GEE 3622 TOPICS

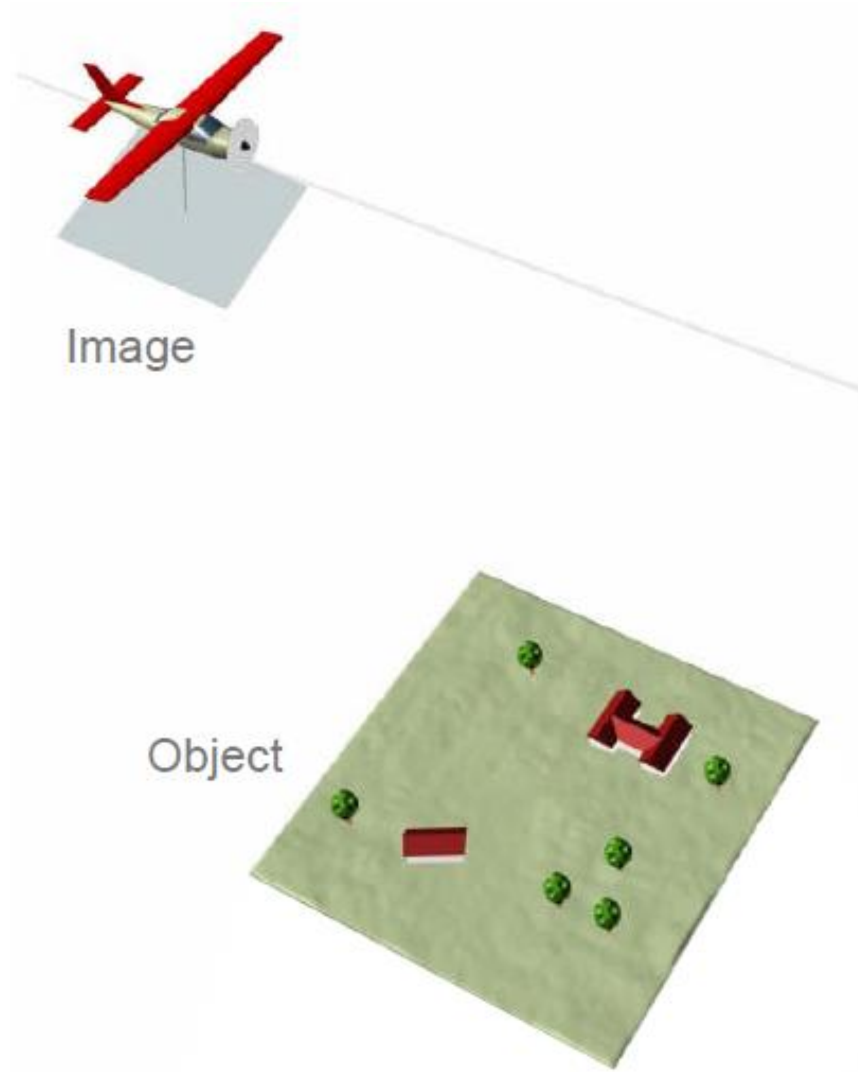
- Photogrammetry
- Laser Scanning
- Introduction to Remote Sensing
- Introduction to GIS

Photogrammetry

- Introduction
- Principles of Photography and Imaging
- Aerial Cameras
- Image measurements and Refinements
- Vertical Photographs
- Stereoscopic Viewing
- Stereoscopic Parallax
- Introduction to Analytical Photogrammetry
- Aerial Triangulation
- Project Planning
- Terrestrial and Close Range Photogrammetry

First! What is Photography?

- process that converts the real 3-dimensional world into flat 2-dimensional images.



Definitions……………….

- **Photogrammetry** is the technology to derive geometric information of objects with the help of image measurements

Definition (cont......................

- **Photogrammetry** is the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs

Definition (cont.................

- **Photogrammetry** is the “science of measuring in photos” traditionally a part of geodesy, belonging to the field of remote sensing

Some basic idea & main task................

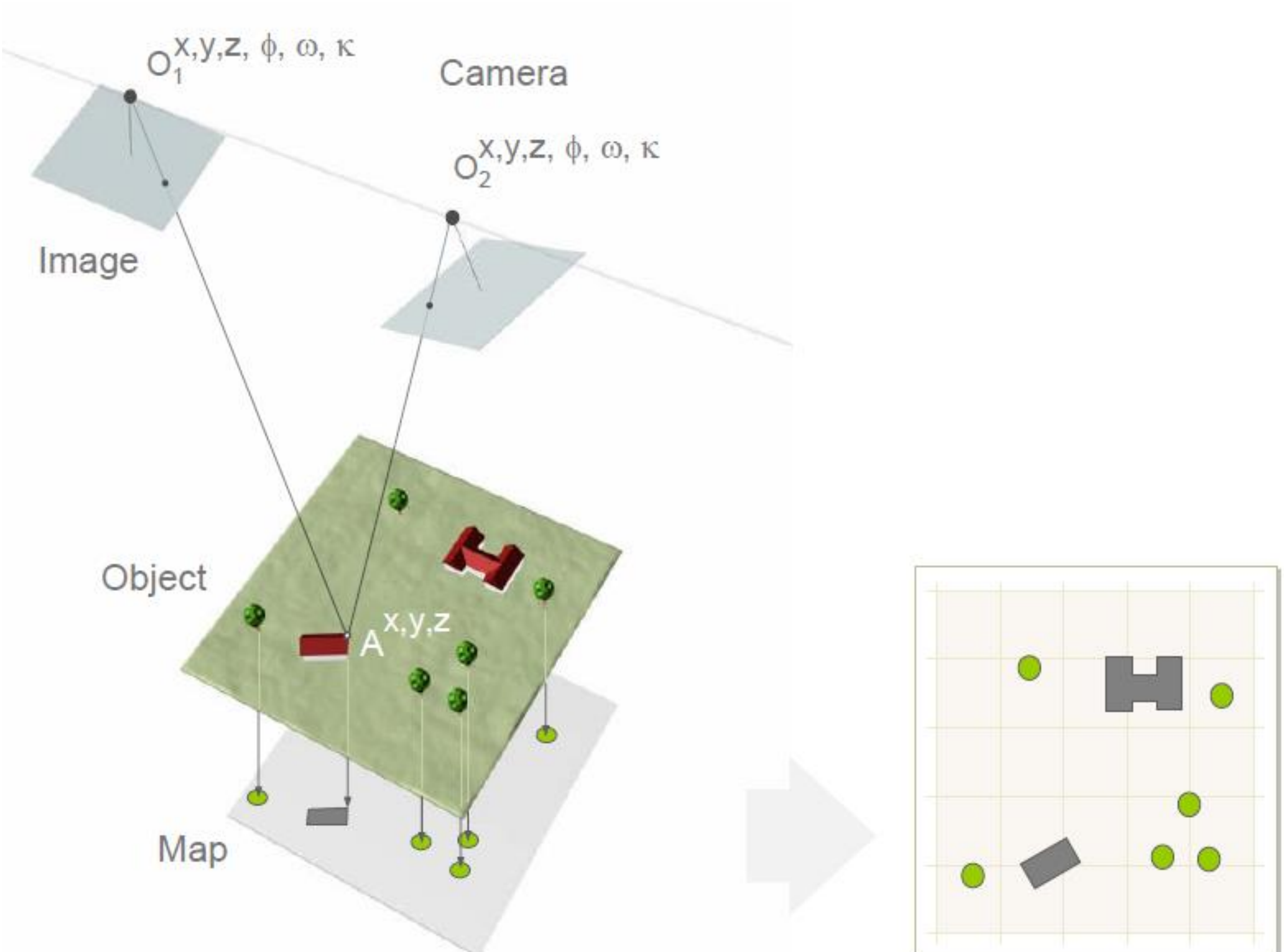
- You want to measure the size of an object length-width-height of HOUSE
- You carry this out directly at the object
- Now imagine the house didn’t exist anymore (Haiti Earthquake Disaster)
- Some historic photos exist
- It must be possible to get the desired data

Information About Objects

- Qualitative data: The house seems to be old- The Walls are coloured light yellow FROM Photo interpretation

- Quantitative data: The house has a base size of 8 by 6 meters FROM photo measurements

In a nutshell!



WHY PHOTOGRAMMETRY?

- measure co-ordinates, distances, areas or volumes

WHY PHOTOGRAMMETRY? (cont'd)

- Similary, the object exists but cannot be reached
- Very smooth objects like liquids, sand or clouds: photogrammetry will be the too of choice
- All kinds of fast moving objects objects will be measured with photogrammetry eg, these maybe running or flying animals or waves

Why Photogrammetry?(cont'd)

- In industry, high density speed cameras with simultaneous activation are used to get data about deformation processes (like car crash tests with cars)
- NOTE: In some examples, nowadays laser Scanner equipment is an alternative to photogrammetry

Cameras and Other Imaging Devices

- Nature of light, fundamentals of lens design, camera, photographic material, contact & projection printing.
- Know the principles of optics such as refraction and reflection;
- Work with the lens formula; Identify film characteristics;
- Understand the basics of digital imagery

Principles of Photography & Imaging

- Aerial Camera :
- Know the classes and types of cameras;
- Be able to identify the component parts and their functions;
- Understand basic optical phenomenon in photogrammetry;
- Know concepts of calibration; Trends in Digital Aerial Mapping Cameras

Principles of Vertical and Tilted Photographs

- Geometry of Aerial Photograph:
- Understand the difference between orthographic and perspective projection;
- Be able to transform image and object space coordinates from one to another;
- To perform basic calculations on vertical and titled (near vertical) photography

Stereoscopic Viewing

- Recognize the basics of vision theory;
- Stereoscopic depth perception,
- Viewing photographs stereoscopically,
- Understand and operate stereoscopes

Stereoscopic Parallax

- Know the theory of parallax and use of parallax equations in solving simple photogrammetric problems
- principle of the floating mark,
- elevation by X parallax differences
- (Notes on Vertical Exaggeration)

Project Planning

- Understand the basic elements of overlap and sidelap; Know the effects of scale variation, crab, and drift; Compute flight plan;
- Understand the basics of contracting for photogrammetric services (Ground Control for Photogrammetry)
- *Technical Aspects for Flight Planning**

  Technical requirements for aerial photographs, photogrammetriccontrol, economic aspects of aerial photography

Principles of Analytical Photogrammetry

(Theory and Techniques of Orientation)

- Definition and geometrical interpretation of interior and exterior orientation parameters of a photograph,
- Rotation matrix, mathematical models for photogrammetric space resection and intersection,
- Relative orientation, absolute orientation by 3D similarity transformation.
- Overall analytical compilation of a photogrammetric model.

Photogrammetry: Ideal technology when measuring objects such as:

- Irregular shapes
- Moving shapes
- Inflated shapes
- Objects that are too
  - Hot or cold
  - Soft
  - Delicate
  - Inaccessible
  - Toxic
  - Radioactive to touch

METRIC PHOTOGRAMMETRY

- Making precise measurements from photos
- and other sources to determine relative
- location
- Three basic applications
- Aerial
- Terrestrial
- Extra-Terrestrial

INTERPRETATIVE PHOTOGRAMMETRY

Recognizing and identifying objects and judging their significance through careful and systematic analysis

- Two main applications

✓ Photographic interpretation

✓ Remote sensing

TERRESTRIAL PHOTOGRAMMETRY

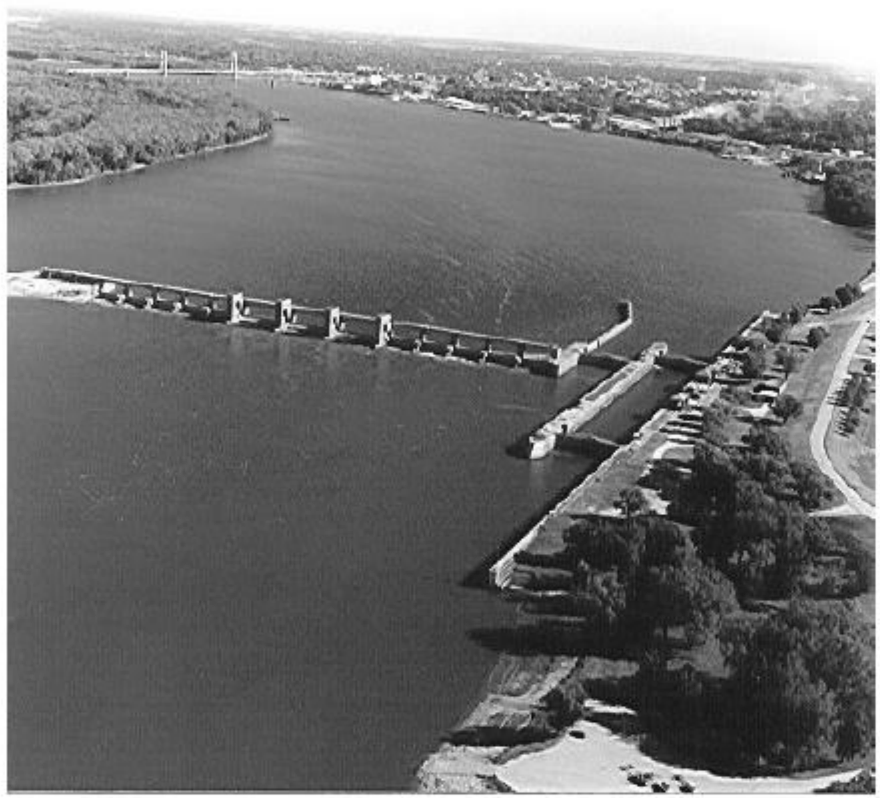
- Taken with ground-based cameras
- Position and orientation often measured

AERIAL PHOTOGRAPHY

- Vertical – camera axis as nearly vertical as possible
- Oblique – camera axis intentionally tilted
  - Low oblique
  - High oblique

VERTICAL
PHOTO

HIGH OBLIQUE



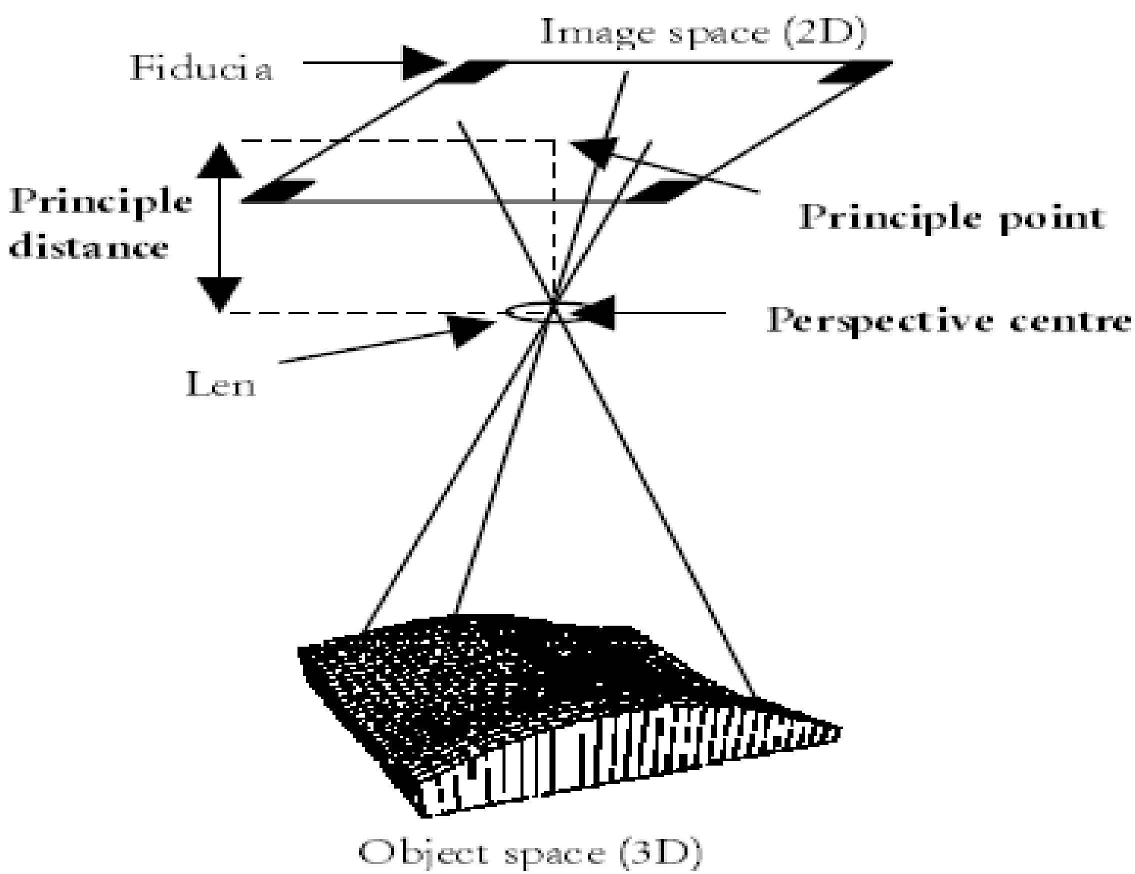
EXTRATERRESETRIAL PHOTOGRAPHY

Extraterrestrial – pictures taken from space-based cameras

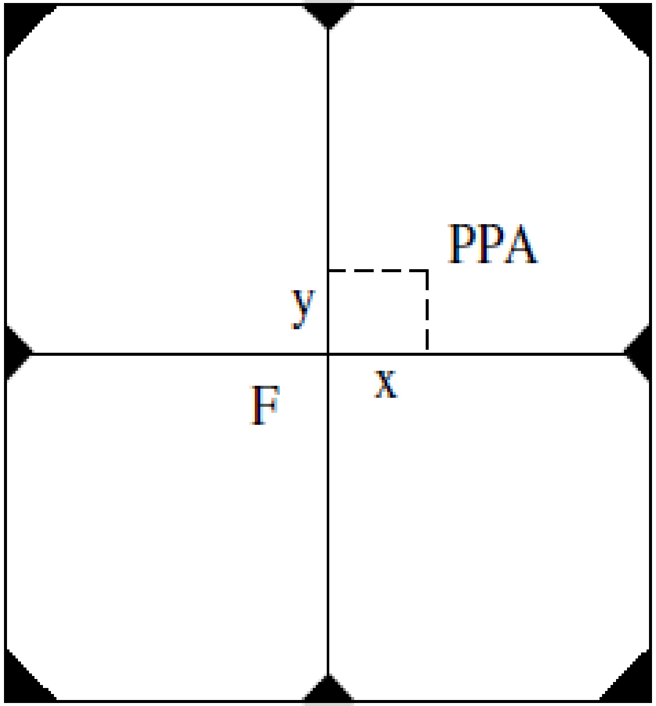
Apollo-Saturn 4

Basics of elementary photogrammetry

Definitions

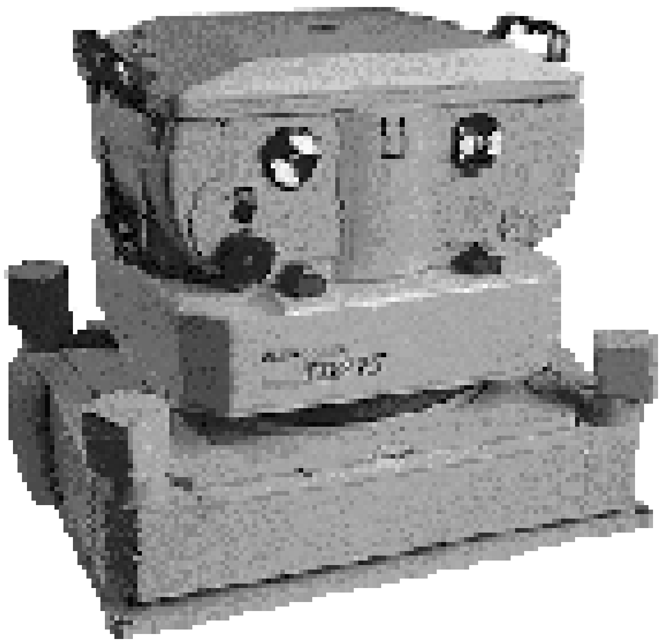


Basics of elementary photogrammetry



PPA = Principal point of autocollimation

Cameras



- Stable and precisely known internal geometry
- Low lens distortion, constant principal distance
- Defined internal coordinate system
- Standard format, 23 x 23 cm

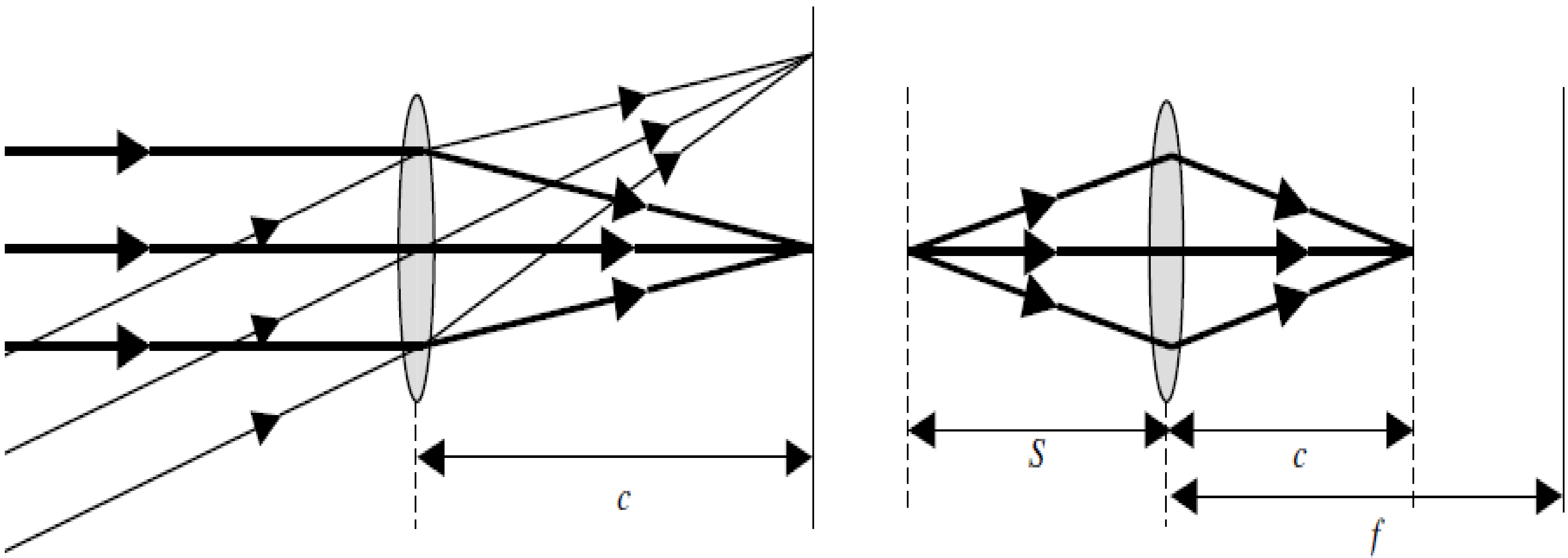
Cameras

- Moderate lens distortion
- Defined internal coordinate system (from CCD)
- Small format

Cameras

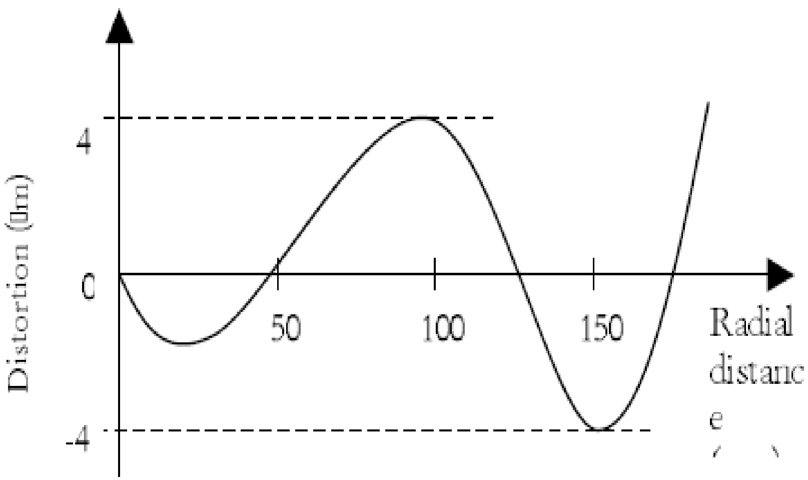
- Large lens distortions and unstable geometry
- Defined internal coordinate system (if CCD)
- No internal coordinate system if film camera

optics



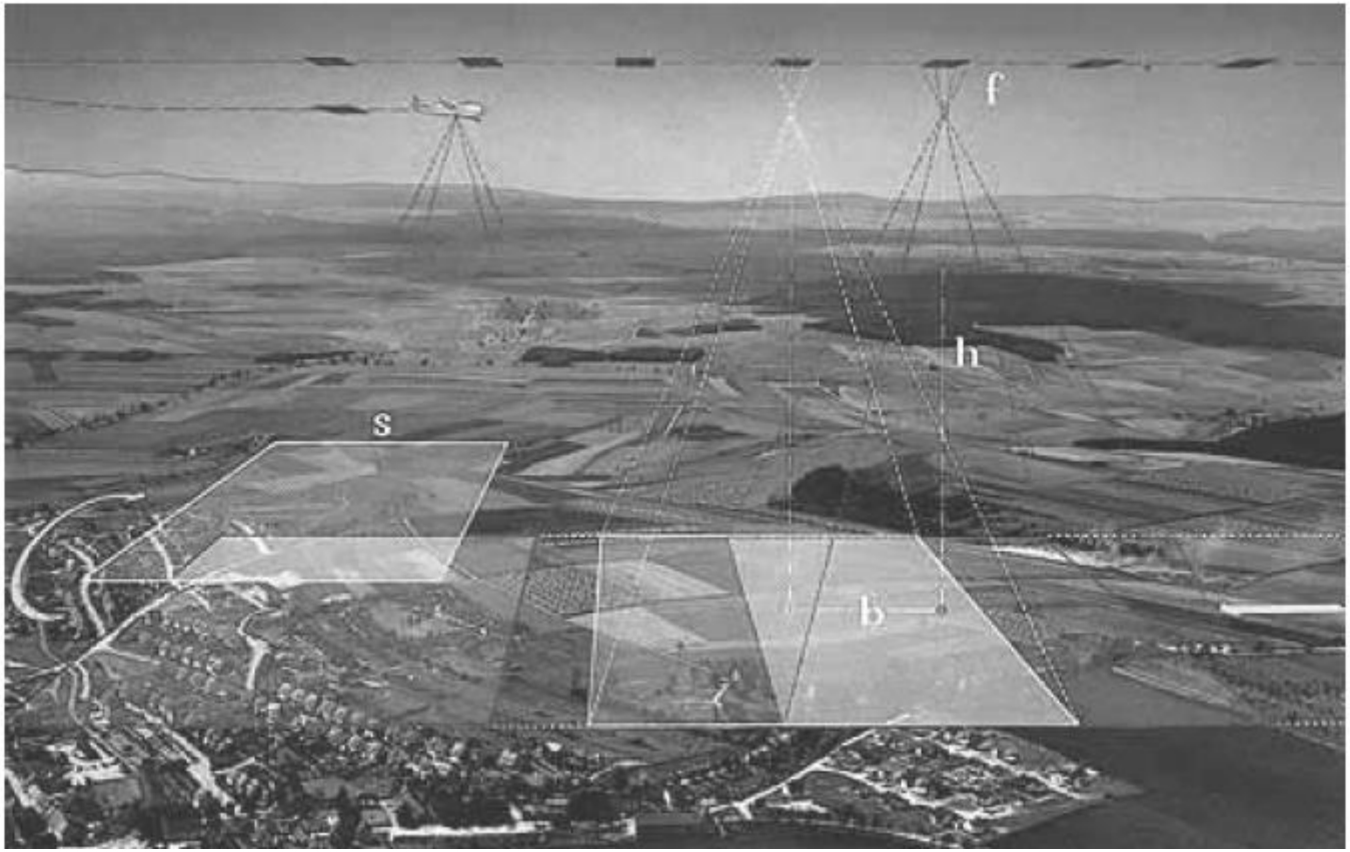
Principal distance is defined by the camera; focal length is defined by the lens.
For a camera focussed at infinity,
$c = f$. For a fixed focus camera, c is constant.

Lens distortions



- Lens distortions are the principal cause of distortions in a camera. This is not a problem, as long as the lens has been calibrated.
- Two components of the distortions are radial and tangential (decentring). Radial are generally a factor of 10 higher than tangential.

TAKING VERTICAL AERIAL PHOTOGRAPHS

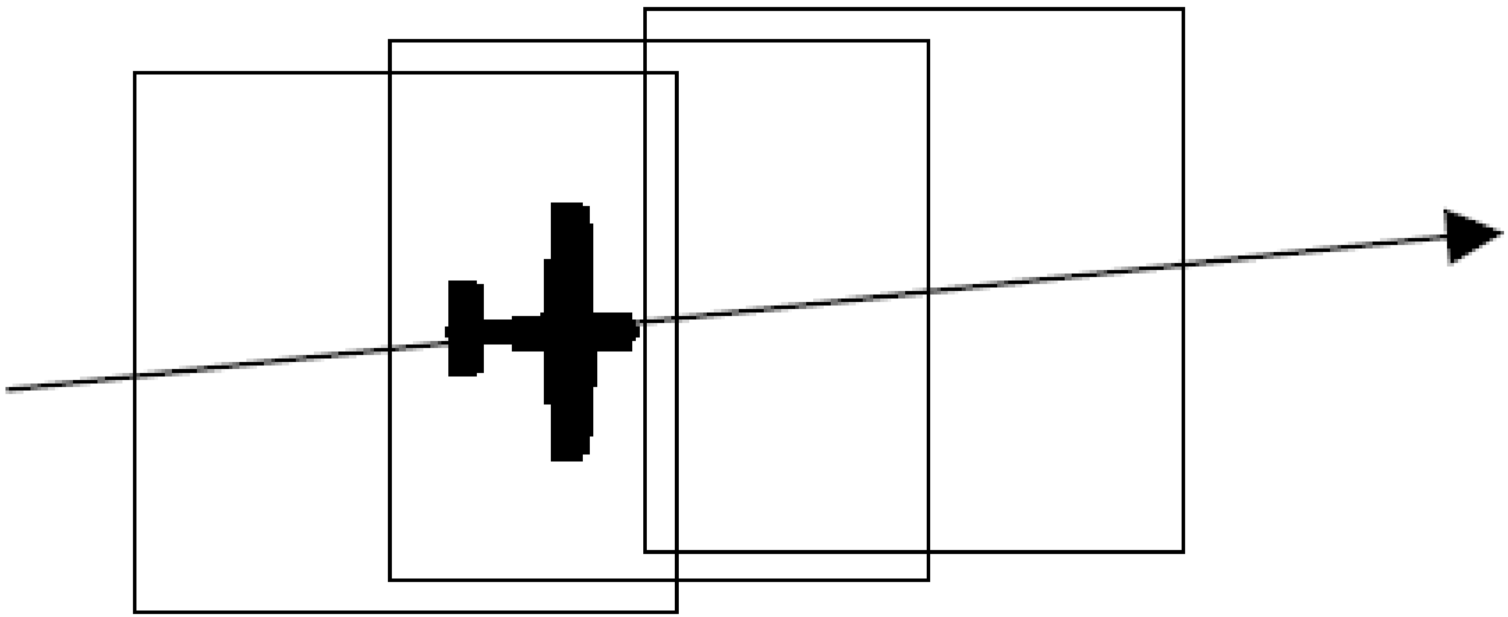


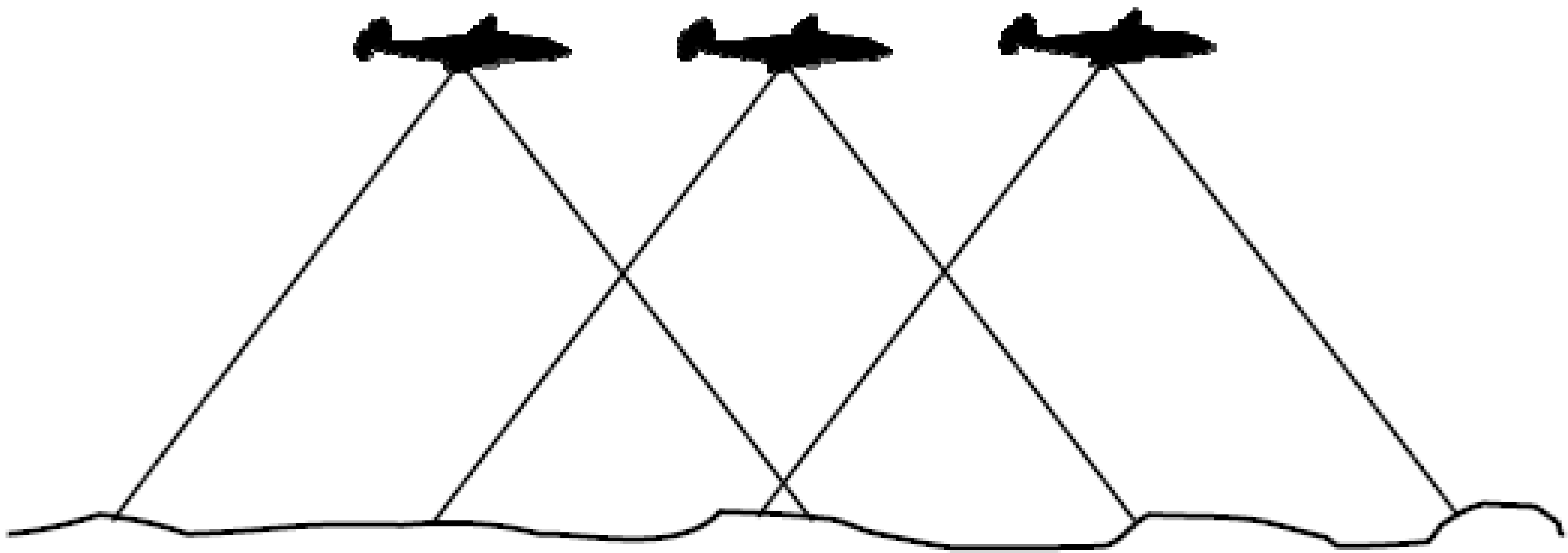
TAKING VERTICAL AERIAL PHOTOGRAPHS

- Position of camera at each exposure called exposure station
- Flying height – altitude of camera
- Adjacent flight strips overlap
  - Called side lap
- Block of photos – photos of 2 or more side lapping strips

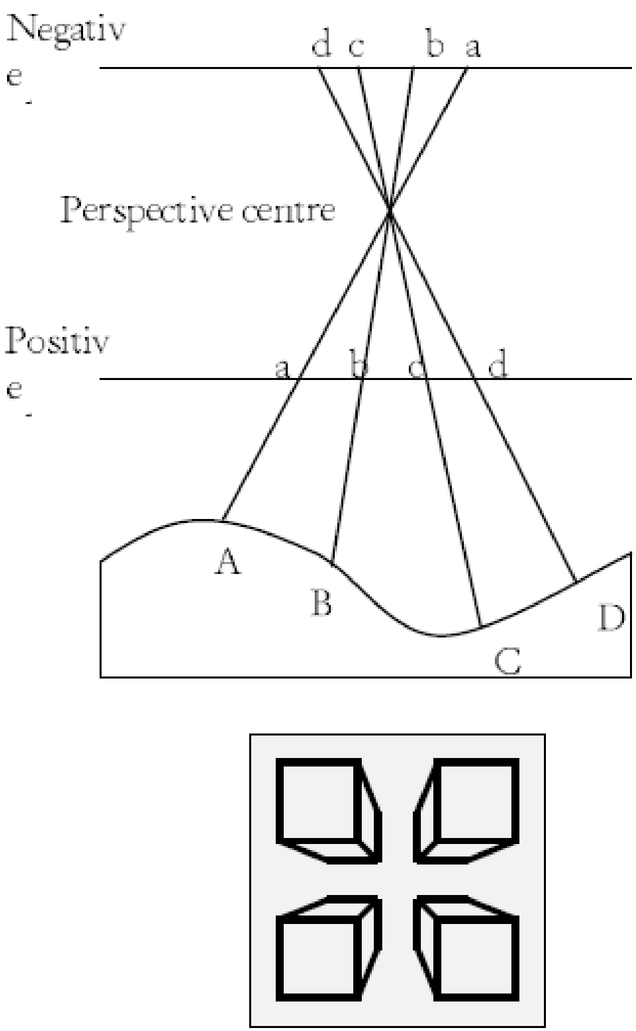
Typical aerial imaging geometry:

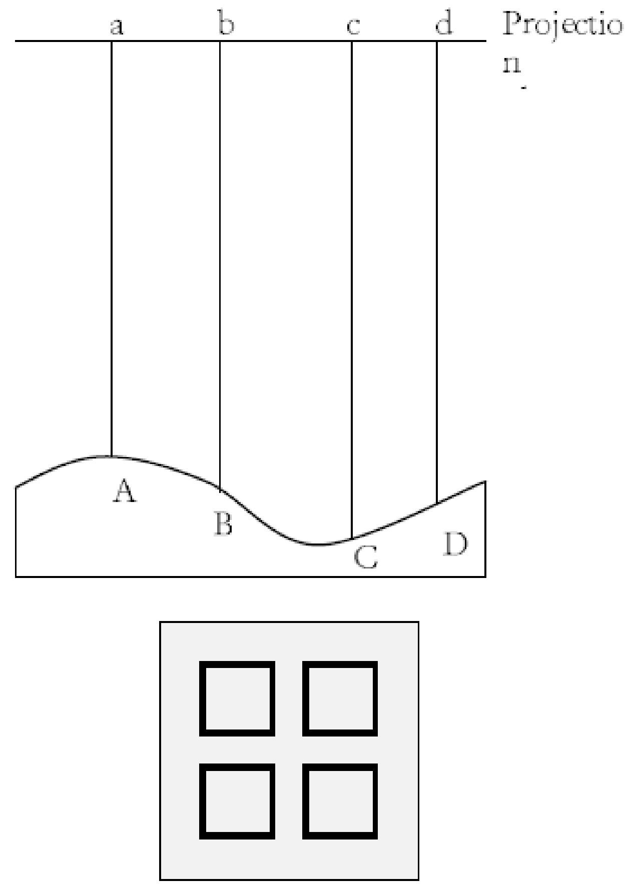
605 forward overlap and 25% side overlap ensures
full stereo coverage for the whole area.





3D object points are transformed to 2D image space via a perspective projection model. A map must present points in their planimetrically correct locations, i.e. Orthographic projection

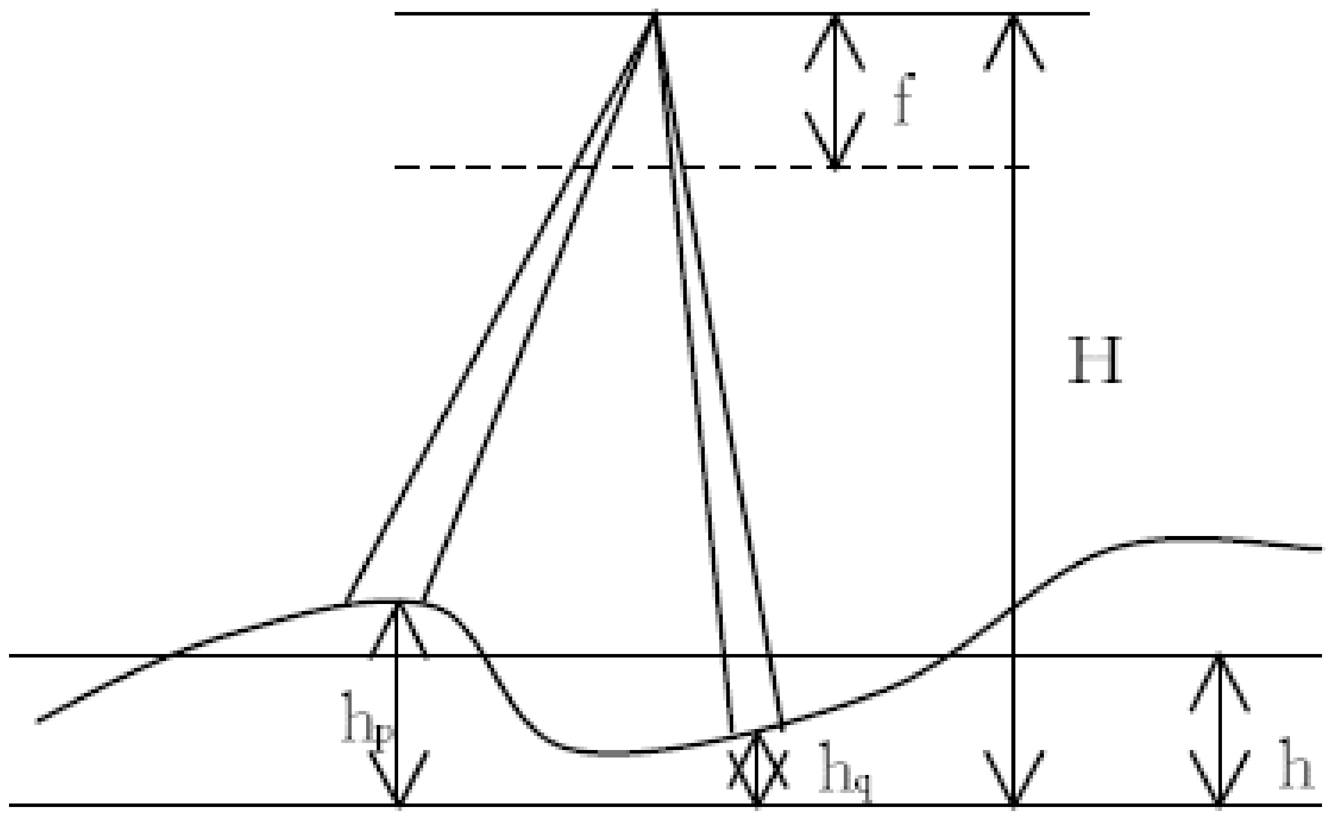


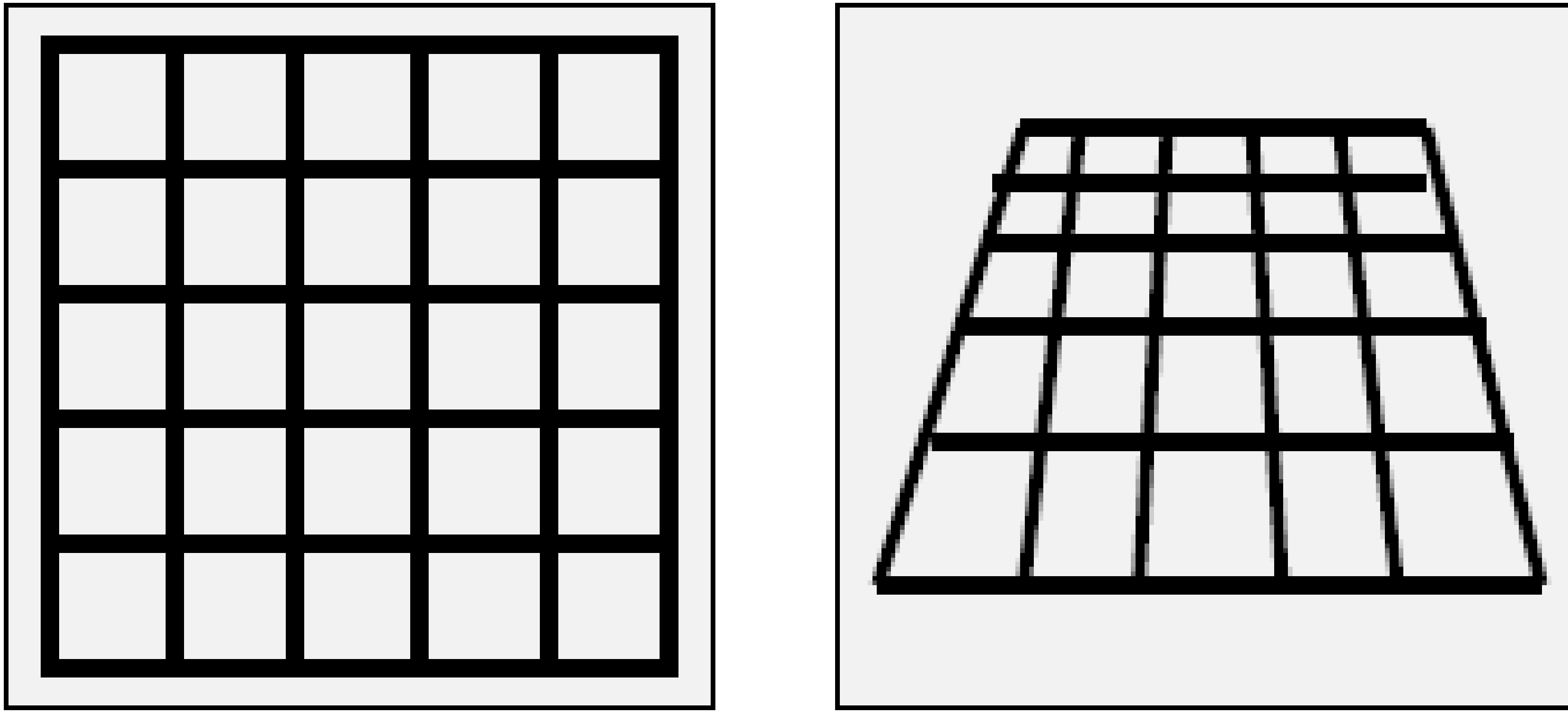


Scale = Image distance / object
Scale varies with height anc

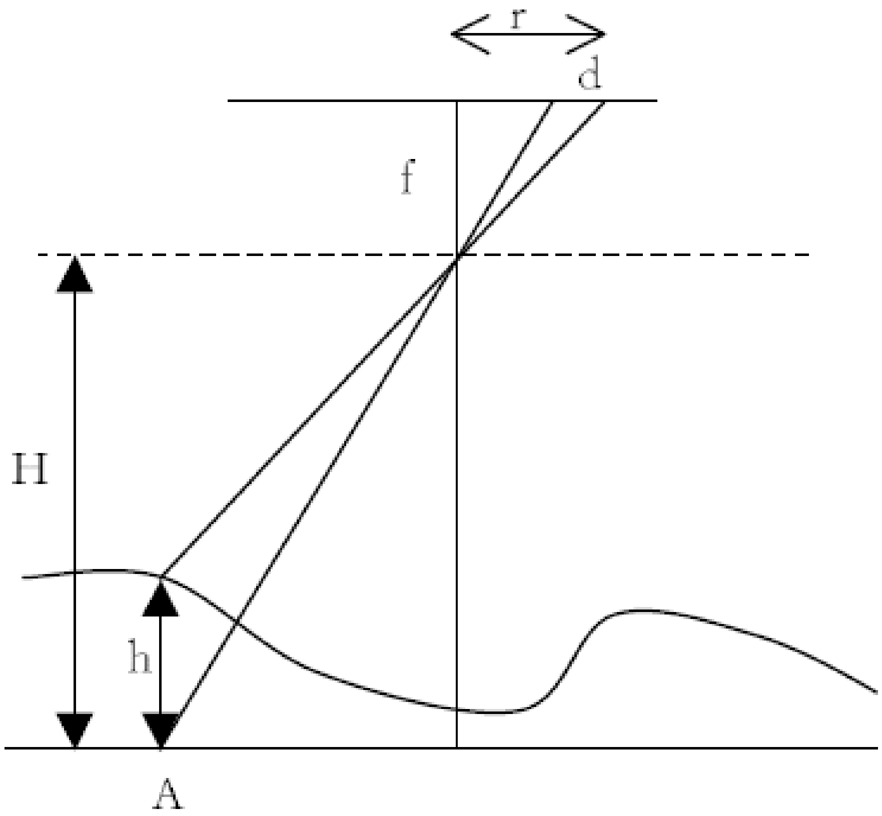
or

$$\text{Scale} = \frac{f}{H - h}$$



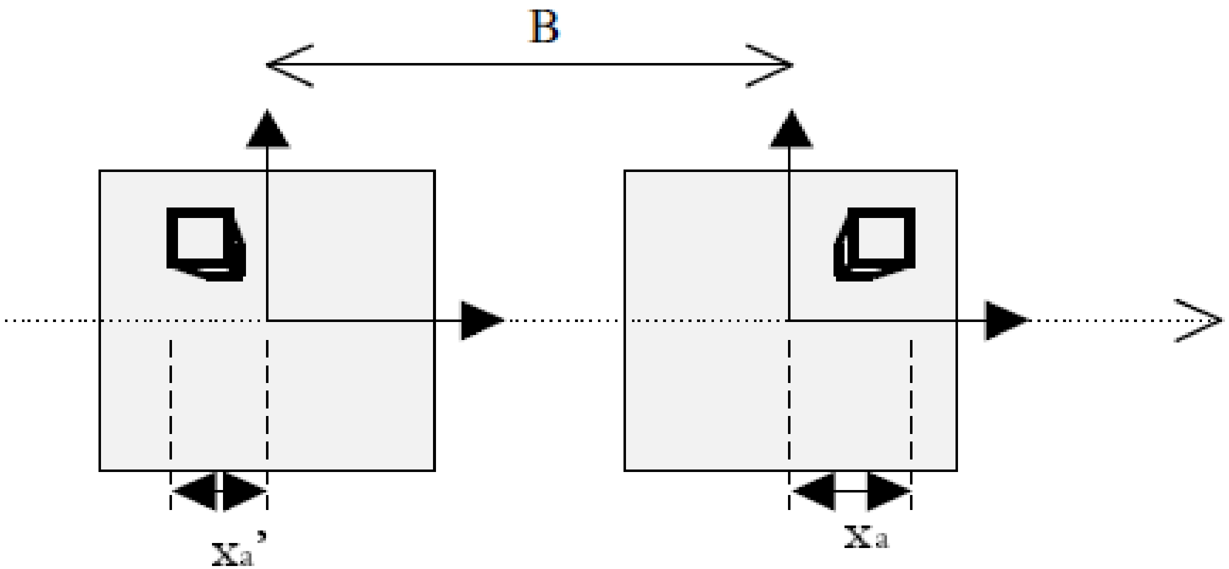


Relief Displacement



$$d = \frac{r \times h}{H}$$

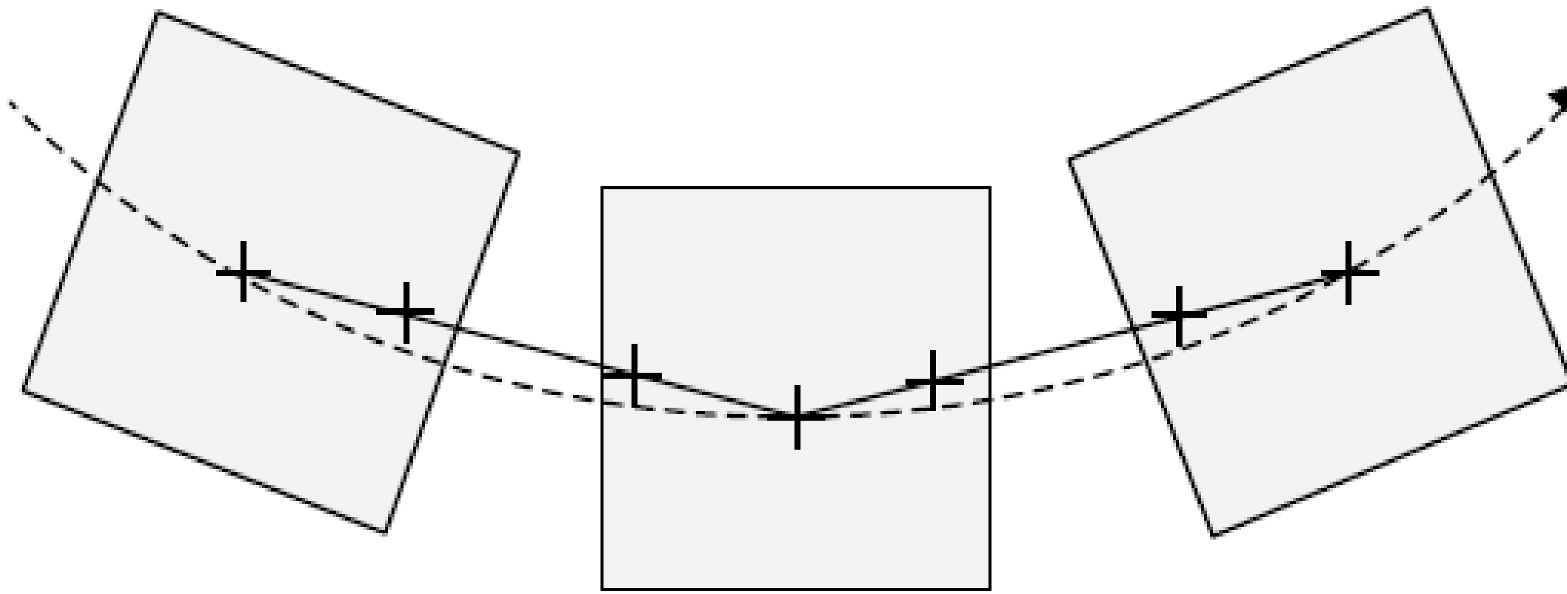
parallax = $x_a - x_a'$



Parallax only occurs parallel to the flight line. Parallax can be used to determine the height of objects.From similar triangles, the height of a point is given by:

$$h = H - \frac{Bf}{p}$$

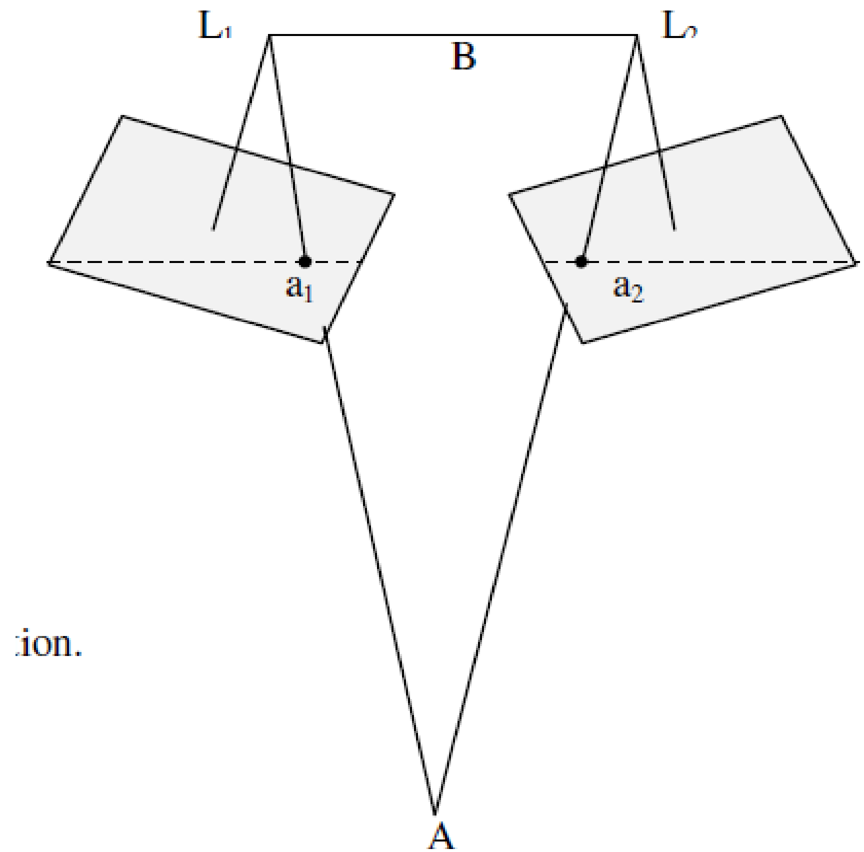
The flight line can be determined by joining principle points



Epipolar Lines

- The plane defined by L1, L2 and A is an *epipolar plane.*

- The intersection of an epipolar plane and the image plane is an *epipolar line.*



Epipolar lines……

- Since the epipolar lines are parallel to the air base, there is no *y-parallax on these lines.*
- A point imaged on an epipolar line in one image will lie on the corresponding epipolar line in the other image.
- Since epipolar lines are not usually parallel to *x-axis (rows)* of the image, it is common to transform the images so epipolar lines are parallel to the rows. This process is known as normalization.

Introduction

- References:

- Kraus, K.: Photogrammetry, Geometry from Images and Laser Scans, 2nd ed., de Gruyter, Berlin, Germany, 2007.
- Lillesand, T.M., Kiefer, and J.W. Chipman: Remote Sensing and Image Interpretation, 6th Edition., Wiley, New York, 2008.
- Mikhail, E.M., J.S. Bethel, and J.C. McGlone: Introduction to Morden Photogrammetry, Wiley, New York, 2001.
- Paul R. Wolf, Bon A. Dewitt, Benjamin E. Wilkinson.,Elements of Photogrammetry with Applications in GIS, 4th ed. 2014

- Problems:

1. Explain the differences between metric and interpretative photogrammetry
2. Describe the different classification of aerial photographs
3. What is the primary difference between high and low oblique photographs?
4. Define the following photogrammetric terms: end lap, side lap, stereopair, exposure station, and flying height.
5. Discuss some of the principle uses of aerial photogrammetry.
6. Discuss some of the principle uses of terrestrial photogrammetry.
7. Discuss how you would go about obtaining existing aerial photographic coverage of an area.
8. To what extent is photogrammetry being used in highway planning in Zambia?
9. Discuss the importance of photogrammetry in geographic information systems
10. Visit the following websites, and briefly discuss the information they provide regarding photogrammetry and mapping.

a) http://www.asprs.org/
b) http://www.isprs.org/
c) http://www.cig-acsg.ca/
d) http://www.sssi.org.au/
e) http://www.rspsoc.org/
f) http://www.nga.mil.org/
g) http://www.fgdc.gov/
h) http://www.usgs.gov/pubprod/