CE-317 GIS/RS Application to Civil Engineering
Spring 2011

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- Lecture 10: Photogrammetry Survey

Overview

- Definition
- Stereoscope
- Main Tasks
- Why
- Sources
- History
- Principle

Photogrammetry

- Photogrammetry can be defined as:
  - the "*science of measuring in photos*"
- It is traditional a part of geodesy, belonging to the field of remote sensing (RS).

Data from Photo

- Qualitative data
  - The house seems to be old, the walls are colored light yellow.
- Quantitative data
  - The house has a base size of 8 by 6 meters from photo measurement.

Data from Photo

- Information in addition to your background knowledge
  - The house has elements of the “art nouveau” style, so may be constructed at the beginning of the 20th century, and so on.

Photogrammetry

- Photogrammetry provides methods to give you information of the second type, **quantitative data**.

From where, 3rd Dimension comes from?

- Properties of human vision.
- We are able to see objects in a spatial manner.
- We are able to estimate the distance between an object and us.
- Our brain at all times gets two slightly different images. (different positions of the left, right eye and the eye's central perspective.)

Stereoscope

- This principle is called stereoscopic viewing.
  - Two (or more) photos from the same object but taken from different positions.
  - The three-dimensional co-ordinates of any point which is represented in both photos.

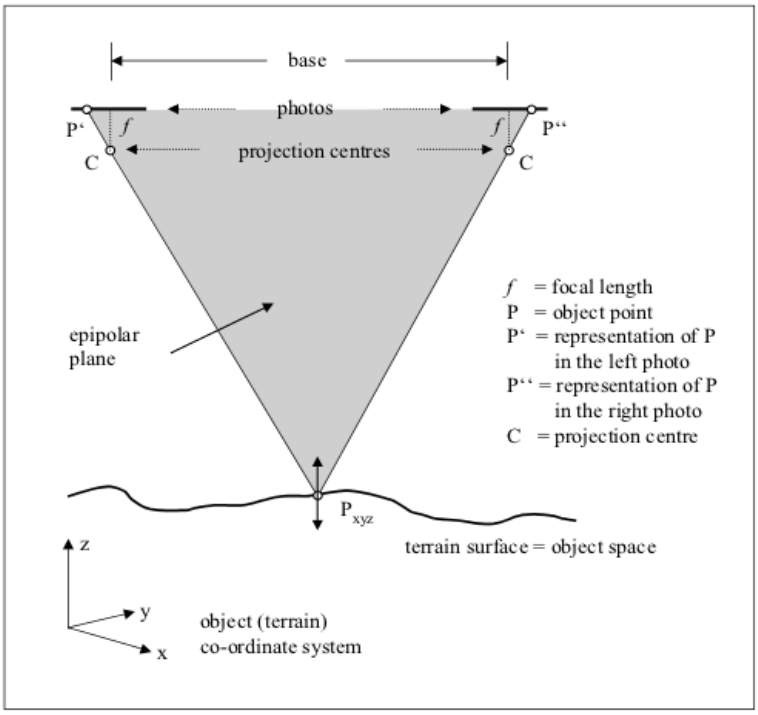

Fig. 1: Geometry in an oriented stereo model. Changing the height in point P (on the surface) leads to a linear motion (left – right) of the points P' and P'' within the photos along *epipolar lines*.

Main Task of Photogrammetry

- For any object point represented in at least two photos we have to calculate the three-dimensional object (terrain) co-ordinates.

Why Photogrammetry ?

- There are many situations in life or science in which we must measure co-ordinates, distances, areas or volumes.
- Photogrammetric techniques may be used as an alternative or in which photogrammetry is the only possible way to measure.

Why Photogrammetry ?

- The object itself doesn't exist any more but only photos from the object.
- Similar to this are situations in which the object cannot be reached.
- For instance, imagine areas far away or in countries without adequate infrastructure, which then can be photographed to create maps.

Why Photogrammetry ?

- Measure in photos means also measure without a physical contact to the object.
- Therefore, if you have very smooth objects like liquids, sand or clouds, photogrammetry will be the tool of choice.
- All kind of fast moving objects will be measured with photogrammetry.
- For instance these may be running or flying animals or waves.

Why Photogrammetry ?

- In industry, high speed cameras with simultaneous activation are used to get data about deformation processes (like crash tests with cars).
- In some examples, nowadays laser scanner equipment is an alternative to photogrammetry.
- In the aerial case laser scanning is used to get information about the relief (terrain models).
- Also to get large amounts of three-dimensional point data (point clouds).

Why Photogrammetry ?

- On the other hand, laser scanning is time consuming and up to now very expensive, comparing with photogrammetric methods.
- Laser scanning cannot be used for fast moving objects.
- Therefore, these methods may be seen as a supplement to photogrammetry.

Image Sources: Analogue and Digital Cameras

- Photogrammetry is closely connected with that of aviation and photography.
- During more than 100 years, photos have been taken on glass plates or film material (negative or positive).
- In principle, specific photogrammetric cameras (also simply called metric cameras) work the same way as the amateur camera you might own.
- The differences result from the high quality demands which the first ones must fulfil.

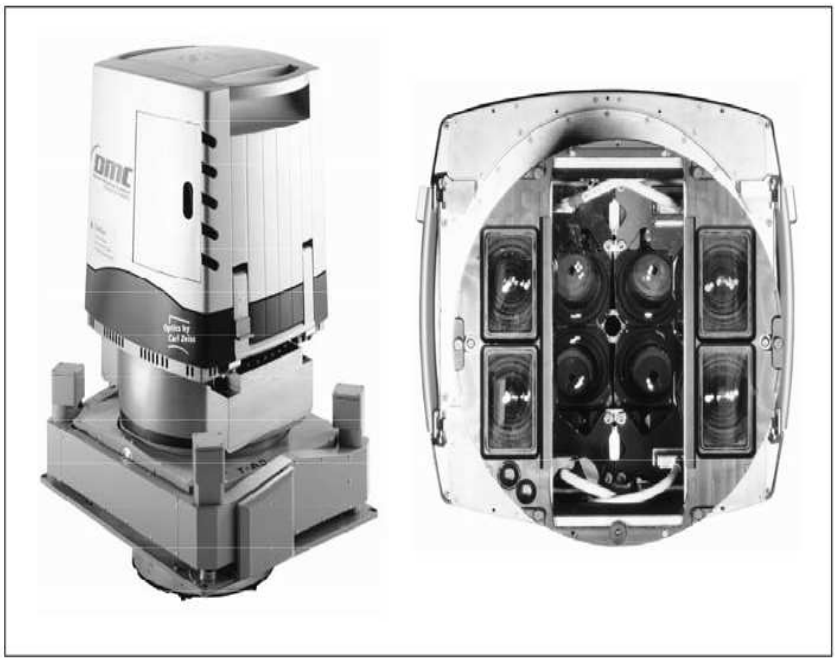

Fig 2: The DMC (Digital Mapping Camera) – an example of a digital aerial camera. Left: Camera mounted on carrier. Right: View from below – you can see the lenses belonging to the four area sensors. Courtesy of Intergraph Corp., USA.

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Fig. 3: Example of metric digital cameras: The medium-format AIC (left) and the small-scale d7 metric (right) from Rollei. Courtesy of Rollei Fototechnic, Germany.

Cameras

- You may know the size of 24 by 36 mm from your own camera – aerial cameras normally use a size of 230 by 230 mm (9 by 9 inch)!
- This is necessary to receive a good ground resolution in the photos.
- As a result, the values of “wide angle”, “normal” and “telephoto” focal lengths differ from those you may know.

Cameras

- For example, the often used wide angle aerial camera has a focal length of about 153 mm, the normal one a focal length of about 305 mm.
- Furthermore, the lens system of aerial cameras is constructed as a unit with the camera body.
- No lens change or “zoom” is possible to provide high stability and a good lens correction.
- The focal length is fixed, and the cameras have a central shutter.

Cameras

- Close-range applications special cameras were developed with a medium or large film format and fixed lenses.
- Z/I imaging (now Intergraph Corp.), Leica or Vexcel have been developing digital aerial cameras.
- Nowadays digital consumer cameras have reached a high technical standard and good geometric resolution and are available for low prices.

Digital Consumer Cameras

- The differences of the construction principles between metric and consumer cameras can be seen in general in quality and stability of the camera body and the lens.
- Consumer cameras usually have a zoom (“vario”) lens with larger distortions which are not constant but vary for instance with the focal length.
- So it is difficult to correct them with the help of a calibration.

To Purchase a Digital Camera

- To purchase a digital camera to use it for photogrammetry please take the following remarks into account:
- **General:** It should be possible to set the parameters focal length, focus, exposure time and f-number manually, at least as an option.
- **Resolution (Number of pixels):** Decisive is the real (physical), not an interpolated resolution!
  - The higher the number of pixels, the better.

To Purchase a Digital Camera

- **Focal length range (zoom):** Decisive is the optical, not the digital (interpolated) range!
- **Distance setting (focus):** It should be possible to de-activate the auto focus.
  - If the camera has a macro option you can use it also for small objects.
- **Exposure time, f-number:** The maximum f-number (lens opening) should not be less than 1:2.8, the exposure time should have a range of at least 1 ... 1/1000 seconds.

To Purchase a Digital Camera

- **Image formats:** The digital images are stored in a customary format like JPEG or TIFF.
- **Storage:** Usual are SD memory cards with capacities up to 1 GB.
- **Energy supply:** Make sure that you can use customary batteries or accumulators.
- **Others:** Sometimes useful are a tripod thread, a remote release and an adaptor for an external flash.

Short History of Photogrammetric Evaluation Methods

- Three main phases of photogrammetry.
- Each took a time of about 20 years or even more.

1. Analogue Photogrammetry:

- Reconstruction of the orientation or briefly orientation
- In the first decades of photogrammetry this was done in a pure optical-mechanical way.
- Work like measuring, mapping and so on was carried out mechanically.

Short History of Photogrammetric Evaluation Methods

2. **Analytical Photogrammetry:**
   - With the upcoming of computers, the idea was to reconstruct the orientation no more analogue but algorithmic – via formulas with their parameters (coefficients)
   - Analytical plotter
3. Digital Photogrammetry:
   - PC nowadays has power and storage capacity enough to handle high-resolution digital photos.

Short History of Photogrammetric Evaluation Methods

- "Classical" aerial cameras are in use.
- Only digital scanner is required.
- On the other hand, Digital camera has its own advantages.

Geometric Principles

1. Camera position, Focal Length
   - The smaller the distance camera – object and the wider the lens angle, the greater are the displacements due to the central perspective, or, vice versa:
   - The greater the distance camera – object and the smaller the lens angle, the smaller are the displacements.

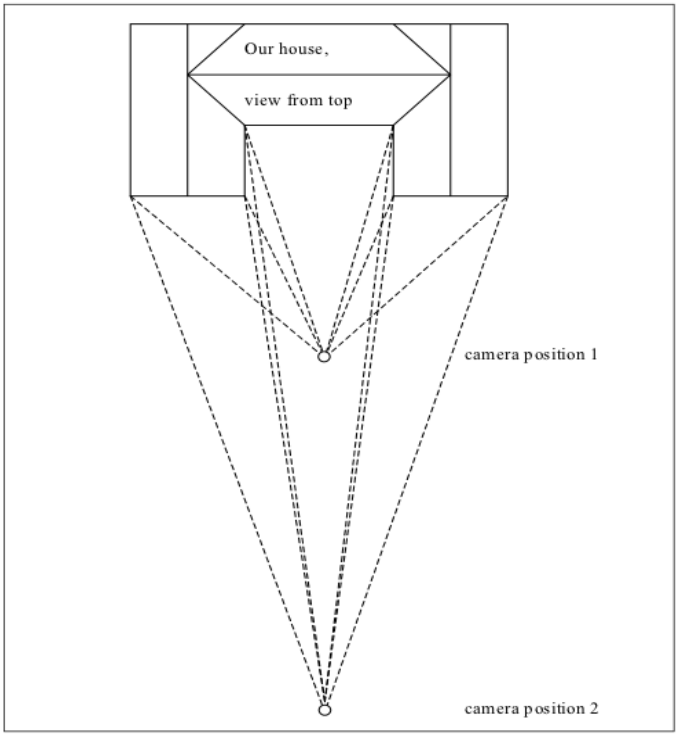

Fig. 4: Different positions and lens angles. The situation, view from above.

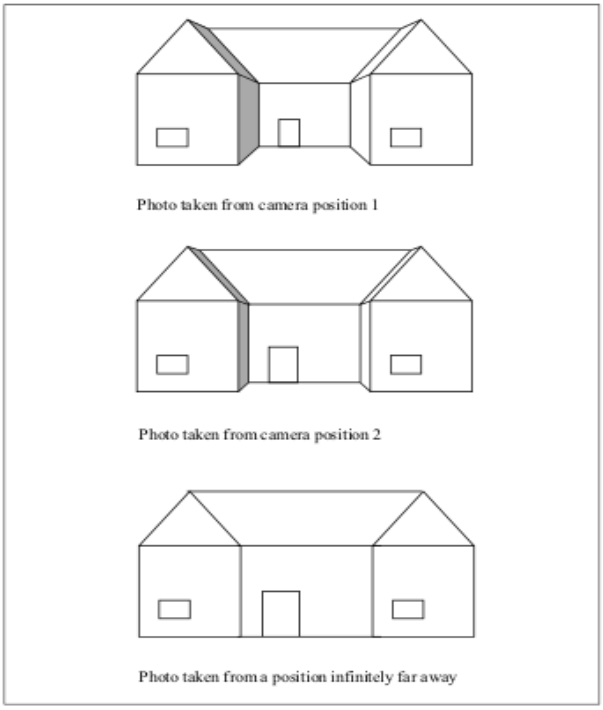

Fig. 5: The results: Photos showing the house in same size but in different representations due to the central perspective.

Geometric Principles

2. Image Orientation??
3. Relative camera positions (stereo)??

- Some definitions:
  - Photo, Image, Model (stereo model, image pair), Strip, Block, Base??

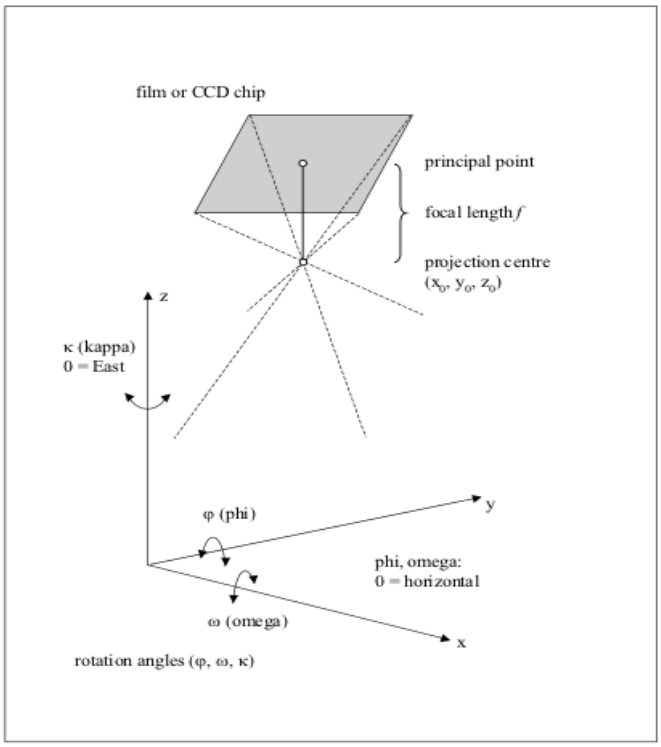

Fig. 6: Focal length, projection centre and rotation angles

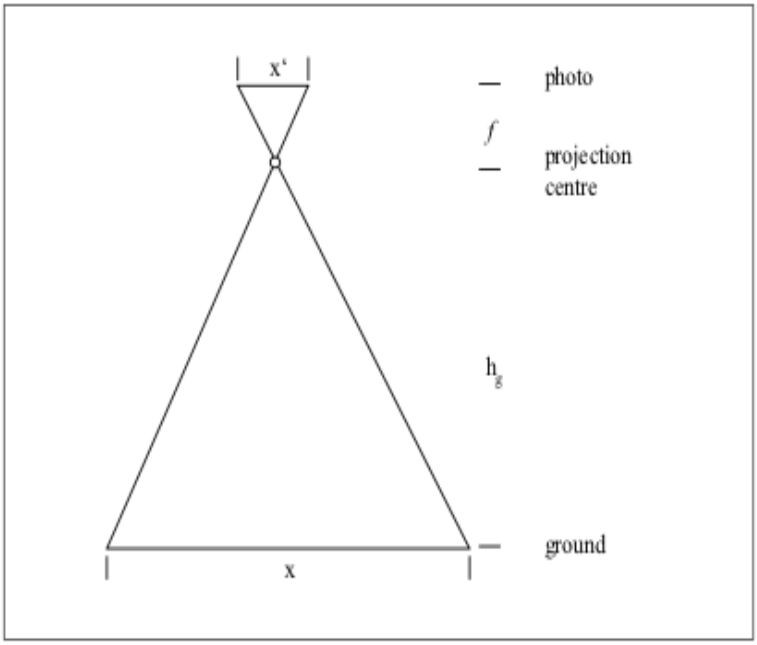

Fig. 7: Relations between focal length *f*, height above ground h_g and the photo scale f/h_g

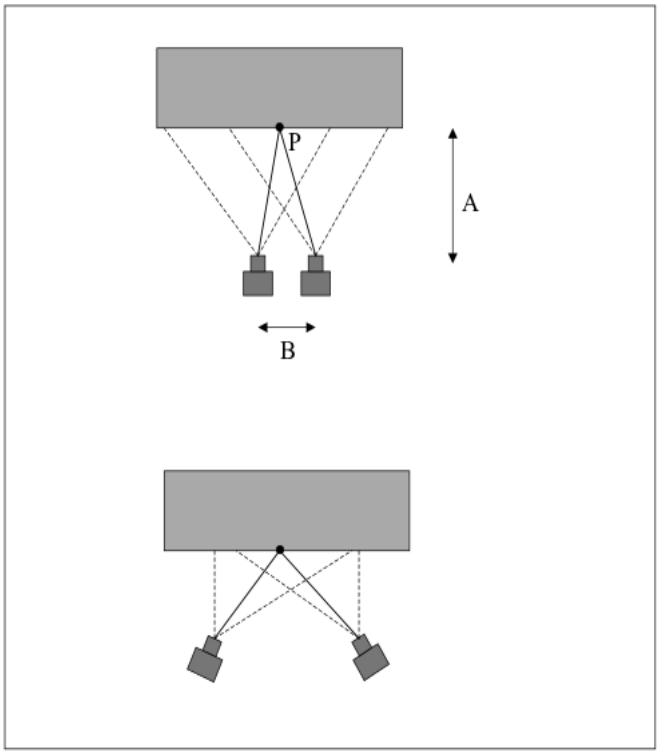

Fig. 8: Camera positions parallel (above) and convergent (below). MapTEC, Germany (2004).

Length and Angle Units

- For Co-ordinates and Distances in photogrammetry, we use metric units.
- Foot ('): Sometimes used to give the terrain height above mean sea level, for example in North American or British topographic maps, or the flying height above ground.
- Inch ("): For instance used to define the resolution of printers and scanners (dots per inch).

Length and Angle Units

- 1' = 12" = 30.48 cm 1" = 2.54 cm
- 1m = 3.281' 1 cm = 0.394"

- You will surely know angles given in degrees. In mathematics also radians are common.
- In geodesy and photogrammetry, we use grads. In the army, the so-called mils are used.

Length and Angle Units

- A full circle has
- 360 degrees = 400 grads = 2 (pi) = 6400— (mils)

Workflow in Photogrammetry

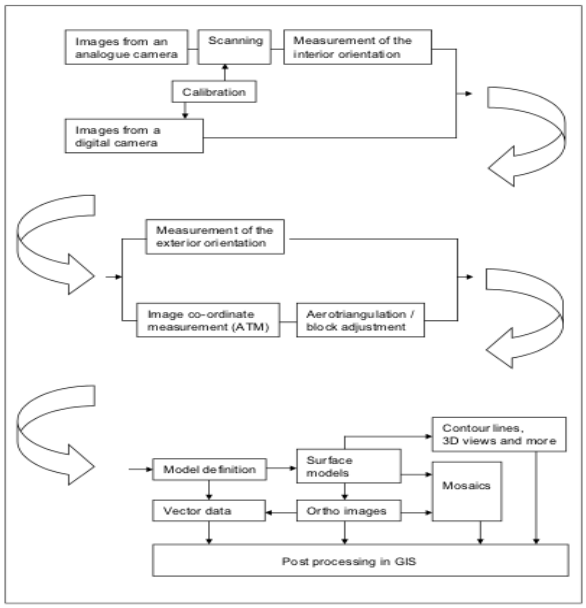

Fig. 10: A typical workflow