Photogrammetry II

3^{rd} Stage

Stereoscopic Viewing – lecture 1

Dr. Fanar Mansour

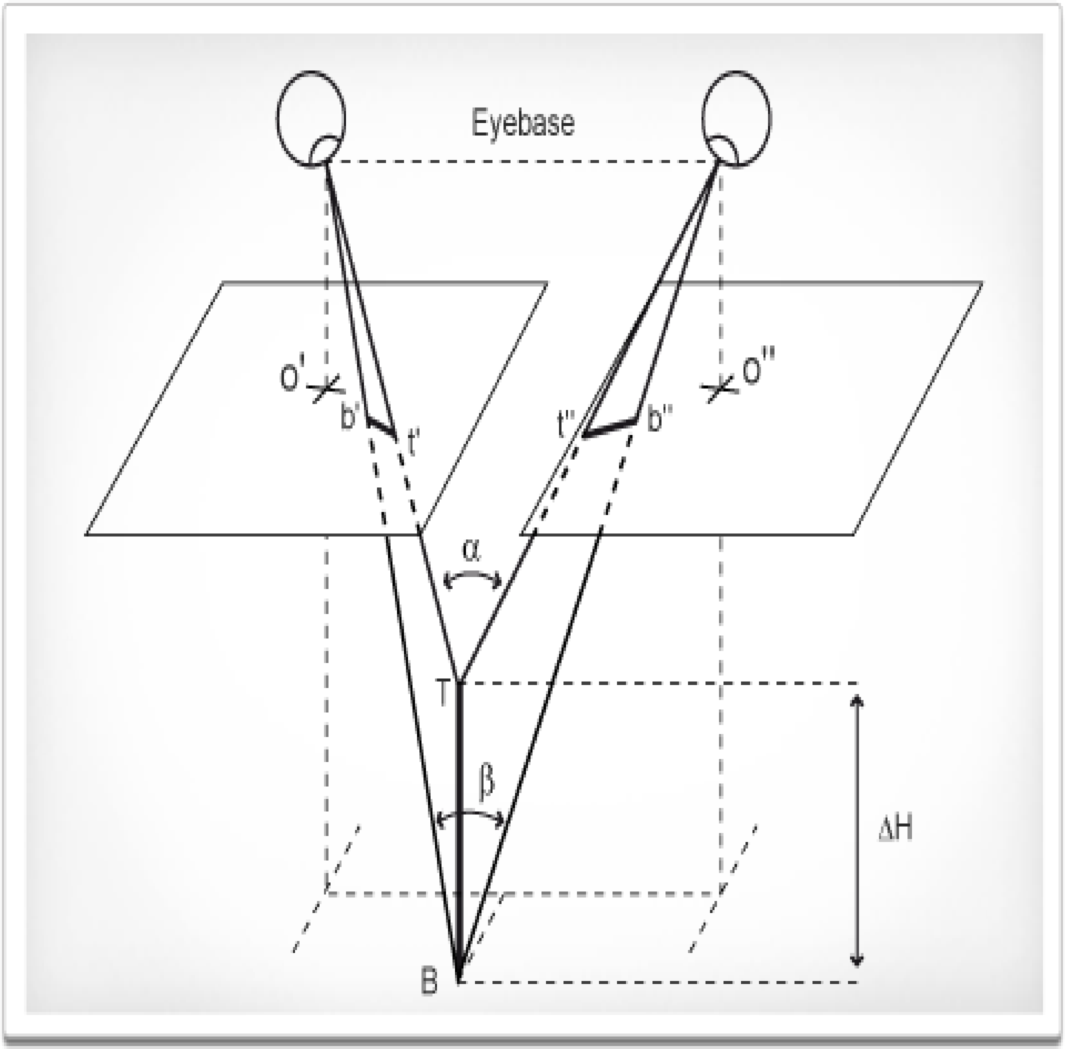
E-mail : fanar.mansour@london.com

Depth conception

- Methods of measure depth or judge distances through our normal process of vision maybe classified to:
- Stereoscopic
- Monoscopic
- People can see with both eyes simultaneously called people with “binocular vision” ⟶ stereoscopic viewing.
- Viewing with one eye ⟶ monocular viewing.
- With stereoscopic viewing, greater accuracy in depth perception can be attained! ⟶ Very importance in photogrammetry!

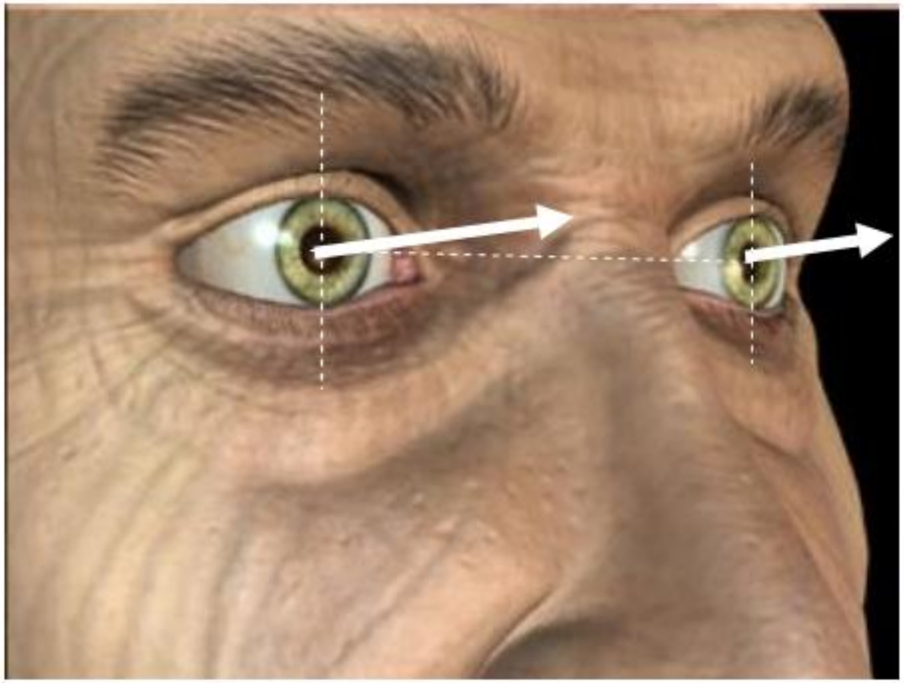
Depth conception

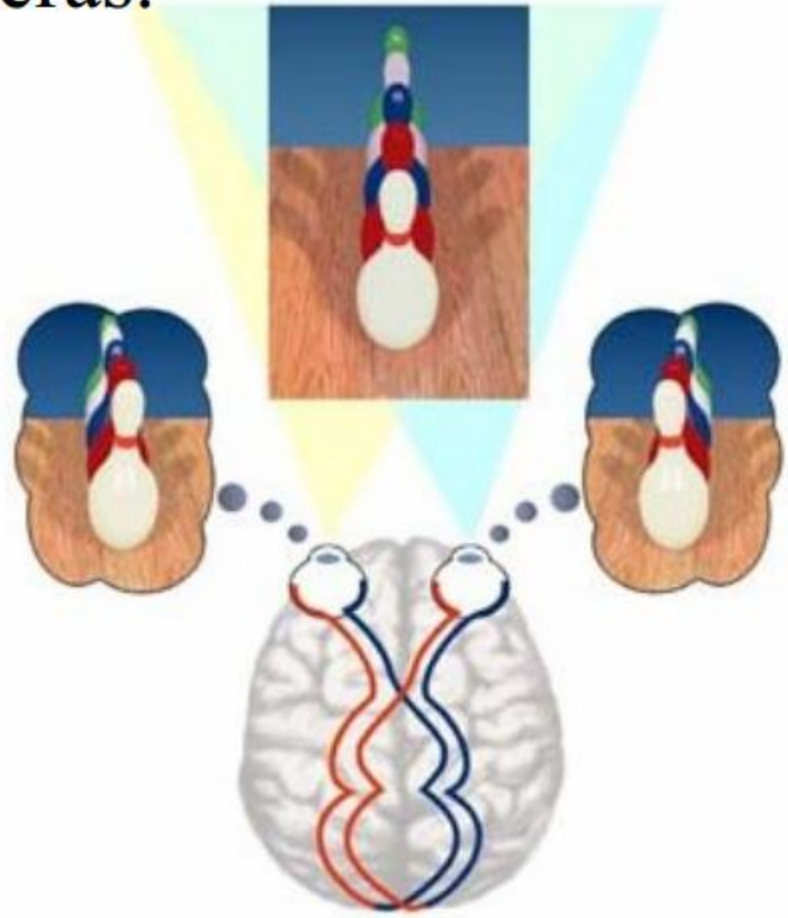
- Eye base $\cong$ 2.6 in
- Parallactic angle
- The depth between objects is perceived from the difference in parallactic angle.



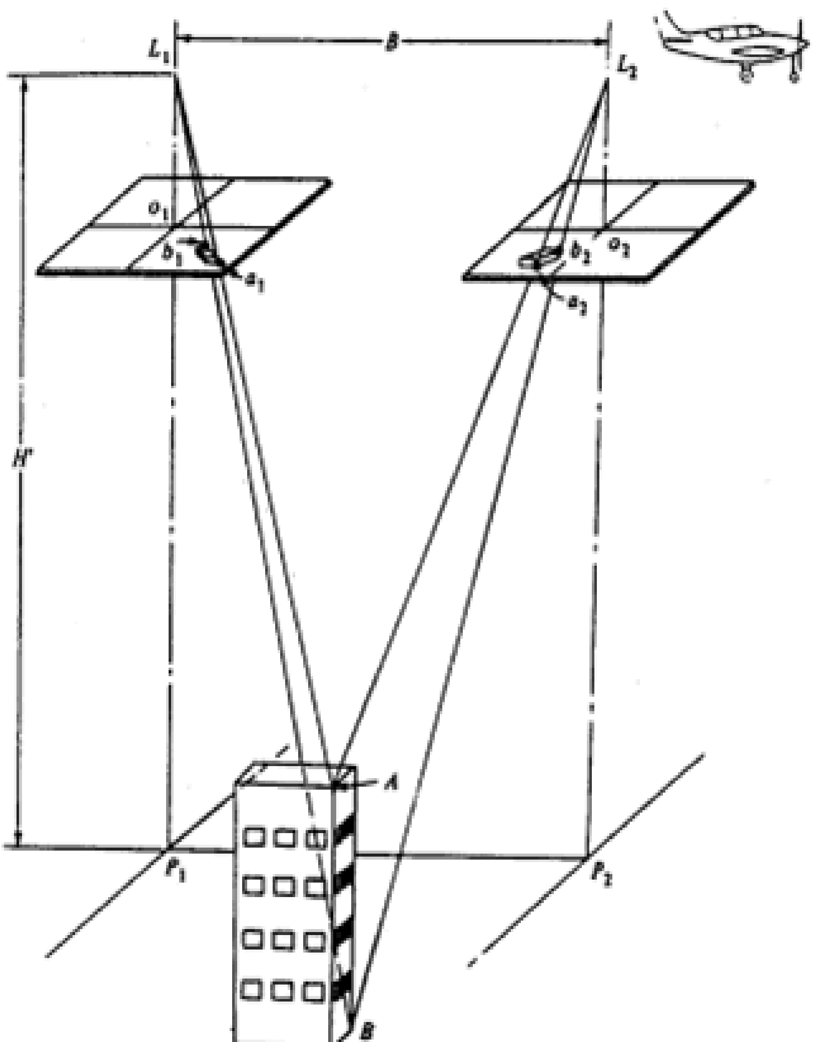
Stereo vision

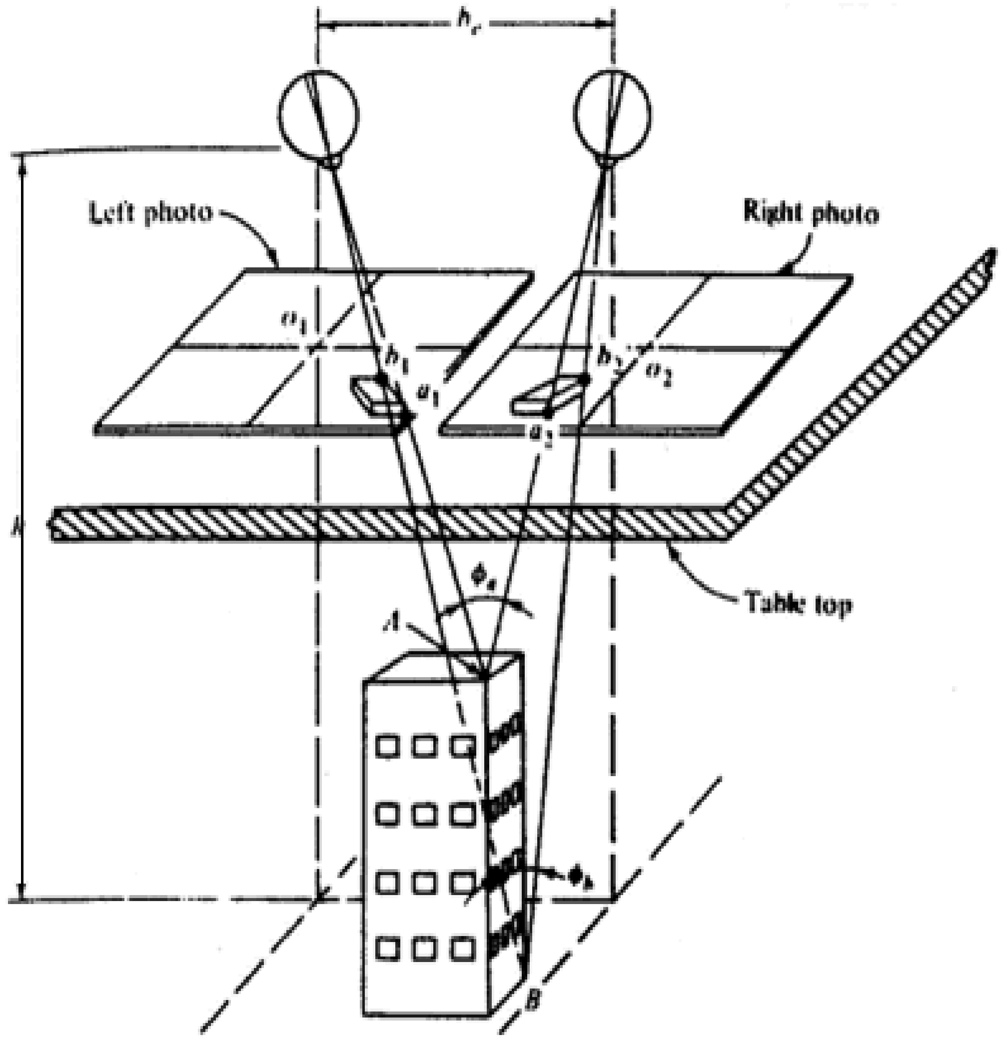
Inferring depth from images taken at the same time by two or more cameras.



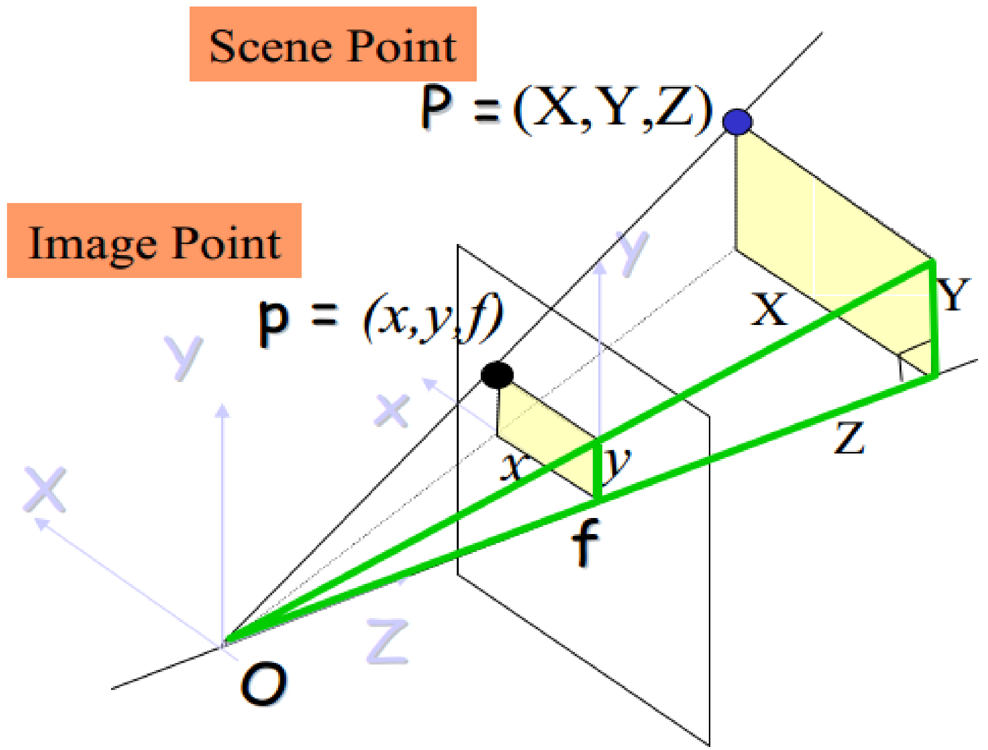


Stereoscopic model (stereomodel)





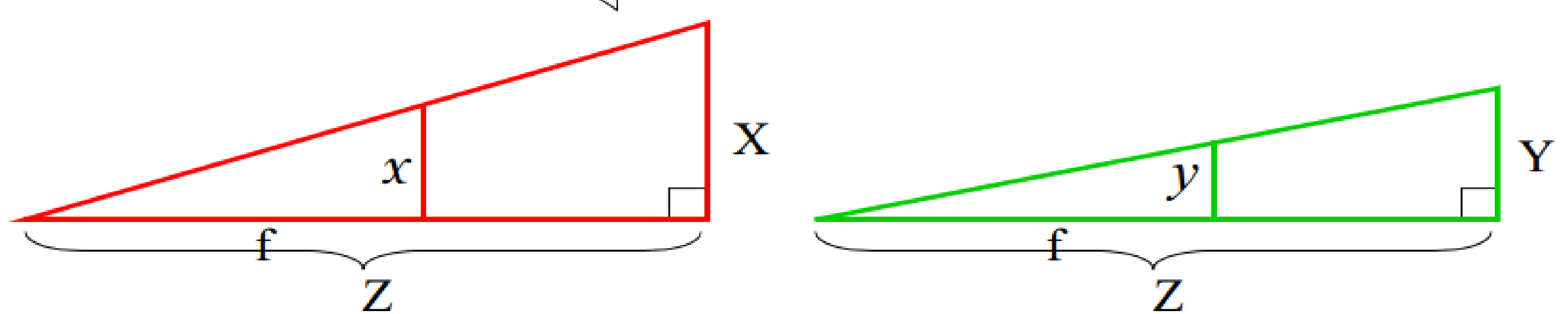
Perspective projection



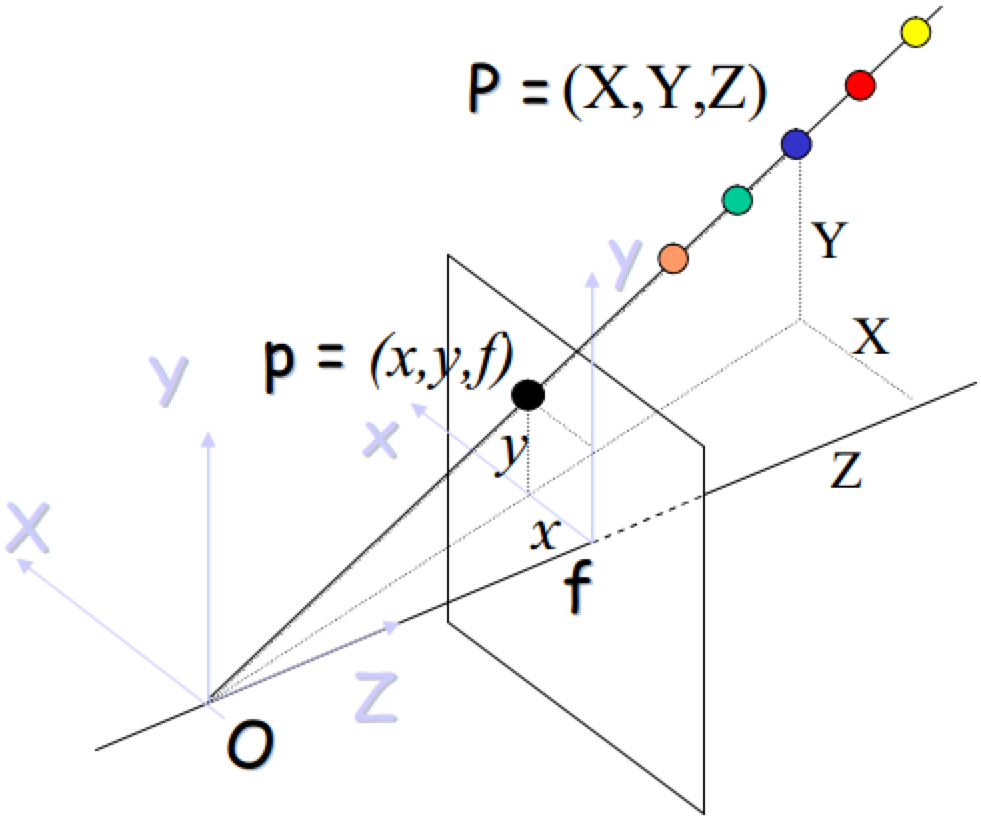
Perspective Projection Eqns

$$x = f\,\frac{X}{Z}$$

$$y = f\,\frac{Y}{Z}$$



Why stereo vision?



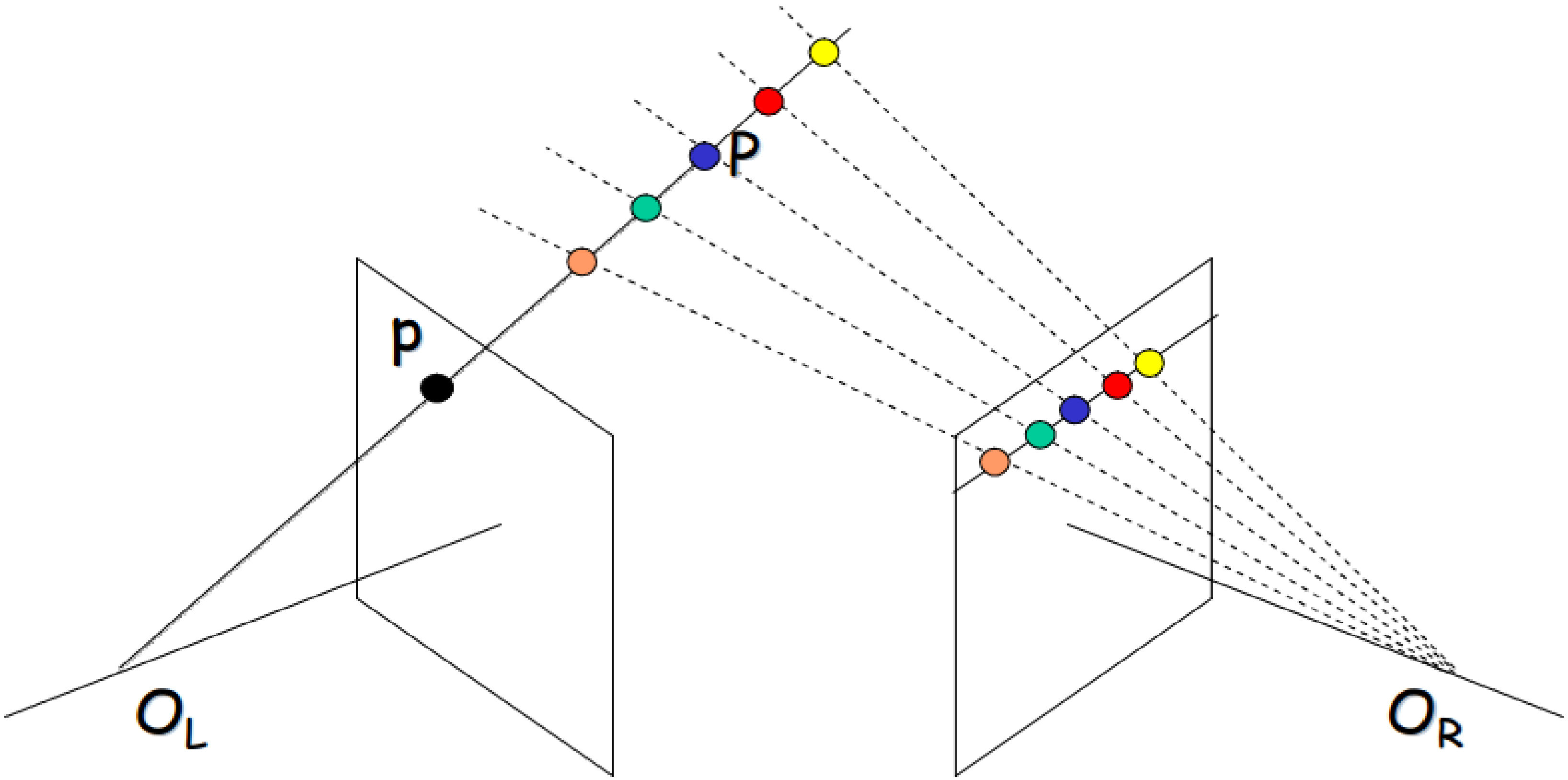
$$x = f\frac{X}{Z} = f\frac{kX}{kZ}$$

$$y = f\frac{Y}{Z} = f\frac{kY}{kZ}$$

Fundamental Ambiguity:

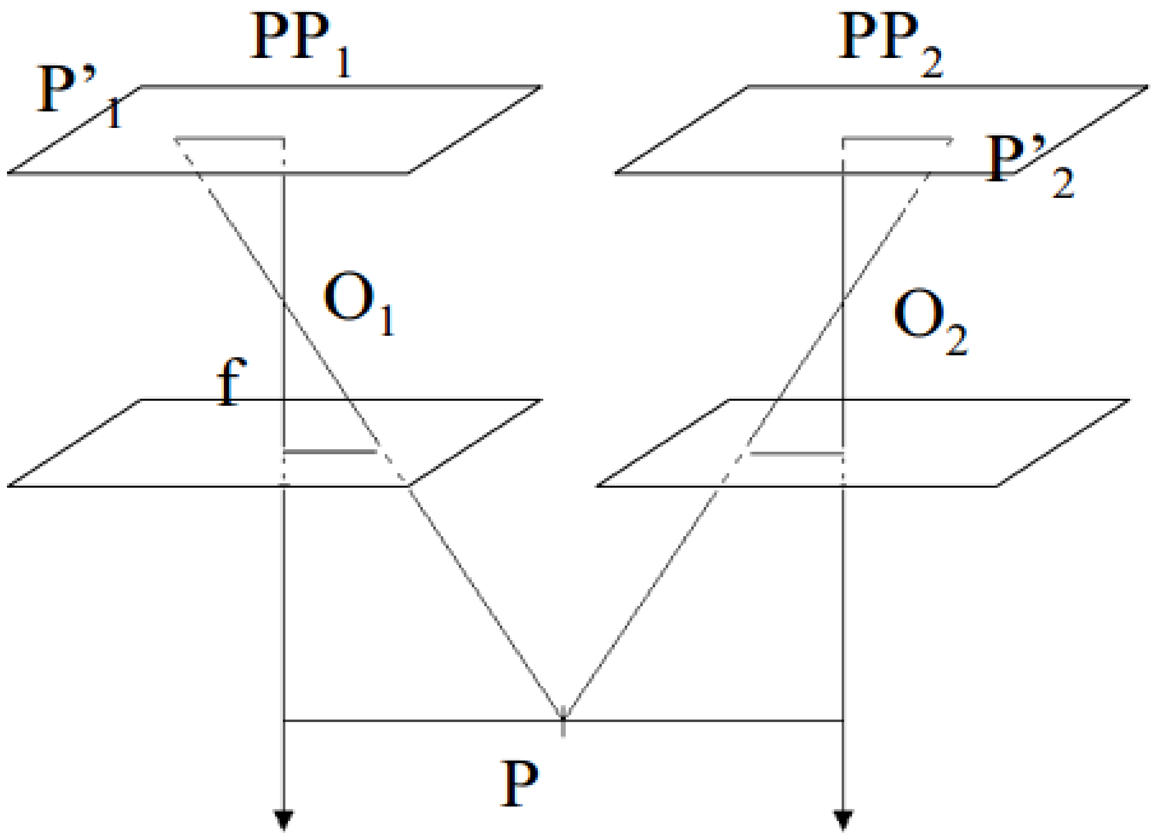
Any point on the ray OP has image p

Why stereo vision?



A second camera can resolve the ambiguity, enabling measurement of depth via triangulation.

Principle of Stereo Photogrammetry



Position of P is uniquely determined by the intersection of lines P'_1O_1 and P'_2O_2

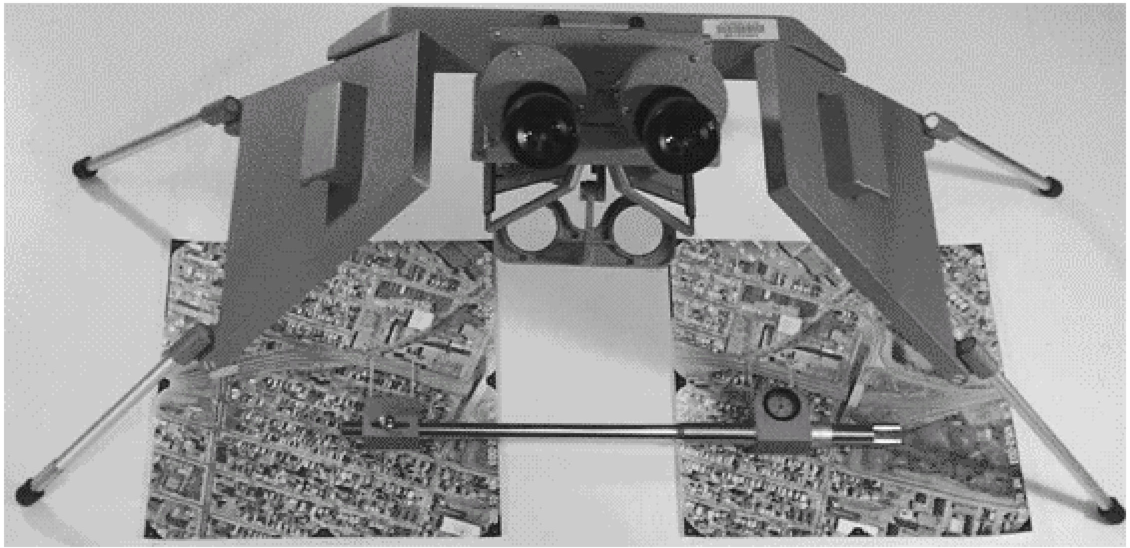
Stereoscopes

- Two photographs of the same terrain, but taken from different camera stations, permit three-dimensional viewing and are said to comprise a <u>stereoscopic pair</u>, or stereo pair.
- Stereoscopic pairs typically are viewed under a stereoscope.
- Stereoscope is a device constructed to force each eye to look straight down and along lines that are parallel or nearly so.
- There are two basic types of stereoscopes: pocket stereoscope & mirror stereoscope.

Stereoscopes

- Pocket stereoscope

- Mirror stereoscope



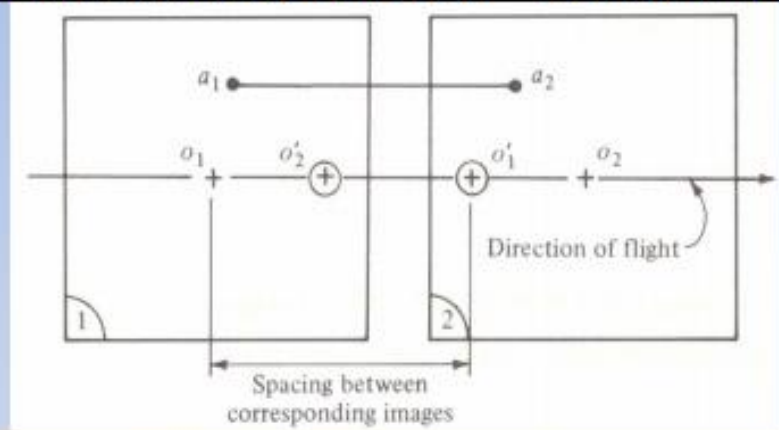
Ideal Case

- Consider the ideal case where photographs are separated by a distance B along the x axis. Both photographs are perfectly normal, the exterior orientations are known, and the location of the principle point is at (0,0)
- *def*^{n}:The Stereo Baseline, B, is the distance between the projection centres of the two cameras in stereo photography.

Y Parallax

- Y parallax is created in stereo viewing when corresponding images fail to lie along a line parallel to the flight line.
- Y parallax causes eyestrain.

Photos properly oriented – no y parallax



Source: Wolf (1974)

Photos with y parallax

Improper orientation of the photos

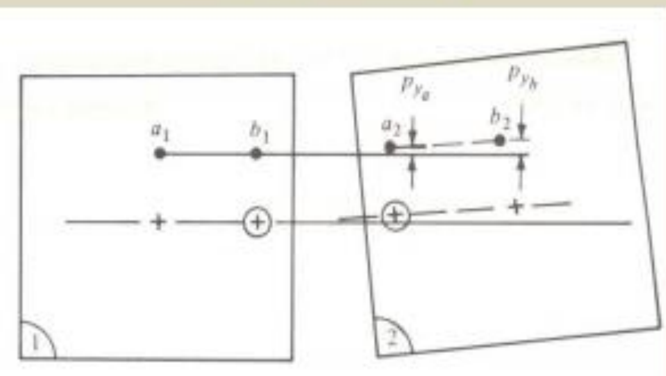
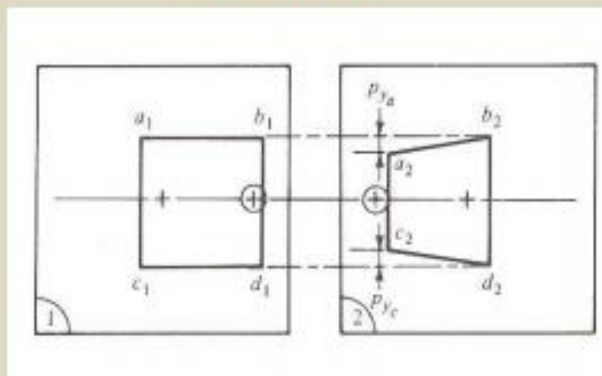
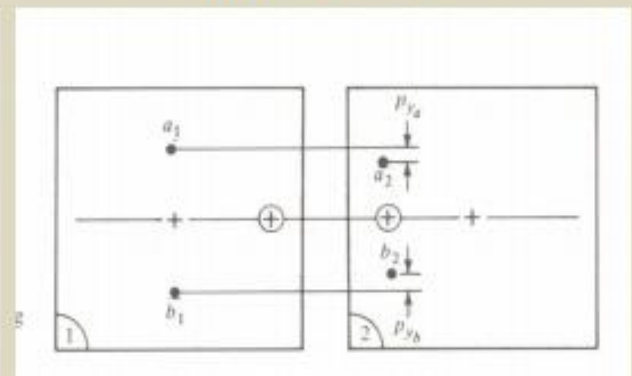


Photo tilt

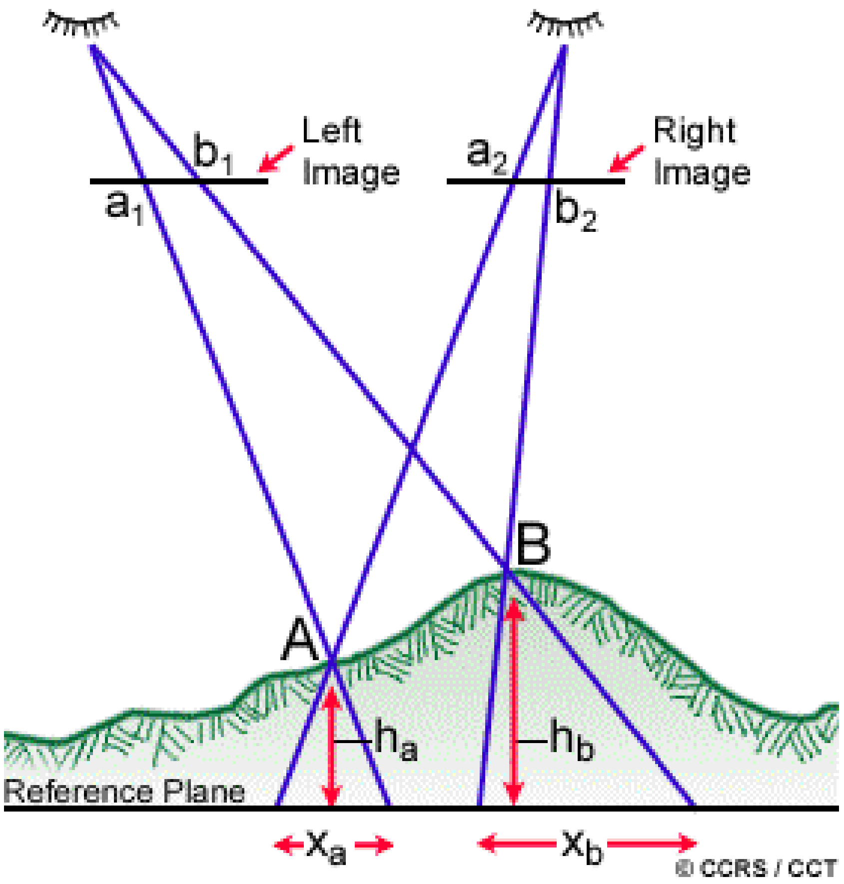


Variation in flying height



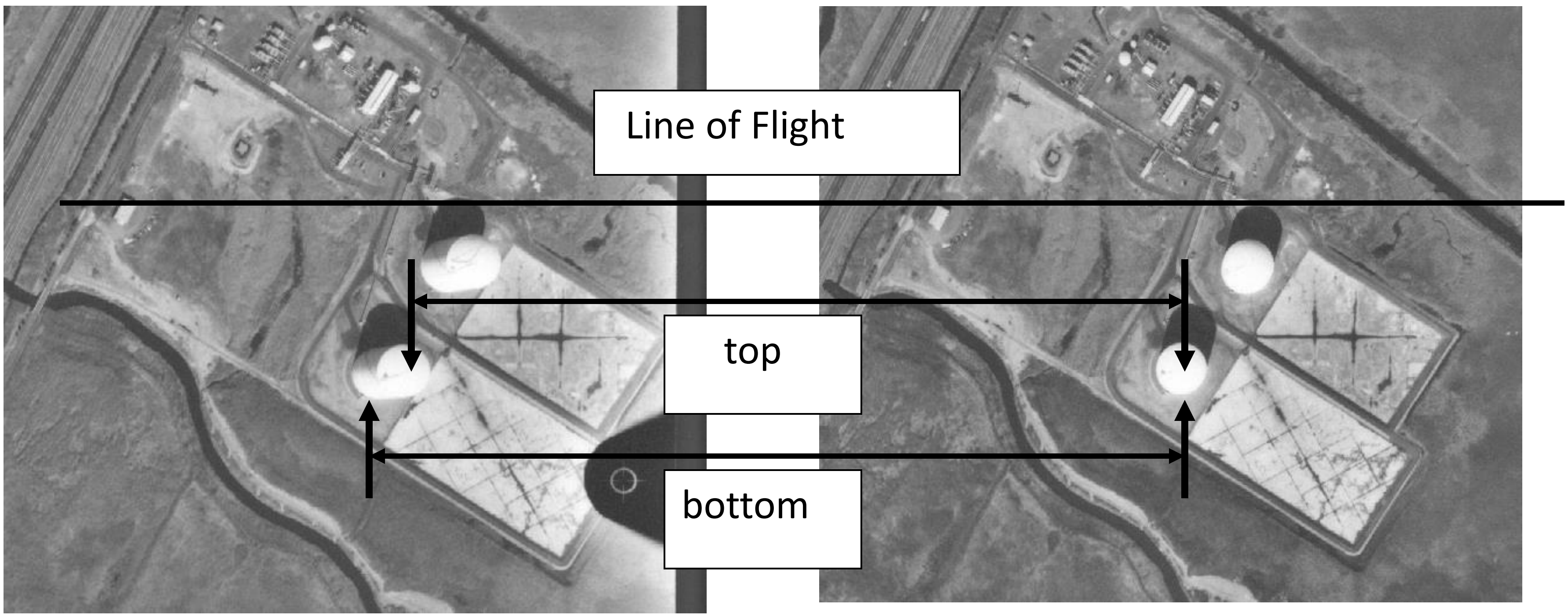
Stereoscopic Parallax

- The displacement of an object caused by a change in the point of observation is called parallax.
- Stereoscopic parallax is caused by taking photographs of the same object but from different points of observation.



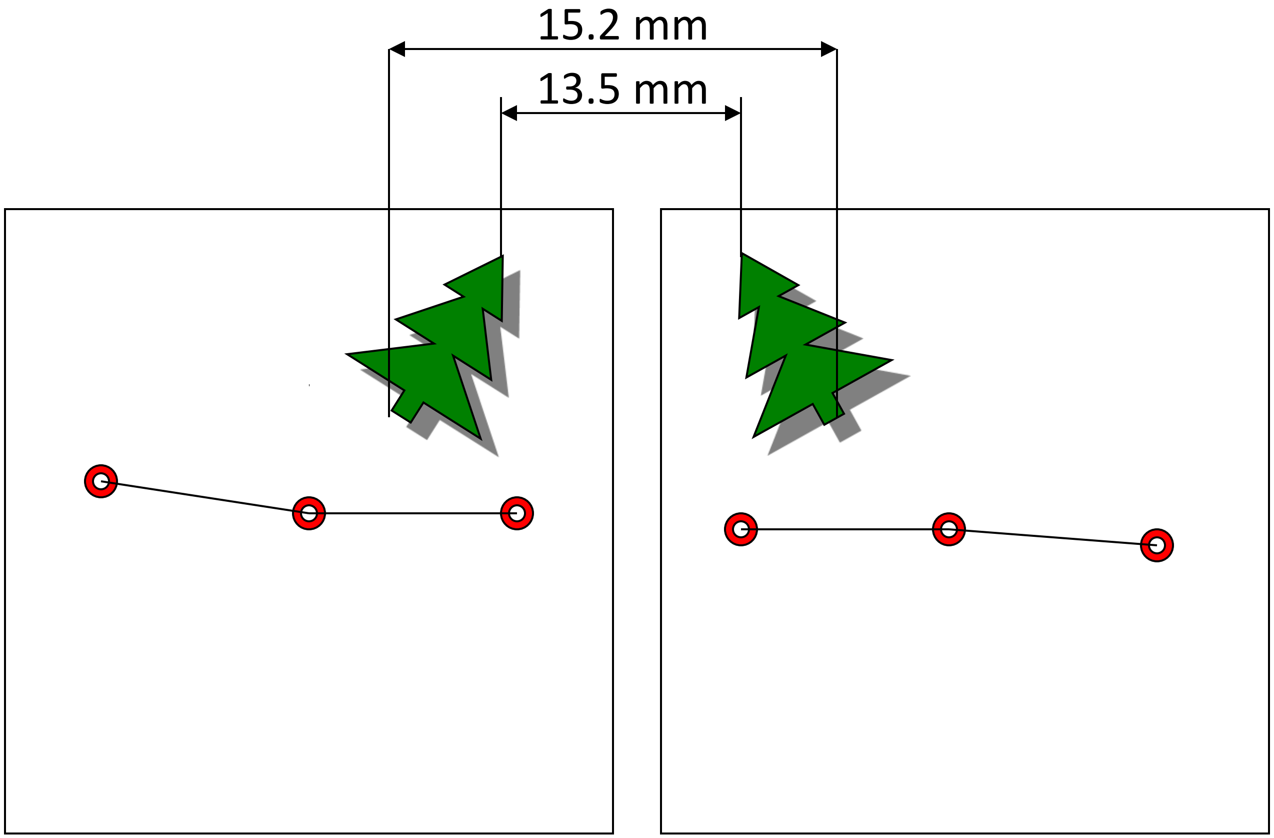
Stereoscopic parallax

Note the displacement between the top and base of the storage towers in this photo stereo-pair



Differential parallax

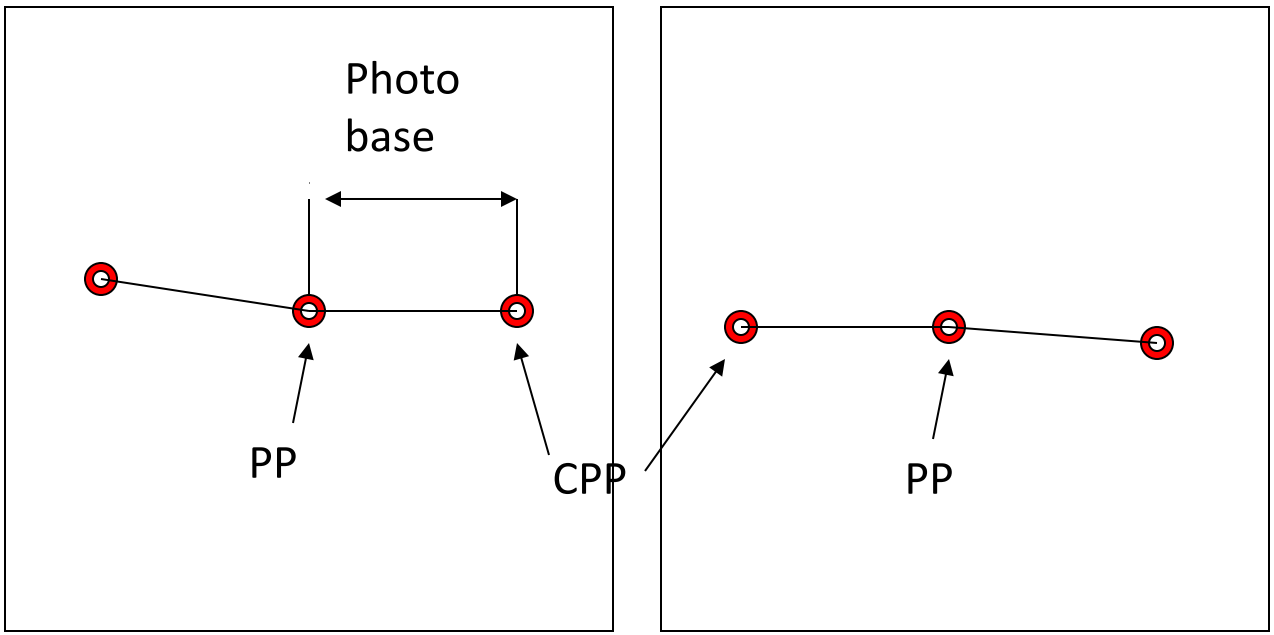
- Differential parallax - the difference between the stereoscopic parallax at the top and base of the object.



dP = 15.2mm – 13.5mm = 1.7 mm

Absolute stereoscopic parallax

- PP = Principal point = center of photo
- CPP = Conjugate principal point = adjacent photo's PP
- Absolute stereoscopic parallax → the average photo base length = average distance between PP and CPP



Computing height using stereoscopic parallax

- $h = (H') * dP / (P + dP)$

  where h = object height

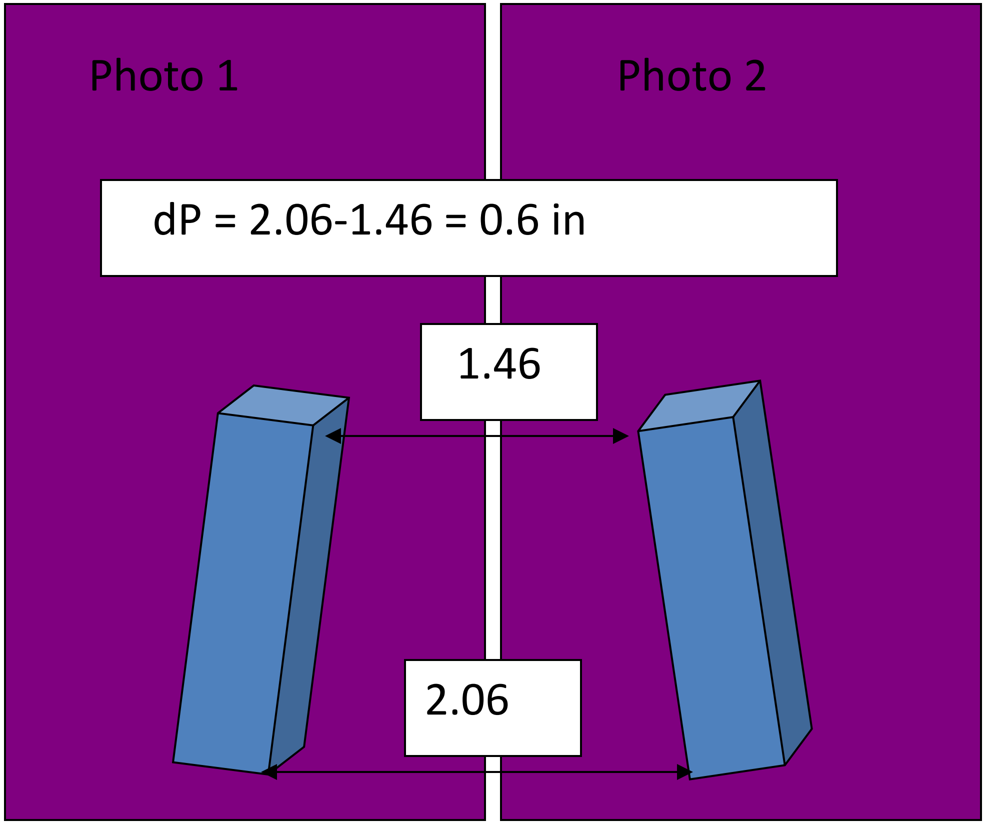
  H' = flying height

  dP = differential parallax

  P = average photo base length

Calculating Object Heights using Stereoscopic parallax

Following example taken from: T.E. Avery & G.L. Berlin. 1992, Fundamentals of Remote Sensing and Air Photo Interpretation, MacMillan P



Calculating the height of the Washington Monument via stereo parallax

Example: Computing height using stereoscopic parallax

- $h = (H') * dP / (P + dP)$
  where h = object height
  H' = flying height = 4,600ft
  dP = differential parallax = 0.6in
  P = average photo base length = 4.4in
- h = (4,600ft * 0.6in) / (4.4in + 0.6in) = 2760 ft in / 5 in = 552 ft
- True height = 555.5 ft

Alternate formulation: taken from one photo

h = (H') * d / (r)

where h = object height

H' = flying height = 4,600ft

d = relief displacement from base to top = 0.6in

same as dP

r = distance from PP to top of object

same as (P + dP)

h = (4,600ft * 0.6in) / (5.0in) = 2760 ft in / 5 in = 552 ft

Calculating Object Heights

- Object heights can be determined as follows:
  - calculate flight altitude (H’) by multiplying the RF denominator by the focal length of the camera
  - h = d * H’ / r where:

    h = Object height

    d = length of object from base to top

    r = distance from P.P. to top of object

Example: Calculating object height from relief displacement

Photo Relief displacement for Tank, d = 2.0 mm

Radial distance from P.P. to top of Tank, r = 71.5 mm

Flying Height above terrain, H’ = 918 m

Example: Calculating object height from relief displacement

Photo Relief displacement for Tank, d = 2.0 mm

Radial distance from P.P. to top of Tank, r = 71.5 mm

Flying Height above terrain, H' = 918 m

$$h = d * H' / r = (2.0 \text{ mm} * 918 \text{ m}) / 71.5 \text{ mm}$$

$$= 25.7 \text{ m} = 26 \text{ m}$$

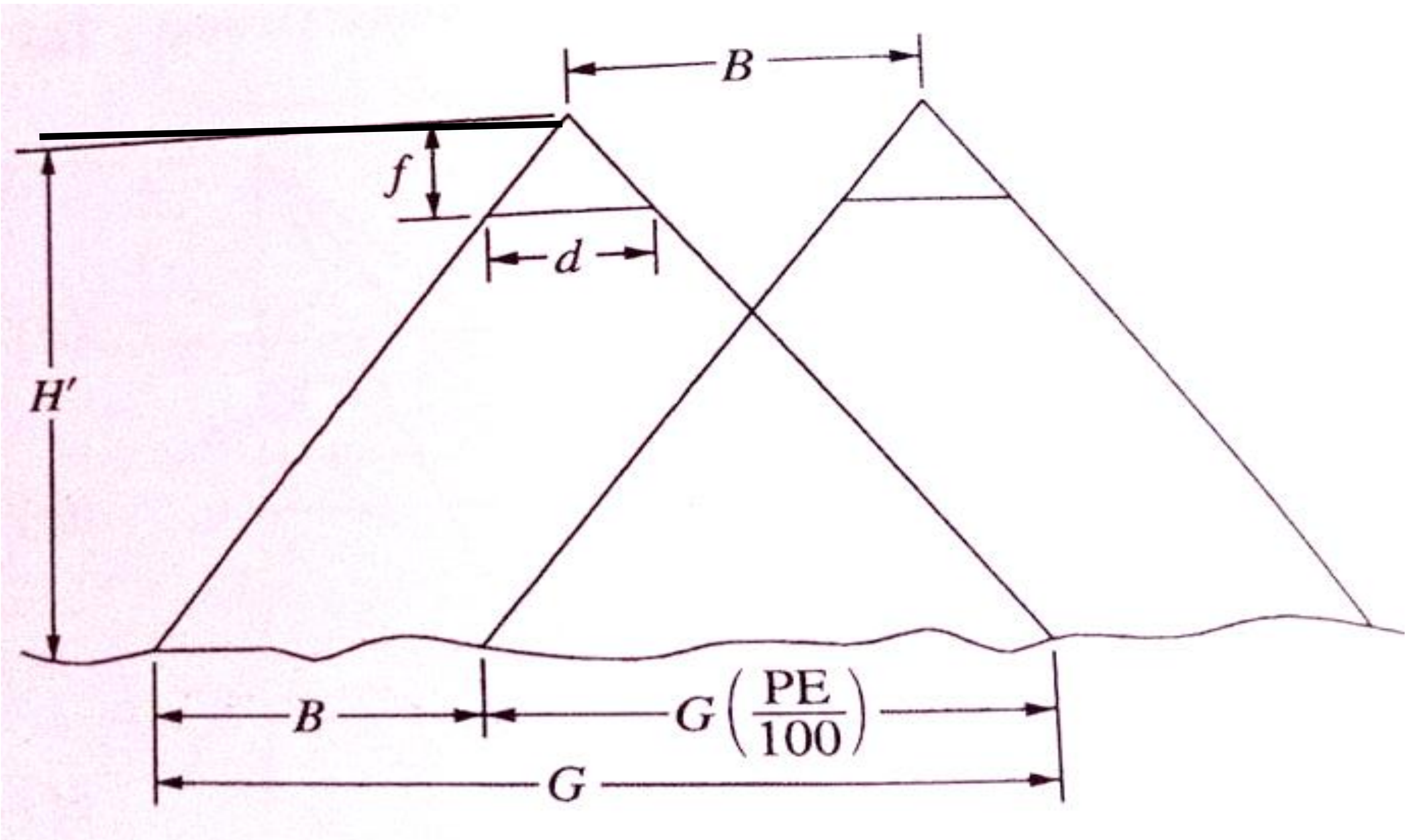
Vertical exaggeration

- Vertical exaggeration (V): vertical scale appears > horizontal scale in stereomodel.

$$V = \left(\frac{B}{H'}\right)\left(\frac{h}{b_e}\right)(approx.)$$

V – vertical exaggeration
B/H' – base-height ratio
b_e/h – stereoviewing ratio (inversed in equation on the left)

Base-height ratio



Base-height ratio

- $\frac{B}{\acute{H}} = \left(1 - \frac{PE}{100}\right)\frac{d}{f}$

Where:

PE: percentage of endlap

d: photo format

f: focal length

TCP Stereo!

Credits

- Natural resources Canada
- Civil and Surveying Engineering/ Penne State
- TCP Stereo software