your viewer and open the file tm95_fs.img. Set the image to bands 4, 3, 2 RGB.

Now, open a second Viewer (#2), and open the tm940705.img file. Before you say OK to open it, choose the Raster Options tab here. Note that you can set the Band Combinations using this option. Set the image to bands 4, 3, 2 RGB.

Raster Options



Change Band Combinations



The image tm940705.img has been geometrically corrected. Look at the Image Info on this image to see that it has coordinate information, and compare that to the Image Info for the uncorrected image. Then close Image Info.

Click on the DataPrep Icon on the Main Icon Panel, and choose the Image Geometric Correction button. This brings up a dialog which asks if you will be correcting an image from a viewer, or from an image file. We will be correcting an uncorrected image from a viewer, so choose the Select Viewer button, and then left-click your mouse in the viewer with the geometrically uncorrected image file (this should be Viewer #1).

5.8 The Ukrainian coordinate system



You then need to Set Geometric Model. In this case we will be using a Polynomial model. So choose Polynomial, and then OK. The Polynomial Model Properties will use a 2nd order Polynomial, so change this in the dialog. Under the Projection tab at the top, set Map Units to Meters, and then choose Add/Change Projection, then choose the Standard tab.

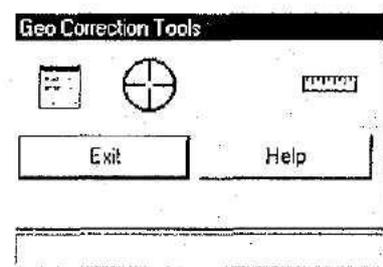
This is the part where you tell the program what projection the Reference Image is in, and what projection we would like the Uncorrected Image to be in. The Reference Image is in the Pulkovo? projection, which is Ukraine variant on a Transverse Mercator projection..

Choose Ukraine under Categories. You'll see there are several different projections. By clicking on the Custom tab for each of these projections, you can look at each of the projections parameters. Choose the one that matches the description in the gray box below:

Choose "Close" after the projection is set, and click Ok on the following dialog box to choose points from an Existing Viewer. Click your left mouse button in the Viewer with the reference image (tm940705.img). Reference Map information then appears, and since this is correct, Press OK. A whole bunch of new windows appear.

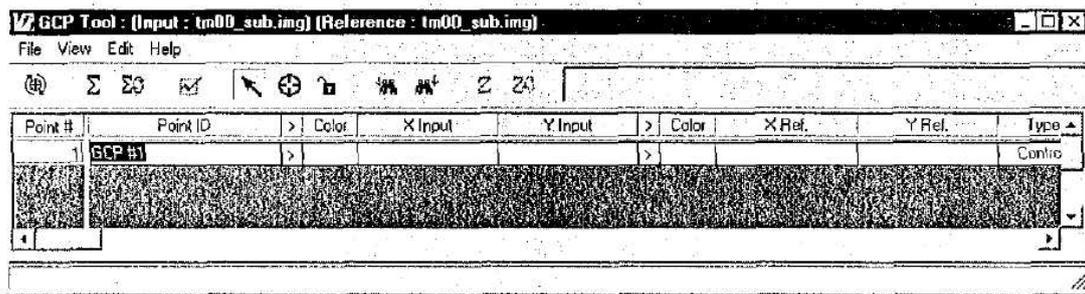
5.9 Selecting Ground Control Points

Notice that one of the windows that opened is called the Geo Correction Tools panel. There are icons for four different functions here. Note that this tool is available for quick access to the different GCP Tools that we will be using.



There is also a window called the GCP Tool (see below). This dialog box will contain the coordinate and error information on the GCPs that you will collect visually from the viewers.

For now, click the button for "Toggle FullyAutomatic GCP Edit Tools" that it is turned OFF and not pressed in (e.g, as it is in the box below).



You will also see that there are two smaller magnifying windows that have opened above Viewers #1 and #2. These represent the area shown in the white box in your main Viewers. These magnifiers help you zoom in on choosing Ground Control Points. It is a good idea to be zoomed in pretty far, so that you can try to choose the same pixel in each of the images.

You may have a lot of windows on your screen just now. You can resize the GCP Tool so it's smaller, and minimize the polynomial model properties box if you want. But you need the Viewers and their magnifiers.



There are certain features which make better GCPs than other features. These features should be seen easily in the imagery, and also be something that will not change over time or between seasons. Road crossings are an excellent GCP source. Clearly identifiable pairs of roads are also good.

Because we are doing a 2nd order polynomial transformation, we need at least 6 GCPs for this operation. The higher the level of polynomial transformation, the more GCPs are needed. You can always use more GCPs than the minimum required. There are varying opinions on whether collecting many GCPs are better. It may depend on the characteristics of the area you are correcting, such as the topography in the area of the scene you are correcting. In a scene with little topographic differences, the current opinion is that you need no more than 6 well-located GCPs to achieve a good geometric correction.

A good geometric correction should give you an error of V_i a pixel Root Mean Square Error (RMSE) or lower. This means that if you are using Landsat TM data, and the pixel size is 30 meters, your geometric error should be no more than 15 meters off in any area of the scene.

In order to obtain at least 6 good GCPs, you will want to collect at least 10 GCPs. Then you can delete a few GCPs that contribute most to the error in the geometric correction.

GCPs should also be taken over the entire scene. Meaning that they should not all be gathered in one area of the scene, but have at least one GCP in each corner of the satellite data. If the GCPs are not spread out, the areas without GCPs will not be geometrically corrected.

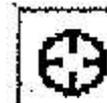


Having read the very important information above, you're ready to collect GCPs. You will choose the GCPs in the smaller Magnifier windows and use the Viewers #1 & 2 as overviews. In Viewer #1, move the small white box to a good GCP area by clicking in the middle of it and dragging the box to that area. Note that the white box corresponds to the Magnifier Box.

You can resize the Magnifier Box if you want.

1. in the magnifying window, right click to zoom in or out by 2, or
2. in the main Viewer, you can click and drag on a corner of the white box to make it bigger or smaller.

One way to know whether this is a good GCP or not is to look in both images to see that it is identifiable in both images before choosing it. So, once you identify a possible GCP in Viewer #1, look for the same spot in Viewer #2. If it is easily identifiable in both images, go



back down to the GCP tool and choose the "Create GCP" button. Go up into your magnifying window for Viewer #1 and left-click the mouse at exactly the point you want your GCP to be. Repeat this process for the very same spot in Viewer #2 (Choose the "Create GCP" button again).

Collect 10 GCP pairs total. Because you may want to go back to these as some point in the exercise, you should save the GCP files after you've collect 10. Go to File/Save Input As and name the file Inputl.gcc. Then choose File/Save Reference As Rcf1.gcc.

Go to the "Solve Geometric Model with Control Points" button in the GCP Tool Icon Panel. Note that this automatically calculates the X Residual, Y Residual and RMS Error for each point, as well as the Cumulative Control Point Error for X, Y and Total. The error unit is in meters.

Earlier, this exercise mentioned the total acceptable RMSE for geometric correction. Does your current model for the geometric correction meet that error level? (The total Control Point Error is shown next to the Icon Panel on the GCP Tool). If so, congratulations! If not, don't worry! It most likely wouldn't be so correct the first time!

Correcting your model



You probably have points that are more right or wrong than others. The RMS Error column in the GCP tool shows you the error for each of GCP pair. You should identify the GCP pair with the highest error, and then look at it in your Viewers,

To make a better model, identify the plot with the highest RMSE, and either:

1. consider whether to delete that plot from your model. Does this GCP look like it could be in a difficult to choose or questionable spot?
2. consider whether to move it slightly. Maybe you can see that it should have been a reasonable GCP, but you did not place it well the first time. However, don't just move around GCPs until the RMSE is good - the selection of GCPs should be more systematic than that.
3. consider whether you need to add more GCPs. Maybe you need to choose some better GCPs. If you have to delete several, you may need to add new ones.

The best advice is to deal with one GCP pair at a time, and reconsider your next move after you've dealt with the one GCP that gives you the highest errors.

Change the "Toggle Fully Automatic GCP Edit Tools", which we switched off earlier, to on. This way, when you now make changes to your GCPs, it automatically recalculates your RMS Error, which you can see right away.

Act according to your decision about what to do with the GCP pair with the highest error (delete or move). Remember that you have 10 GCPs, and only need 6 for this resampling. However, also remember that you want to need to have the GCPs well distributed over the area.

If you want to delete a GCP, you should select the row by clicking on the Point # in the GCP Tool, right click, and Delete Selection. If you want to move it in either of your Magnifier windows, just click on the GCP and drag it to the spot you want it.

Once you are satisfied with your number of GCPs and the RMSE, then save the Input GCP coordinates as `Inputfinal.gcc`, and the Reference coordinates as `Reffmal.gcc`.



Once you have your GCPs, you are ready to rectify the image - this means you will be creating a new image from the uncorrected one, which will be in a geographically correct coordinate system. In this process, the GCPs will act as ties to the coordinate system, and the rest of the image will be shifted and interpolated in the resampling process.



Go up to the GeoCorrection Tool, and click on the 3rd icon. (If you have lost the Geo Correction Tool, go to DataPrep Icon/Image Geometric Correction to get it back).

This brings up the Resample dialog, where you need to specify an output file name, and your resample methods.



There are three different resampling algorithms. Nearest neighbor often creates an image that may have "stair stepping", or a jagged look to previously linear features. Bilinear interpolation and Cubic convolution provide a smoother looking image, and cubic convolution provides a sharper image than the bilinear interpolation.

You are going to run tin's resampling three times, in order to test each resampling method. So, make the first output file tm95_nn.img and choose Nearest Neighbor resampling.

You also need to make sure the ULX, ULY, LRX, LRY coordinates are divisible by the pixel size. Check the pixel size in the Geo-corrected image. Then take the coordinate that appears in the ULX box and round it up or down to the nearest number divisible by the pixel size. Do this for all 4 coordinates (write these numbers down since you will use them again). After that you also need to give the correct output pixel size. Now - hit the OK button. This creates the new resampled file. Press OK when it is finished.

Reselect the Resampling Icon, and run this two more times, once for the bilinear interpolation and once for the cubic convolution, naming these files tm95_bi.img, and tm95_cc.img, accordingly. Note that you may have to reset the pixel size and the ULX, ULY, LRX, LRY information again.

Open three new viewers, and look at the three files which are the results of your resampling.



#1 Describe the differences you can see between the three different resampling methods.

Bring up a new viewer, and display the image tm940705.img in any band combination. Now, in the same viewer, open the tm95_cc.img file, and using Raster Options (see page 3), click OFF the "Clear Display" option, and choose OK. This opens two images in the same viewer.

In this Viewer, choose the Utility/Swipe function. Move the bar in the Swipe window back and forth to check how your geocoding turned out, compared to the already geo-coded scene. Did your geocoding turn out well? Does it look good over the whole image?

Try also the functions Utility/Flicker and Utility/Blend.



#2 What could be the disadvantages of a poorly geocoded image?



#3 If you had some GCPs that were poorly located, what in the image were they located on (e.g., a road end, an agricultural field corner, a river, etc.), and why do you think they were not good to use as GCPs?



#4 Of the following terms, which one is different from the others, and why? You can use the Exercise, the Imagine help, and/or the Lillesand and Keifer text book to help in the answer. Geocoding, Geometric Rectification, Geographic Registration, Resampling