Geographic Information Systems 2018/19
Week 8, Topic 2

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In this session...

Data transformation & accuracy

- Transformation
  - Geometric transformation
  - Root mean square (RMS) error
  - Line simplification
  - Vector to/from Raster
- Accuracy
  - Standards
  - Error handling

Geometric transformation

The process of using a set of control points and transformation equations to register a digitized map, satellite image or aerial photo onto a pprojected coordinate system

Map to map

- Digitizer units (e.g. dpi) to coordinates

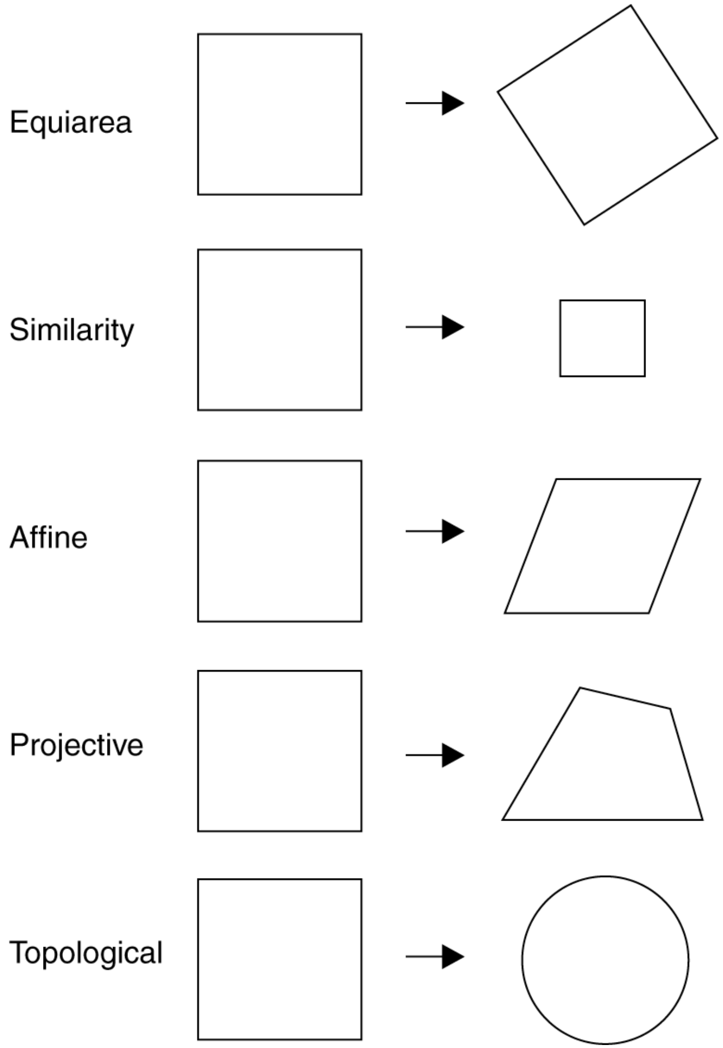
Image to map

- Row/column values of pixels to coordinates
- Also called georeferencing

Both use a set of control points to establish a mathematical model relating image coordinates to projected coordinates

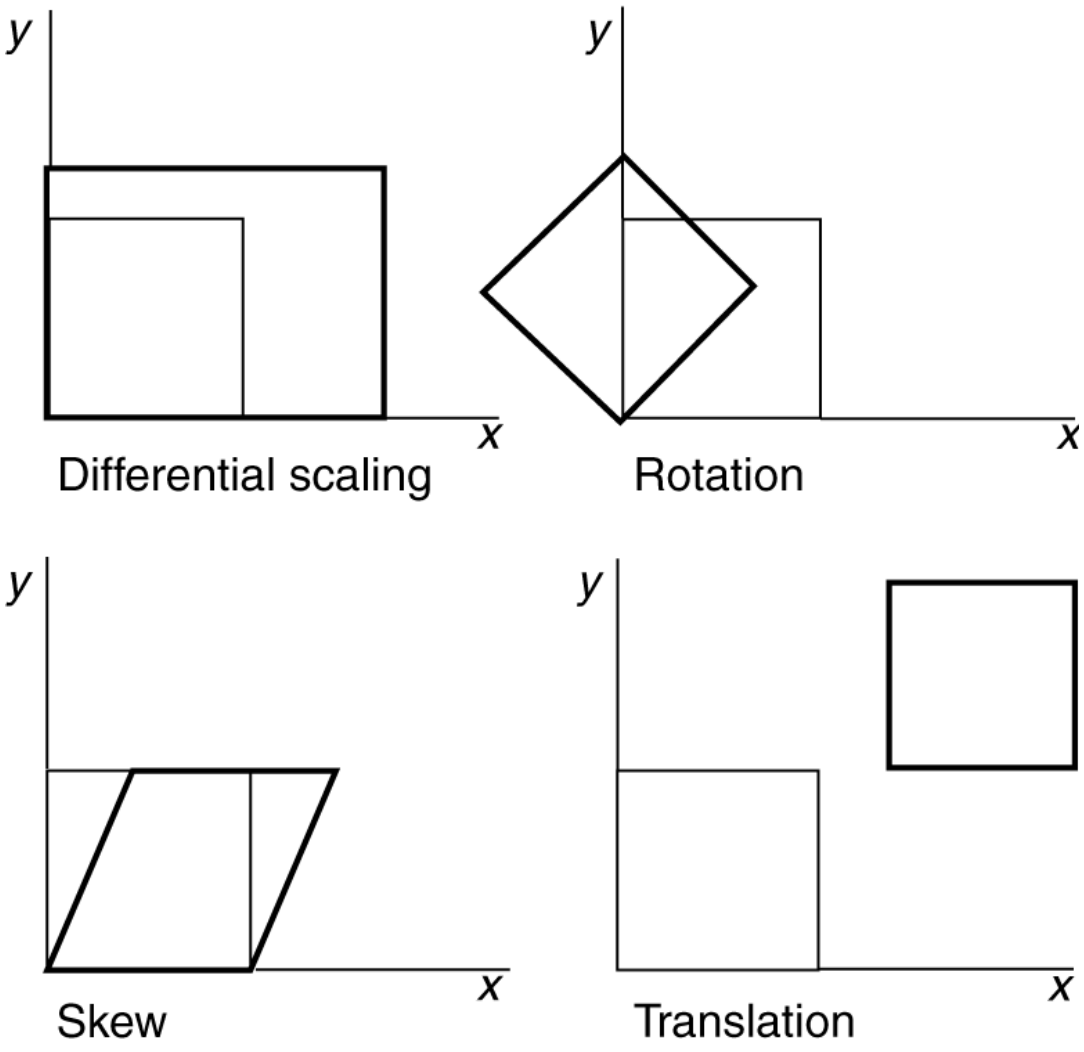
Root mean square (RMS) error measures the quality of the transformation

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.

Affine transformation
(allows angular distortion but preserves parallelism)



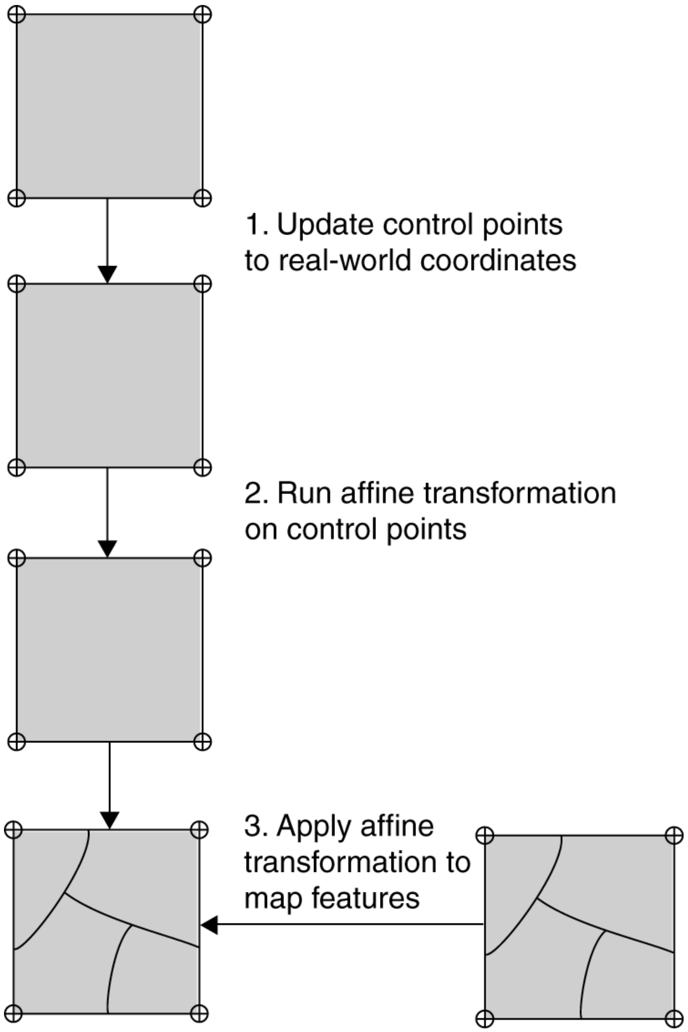
Differential scaling, rotation, skew, and translation in the affine transformation.

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.



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

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(P_i - O_i\right)^2}{n}}$$

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.

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.

Resampling of Pixel Values

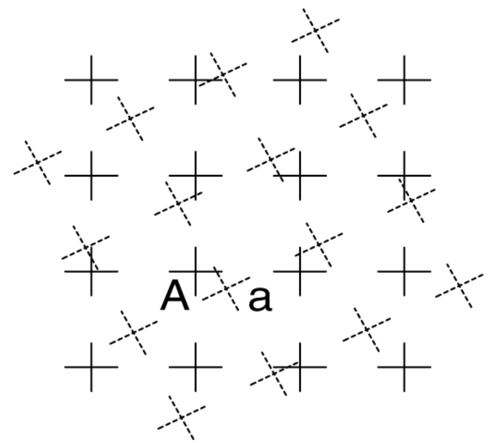
Resampling is a process that fills each pixel of the new image derived from an image-to-map transformation with a value or a derived value from the original image.

Three common resampling methods are nearest neighbor, bilinear interpolation, and cubic convolution.

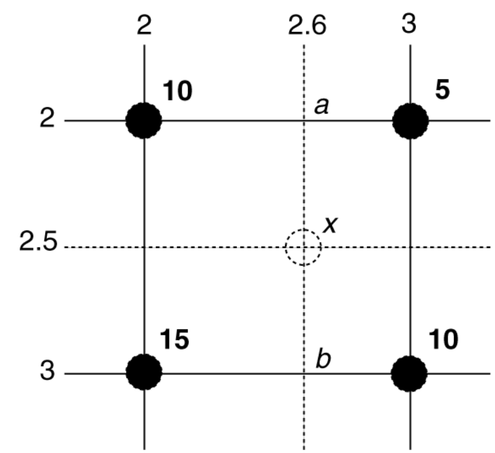
The nearest neighbor resampling method fills each pixel of the new image with the nearest pixel value from the original image.

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.

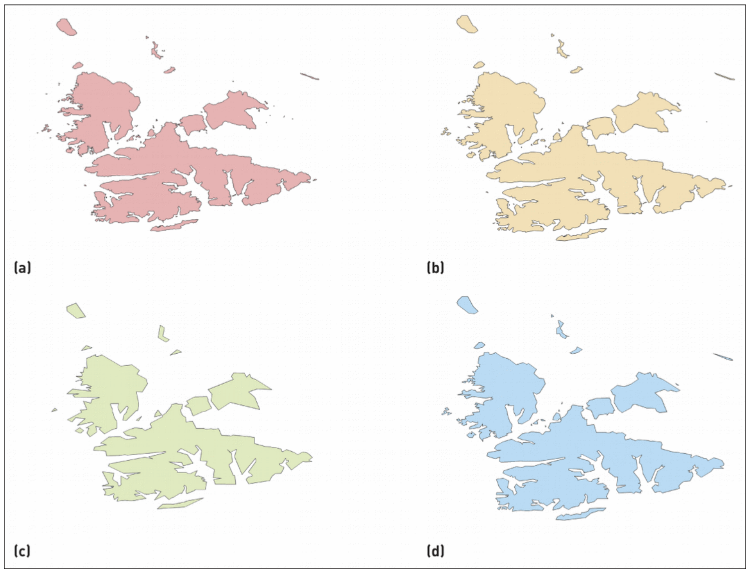


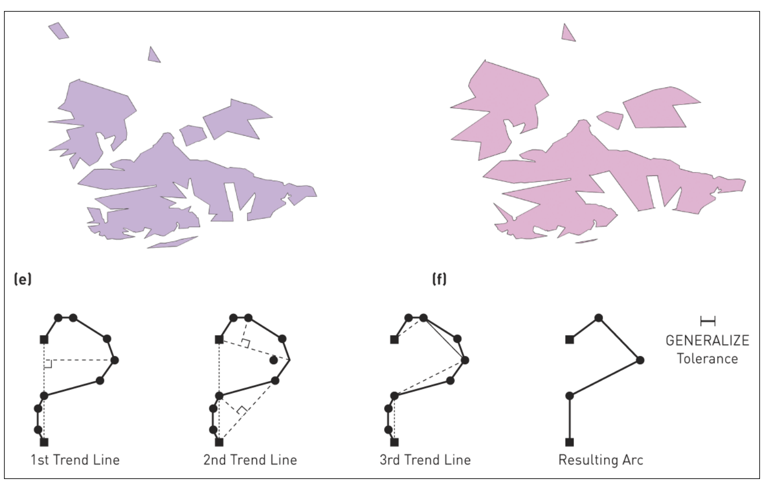
Because a in the original image is closest to pixel A in the new image, the pixel value at a is assigned to be the pixel value at A using the nearest neighbor technique.



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.

Douglas-Peucker Algorithm





Join start/end nodes of a line with a straight line

Examine the perpendicular distance from this straight line to vertices along digitized line

Discard points within a certain threshold of the straight line

Move the straight line to join start point to vertex greatest distance from original straight line

Repeat until no more points closer than the threshold distance

Coming next...

Spatial Data Quality and Accuracy

- Standards
- Error handling