

## Lesson 5: Image Georeferencing

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**What You'll Learn:** This lesson introduces image georeferencing, also known as image registration or image transformation. We'll then update a data layer through vector digitizing.

You should read the section "Coordinate Transformation", beginning on page 146 of the GIS Fundamentals textbook before starting this lesson.

**Data:** The two data layers are in the L5\ subdirectory:

*Scand.jp2* is an unregistered, scanned image in arbitrary scanner coordinates, with a 0.9 meter cell size.

*Big\_Mar\_Roads*, a road data layer for the study area, in NAD83 UTM zone 15 coordinates, units are meters

**Background:** Image data are a common source of information, and particularly useful when mapping vegetation, wetlands, and land use change. While many images are provided in digital formats and already "registered" to a projected coordinate systems, many times they are not. This is particularly true for historical images, which often are only available in paper or film media. These are often scanned, and must then be georeferenced. Georeferencing an image, often called an image transformation, converts the image from a file or scanner coordinate system to a projected map coordinate system.


There are many forms of image registration, but the simplest is called a *first-order* or *affine* transformation. An affine transformation is appropriate when the terrain is flat and the photograph has been taken with a vertically oriented mapping camera. When the camera is not pointed straight down (vertical), then at least a projective transformation should be used, and if there is significant surface height variation, then a complete geo-correction, or photo resection, should be performed. In this lab we'll just cover the affine transformation.

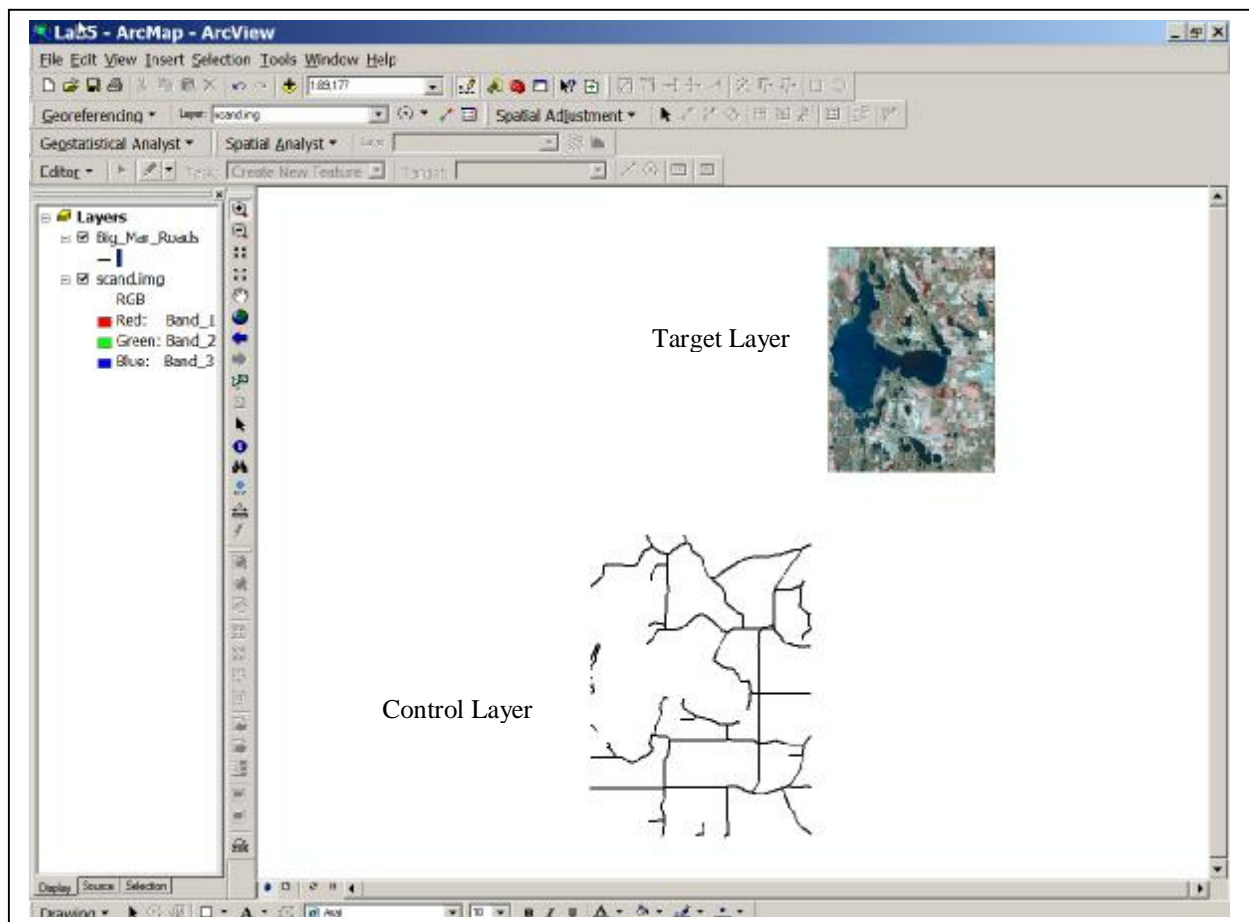
### Control and Image Data

Image georeferencing require both a source for geographic coordinates (our control layer), and the target layer to be transformed. In our case the target layer is an image, but there are times when we wish to register point, line, or polygon feature layers. Here, our target aerial photograph is in an arbitrary scanner coordinate system. This system has been slightly modified to make viewing easier, but is representative of what most scanners produce. This is the image you wish to register.

The control layer, in this case a vector roads data, is the source for your control information. This control layer must be in the desired map coordinate system. You will identify points in the control layer, and match them to corresponding

points in the target image. When you have enough points and are satisfied with them, you create the transformed image (**Video: L5\_Georeference.mov**).

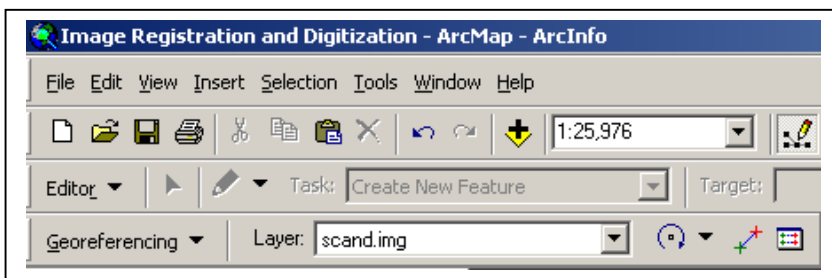
- Start ArcGIS - ArcMap, and open a blank map.
- Add *Big\_Mar\_Roads.shp*. This is our control layer, the one from which we will get control locations. You need to load (open) this data layer first.
- Add *scand.jp2*, our **target layer**. Ignore the 'No Coordinate System' message, as the point of georeferencing is to provide a coordinate system.
- Save the project.
- Notice how the two data layers are in different locations on view. If you can't see both layers, click the zoom to full extent button,  and you should now see both the image layer and roads layer (see figure)



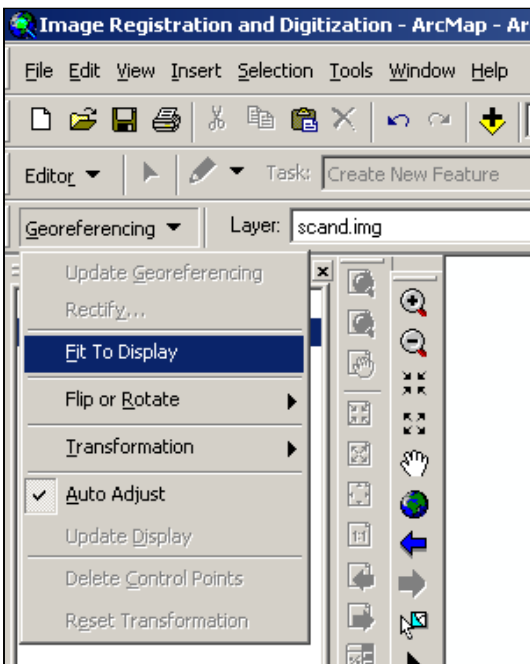
- Make the *Big\_Mar\_Roads.shp* layer active (click on it) then right click and select Zoom to, Layer. This will put the roads into the center of the display. We need to see all the roads to begin Georeferencing.

Look for the georeferencing toolbar, shown at the bottom of the figure below. If this toolbar is not displayed, right click on any toolbar, and make sure there is a checkbox next to the Georeferencing entry, as described in Lesson 4, and in the **Video: L4\_1\_toolbars.mov**.

Inspect the Georeferencing toolbar, and make sure the **Layer:** is scand.jp2. This is the target layer



Note the toolbar buttons  
View Control Points Table  
Select Control Points  
Rotate the image



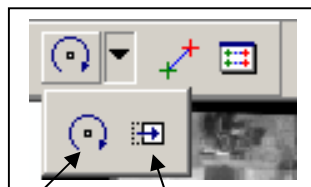
Left click the triangle to the right of the Georeferencing drop down box, and

Left click on **Fit to Display**

This will bring the target and control layers to be roughly coincident (see below).



First, we'll attempt to manually rotate and move the image fit the roads.



Use the **Rotate** cursor or the **Pan** cursor to try and move the picture to match the roads. You will notice you can't do it. Sometimes you get close with one road, but at the expense of mis-alignment with others. That is because the roads layer and the unregistered image are not only out of alignment but also differ in scale.

The affine transformation will shift, scale, and rotate the image.

We georeference an image using the **Control Point Cursor**.  
Left click on the icon to activate the cursor.



Now left click to mark a succession of control links, or points, between the target layer and the control layer.

**Note that the selections should always proceed as:**

- **First select a point in the target layer (the image),**
- **then select the corresponding point in the control layer (the roads in this case)**

Zoom in on the view to a portion with a road intersection. Zoom in enough so that you may clearly see the width of the road, and easily position the cursor in the middle of the road on the image (please see the figure).

Carefully place the cursor in the center of a road intersection in the image, and left-click.

Now, carefully place the cursor over the corresponding road intersection in the vector layer, and click. If all went well, you should see the image shift slightly to match the feature a bit more.

It is best to pick well distributed points, so for your second point select an intersection on the right side of the image.

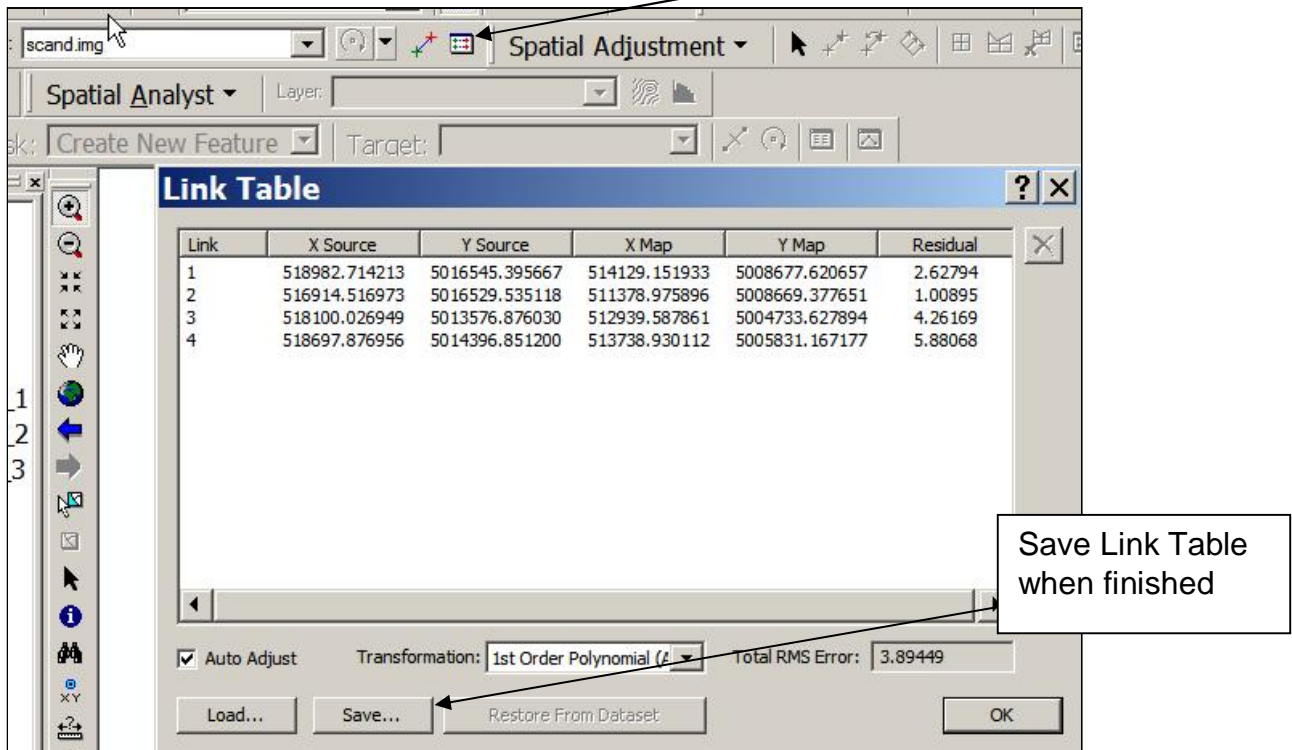


Repeat this procedure, panning and zooming to a different road intersection. First, click on the image version (target layer), then on the feature layer version (control layer).

If you lose your link line after you zoom or pan, click once on the Control Point button. This should display your active line.

With each successive control link, the image should line up a bit better.

After your 4<sup>th</sup> link examine the Control Link Table. (Use the table button)



Notice that after the 4<sup>th</sup> link you get a report of the current point error, and the RMS error in the lower right Link Table. This reports an index of the accuracy of your transformation. Strive to keep your mean number below 13, and if you can, below 10.

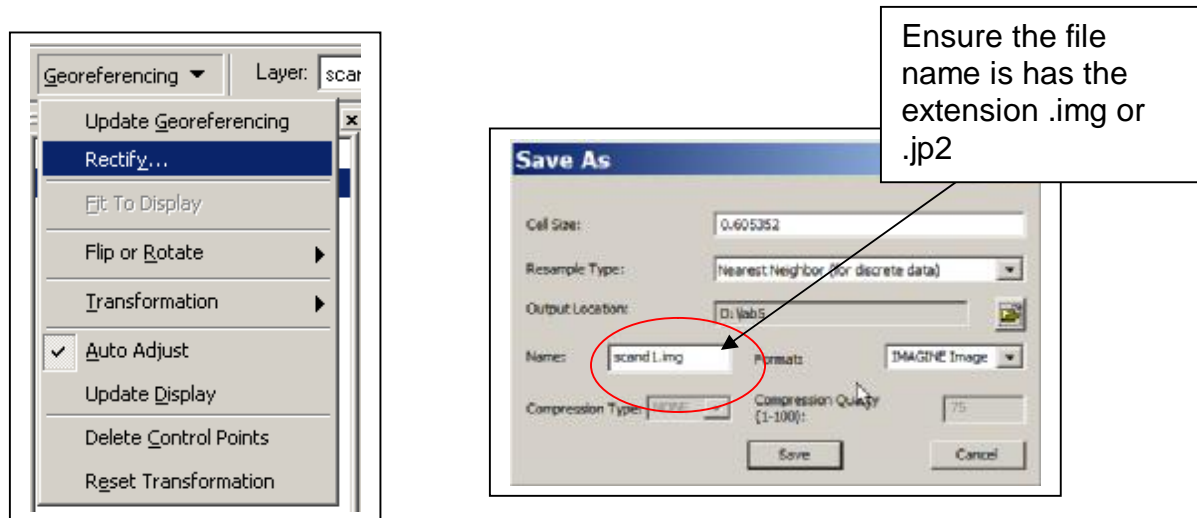
Continue until you have at least eight control links. If you make a mistake, open the Link Table, select the line and push the Delete key.

*One tip: You can often select more than eight points and delete the ones that contribute the least to the fitting equation. The Residual numbers on the right side of the Link Table tell which ones are most helpful, those with the smallest residuals. Remember to keep your points well distributed, don't delete all the high residuals so that your retained points are all on one side of the image*

Write down your final RME value. You will later add this to you printed Map.

When you are done, from the Control Link Table, save your link point table, carefully noting the file name and location for your output image.

From the Georeferencing Toolbar select **Rectify** to save the image to a file.



Remove you unregistered photo (scand.img) from the Map and add your new registered image. If you used the default name it will be scand1.img.

Using you newly registered photo, now digitize the new roads/driveways and lakes that you can see on the image at 1:5000 scale. (See the example in the figure below. Your work will be looked upon favorably if you are more thorough).

To digitize, remember:

- From ArcCatalog, **Create a new Shapefile**, Name it Driveways. Remember to specify a Poly-line, Import the Projection from the control layer or registered image layer.
- From ArcCatalog, **Create a new Shapefile**, Name it Lakes. Specify a Polygon, and Import the Projection from the other layers in the Map.

Start editing; set Snapping to the *Big\_Mar\_Roads* (roads) and to the new driveway layers. Select the draw line button, and digitize the lines. Remember to double click to end a line, and pan and zoom to get a detailed view so that you may digitize them accurately. Refer to the previous digitizing lab for instructions on setting up the snapping.

As there are many driveways and lakes, digitize as many as you can; at least 30 driveways and 10 lakes. The digitizing experience you learn in this exercise will help you when you use GIS later in your career; please get the most out of this assignment.

Digitize at 1:5000 scale.

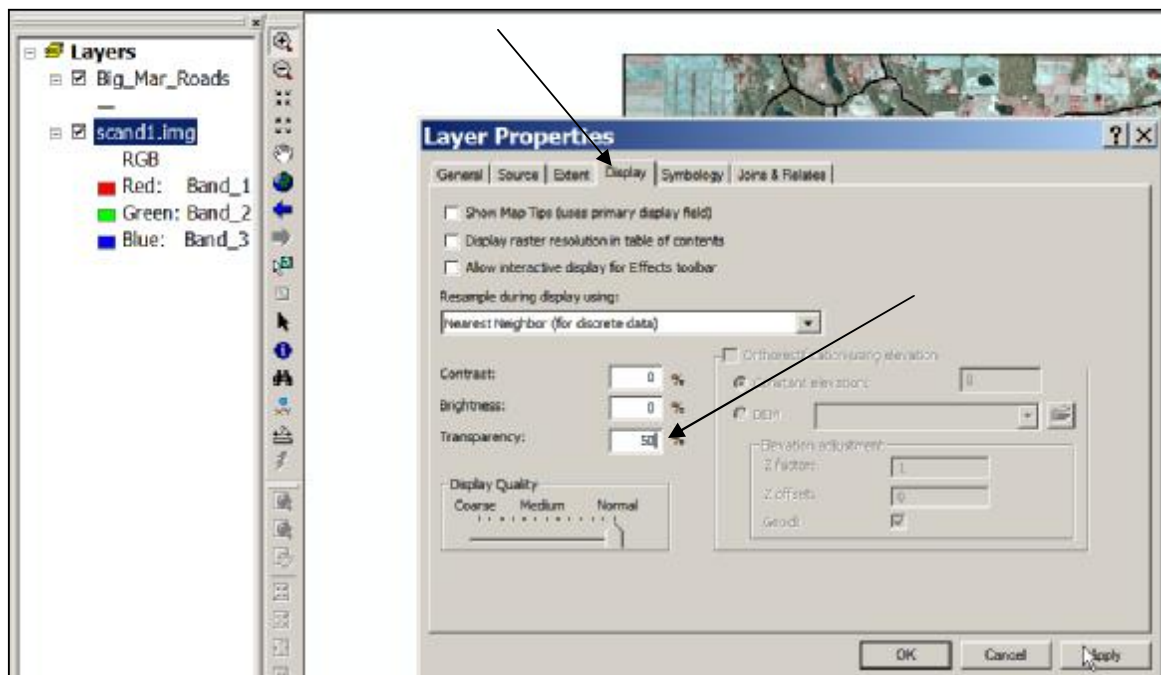
Snap roads to driveways but Snap the lakes only to themselves.

When you digitize lakes, consider moving COUNTER CLOCKWISE around the lake, this will make fixing errors easier. If you make a mistake and end the lake too soon the polygon will most likely be in the lake. Then you can change the Editing Task to Modify Feature and correct the boundary. Another option is to create another lake polygon for the missing portion and with both polygons selected, use the **Edit à Merge** option, to put the two polygons together.

When you are done, remember to select **Save Edits**, and then **Stop Editing**.

Right click on the registered image layer and left click on **Properties**, then **Display**.

Change the **Transparency** to 50%. This will help you see the roads and driveways on the printed Layout.



Create and Print layout or Export Map as a .pdf, containing the transformed image, roads, driveways, lakes, a scale bar, north arrow, title, and a legend. See the example map below. Make sure you include the RMSE of you transformation.

