Cornell University
Albert R. Mann Library

ArcGIS Tutorial: Georeferencing an Image

Introduction

This tutorial describes how to georeference a digital image (raster data set) in ArcMap. In some cases, one of your data sources may be in the form of a paper map, a scanned version of a paper map, or some other digital image which does not contain spatial reference information. Scanning a paper map produces a raster data set that can then be used in a GIS project, once it has been georeferenced. *Georeferencing* is the process of aligning a raster data set to known map coordinates and assigning a coordinate system. Georeferencing creates additional information within the file itself and/or in supplementary files that accompany the image file that tells GIS software how to properly place and draw it.

In general, the process consists of the following steps:

- Identification of appropriate reference data. You need a georeferenced data set in the desired coordinate system (preferably the same as your scanned map or digital image) which you will use to align with and georeference your raster data (target data). Your raster data and the reference data must have some features in common that are visible in both data sets, such as street intersections, hydrographic features, or building outlines.
- Selection of control points (based on common features) to link known locations in both data sets.
- Transformation of the target data to align with the reference data.
- If you plan to use your newly-georeferenced raster for analysis, or in some other GIS program that does not recognize the georeferencing information created by ArcMap, you should rectify it. This will create a new, georeferenced raster data set, which can be saved in GRID, IMG, TIFF, BMP, GIF, JPEG, JPEG 2000, or PNG format..
- For additional information on georeferencing raster data in ArcMap, see the *Georeferencing a raster dataset* topic in ArcGIS Desktop Help.

Some general tips for working with ArcGIS:

- Use the **Workspace** directory at the top level of the **C:** drive on the classroom computers.
- More generally, make sure your folders, directories, and files have short names that contain no spaces or special characters.
- Keep data files together.
- Use **ArcCatalog** to move, copy, rename or otherwise change spatial data, to ensure that all of the constituent files are included.
- Set **Data Source** options (From File>Document Properties) to store relative names for data sources, to make map documents portable from one computer or drive to another. Maps created in ArcGIS will need to reference the original data layers used in them to draw properly.

Exercise

All the data for this workshop are located in the directory **\GIS\ArcGIS_2\Georeference** in the **Classroom Files** folder (use the desktop shortcut to get there). Check to see if there is a folder named **workspace** at the top level of the **C:** drive on your computer. If no such directory exists, create one. It's important to have no spaces or special characters anywhere in the path directories of your data files, so be sure to create this directory at the top level of the **C:** drive. Copy the **Georeference** folder (7 files in all) to **C:\workspace** on your computer.

1. Using Windows Explorer, find and open (double-click) the **Cornell_map.gif** image file in the with the default image viewer. This is map of the Cornell campus is the target data set, the raster we will be georeferencing.

2. From the **Start** menu, select **All Programs>ArcGIS>ArcMap 10.** Click **OK** when asked you if you'd like to begin with **a new empty map**. Maximize the window and dock (drag) any toolbars so they are out of the way.

3. **Add** (click on the add data icon ) the **buildings.shp** layer from the Georeference folder. This is a data set showing building outlines for Tompkins County, and will serve as our reference data set.

4. Using the Zoom  and Pan  tools, get the data frame extent in ArcMap to match the area displayed on the Cornell map, as closely as you can. If you know the scale of the image you are georeferencing, adjust your map data frame scale to the same to start, using the top scale window. For this tutorial, try this scale to start: 

. You can fine tune later as needed.

5. Once you have the same approximate areas displayed in ArcMap and the image viewer, close the image viewer. Note that in some cases, you may find it useful to use one data set to get oriented and adjust the data frame extent in ArcMap, and another for the georeferencing operation, but in this exercise we'll use one reference data set for both purposes.

6. **Add** the **Cornell_map.gif** image file to ArcMap. You may get a message asking if you want to **build pyramids**; click **Yes**. You will also get a message stating that spatial reference information is missing. Click **OK**. Make sure the added image file is placed below the buildings layer in the table of contents (with Display tab selected in lower left). Don't worry if you can't see the Cornell_map.gif image yet.

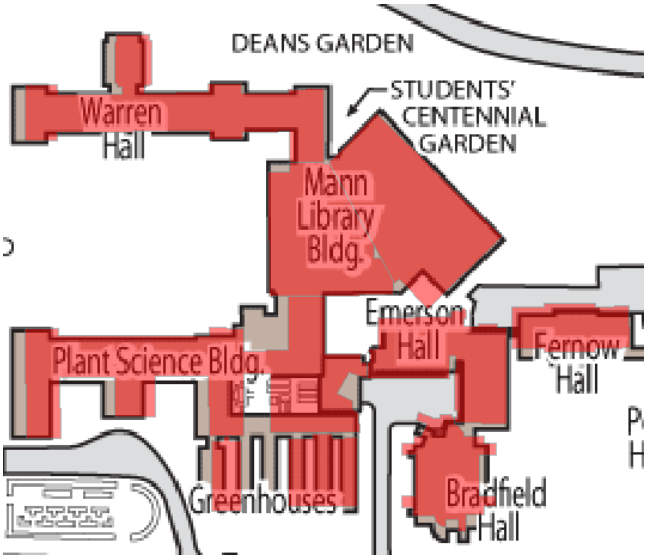
7. Add the **Georeferencing toolbar** by right clicking over the toolbar area and checking.

8. From the toolbar, click the **Layer** dropdown arrow and select the Cornell_map.gif file as your target,


then click **Georeferencing – Fit to Display**. Now you should be able to see both the Cornell map and the buildings layer – though they will not be perfectly aligned.

9. You may find it helpful to make the buildings layer partially transparent, or to change the display to building outlines only, so you can see both layers better. Do this by opening the **Properties** dialog (right-click on **buildings** in the table of contents and choose **Properties**). To make the layer partially transparent, click the **Display** tab and type a number in the **Transparent** box (try 50 to start). Click **OK** to apply this setting. To change the color, or to show building outlines only, click on the color symbol below the **buildings** layer in the table of contents. Make any desired changes to the **Fill** and **Outline** colors and click **OK** when you're finished

10. Use the **Rotate Shift, or Scale tools**  on the Georeferencing toolbar (you should only need shift and scale here) as needed to align the imported campus map image with the building layer. After selecting a tool, click and drag over the image to move or size it. For the scale tool, drag toward center to shrink image, outward to enlarge. You may also need to use the **pan tool**  to adjust the data frame. On some machines there may be lag in response time, so wait for the screen to redraw before moving again.



Don't worry about getting everything to line up. In some cases (such as here) your scanned image will need to be stretched along the perimeter later to align properly. Focus on getting objects in the center of your image (e.g. Mann Library) aligned and sized correctly to match the reference data.

If you need to restart, you can zoom the data frame back to the approximate extent of the scanned map again using the  tools, then reset the scanned image accordingly by clicking Fit to Display again.

Tip: If you have trouble getting the image and base layer to align even after adjusting position and scale, sometimes changing the data frame coordinate system may help (adjustable from the View>Data Frame Properties>Coordinate System menu). You will need to re-do the Fit to Display process again. Skip that process for this exercise.

11. Once you have the scanned image file centered in its approximate location and scale, from the **Window** menu, select **Magnifier**. You can change the magnification by right clicking the window and selecting properties.

12. **Move the Magnifier** window over an area where you can see the same feature clearly on both layers – in this exercise, building corners are the only features you can use for this purpose. On other reference layers, you might look for features like street intersections or stream confluences – but no matter what you choose, they should be features with a fairly precise location that are visible on both layers.

13. Click the **Control Points** tool  from the Georeferencing toolbar to add control points. These will be used to rubber sheet the image.

14. Click the **Georeferencing button**, and check that Auto Adjust is on (checked). This will update the image with the addition of each control point (as a personal preference, some people may prefer to turn this off while adding points).
    To **add control points** (links), within the magnifier window:

    a. click the mouse pointer on a landmark (building corner, in this case) on the Cornell map (target data) first,
    b. Then click on the same landmark on the **buildings** dataset (reference data).

    Add 4 or 5 more points, scattering your control points over the entire image. Move the magnifier around as needed to do this accurately. If you are unhappy with the results of any control points added, you can open the View Link Table  to select and delete the point.

    You need a minimum of three links for a first-order transformation, six links for a second order, and 10 links for a third order. Higher orders can fit a more complicated surface to the input points. A first order transformation is sufficient for our purposes.

15. **Click View Link Table**  to evaluate the transformation, and choose the type (first order) from the bottom Transformation drop-down menu (do not select Adjust). You can also examine the residual error for each link and delete control points (select, then use delete key or X in upper right). Click **OK** to close the Link Table.

16. If you chose to turn Auto Adjust off earlier, on the **Georeferencing** toolbar, select **Update Display**. If you're satisfied with the registration, you can stop entering links.

17. Click Georeferencing and click **Update Georeferencing** to save the transformation information with the raster dataset. **DO NOT CLICK UPDATE GEOREFERENCING MORE THAN ONCE**. This will result in the image being distorted. If you mistakenly do this, remove the layer and delete the accessory .tfw and .aux files from the data folder before reloading the data (The files will be rebuilt using internal information).

18. You can permanently save the transformation of the image itself by selecting **Rectify** from the **Georeferencing menu**. For data that represents discrete or "thematic" values (as with a DRG or land use/land cover map) choose the nearest neighbor resample type. The other resample types are for continuous data types like satellite imagery and aerial photos, which will "smooth" the values for each cell. You should rectify your raster dataset if you plan to perform analysis with it or want to use it with another software package that doesn't recognize the external georeferencing information created by ArcMap.

Scanned images can also be georeferenced without reference layers if you have labeled coordinates on your image, by editing the Link Table after entering "place holder" control points. Make sure your data frame coordinate system is set to the same system your image coordinates are in (**View>Data Frame Properties>Coordinate System**).