GEOG 4140/6140 – Winter 2021
Lab 2: Georeferencing
Due Thursday, February 11 at 11:59PM

Overview

In this assignment, we will use US Topo maps and aerial imagery to map the location of the historic California Trail through Salt Lake and part of Tooele County. Over the years, the California Trail has been mapped on a variety of paper formats (maps, aerial photos, etc.) by individuals in association with the National Park Service. In order to digitally capture data provided in aerial photography, photos are converted to a digital format through scanning. GIS software can then be used to position the scanned images in their proper spatial location using a technique called georeferencing. Steps towards the proper georeferencing of an image include choosing the correct geographic coordinate system, creating control point pairs, and rectification of the image. Once the image is properly georeferenced, data/information are digitized to create vector GIS features.

The following resources may be useful in the completion of this assignment:
Overview of georeferencing
Project
Merge

Required Data (*Sources*)

1. USA USGS 24k Topo Map Boundaries polygon (*ArcGIS Online portal*)
2. 7.5' USGS topographic maps (US Topo) (*Lab data on Canvas*)
3. Aerial photographs (*Lab data on Canvas*)

Workflow

1. Open ArcGIS Pro and create a new project titled *Lab02 YourLastName* in your working directory for this lab.

2. Using the All Portal, add the *USA USGS 24k Topo Map Boundaries* polygon.

3. Explore the provided images in the Topographic folder. View the metadata at the bottom of the US Topo maps to identify the coordinate system.
    a. **Change the *projected coordinate system* of the Project Map to match that of the US Topo map.**

4. Navigate to the general area in which the topographic map should be located and load one of the seven US Topo maps.
    a. **Fit the US Topo map to the display** utilizing the Georeferencing tools. Once in a general location, **Move** and **Scale** the image as needed.

5. Once fit to the general location, begin **adding control points** using the Topo Map Boundaries polygon as a reference. Be sure the title of the map matches the quad you are matching.
   a. For reference, utilize the underlying basemap to check for consistent placement of landmarks such as elevation points, streets, water features, or points of interest. When using a footprint, this is mostly just for reference to be certain of proper placement.
   b. Your target data will be the *USA USGS 24k Topo Map Boundaries*.
   c. Record the transformation type and the root mean square error (RMSE) when finished georeferencing your scanned topo map. (Note that you need at least a couple of control points before ArcGIS Pro is able to calculate the RMSE.)
   d. When satisfied with the raster's placement, **rectify/save** the raster to permanently transform the dataset.
   e. Using the same steps, **georeference** the remaining six US Topo maps.

6. Next, you will digitize the California Trail from your georeferenced images. Digitize all sections of the trail marked by a thick red line in the US Topo maps that begins near Big Mountain Pass.
   a. **Create a new line feature** for the trail and **add fields** titled *Section* and *Comments* to record any additional information on the topographic maps. Also, be sure that the coordinate system of the line feature class is based on the same coordinate system as the US Topo maps.
   b. Create the line as a multipart feature with each section beginning and ending on each topographic map.

7. Use the historical imagery to continue digitizing the trail further west into the Tooele Valley. For this lab you have been provided 6 images that follow the trail west of where the seven US Topo maps stop. In order to use these images to digitize the trail, they will also need to be georeferenced.
   a. Change the **projection** of your map to a more appropriate projection considering the timeframe of the imagery.
   b. **Add** the first provided historical aerial image to the map and fit to the area. Use roads, water features, elevation points, and other unique identifiers to **georeference** this image.
   c. Record the transformation type, RMSE value, and then **rectify/save**.
   d. **Georeference** the other five images the same way.

8. To capture the trail alignment from the georeferenced images, first **create a new line feature class** to digitize the final part of the trail that was missing from the provided quads into its own feature.
   a. The feature class needs to be in the same coordinate system as the georeferenced imagery.

9. The trail features need to be merged into a single feature; however, their coordinate systems are not the same. Choose the appropriate coordinate system that is either more accurate or more up to date and **project** all line features to this coordinate system.

10. Once your line features are in the same coordinate system, **merge** them into a single feature and edit the end vertices of the lines so that they snap together at their endpoints.

11. Add the ESRI standard metadata (title, tags, summary, description, credits, use limitations) to the digitized trail layer. Save your project.

12. Create a map showing the digitized trail.

Deliverables

1. A map of the California Trail across Salt Lake and Tooele County.

2. A screenshot of the metadata you added to the California Trail feature you created.

3. Responses to the following. (1 point each)
   a. Describe the difference between a *geographic coordinate system* and *projected coordinate system*.
   b. In which coordinate system did you choose to keep your final line feature? Explain your choice.
   c. Discuss the limitations of geographic coordinate systems and projected coordinate systems.
   d. What is the difference between the transformations commonly utilized to georeference an image? How many control points must be created for each type of transformation?
   e. What were your transformation types and RMSE values for the georeferenced images? What does the RMSE value indicate?

Scoring Rubric (14 points total)

D1: 7 points
   5 points - The California Trail accurately digitized across Salt Lake and Tooele County.
   0.5 point - Legend
   0.5 point - Title
   0.5 point - North arrow
   0.5 point - Scale

D2: 2 points
   2 points – Screenshot of metadata includes tags, summary, description, credits, use limitations, extent, etc.

D3: 5 points
   1 point for each question