Chapter 6 Geometric Transformation

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Geometric Transformation

- Geometric transformation is the process of using a set of control points and transformation equations to register a digitized map, a satellite image, or an air photograph onto a projected coordinate system.
- In GIS, geometric transformation includes map-to-map transformation and image-to-map transformation.

Transformation Methods

Different methods have been proposed for transformation from one coordinate system to another. Each method is distinguished by the geometric properties it can preserve and by the changes it allows.

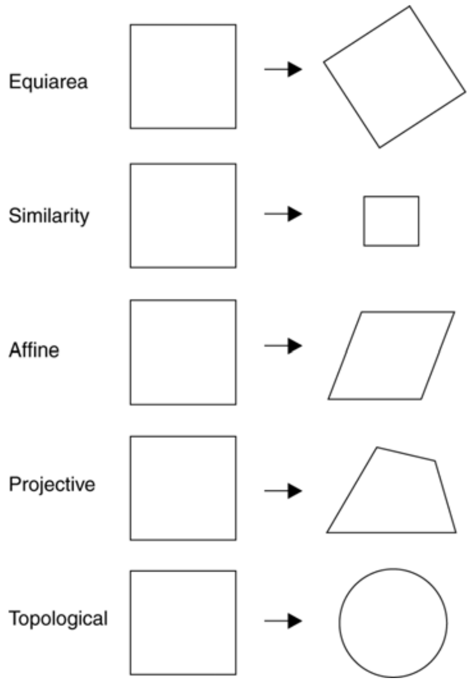

Figure 6.1
Different types of geometric transformations.

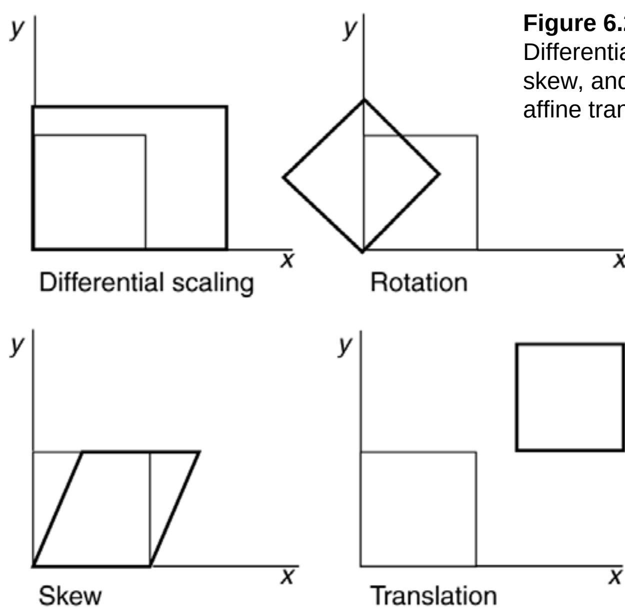

Figure 6.2
Differential scaling, rotation, skew, and translation in the affine transformation.

Control Points

- Control points play a key role in determining the accuracy of an affine transformation.
- Selection of control points for a map-to-map transformation is relatively straightforward. What we need are points with known real-world coordinates.
- Control points for an image-to-map transformation, also called ground control points, are points where both image coordinates (in rows and columns) and real-world coordinates can be identified. GCPs are selected directly from a satellite image; the selection is not as straightforward as selecting four tics for a digitized map.

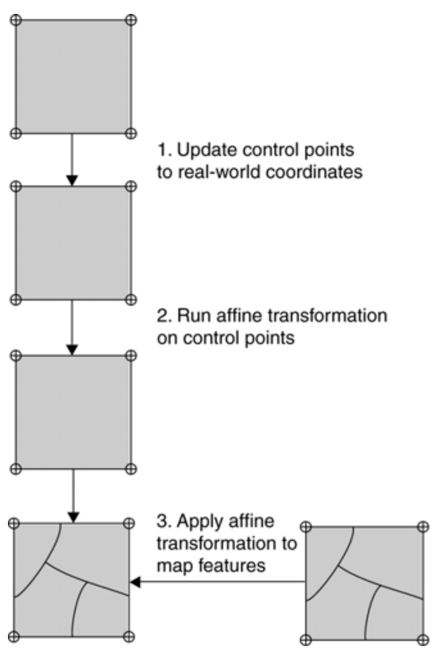

Figure 6.3
A geometric transformation typically involves three steps. Step 1 updates the control points to real-world coordinates. Step 2 uses the control points to run an affine transformation. Step 3 creates the output by applying the transformation equations to the input features.

Root Mean Square (RMS) Error

The root mean square (RMS) error is a common measure of the goodness of the control points. It measures the deviation between the actual (true) and estimated (digitized) locations of the control points.

Interpretation of RMS Errors

- If a RMS error is within the acceptable range, we usually assume that the transformation of the entire map is also acceptable.
- This assumption can be quite wrong, however, if gross errors are made in digitizing the control points or in inputting the longitude and latitude readings of the control points.

Figure 6.4
Inaccurate location of soil lines can result from input or estimated tic location errors. The thin lines represent correct soil lines and the thick lines incorrect soil lines. In this case, the *x* values of the upper two tics were increased by 0.2'' while the *x* values of the lower two tics were decreased by 0.2'' on a third quadrangle (15.4'' x 7.6'').

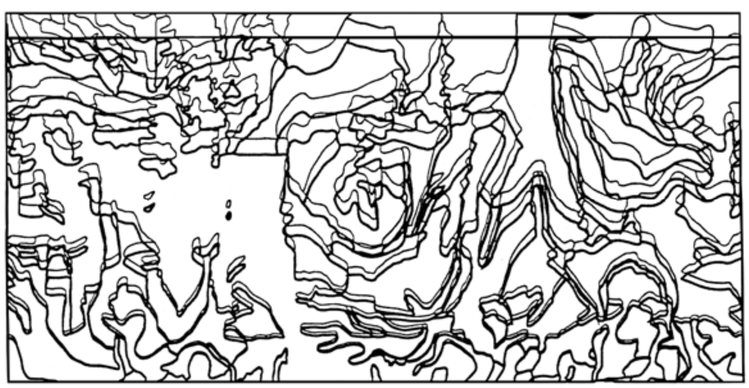

Figure 6.5
Incorrect location of soil lines can result from output or actual tic location errors. The thin lines represent correct soil lines and the thick lines incorrect soil lines. In this case, the latitude readings of the upper two tics were off by 10'' (e.g., 47˚27'20'' instead of 47˚27'30'') on a third quadrangle.

Resampling of Pixel Values

Resampling is a process that fills each pixel of the new image derived from an image-to-map transformation with a value or a derived value from the original image.

Resampling Methods

- Three common resampling methods are nearest neighbor, bilinear interpolation, and cubic convolution.
- The nearest neighbor resampling method fills each pixel of the new image with the nearest pixel value from the original image.
- The bilinear interpolation method uses the average of the four nearest pixel values from three linear interpolations.
- The cubic convolution method uses the average of the 16 nearest pixel values from five cubic polynomial interpolations.

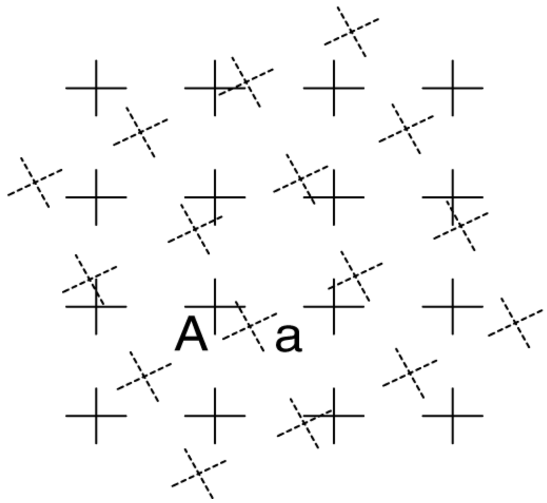

Figure 6.6
Because *a* in the original image is closest to pixel *A* in the new image, the pixel value at *a* is assigned to be the pixel value at *A* using the nearest neighbor technique.

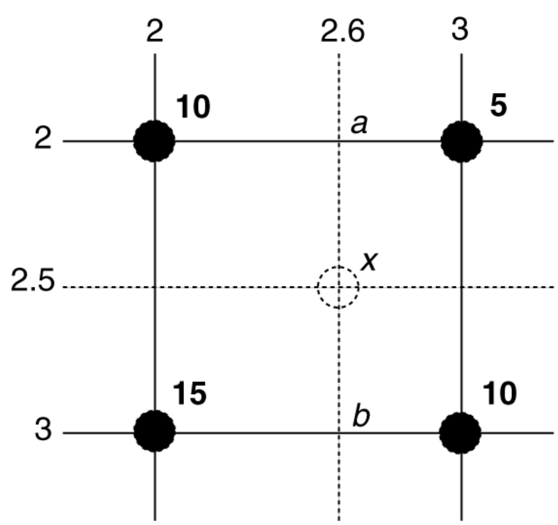

Figure 6.7
The bilinear interpolation method uses the value of the four closest pixels (black circles) in the original image to estimate the pixel value at *x* in the new image.

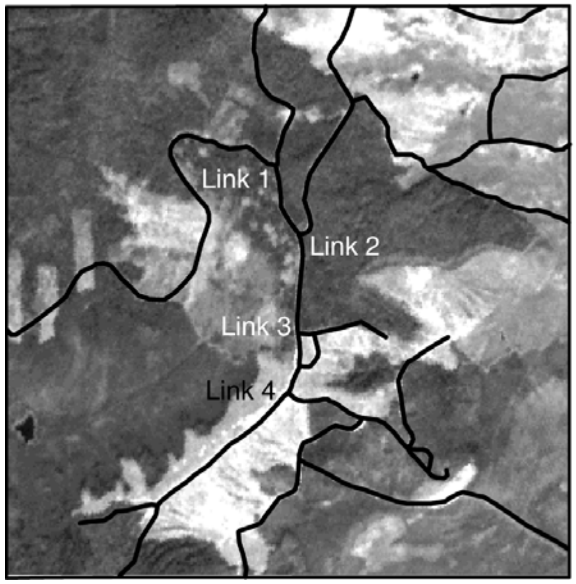

Figure 6.8
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