Georeferencing

Sometimes in your projects, you will want to use image data that lacks a spatial reference. Examples of this are aerial imagery or scanned historical maps. These ungeoreferenced image data are often used for general reference or as base layers, but in order for the image data to align properly with other data features, you may need to georeference the data. Georeferencing assigns spatial references to the ungeoreferenced image when you place control points on the ungeoreferenced image corresponding with other existing data you are using.

Note: Imagery, like an aerial image or scanned historical map, is called raster image data.

1: Open a blank map file, then add the provo_roads shapefile that is in the georeferencing.gdb. Once the roads shapefile has been added, drag the raster image file byu.jpg into your workspace.

An alert will appear which will inform you that the image lacks spatial reference. After doing this tutorial the image should be aligned properly with the already referenced roads data. Click OK.

2: Right-click on the roads layer and then select **zoom to layer**. Notice that this will take you to a view of the roads that run by the BYU campus in Provo Utah. If you are familiar with the area, you may recognize important streets and intersections which will help you later on in the tutorial.

3: Now right-click on the byu.jpg image layer and zoom to this layer. This is an image of Provo that we want to use as a base map for our tutorial. In order for this image to line up with our roads layer, we need to identify specific locations we can use for control points.

4: At the top of your screen, click on the customize menu. Then select “toolbars” and then “georeferencing” (Figure 1).
5: Once you have identified some of the key features in the raster image, we can begin adding control points to align the raster image and the roads shapefile. Click on the **add control points** button. The first point we will add is located at the Northwest corner of the image near the football stadium (Figure 2). There is a four-way intersection, where one of the roads curves to the north next to a big grass field. On the image, click in the center of that intersection to place the first point.
6: Zoom to the roads layer and find the intersection where we placed the first point (Figure 3). Once you have found the correct intersection, click on the intersection to add the point.

You may notice that as you move your mouse over to the intersection, it will automatically “snap” onto the lines or intersection. This can be helpful when working on a large-scale map, but if you prefer to place the points without the snapping feature, it can be turned off by navigating to the snapping toolbar. Under the “customize” menu, click on “toolbars” and select “snapping.” On the Snapping toolbar, click “snapping” and click “use snapping.” The checkmark disappears and snapping has been disabled.
Now you will notice that the intersection on the image and the intersection on the roads features line up; however there is a big problem. The most noticeable issue is that the image is not to scale, appearing much smaller than what it should be (Figure 4). As we continue adding control points, this issue will be corrected. For the most accurate georeferencing, it is good to select control points that are spread out on the image. If the control points are too close together, the accuracy will decrease dramatically.

7: We will place our second control point closer to the center of our image. Un-check the roads box to make the raster image the only thing visible. The next control point will be place at a 4-way intersection East of BYU Campus (Figure 5). It is the intersection located next to the construction site. You’ll notice one of the roads gradually curving south from the intersection. Once that control point has been added, turn the raster image layer off and the roads layer back on.

8: With the roads layer viewable, locate the same intersection and place your point (Figure 6).
Notice the image is now resized to a more accurate scale (Figure 7). This means that you are getting closer to having your image georeferenced. There are still some areas that have issues though. As you move farther away from your control points, you’ll see some inaccuracies start to occur. Notice the bottom-left corner of the image has some roads that are not aligned properly. Adding more control points will correct those inconsistencies. For the remainder of this tutorial we will add two more control points.

9: Our next control point will be located at the intersection next to BYU’s indoor practice facility. This is in the bottom-left corner of the image and is a green rectangular field next to a silver rectangular building. There is also a parking lot just to the north of these two features. Place the third point at the intersection near the bottom left corner of the field (Figure 8). With the map now at a scale similar to the roads data, you should be able to find the corresponding points more easily.
After placing your third point, you will notice a small blue line connecting the control point on the raster image and the control point placed on the roads data. This blue line is known as a *residual line* and it measures the distance between those two control points placed and calculates the error margin. Because of distortions in aerial imagery, most maps can only be georeferenced to a certain extent before some errors occur.

10: Once your third point has been placed, you can select the next location for your fourth point. Some potentially ideal locations would be at the Northeast or Southeast corners of the image.

If ever a mistake is made and a control point is placed in the wrong location, you can use the *select link* tool to highlight the erroneous point and the *delete link* tool to remove it.

Because of the distortion of aerial imagery, most large scale maps are actually a series of smaller images pieced together called *mosaics* allowing the viewer to observe a region with as little distortion as possible.

For more information on georeferencing see: