LA502 Special Studies Remote Sensing

Image Geometric Correction

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Overview

- Image rectification
- Geometric errors
- Transformation methods
- Resampling methods
- Rectification procedures

Why Geometric Correction?

- Essential for almost all remote sensing projects
- Allows image to correspond to real world map coordinates
- Critical for combining imagery and GIS
- Essential for obtaining spatially accurate products—requires considerable care

Images rectification

- Images rectification and image restoration techniques are used to correct image data for distortions, noise reduction, or data reconstruction.
- Data reconstruction is necessitated by the design of the sensor system, by the limitations of one or more of its components, or by the malfunction of components.

Image rectification

- Image rectification is the processing by which the geometry of an image is made planimetric.
- Whenever accurate area, direction, and distance measurements are required, image rectification (image to map) should be performed.
- However, it may not remove all distortion caused by topographic relief displacement in images.

Preprocessing

Because rectification and restoration techniques are often followed by other image processing techniques, they are commonly referred to as *preprocessing* techniques.

Geometric transformation

These rectification techniques are very similar to or identical to the techniques that are used to register vector or raster data layers to real world coordinate systems by converting existing coordinates to coordinates that are tied to a mapping coordinate system.

Therefore, they are also referred to as *geometric transformation techniques*.

Geometric transform

- The need to transform the coordinates of input data to real world coordinates applies also to data that is originally acquired in analog format but has been converted to digital format by scanning, including:
- Aerial photographs,
- Scanned map images, and
- Vector features digitized from hardcopy or softcopy documents with a digitizer or with onscreen digitizing techniques.

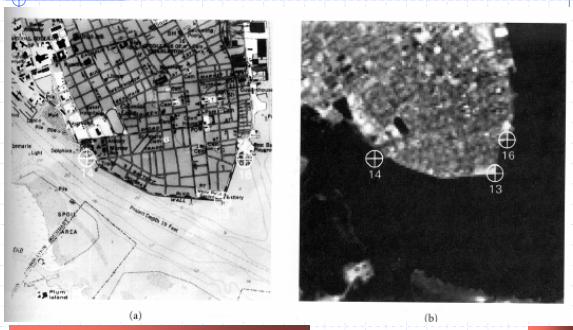
Control points

- Control points are needed to correct non-systematic distortions.
- These points are clearly discernible points have known coordinate values in both the input coordinate system and the desired output coordinate system.

Ground Control Points

- The true ground coordinates are typically measured from a map.
- GPS is a new tool for obtaining GCPs.
- Geometric registration may also be performed by registering one (or more) images to another image, instead of to geographic coordinates. This is called *image-to-image registration*

Ground Control Points (GCPs)



Ground Control Points

- The coordinates of control points are used by image processing software in a *least squares regression analysis* to determine the parameters of formulas that can be used to calculate new output coordinates for points where only the input coordinates are previously known.

Digital Image Processing

- The geometric transformation process is also commonly referred to as *georeferencing* because it fits the original coordinate data for a coordinate system that can be tied to the Earth's surface.
- Georeferenced data layers correctly overlay other data layers referenced to the same coordinate system in a GIS.

Terminology

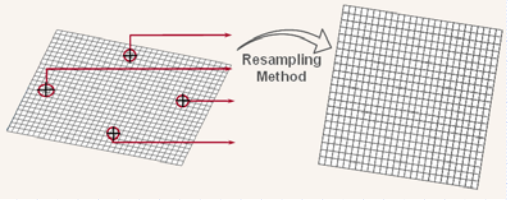
- *Rectification*: the alignment of an image to a map so that the image is planimetric. (aks *Georeferencing*)
- *Registration*: the alignment of one image to another image of the same area.
- *Orthorectification*: Correction of the image, pixel-by pixel, for topographic distortion.
- *Geocoding:* a special case of rectification that includes scaling to a uniform, standard pixel size.

Accuracy

- Because the coordinates of a set of control points are used to calculate the coordinates of all other points in the output data layer, any imprecision in the values in either the input or output coordinate system will be passed on to the output values calculated for *all* of the input coordinates.

Resampling

Resampling techniques use data contained in an input grid to generate data values for an output grid with different geometry.



Resampling techniques

One objective of all resampling techniques is to eliminate or minimize data loss by not altering pixel values (as is accomplished with the nearest neighbor technique) or by minimizing the alteration of pixel values to maintain data integrity (using the other resampling techniques).

Rectification procedures

- General procedures of image rectification:
  1. Select the polynomial models (the order)
  2. Select GCPs (get image coordinates and their corresponding map coordinates)
  3. Determine the coefficients
  4. Coordinates transformation between image coordinates and map coordinates via the selected GCPs based on polynomial models
  5. Resampling

Image rectification

- **1. Select Polynomial models**

$u = f(x, y) \quad v = g(x, y)$

(x, y) are the map coordinates and (u, v) are the image coordinates

First-order polynomial:

$u = a_0 + a_1 x + a_2 y$

$v = b_0 + b_1 x + b_2 y$

Second-order polynomial:

$u = a_0 + a_1 x + a_2 y + a_3 xy + a_4 x^2 + a_5 y^2$

$v = b_0 + b_1 x + b_2 y + b_3 xy + b_4 x^2 + b_5 y^2$

Polynomial models

- 1st Order
  - Requires minimum of 3 GCPs
  - Use for small, flat areas
- 2nd Order
  - Requires minimum of 6 GCPs
  - Use for larger area where earth curvature is a factor
  - Use where there is moderate terrain
  - Use with aircraft data where roll, pitch, yaw are present

Polynomial models

- 3rd Order
  - Requires minimum of 10 GCPs
  - Very rugged terrain

Image rectification

- **2. Select GCPs**
  - Road intersections, river bends, distinct natural features, etc.
  - GCPs should be spread across image
  - Requires a minimum number depending on the type of transformation
  - [N= (t+1)(t+2)/2] where t: polynomial order
  - Must choose a map projection for GCP coordinates.

Image rectification

- **3. Determine the coefficients**

First-order polynomial:

$$u = a_0 + a_1 x + a_2 y$$

$$v = b_0 + b_1 x + b_2 y$$

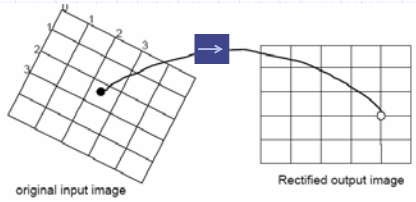
Second-order polynomial:

$$u = a_0 + a_1 x + a_2 y + a_3 xy + a_4 x^2 + a_5 y^2$$

$$v = b_0 + b_1 x + b_2 y + b_3 xy + b_4 x^2 + b_5 y^2$$

Image rectification

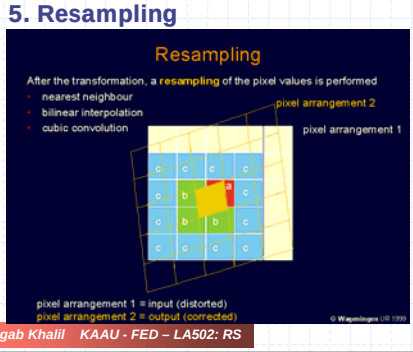
- **4. Coordinate transformation**



$u = a_0 + a_1 x + a_2 y = a_0 + xa_1 + ya_2 = 2.1$
$v = b_0 + b_1 x + b_2 y = b_0 + xb_1 + yb_2 = 2.5$
(x, y) is the UTM coordinate

Image rectification

- **5. Resampling**



Procedures _Summery

General procedures of image registration:

1. Select the polynomial models (the order)
2. Select GCPs (get image coordinates in both images)
3. Establish the mathematical relationship between image coordinates in the reference image and uncorrected image via the selected GCPs based on polynomial models.
4. Coordinates transformation
5. Resample