Introduction to GIS

Lab03 Geometric Transformation

This lab is related to Lecture 6 - Geometric Transformation

Exercise 01 – Geometric Transformation – Map-to-map transformation

> Objectives of this exercise:
> To learn how to conduct geometric Transformation with ArcGIS Pro
> - Conduct map-to-map transformation
> - Conduct image-to-map transformation
>
> To complete exercises, you need the following:
> - ArcGIS Pro 3.3.1 (Basic, Standard, or Advanced)
>
> The data needed for this exercise is under the folder Lab 03, named Lab03Data.zip (download and unzip it to your own folder).
> Exercise 1 demonstration video:
> https://mediaweb.ap.panopto.com/Panopto/Pages/Viewer.aspx?id=b31728d0-1196-4a8c-b090-aeb000497038

Georeference a Scanned Map

In this task, we will use a TIFF file *hoytmtn.tif*, which contains scanned soil lines. The bi-level scanned file *hoytmtn.tif* is measured in inches. For this task, you will convert the scanned image into UTM coordinates. The conversion process involves two basic steps. First, you will georeference the image by using four control points which correspond to the four corner points on the original soil map. Second, you will rectify or transform the image by using the results from georeferencing. The four control points have the following longitude and latitude values in degrees-minutes-seconds (DMS):

Pt-ID	Longitude	Latitude
1	-116 00 00	47 15 00
2	-115 52 30	47 15 00
3	-115 52 30	47 07 30
4	-116 00 00	47 07 30

Table 1: Long/Lat in DMS

After being projected onto the NAD 1927 UTM Zone 11N coordinate system, these four control points have the following x- and y-coordinates:

Pt-ID	x	y
1	575672.2771	5233212.6163
2	585131.2232	5233341.4371
3	585331.3327	5219450.4360
4	575850.1480	5219321.5730

Table 2: x/ y in NAD 1927 UTM Zone 11N

Now you are ready to perform the georeferencing of *hoytmtn.tif*.

1. Start ArcGIS Pro and sign in if necessary. Click **Map**, and create a new project named **IntroToGIS_Lab03**.

2. In the **Catalog** pane, right-click **Folders** and choose **Add Folder Connection**. Create a folder connection to the **Lab03Data** folder.

3. Expand the folder **Lab03Data**, right click *hoytmtn.tif* and then select Copy, then right click the folder **Lab03Data** and select paste, a new raster file named *hoytmtn_1.tif* has been added to the folder. Rename *hoytmtn_1.tif* as *hoytmtn_rect.tif*, and then drag *hoytmtn_rect.tif* to the map area. Click **OK** if you are asked to build pyramids.

4. In the **Contents** pane, right-click on *hoytmtn_rect.tif* and click **Zoom to Layer**. You can see that it falls somewhere in the ocean, so obviously the location is incorrect. We have to do a Geometric Transformation so that the map will be moved to an inland area which the mapped area should be located at.

5. On the ribbon, click the **Imagery** tab. In the Alignment group, click the **Georeference** tab. The tools of **Georeference** appear and are split into several groups.

6. In the Prepare group, click **Set SRS** to set the spatial system.

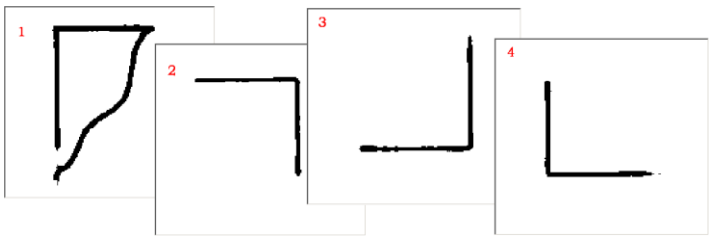
   ***Note**: If your raster dataset already has a spatial reference, it will be automatically used as the coordinate system for the map and the georeferencing session. If your raster dataset does not have a spatial reference, the **Map Properties** dialog box will appear, and you can choose the coordinate system to set for the georeferencing session; the default spatial reference is the current coordinate system of the map.*

   For this case, please set SRS to be "**NAD 1927 UTM Zone 11N**". The search box can be used for quick selection. Click **OK**.

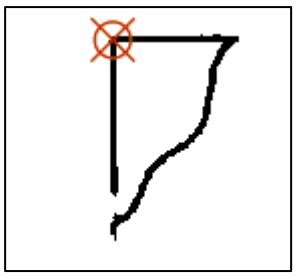
   Q-1. What is NAD 1927 UTM Zone 11N? Please describe it in detail. Why do we need to set the SRS as NAD 1927 UTM Zone 11N? (4 marks)

7. In the **Adjust** group, make sure that **Auto Apply** is activated. As this option is activated, the image would automatically move each time you update control points. Make sure you always right-click "**Zoom to layer**" at the source layer to see the scanned image again. It is ok to see that you are in the middle of the ocean - the map is not georeferenced yet.

8. In the Adjust group, click on Add Control Points to add control points. Zoom in *hoytmtn_rect.tif* and locate the four control points. These points are shown as brackets: two at the top and two at the bottom of the image. They are assigned numbers 1 through 4 in a **clockwise** direction, with 1 at the upper-left corner, and 4 at the bottom-left corner. (see the figure below)

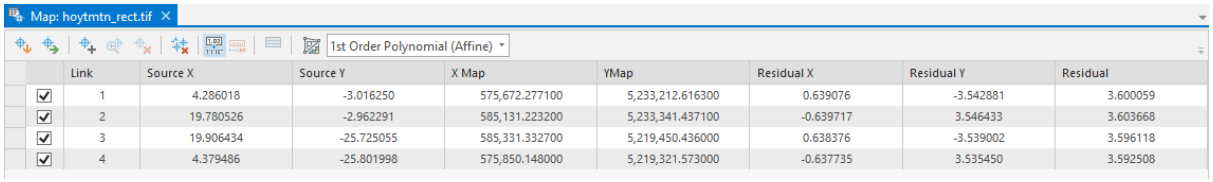


9. Zoom in around the first control point. Click the intersection point where the centerlines of the bracket meet. Right-click to bring up the Target Coordinates dialog box. Enter the x- and y-coordinates respectively. For the first point, its x- and y- coordinates are 575672.2771 and 5233212.6163. Click **OK**. A red cross sign will be added to the control point. Make sure to use Zoom to layer to put *hoytmtn_rect.tif* back into the map.



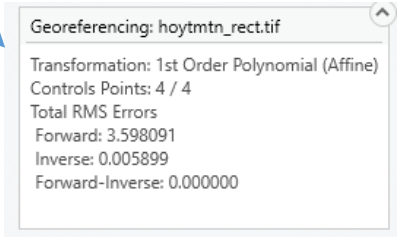
10. Repeat the above two steps to add the other three points. Their corresponding x- and y-coordinates can be found in the Table 2 above Step 1. As the **Auto Apply** is active, your image will move and disappear from your map.

11. In the Review group, click on **Control Point Table** and you will see that 4 control points are created. Check to see if the x- and y-coordinates are added correctly.



	Link	Source X	Source Y	X Map	YMap	Residual X	Residual Y	Residual
☑	1	4.286018	-3.016250	575,672.277100	5,233,212.616300	0.639076	-3.542881	3.600059
☑	2	19.780526	-2.962291	585,131.223200	5,233,341.437100	-0.639717	3.546433	3.603668
☑	3	19.906434	-25.725055	585,331.332700	5,219,450.436000	0.638376	-3.539002	3.596118
☑	4	4.379486	-25.801998	575,850.148000	5,219,321.573000	-0.637735	3.535450	3.592508

12. In the upper-right corner of the Map, expand and review the **on-screen georeferencing details**. Note the Total RMS Errors values and keep in mind that your value may differ. The forward residual shows you the error in the same units as the data frame spatial reference. The inverse residual shows you the error in the pixel units. The forward-inverse residual is a measure of how close your accuracy is, measured in pixels. Residuals closer to zero are considered more accurate.



13. The total RMS error should be smaller than 4.0 (meters) if the control points are added to the correct location on the image. If the RMS error is very high, highlight the record with a high residual value and delete it. Go back to the image and re-select the control point.

    Q-2. Submit a screenshot of your Control Point Table and the on-screen image georeferencing details. What is the total RMS error in meters? Please explain how it is calculated using equation(s) and the values in your Control Point Table. (3 marks)

14. This step is to save the transformed *hoytmtn_rect.tif*. Click **Save** from the **Save** group.

15. Select the *hoytmtn_rect.tif* layer. Go to the **Raster layer** tab on the ribbon (Raster Layer Data).

16. Under the **Effect** group, set the **Layer Transparency** to 50%. Now you can check if the georeferenced map coincides well with the base map. You can also use the **Swipe** tool under the **Effect** group to easily make the comparisons.

    Q-3. Insert the screenshot of the overlaying of the georeferenced map and the base map in a Word document. (0.5 marks).

17. In the **Georeference** tab, Select **Export Control Points** to save your control points to a text file in case you need them later.

18. Exit Georeference by clicking **Close Georeference**. Save the project as **IntroToGIS_Lab03_Exercise01**.

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Exercise 02 – Image-to-Map Transformation

Video demonstration: https://mediaweb.ap.panopto.com/Panopto/Pages/Viewer.aspx?id=24a6f354-bb09-4c97-8e67-aeb4000ec6e7

In this task, the following data will be used:

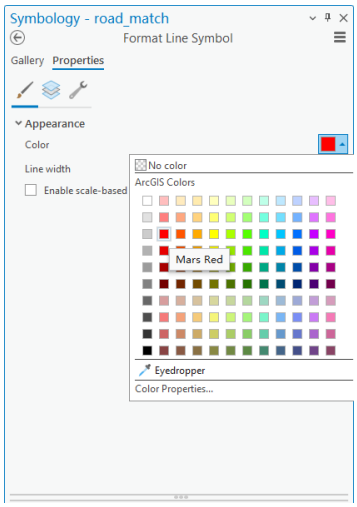
A. spot-pan.bil, a 10-meter SPOT panchromatic satellite image;

B. road.shp, a road Shapefile acquired with a GPS receiver and projected onto UTM coordinates.

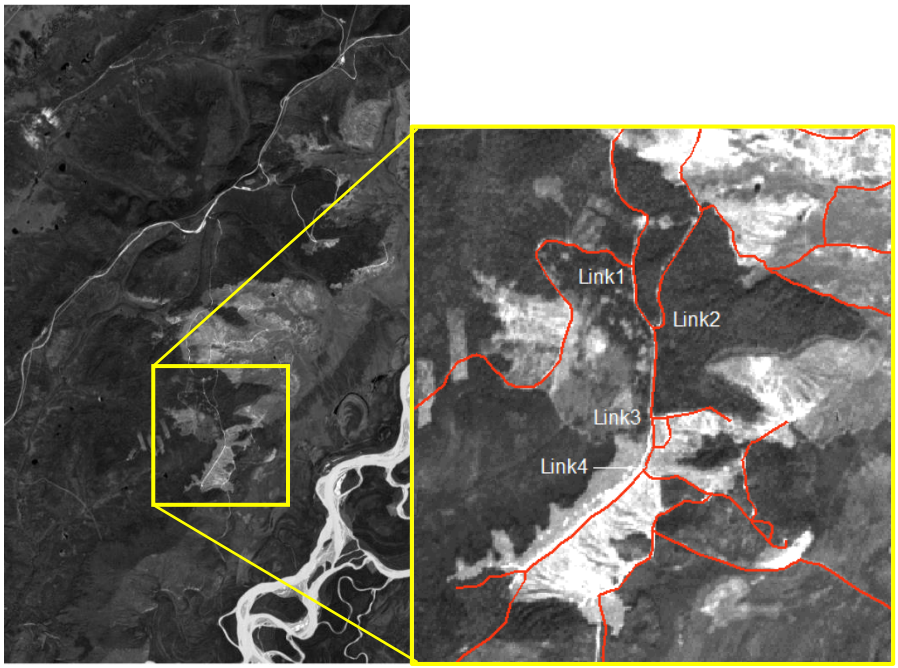
In this task, we will use a vector map and tools in the Georeferencing toolbar to georeference and rectify a satellite image.

1. Open the project **IntroToGIS _Lab03_Exercise01** and save it as **IntroToGIS _Lab03_Exercise02**, in **Catalog** Pane, right-click **Maps** and choose **New Map**. A new map is created, and rename it **Exercise2**.

2. In the Lab03Data folder, make a copy of *spot-pan.bil* and *road.shp*, then rename them as *spot-pan_match.bil* and *road_match.shp* (Note: this is to keep the original data, *spot-pan.bil* and *road.shp, as backup*). Add *spot-pan_match.bil* and *road_match.shp* to the Exercise2 map. Click the **symbol** for *road_match*, and change it to **Mars Red**.



3. You can use the **Zoom to Layer** tool in the context menu to see *road_match*, or *spot-pan_match.bil*, but not both. This is because they are in different coordinates. To see both of them, you must have one or more links to initially georeference *spot-pan_match.bil*. The figure below marks the first four recommended links. They are all at road intersections. Examine these road intersections in both *spot-pan_match.bil* and *road_match* so that you know where they are.



4. Click *spot-pan_match.bil* layer. On the ribbon, click **Imagery** and click on **Georeference** tool. Click Control Point Table in the Review group, select all links from Task 1 in the table and delete them, if they are still there. Save your project.

5. Make sure that **Auto Apply** is activated. Right-click *spot-pan_match.bil* layer and choose **Zoom to Layer**. Zoom in the first road intersection in the image, click **Add Control Points**, and click the first intersection point. Right-click *road_match* and choose **Zoom to Layer**. Zoom in the corresponding first road intersection in the layer, and click the road intersection point. The first link brings both the satellite image and the roads to view. But they are still spatially far apart. Watch the demonstration video if you get confused. Repeat the same procedure to add the other three links (Note: it is recommended to toggle off one layer before you click on the other layer, to avoid clicking on the wrong layer). Each time a link is added, the image is adjusted automatically, and you will find that the two data sources align better. Click **Save** from the **Save** group.

   Note that the starting point is on the *spot-pan_match.bil* image, while the ending point is on the *road_match* vector.

6. Click **Control Points Table**. The table shows four records, one for each link you have added. The Source X and Source Y values are based on the image coordinates of *spot-pan_match.bil*. The image has 1087 columns and 1760 rows (under Source in Layer Properties of *spot-pan_match.bil*). The Source X value corresponds to the column and the Source Y value corresponds to the row. Because the origin of the image coordinates is at the upper-left corner, the Source Y values are negative. The Map X and Map Y values are the UTM coordinates of road. The Residual value shows the RMS error of the control point. The table also shows the transformation method. You can export the link table as a text file at any time, and you can load the file next time to continue the georeferencing process.

7. An image-to-map transformation usually requires more than four control points. For this practice, please identify **a total of no less than 10 links (control points)** and **keep the total RMS error lower than 15 meters**. If a link has a large residual value, delete it and add a new one. Each time you add or delete a link, you will see a change in the total forward RMS error. Export all the control points.

8. Click **Save** to save the rectified spot image.

   Q-4. Please submit the screenshot of your selected GCP points superimposed on the image together with your on-screen georeferencing details (4 marks).

9. Save your project.