Photogrammetry: DTM Extraction & Editing

How can one determine the x, y, and z of a location?

Approaches to DTM Extraction

- Ground surveying
- Digitized topographic maps
- Traditional photogrammetry
  - Hardcopy vs. softcopy approach
- Radar
- LIDAR
Photogrammetry

- The science of making reliable measurements by the use of photographs and especially aerial photographs.

- Challenges:
  - Geometric distortions (transformation)
  - Relief displacement (ortho-rectification)
  - Obscured targets (true-orthorectification)

Distortion

- Distortion: shift in the position of an image on a photograph that alters the perspective characteristics of the image.

- Displacement: shift in the position of an image on a photograph that does not alter the perspective characteristics of the photo
Types of Distortion

• Film and print Shrinkage
• Atmospheric Reaction of light rays (refraction)
• Image motion
• Lens Distortion

The effects of film shrinkage, atmospheric refraction are usually negligible in most cases.

Geometric Distortions

• External errors
  – Altitude changes
  – Attitude changes (roll, pitch, and yaw)

• Internal errors
  – e.g., lens distortion, earth rotation
Methods of Correcting Geometric Distortion

- Affine Transformation (aka linear or first-order transformation)
- Higher order polynomial transformation
Orthophoto & Ortho-rectification

Orthophotos - orthographic photographs
  • Photographs that do not have distortions nor displacements.

True orthophotos:
http://www.sharpqis.net/page/True-Orthophoto-Generation.aspx

How to tell if triangles are similar
  • AAA are congruent (i.e., coincident)
  • SSS in same proportion
  • SAS (proportional sides next to congruent angle)
Known: $x_0, y_0, x_1, y_1$, and $x$
Find: $y$

\[
\frac{y - y_0}{y_1 - y_0} = \frac{x - x_0}{x_1 - x_0}
\]

\[
y = y_0 + \left( x - x_0 \right) \frac{y_1 - y_0}{x_1 - x_0}
\]

Basic Aerial Photography Geometry

- Fiducial marks
- Principal point
Geometric Components of Relief Displacement

\[ \frac{1}{S} = \frac{f}{H} \]

1/S: photo scale  
f: focal length of camera  
H: flying height

\[ d = \frac{rh}{H} \]

\[ h = \frac{dH}{r} \]

d = relief displacement  
h = object height  
r = radial distance between location and PP on photo  
H = flying height

Relief Displacement

RD changes the measured distances and angles on photos.
Correcting for Relief Displacement: Orthorectification

\[ d = \frac{r h}{H} \]

d = relief displacement
h = object height
r = radial distance between location and PP on photo
H = flying height

Image Parallax

- the apparent displacement or the difference in apparent direction of an object as seen from two different points not on a straight line with the object.

\[ p_a = x_a - x'_a \]

\( p_a \) = parallax of point A
\( x_a \) = x coor of a on left photo
\( x'_a \) = x coor of a' on right photo

Figure 3.15 Parallax displacements on overlapping vertical photographs.
Figure 189: Exposure Stations Along a Flight Path

Figure 190: A Regular Rectangular Block of Aerial Photos

Image Parallax

\[
p_a = x_a - x'_a
\]

\[
p_a = d_a + d'_a
\]

\[
p_a = d_a - d'_a
\]
Calculating Object Height & Location from Parallax

Parallax Equations:

\[ h_A = H - \frac{B \times f}{p_a} \]
\[ X_A = B \frac{x_a}{p_a} \]
\[ Y_A = B \frac{y_a}{p_a} \]

- \( p_a \) = parallax of A
- \( x_a \) = x coor of A on left photo
- \( X_A \) = ground coor of A
- \( h_a \) = height of A
- \( B \) = air base
- \( H \) = flying height

Figure 1.17 Parallax relationships on overlapping vertical photographs: (a) adjacent photographs forming a stereopair; (b) superimposition of right photograph onto left.
Measuring Parallax

Based on a stereopair of photos
- Floating half marks
- Parallax wedge

Digital Photogrammetry:
Softcopy Photogrammetric Systems

- Scanned stereopair photos
- Interior and exterior orientations
  - Camera & photo parameters
  - Flight parameters
  - GCPs
- Image matching
  - Tie points
  - Algorithms
- Generate DEM and orthophotos
Collinearity Condition & Equations

- Alignment of exposure station (O), object location on the photo (p), and object location on the ground (P).

- If collinearity condition is achieved on both photos in a stereopair then the ground X, Y, Z can be computed from x and y within the image coordinate system on both photos.

- Six exterior orientation parameters

- Collinearity equations can be derived using GCPs.

- Inertial Measurement Unit (IMU)