APPLICATIONS: GEOMETRIC TRANSFORMATION

This applications section covers three tasks. Task 1 covers the affine transformation of a scanned file. In Task 2, you will use the transformed scanned file for vectorization. As covered in Chapter 5, scanning is a popular data acquisition method. Task 3 covers the affine transformation of a satellite image.

Task 1: Georeference and Rectify a Scanned Map

What you need: *hoytmtn.tif*, a TIFF file containing 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, also called tics, which correspond to the four corner points on the original soil map. Second, you will 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):

Tic-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

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

Tic-Id	*x*	*y*
1	575672.2771	5233212.6163
2	585131.2232	5233341.4371
3	585331.3327	5219450.4360
4	575850.1480	5219321.5730

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

1. Launch ArcMap, and rename the data frame Task 1. Add *hoytmtn.tif* to Task 1. Click the View menu, point to Toolbars, and check Georeferencing. The Georeferencing toolbar should now appear in ArcMap, and the Layer dropdown list should list *hoytmtn.tif*.
2. Zoom in on *hoytmtn.tif* and locate the four control points. These control points are shown as brackets: two at the top and two at the bottom of the image. They are numbered 1 through 4 in a clockwise direction, with 1 at the upper-left corner.
3. Zoom to the first control point. Click (Activate) the Add Control Points tool on the Georeferencing toolbar. Click the intersection point where the centerlines of the bracket meet, and then click again. A plus-sign symbol at the control point turns from green to red. Use the same procedure to add the other three control points.
4. This step is to update the coordinate values of the four control points. Click the View Link Table tool on the Georeferencing toolbar. The link table lists the four control points at the top with their X Source, Y Source, X Map, Y Map, and Residual values. The X Source and Y Source values are the coordinates on the scanned image. The X Map and Y Map values are the UTM coordinates to be entered. The link table offers Auto Adjust, the Transformation method, and the Total RMS Error. Notice that the transformation method is 1st Order Polynomial (i.e., affine transformation). Click the first record, and enter 575672.2771 and 5233212.6163 for its X Map and Y Map values, respectively. (Ignore the warning message about the control points being collinear or not well distributed.) Enter the X Map and Y Map values for the other three records.

Q1. What is the total RMS error of your first trial?

Q2. What is the residual for the first record?

5. The total RMS error should be smaller than 4.0 (meters) if the digitized control points match their locations on the image. If the RMS error is high, highlight the record with a high residual value and delete it. Go back to the image and re-enter the control point. After you have come to an acceptable total RMS error, click OK on the Link Table dialog.
6. This step is to rectify (transform) *hoytmtn.tif.* Select Rectify from the Georeferencing dropdown menu. Take the defaults in the next dialog but save the rectified TIFF file as *rect_hoytmtn.tif.*

Task 2: Use ArcScan to Vectorize Raster Lines

What you need: *rect_hoytmtn.tif,* a rectified TIFF file from Task 1.

ArcScan is an extension to ArcGIS. To use ArcScan, you need to check the extension in ArcMap's Tools menu and to check the toolbar in the View menu. ArcScan can convert raster lines in a bi-level raster such as *rect_hoytmtn.tif* into line or polygon features. The output from vectorization can be saved into a shapefile or a geodatabase feature class. Task 2 is therefore an exercise for creating new spatial data from a scanned file. Scanning, vectorization, and vectorization parameters are topics already covered in Chapter 5.

Vectorization of raster lines can be challenging if a scanned image contains irregular raster lines, raster lines with gaps, or smudges. A poor-quality scanned image typically reflects the poor quality of the original map and, in some cases, the use of the wrong parameter values for scanning. The scanned image you will use for this task is of excellent quality. Therefore, the result from batch vectorization should be excellent as well.

1. This step creates a new shapefile that will store the vectorized features from *rect_hoytmtn.tif.* Right-click the Chapter 6 folder in ArcCatalog, point to New, and select Shapefile. In the Create New Shapefile dialog, enter *hoytmtn_trace.shp* for the name and polyline for the feature type. Click the Edit button in the Spatial Reference frame. Select NAD 1927 UTM Zone 11N for the new shapefile's coordinate system. Click OK to exit the dialogs.
2. Insert a new data frame in ArcMap and rename the data frame Task 2. Add *rect_hoytmtn.tif* and *hoytmtn_trace.shp* to Task 2. Select Properties from the context menu of *rect_hoytmtn.tif.* On the Symbology tab, choose Unique Values and change the symbol for the value of 0 to red. Because raster lines on *rect_hoytmtn.tif* are very thin, you do not see them at first on the monitor. Zoom in and you will see the red lines.
3. Make sure that ArcScan is checked in both the Tools menu and the View menu. Select Start Editing from the Editor's dropdown menu. Select *hoytmtn_trace* to edit. The edit mode activates the ArcScan toolbar. The Raster dropdown list should show *rect_hoytmtn.tif.*
4. This step is to set up the vectorization parameters, which are critical for batch vectorization. Select Vectorization Settings from the Vectorization menu. You can enter the parameter values in the settings dialog or choose a style with the predefined values. Click Styles. Choose Polygons and click OK in the next dialog. Click Apply and then Close to dismiss the Vectorization Settings dialog.
5. Select Generate Features from the Vectorization menu. Make sure that *hoytmtn_trace* is the layer to add the centerlines to. Notice that the tip in the dialog states that the command will generate features from the full extent of the raster. Click OK. The results of batch vectorization are now stored in *hoytmtn_trace.*

Q3. The Generate Features command adds the centerlines to *hoytmtn_trace.* Why are the lines called centerlines?

Q4. What are the other vectorization options besides batch vectorization?

6. The lower-left corner of *rect_hoytmtn.tif* has notes about the soil survey, which should be removed. Click the Select Features tool on the standard (Tools) toolbar, select the notes, and delete them.
7. Select Stop Editing from the Editor's menu and save the edits. Check the quality of the traced soil lines in *hoytmtn_trace.* Because the scanned image is of excellent quality, the soil lines should also be of excellent quality.

Task 3: Perform Image-to-Map Transformation

What you need: *spot-pan.bil,* a 10-meter SPOT panchromatic satellite image; *road.shp,* a road shapefile acquired with a GPS receiver and projected onto UTM coordinates.

You will perform an image-to-map transformation in Task 3. ArcMap provides the Georeferencing toolbar that has the basic tools for georeferencing and rectifying a satellite image.

1. Insert a new data frame in ArcMap and rename the data frame Task 3. Add *spot-pan.bil* and *road.shp* to Task 3. Click the symbol for *road,* and change it to orange. Make sure that the Georeferencing toolbar is available and that the Layer on the toolbar shows *spot-pan.bil.* Click View Link Table on the Georeferencing toolbar, select all existing links in the table, and delete them. (If the toolbar does not show *spot-pan.bil,* right-click *spot-pan.bil,* point to Data, and select Export Data. In the next dialog, export *spot-pan.bil* to a TIFF file called *spot-pan.tif* and use the TIFF file for the rest of the task.)
2. You can use the Zoom to Layer tool in the context menu to see *road,* or *spot-pan.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.bil.* Figure 6.8 marks the first four recommended links. They are all at road intersections. Examine these road intersections in both *spot-pan.bil* and *road* so that you know where they are.

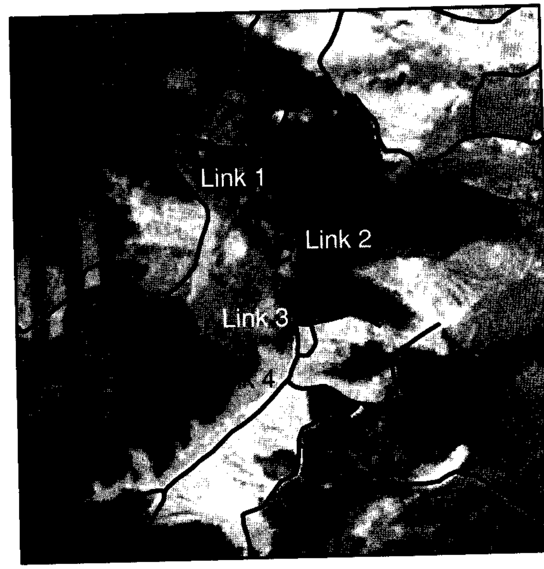

Figure 6.8
The four links to be created first.

3. Check Auto Adjust in the Georeferencing dropdown menu. If Task 3 shows *road,* right-click *spot-pan.bil* and select Zoom to Layer. Zoom to the first road intersection in the image, click Add Control Points on the Georeferencing toolbar, and click the intersection point. Right-click *road* and select Zoom to Layer. Zoom to the corresponding first road intersection in the layer, click the Add Control Points tool, and click the intersection point. The first link brings both the satellite image and the roads to view, but they are still far apart spatially. Repeat the same procedure to add the other three links. Each time you add a link, the Auto Adjust command uses the available links to develop a transformation.
4. Click View Link Table on the Georeferencing toolbar. The Link Table shows four records, one for each link you have added in Step 3. The X Source and Y Source values are based on the image

coordinates of *spot-pan.bil.* The image has 1087 columns and 1760 rows. The X Source value corresponds to the column and the Y Source value corresponds to the row. Because the origin of the image coordinates is at the upper-left corner, the Y Source values are negative. The X Map and Y Map values are based on the UTM coordinates of *road.* The Residual value shows the RMS error of the control point. The Link Table dialog also shows the transformation method (i.e., affine transformation) and the total RMS error. You can save the link table as a text file at any time, and you can load the file next time to continue the georeferencing process.

Q5. What is the total RMS error from the four initial links?

5. An image-to-map transformation usually requires more than four control points. At the same time, the control points should cover the extent of the study area, rather than a limited portion. For this task, try to have a total of 10 links and keep the total RMS error to less than 1 pixel or 10 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 RMS error.

6. This step is to rectify *spot-pan.bil* by using a link table you have created. Select Rectify from the Georeferencing menu. The next dialog lets you specify the cell size, choose a resampling method (nearest neighbor, bilinear interpolation, or cubic convolution), and specify the output name. For this task, you can specify 10 (meters) for the cell size, nearest neighbor for the resampling method, TIFF for the format, and *rect_spot.tif* for the output. Click Save to dismiss the dialog.

7. Now you can use *rect_spot,* a georeferenced and rectified raster, with other georeferenced data sets for the study area. To delete the control points from *rect_spot,* select Delete Control Points from the Georeferencing menu.

8. If you have difficulty in getting enough links and an acceptable RMS error, first select Delete Control Points from the Georeferencing toolbar. Click View Link Table, and load *georef.txt* from the Chapter 6 database. *georef.txt* has 10 links and a total RMS error of 9.2 meters. Then use the link table to rectify *spot-pan.bil.*

9. If the rectified raster turns out to have values ranging from 16 to 255 (and a black image), instead of the expected range of 16 to 100, it means the value of 255 has been assigned to the area outside the image. You can correct the problem by going through the following two steps. First, select Reclassify from the Spatial Analyst dropdown menu. In the Reclassify dialog, click Unique. Click the row with an old value of 255, change its new value to NoData, and click OK. The *Reclass of rect_spot* now has the correct value. Second, right-click *Reclass of rect_spot* and select Properties. Select Stretched in the Show frame. Change the Low Label value to 16, the High Label value to 100, and click OK. Now *Reclass of rect_spot* should look like *spot-pan.bil* except that it has been georeferenced. To save the corrected file, right-click *Reclass of rect_spot,* point to Data, and select Export Data. Then specify the output name and location.

Challenge Task

What you need: *cedarbt.tif.*

The Chapter 6 database contains *cedarbt.tif,* a bi-level scanned file of a soil map. This challenge question asks you to perform two operations. First, convert the scanned file into UTM coordinates (NAD 1927 UTM Zone 12N) and save the result into *rec_cedarbt.tif.* Second, vectorize the raster lines in *rec_cedarbt.tif* and save the result into *cedarbt_trace.shp.* There are four tics on *cedarbt.tif.* Numbered clockwise from the upper left corner, these four tics have the following UTM coordinates:

Tic-Id	x	y
1	389988.78125	4886459.5
2	399989.875	4886299.5
3	399779.1875	4872416.0
4	389757.03125	4872575.5

Q1. What is the total RMS error for the affine transformation?

Q2. What problems, if any, did you encounter in vectorizing *rec_cedarbt.tif*?

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