GIS Tips & Tricks

By Delaney Resweber and
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When Paper Maps Just Aren't Enough

Among the most practical exercises in most GIS classes, including mine, is incorporating a series of historical and contemporary maps and images into a project and mapping the changes over a time period, i.e. change detection. Sometimes, you get lucky and all of the maps/images include "world files" or Geotiff tags that enable your GIS to spatially index the maps/images and everything fits. However, most of the time, you don't get so lucky and the maps/images are not "georeferenced". The good news is that most GIS software packages provide for some level of assigning real-world coordinates, in a projected coordinate reference system (CRS), to those "raw" maps/images. The process of assigning those coordinates and indexing the raw images to a CRS is called "georeferencing".

Georeferencing is a great way to incorporate digitally scanned maps and other images into a GIS dataset. From scans of historical parchment maps from the 1600s, to Computer Aided Drafting (CAD) city-drafted utility maps created in the 1980s, to scanned modern paper maps for which we do not always have the GIS data layers, there are many instances where you might want to georeference either the electronic computer aided design (CAD files; .DXF/.DWG) InterGraph Design files (.DNG) or scans and images; Joint Photographic Experts Group; Tagged Image File, International Management Group, or Portable Network Graphic (.JPG, .TIF, .IMG, .PNG, etc.), as well as those paper maps, so they can be used as layers in your GIS.

This month, I am collaborating with Delaney Resweber to provide some tips and tricks that she's learned over the years to make georeferencing easier!

TIP #1 — Start with a High-resolution Image; the Higher the Better!

Ideally, the image you are georeferencing is a high-resolution .TIF, .JPG, etc. file, 300 dots per inch (DPI) or greater. Crisper details on the image allow you to more accurately choose control points (see TIP #3) which results in better aligning the map geospatially, which, in turn, results in a better product. Starting with a high resolution image makes any of the maps you create easier to read and more professional looking, and if you ever decide to take the additional steps of heads-up digitizing the map into one or more vector layers, it will make that process a lot smoother. As an example, in Figure 1, one map was scanned at 50 DPI (A) and the other 300 DPI (B). The difference in resolution is easily observable.

Figure 1. A portion of a map showing National Parks in the western U.S. Map A was scanned at 300 DPI while Map B was scanned at 50 DPI.

Often, we aren't lucky, and we start with a low-resolution image, as in historical images where you take whatever you can get, or you are stuck with a scan of a scan in Page Description Format form; the worst of all possible worlds. Luckily, there are ways to work around this, including using Adobe Illustrator, Adobe Photoshop or similar programs to increase the image resolution with Artificial Intelligence (AI) image enhancing technologies (beyond the scope of this article).

Photogrammetric Engineering & Remote Sensing
Vol. 90, No. 10, October 2024, pp. 593-594, 600.
0099-1112/22/593-594, 600

doi: 10.14358/PERS.90.10.593

TIP #2 — Don't be Afraid to Crop the Image

Sometimes the image you are georeferencing was not captured to the spatial extent of your project. A typical example may be a Department of Transportation (DOT) or Natural Resources Conservation Service (NRCS) 1:24,000 scanned photograph showing more area than you need. This may make it very difficult to place control points (TIP #3) that allow the image to line up with its real-world locations.

To resolve this, you can crop the image into multiple parts in Adobe Photoshop, Microsoft Paint, or similar programs and align those parts individually if needed. This allows you to place control points specific to those regions and not worry about the rest of the image being skewed as a result.

TIP #3 — Place at Least Five Control Points

The process that GIS software (and photogrammetric packages) use to georeference images requires the user to identify a point (pixel) on the image, in image coordinates, and its real-world cognate coordinates in the desired CRS. The workflow described below is for general reference as more detailed instructions are available at: https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/georeferencing-a-raster-to-a-referenced-layer.htm and/or the videos available on YouTube (https://www.youtube.com/watch?v=3r7ELaxRdDs).

In ArcGIS Pro

Step 1 — The workflow starts with adding the non-georeferenced image, scan or electronic file to a map frame containing a source raster or vector that is properly georeferenced and is referenced to a real CRS.

Step 2 — ArcGIS Pro 3.3 will detect a non-georeferenced image and add a "Georeference Tab" (Figure 2) to the ribbon. In previous versions, you may need to use the Imagery Tab to activate the Georeference Tab.

Step 3 — In ArcGIS Pro, use the "Fit to Display" function on the Georeferencing toolbar to move the non-georeferenced image into the general map space. The image will NOT be scaled or georeferenced, but it will be visible on the map.

Step 4 — Use the "Add Control Points" tool to draw links between the non-georeferenced image and the CRS in your map frame. This tool allows the user to draw a line (called a link) starting at the non-georeferenced layer and ending on the georeferenced layer at the cognate location, the "control point". I tell my students that the links ALWAYS go from the picture to the ground!

Step 5 — These "control points" and links are then used to mathematically transform all of the pixels in the non-georeferenced image (scan or electronic file) to their real-world coordinates. Most GIS software packages offer multiple transformations (beyond the scope of this Tips & Tricks article.)

Try to place at least four control points around the four corners of image with the final, fifth point placed somewhere near the center of the image. This allows the image to more appropriately adjust to the correct location rather than be skewed one way or the other with the transformation applied. If you place all your control points on the northeastern portion of the image, then it's not going to be aligned the right way in the rest of the image and could be badly misaligned.

TIP #4 — Find Landmarks for Control Points

When placing control points, be conscientious of the features your image has mapped versus what the basemap or the imagery layer you're using to georeference your image displays. Avoid placing your control points on arbitrary features that may vary map to map, such as contour lines or wetland boundaries. Try using road intersections, river intersections or building corners (but remember that building corners may display parallax displacement.)

Sometimes you have to get creative. For example, with one of my projects I was georeferencing underground subway plans - so I lined up the street entrances of the subway with the entrance level plans, connecting the entryways. Then, I connected the other levels to this entrance level plan without using the imagery.

TIP #5 — Experiment with New Tools

The GIS world is always expanding and innovating with new solutions and programs. Keep up to date on what other professionals are doing and try experimenting outside of the tried and true to elevate what you can do with your georeferenced imagery.

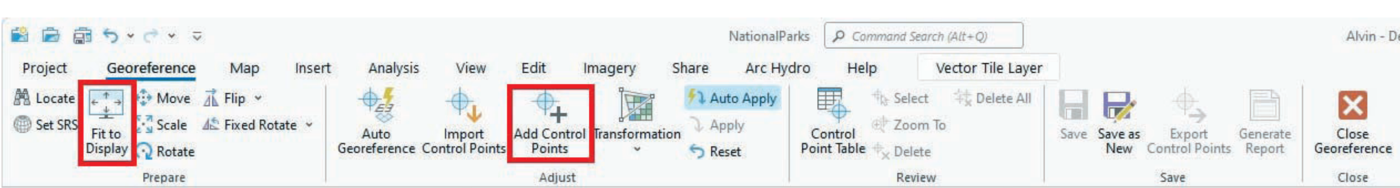

Figure 2. The Georeference Tab in ArcGIS Pro 3.3.

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Recently, Bunting Labs created a QGIS plug-in that automates the vectorization process of taking georeferenced imagery and digitizing it into vector layers. ESRI has developed unique ways to incorporate georeferenced maps using their Story Maps application, allowing a larger audience to interact with maps in an easy to navigate web interface. In addition, it is a great tool to help tell stories and narratives supported by text, audio and video medias.

Send your questions, comments, and tips to GISTT@ASPRS.org.

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photogrammetry, or remote sensing. Certifications and advanced degrees not only validate your skills but also expand your professional network through interactions with peers and instructors. They can lead to higher-paying jobs, leadership roles, and opportunities to contribute to cutting-edge research and development projects.

Author

Hamdy Elsayed, PhD, the head of Innovation at Teledyne Geospatial, is an expert in the field of geospatial and remote sensing, known for his significant contributions to both academia and industry. With a robust academic background and extensive professional experience, Hamdy has established himself as a leader and innovator in the geospatial community. His commitment to excellence and passion for geospatial science inspire those around him and drive his ongoing contributions to the field. Hamdy believes in the transformative power of geospatial technologies and their potential to address some of the world's most pressing challenges. He advocates for a holistic approach that integrates scientific research, technological innovation, and practical application.

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