AERIAL REMOTE SENSING

UNIT 4

Figure 1. 1:3000 Aerial Photograph (Reduced to 85%)

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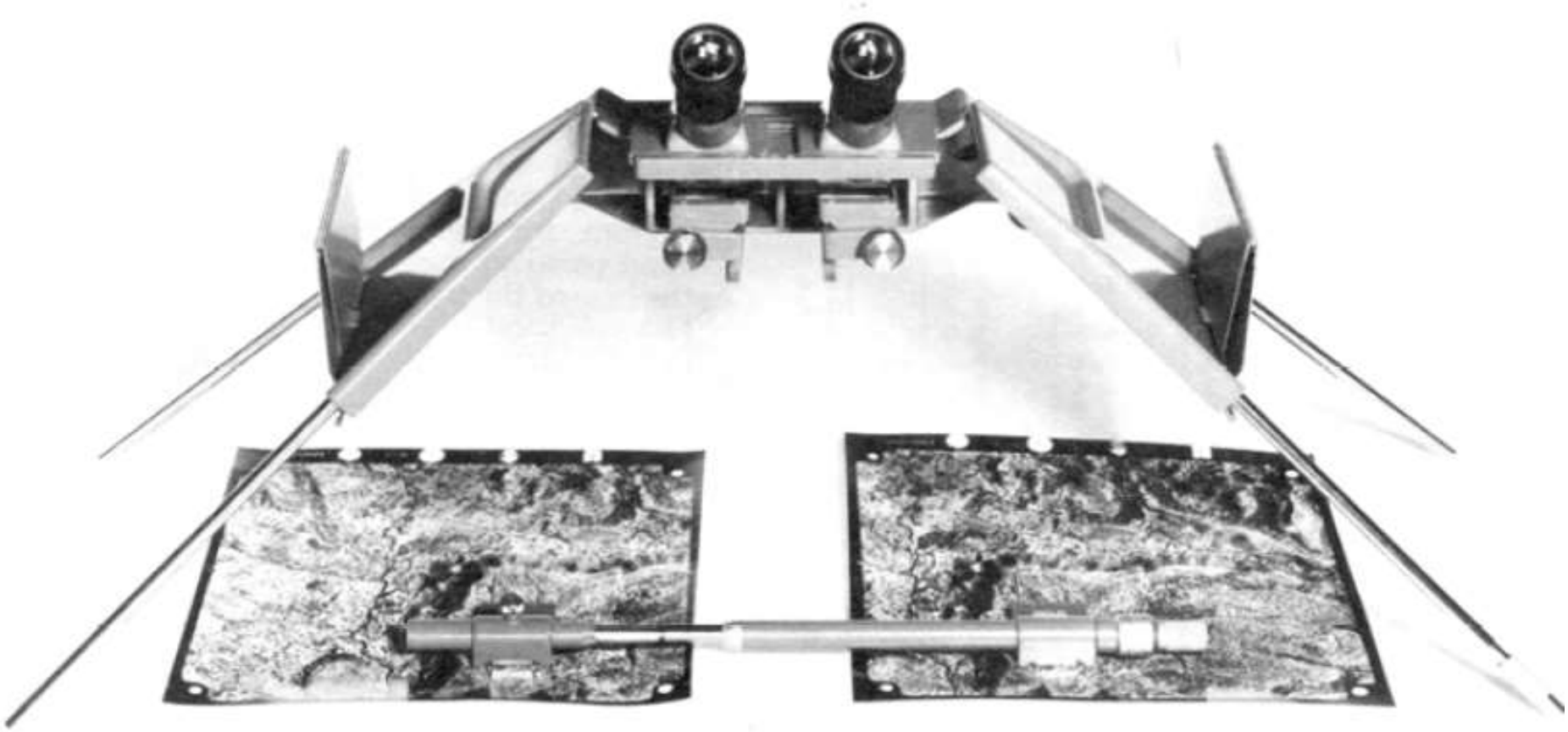
Principles of Stereoscopy



STEREO MODELS

In our daily activities, we unconsciously measure depth or judge distances to vast number of objects about us through our normal process of vision

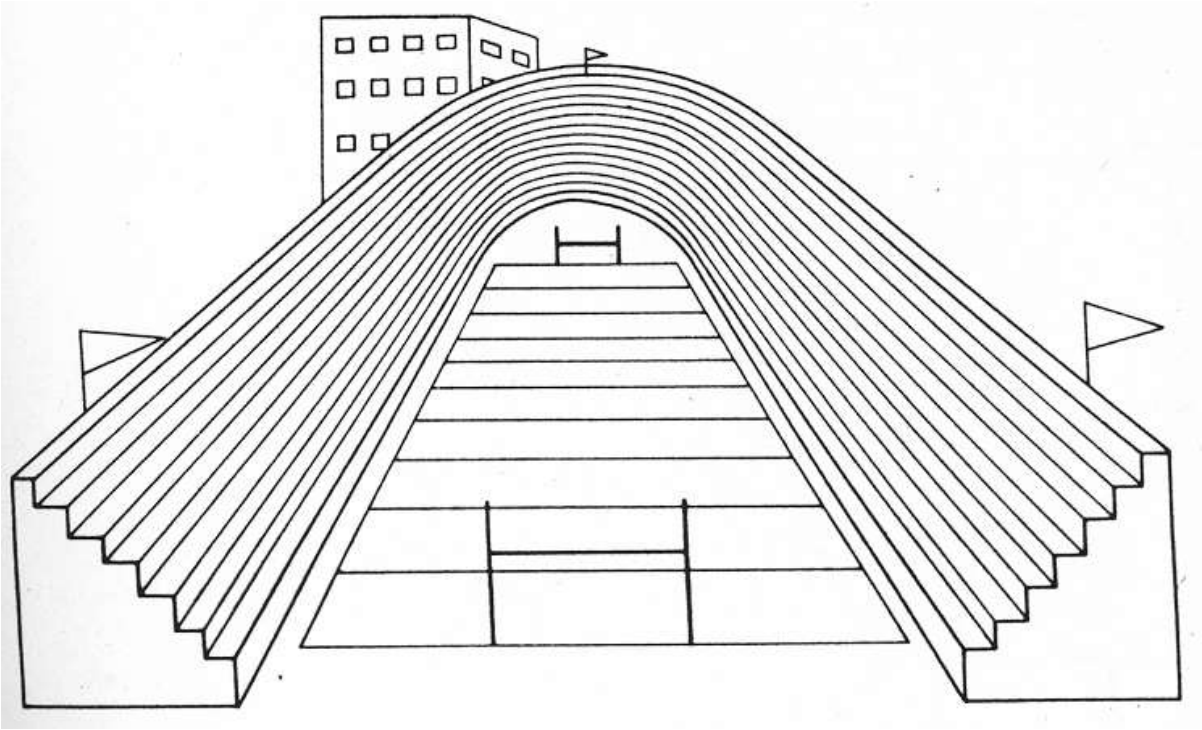
Methods of judging depth may be classified as either **stereoscopic or monoscopic**.

Persons with normal vision (those capable of viewing with both eyes simultaneously) are said to have binocular vision and perception of depth through binocular vision is called **stereoscopic viewing**. Studying the aerial photographs with aid of stereoscope

Monocular vision is the term applied to viewing with one eye and methods of judging distances with one eye are termed **monoscopic.** Studying the aerial photographs with out aid of stereoscope

Distances to objects, or depth can be perceived monoscopically on the basis of

1) Relative sizes of objects, 2) Hidden objects, 3) Shadows and 4) Differences in focusing of the eye for viewing objects at varying distances.



Monoscopic methods of depth perception - Enable only rough impressions to be gained of distances to objects.

Much greater degree of accuracy in depth perception can be achieved by – stereoscopic vision.

Formation of Stereoscopic Model

Flightline

Photo Exposure Centers

Stereoscope

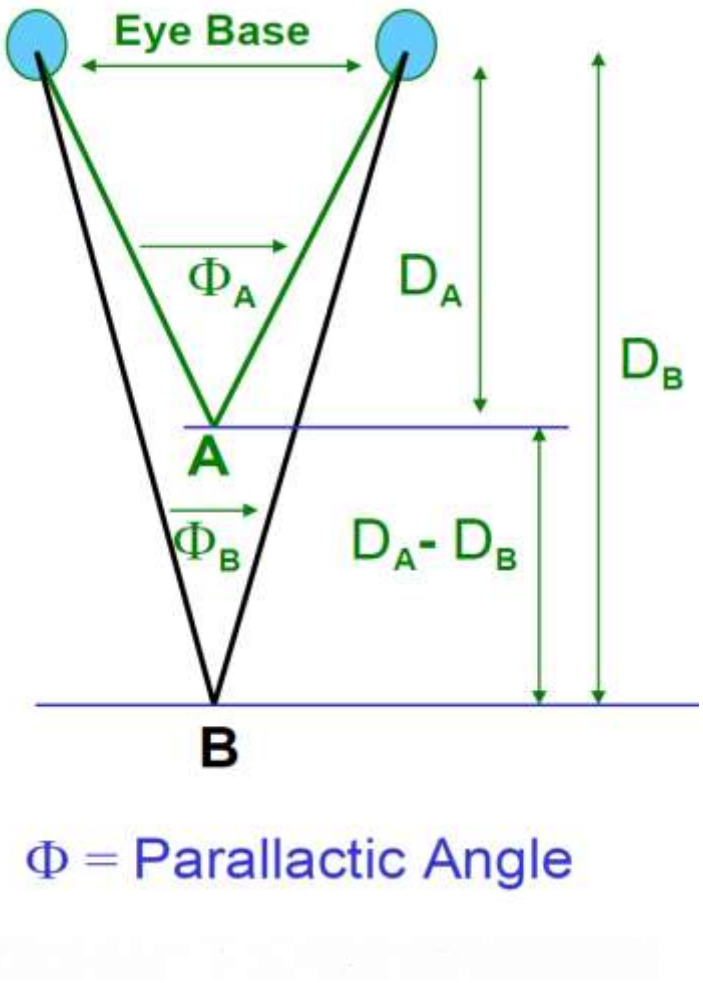
Photo n

Photo n + 1 along flightline

Stereo Model

STEREOSCOPIC DEPTH PERCEPTION

With binocular vision, when the eyes fixate on a certain point, the optical axes of the two eyes converge on that point, intersecting at an angle called the parallactic angle. The nearer the object, the greater the parallactic angle and the object with long distance having the low parallactic angle.



The optical axes of the two eyes L and R are separated by a distance b_e called the eye base. For the average adult, the distance is between 63 and 69 mm or approximately 2.6 in.

When the eyes fixate on point A, the optical axes converge, forming parallactic angle ϕ_a. Similarly, when sighting an object at B, the optical axes converge, forming parallactic angle ϕ_b.

The brain automatically and unconsciously associates distances D_A and D_B with corresponding parallactic angles ϕ_a and ϕ_b. The Depth between objects A and B is D_B - D_A and is perceived from the difference in these parallactic angles.

The ability of human beings to detect changes in parallactic angles and thus judge differences in depth is quite remarkable. Although it varies some what among individuals. The photographic procedures for determining heights of objects and terrain variations based on depth perception by comparisons of parallactic angles can be highly precise.

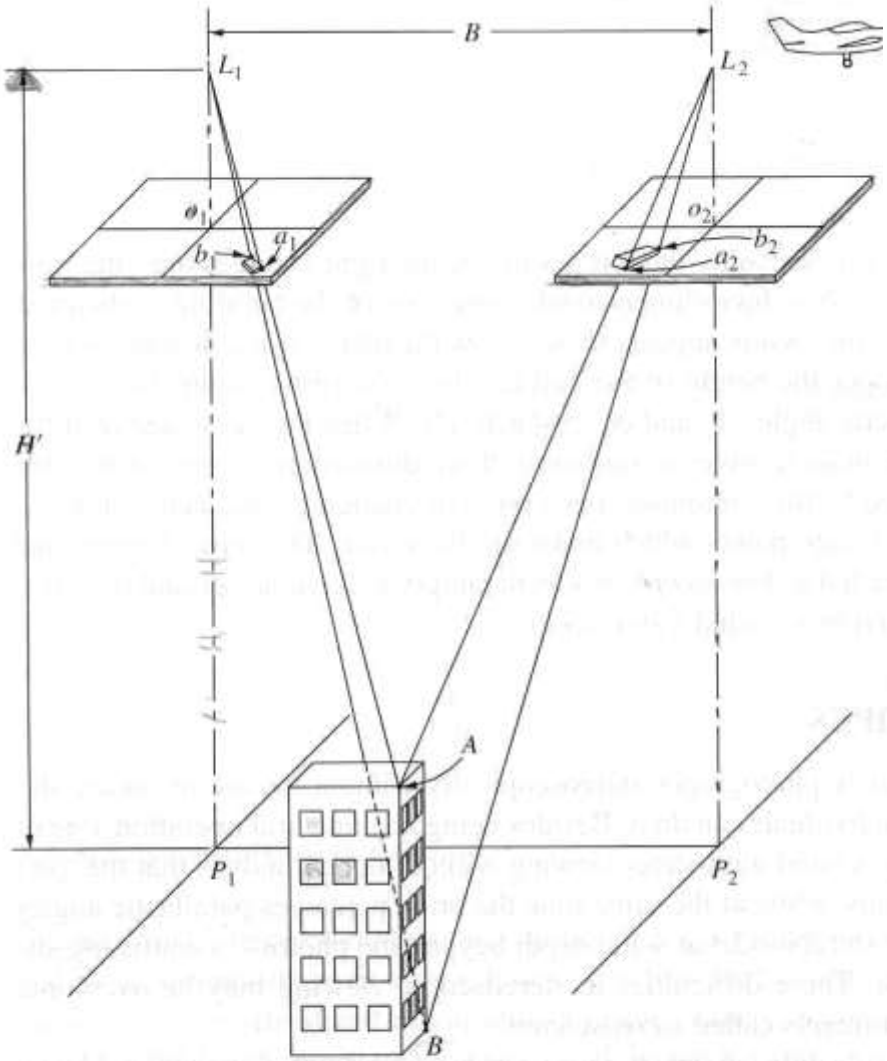


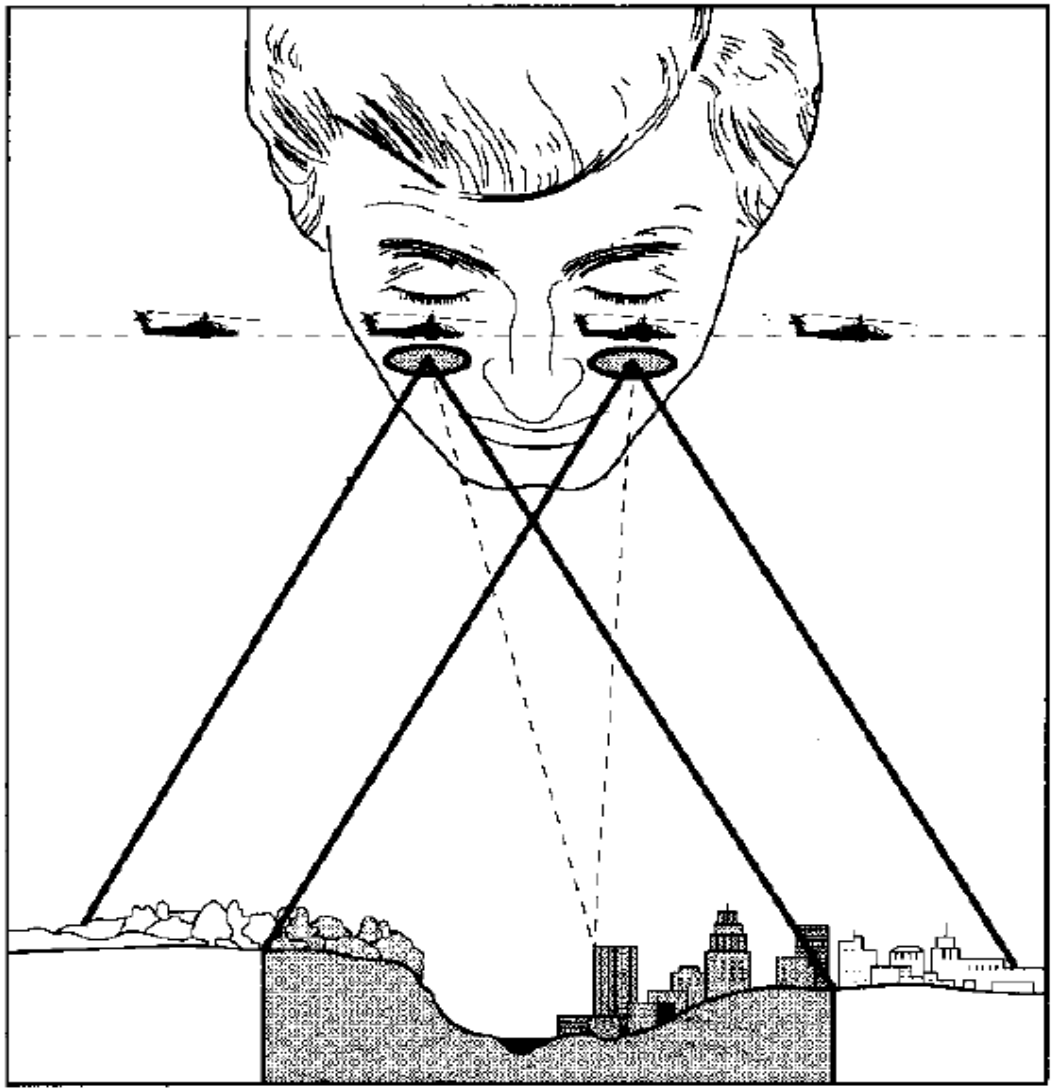
FIGURE 7-5
Photographs from two exposure stations with building in common overlap area.

A pair of aerial photographs is taken from exposure station L_1 and L_2 so that the building appears on both photos.
Flying height above ground is H' and the distance between the two exposures is B, the air base.
Object point A and B at the top and bottom of the building are imaged at a_1 and b_1 on the left photo and at a_2 and b_2 on the right photo.

If these two photos are laid on a table and viewed so that the left eye sees only left photo and the right eye sees only the right photo so that three dimensional impression of the building is obtained

The brain judges the height of the building by associating depths to points A and B with the parallactic angles ϕ_a and ϕ_b respectively.
When the eyes gaze over the area entire overlap area, the brain receives a continuous three dimensional impression of the terrain. The three dimensional model thus formed is called a stereoscopic model or simply **stereomodel** and the overlapping pair of photograph is called a **stereopair**

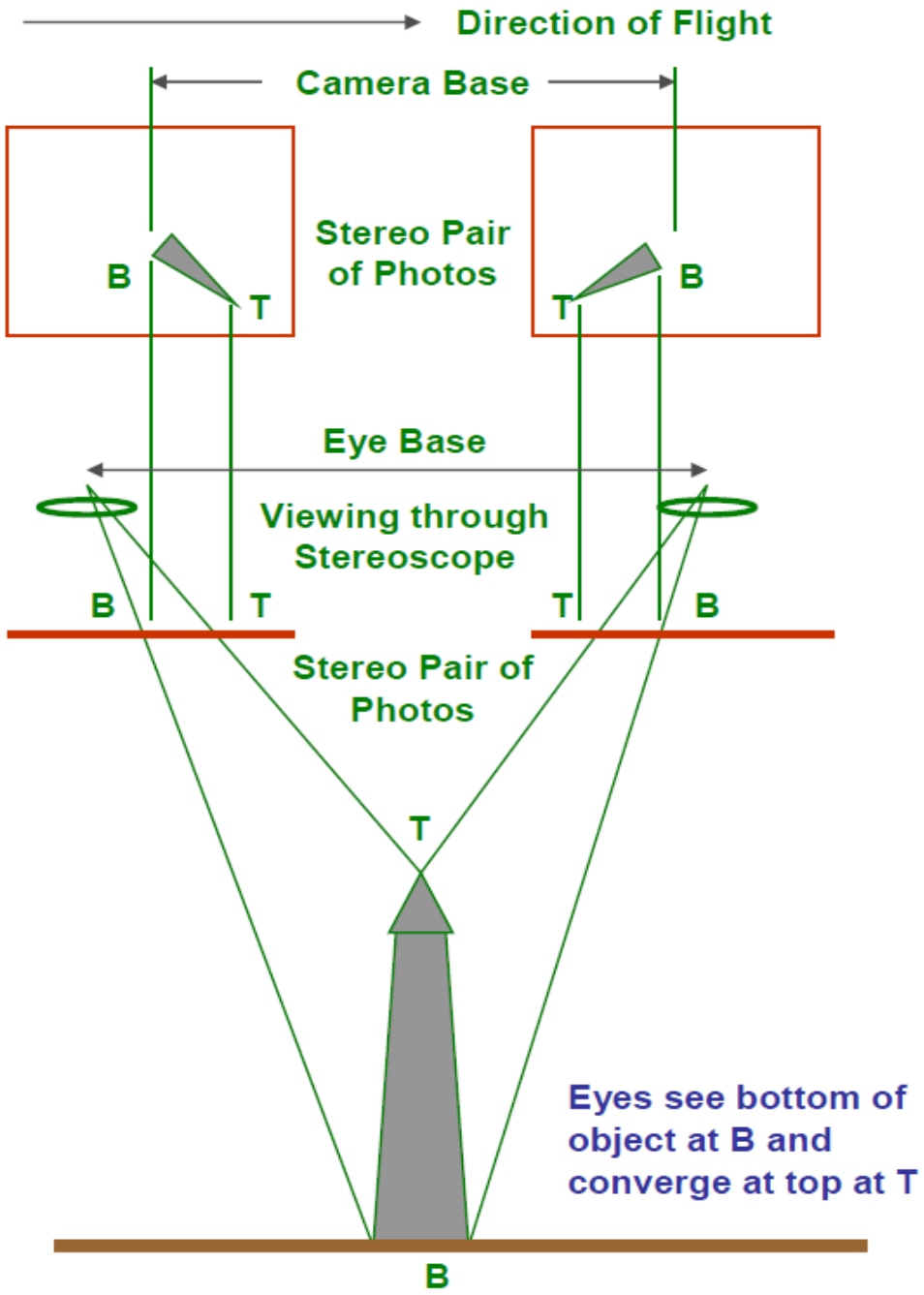
The “giant” eyebase of stereo photography



← Stereo Model →

After Jensen, 2004

Principles of Stereo Viewing



Base Height Ratio – Vertical Exaggeration

Under the normal conditions, the vertical scale of a stereomodel will appear to be greater than the horizontal scale i.e an object in the stereomodel will appear to be toll. This apparent scale disparity is called vertical exaggeration.

The vertical exaggeration is caused primarily by the lack of equivalence of the photographic base-height ratio, B/H' and the corresponding stereo viewing base-height ratio, b_e /h.

The term B/H' is the ratio of the air base (distance between the two exposure stations) to flying height above average ground.

b_e /h is the ratio of the eye base (distance between the two eyes) to the distance from the eyes at which the stereomodel is perceived.

For topographic mapping and other precise quantitative photogrammetric measurements, photography preferably taken with a wide or super wide angle (short focal length) camera so that a large base – height ratio (B/H') is observed

The larger the b/h' ratio, the greater the intersection angles or parallactic angles.

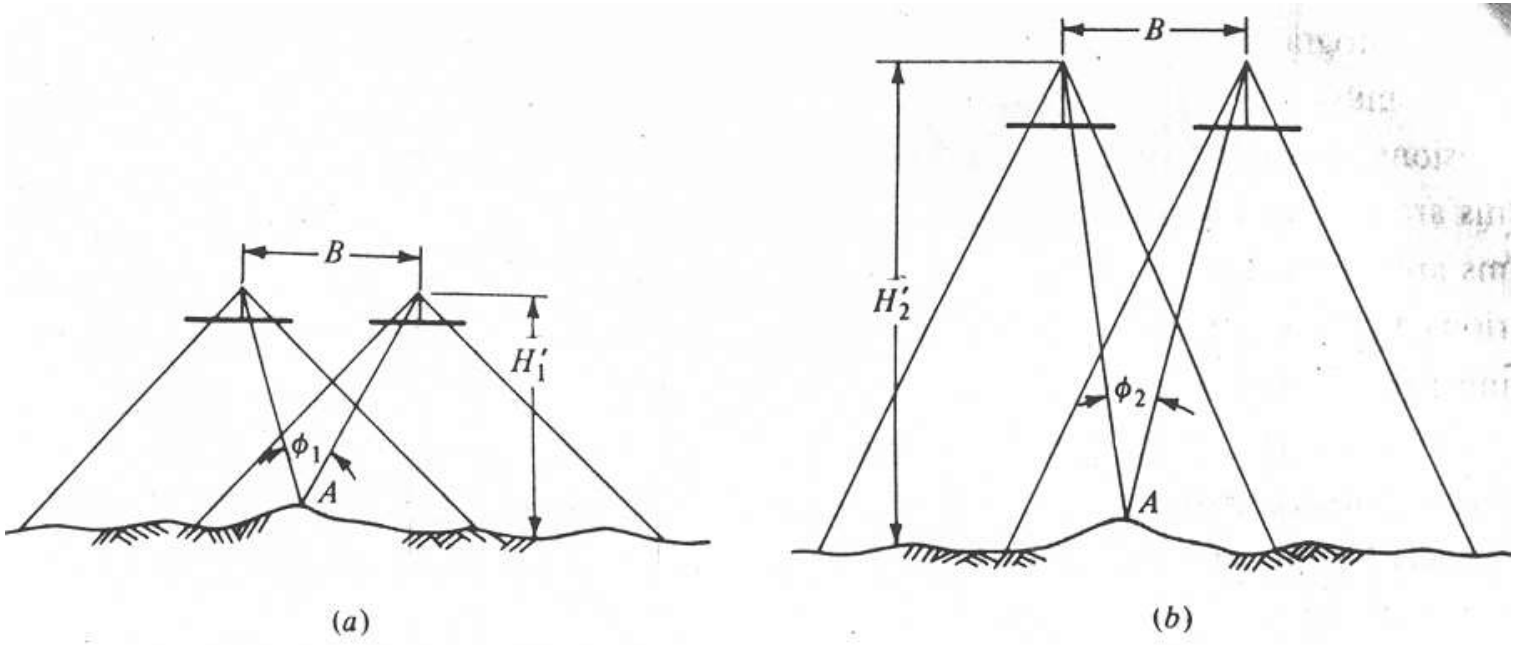


FIGURE 10-6
Parallactic angles increase with increasing B/H' ratios.

The air bases are equal in these two cases. But the focal length and flying height are half those of right side figure

Decreased b/h' ratio can be attained by increasing flying height and now by using a longer focal length camera to compensate the scale reduction, this can be done.

Aerial photographs with Decreased b/h' ratio is more desirable for

- Mosaic construction because
- Scale variations
- Image distortions / displacement due to
- Relief, tilt and flying height variations
- Are much less.

VERTICAL EXAGGERATION IN STEREOVIEWING

The condition of increased vertical scale of the photo object than its normal height is known as vertical exaggeration.

- **Scale disparity**
- **Vertical scale is greater than the horizontal scale**

Although other factors are involved, Vertical Exaggeration is caused primarily by the lack of equivalence of the B/H' ratio in obtaining the photography and the corresponding (be / h) ratio in stereoviewing.

- **Ratio of the air base to flying height above the ground (B/H')**
- **b_e /h – is the ratio of the eye base to the distance from the eyes at which the stereomodel is perceived.**

The product of the B/H' ratio and the inverse of the be/h ratio gives an approximation of vertical exaggeration, or

$$V = \frac{B}{H'} * \frac{h}{be}$$

STEREOSCOPIC PARALLAX

Apparent shift in the position of an object, with respect to a frame of reference, caused by a shift in the position of observation

Change in position of an image from one photo to the next is caused by aircraft's motion

- **Called stereoscopic parallax, x parallax, or simply parallax**

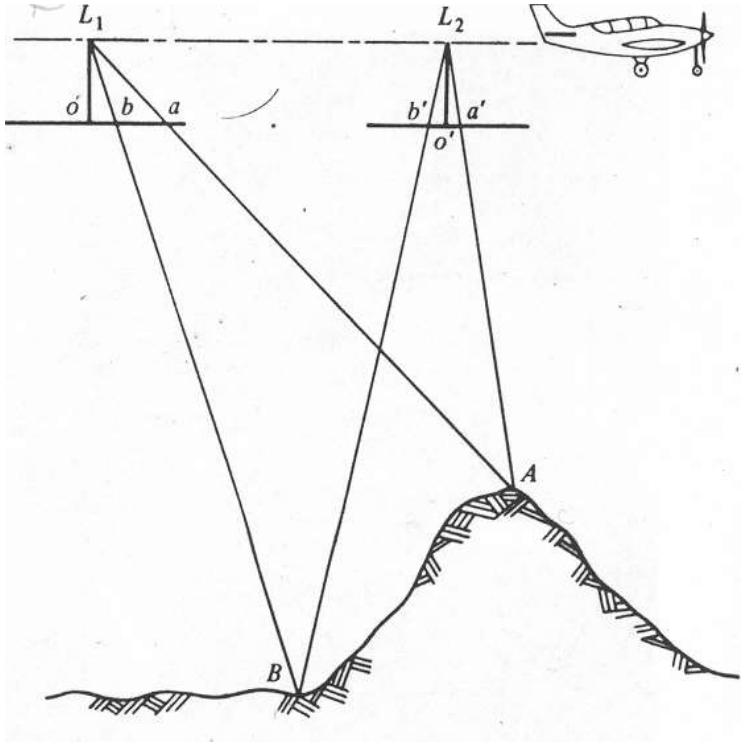
Two important aspects of stereoscopic parallax

- **Parallax of any point is directly related to the elevation of the point**
- **Parallax is greater for high points than for low points**

Images of object point A and B appear on a pair of overlapping vertical photographs which were taken from exposure station L_1 and L_2.

Point A and B are imaged at a and b on the left hand photograph. Because of forward motion of the air craft between exposure, these points appear at a' and b'.

Because Point A is higher than B, in other words the parallax of point A is higher than point B.



This lead to two important aspects of stereoscopic parallax such as

1.The parallax of any point is directly related to the elevation of the point

2.Parallax is greater for high points than low points

Variation of parallax with elevation provides the fundamental basis for determining elevations of points from photographic measurements.

Also, X,Y and Z ground coordinates can be calculated for points based upon their parallaxes

Parallaxes of object points A and B are pa and pb respectively. Stereoscopic parallaxes for any point such as A expressed in terms of flight line photographic coordinates is

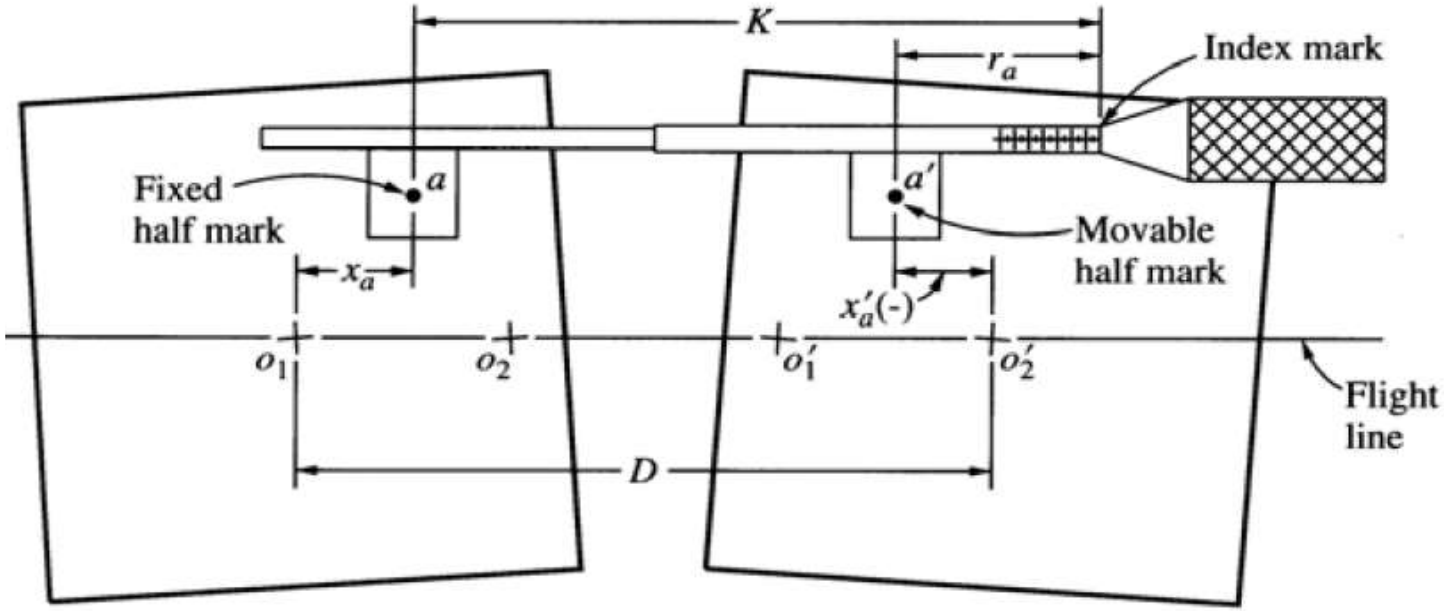
$$pa = xa - x'a$$

pa is the stereoscopic parallax of object point A, xa is the measured photo coordinate of image a on the left photograph of the stereopair and x'a is the photo coordinate of image a' on the right photo.

Stereoscopic Methods of Parallax Measurement

Through the principal of the floating mark, parallaxes of points may be measured stereoscopically. This method employs a stereoscope in conjunction with an instrument called a **parallax bar** also called as **stereometer**.

A parallax bar consist of a metal rod to which are fastened two half marks. The right half mark may be moved with respect to the left mark by turning micrometer screw. Reading from the micrometer are taken with the floating mark set exactly on points whose parallaxes are desired. From the micrometer reading, parallaxes or differences in parallaxes are obtained.



When a parallax bar is used, the two photos of a stereopair are carefully oriented, flight line of each photo lies precisely along a common straight line as line AA'. The left half mark called the fixed mark is unclamped and the right half mark or moveable mark may be moved left or right with respect to the fixed mark (increasing or decreasing parallax) as required to accommodate high points or low points with out exceeding the run of the parallax bar graduation.

After the photos have been oriented and the left half mark is fixed in position as just described, the parallax bar constant C for the setup is determined

The spacing between principal points is a constant (D). Once fixed mark is clamped, the distance from the fixed mark to the index mark of the parallax bar is also a constant (K)

The parallax of point A is

$$p_a = x_a - x'_a = D - (K - r_a) = (D - K) + r_a$$

The term (D – K) is C, the parallax bar constant for the setup. Also r_a is the micrometer reading. By substituting C into the above equation

$$p_a = C + r_a$$

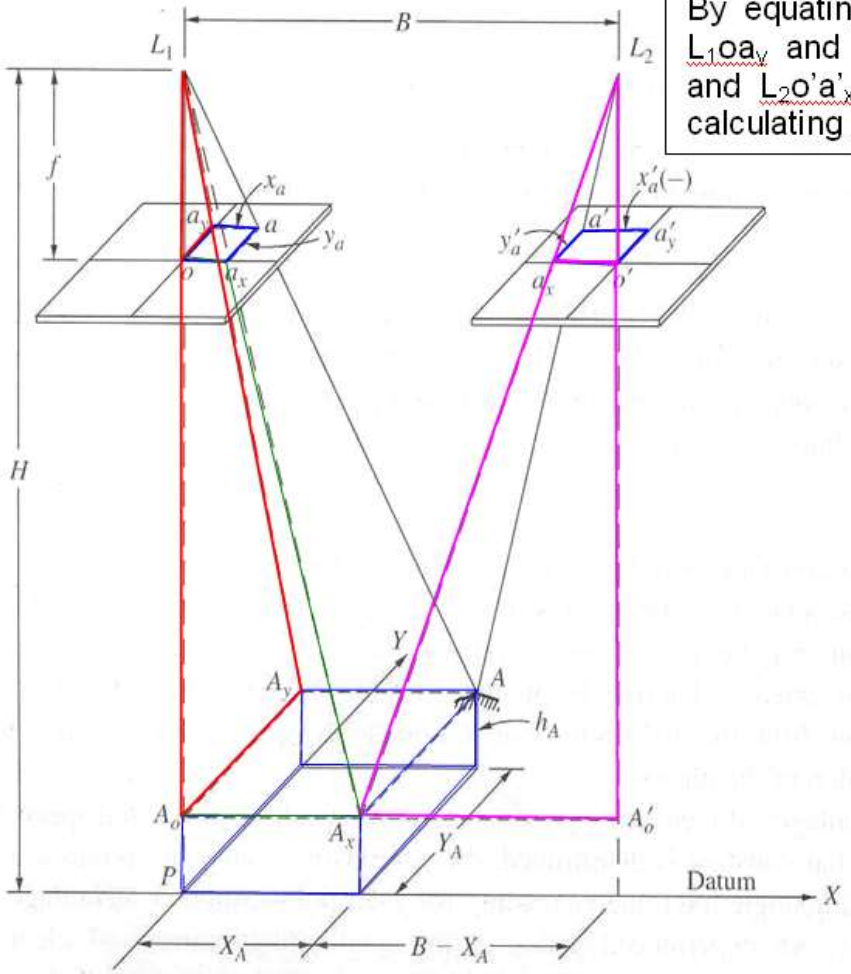
If p and r is known, the value can be calculated by

$$C = p + r$$

The parallax bar constant should be determined on the basis of micrometer readings and parallax measurements for two points.

Parallax Equation

X,Y and Z ground coordinates can be calculated for points based upon the measurements of their parallaxes. An overlapping pair of vertical photographs which have been exposed at equal flying heights above datum



By equating similar triangles such as L_1oa_y and $L_1A_0A_y$, L_1oa_x and $L_1A_0A_x$, and $L_2o'a'_x$ and $L_2A'_0A_x$, formulas for calculating h_A, X_A and Y_A

$$h_A = H - \frac{Bf}{p_a}$$

$$X_A = B \frac{x_a}{p_a}$$

$$Y_A = B \frac{y_a}{p_a}$$

hA is the elevation of point A above datum, H is the flying height above datum, B is the air base, f is the focal length of the camera. pa is the parallax of point A, XA and YA are the ground coordinates of point A, xa and yb are the photo coordinates of point 'a' measured with respect to flight line axes on the left photo.

These equations are called **parallax equations**.

Approximate Equation for Height of Objects from Parallax Differences

In many applications it is necessary to estimate heights of objects to a moderate level of accuracy

By modifying the above equation, we can calculate the approximate height of the object

$$h_A = \frac{\Delta pH}{b + \Delta p} \quad \text{or} \quad h_A \approx \frac{\Delta pH}{b}$$

h_A: Height of the point A above ground

Δp: = pa – pc is the difference in parallax between the top of the feature and the ground

H : is the flying height above ground

b: is the photo base for the stereopair

PHOTO MOSAICS

Mosaics:

An assemblage of two or more individual overlapping photographs to form a single continuous picture of an area.

Photographic reproduction of a whole series of aerial photographs assembled in such a manner that the detail of one photograph matches the detail of all adjacent photographs at a much smaller scale.

Uses of Mosaics:

- ➔Useful in the field of planning – landuse / engineering
- ➔Geological and natural resource inventory
- ➔Many more interpretations and mapping them
- ➔Shows areas completely and comprehensively
- ➔Prepared rapidly and economically
- ➔Alternate plans can be conveniently investigated
- ➔Useful for detailed study and best overall plan can be finally adopted.
- ➔Used as planimetric map substitutes for many engineering projects
- ➔Eliminates most of the ground surveying and plotting
- ➔Design drawings and construction specifications are superimposed directly over the mosaic as overlay
- ➔Time and cost saving and
- ➔Higher accuracy.

Types of Mosaics:

i. Index or photo index
ii. Strip
iii. Controlled
iv. Semi controlled
v. Uncontrolled
vi. Temporary and
vii. Orthophoto mosaic.

1. Photo indexing or index mosaics

Uncontrolled mosaic which has been laid to very rough specifications. Prepared immediately after the flight for the purpose of providing an index to individual photographs for correlating photo numbers and photo coverages.

The primary use

- ➔ **for indexing**
- ➔ **for photo retrieval from the files**
- ➔ **to know the ground coverage and**
- ➔ **to check for any gaps or missed areas for any necessary reflights**
- ➔ **Least expensive type of mosaic – uncontrolled and**
- ➔ **Not permanently mounted on a backing.**

2. Strip Mosaic:

A strip mosaic is the assembly of a series of photographs along a single flight strip. Useful in planning and designing linear engineering projects like, Rail roads, pipelines, etc.
May be controlled, uncontrolled or semicontrolled.

3. Controlled Mosaic

A compilation of rectified photographs, so assembled that their principal points and other selected intermediate points are located in their true horizontal positions.
Rectification – the process of projecting a tilted or oblique photo on to a horizontal plane.
This projection may be of graphic or by photography in a special camera called rectifier or rectifying camera.

Each photograph is oriented in position by matching the photographic images of selected control points to the corresponding plotted position of the pre-established points

The rectified photo will have

➔horizontality or free from tilt

➔better uniformity of scale

➔uniformity in tones and contrasts of the print.

4.0 Uncontrolled mosaic

Prepared by simply matching the image details of adjacent photos.

- ➔ There is no ground control and
- ➔ Vertical photos which have not been rectified or ratioed are used.
- ➔ They are not as accurate as controlled mosaics
- ➔ But for quaitative uses they are completely satisfactory.
- ➔ Usually, the central portion of each photograph is taken which is relatively free from relief and tilt displacements, and scale distortions.
- ➔ The photos are laid out in strips in straight lines.
- ➔ Then the different strip mosaics are matched together to compile a mosaic for the entire area.

5.0 Semicontrolled mosaic:

Assembled utilizing some combination of the specifications for controlled and uncontrolled mosaics.

- **By using ground control but using**
- **Photographs that have not been rectified or ratioed (or)**
- **Use rectified and ratioed photos but no ground control**
- **These mosaics are a compromise between economy and accuracy.**

6.0 Temporary Mosaic:

Whenever the conditions do not permit to prepare a controlled or uncontrolled mosaic and a large area needs to be viewed within a short time, then a very temporary mosaic may be prepared.

- ➔ Save the photo from trimming and
- ➔ The same photos can be used for stereoscopic viewing for photo interpretation after this purpose
- ➔ Alternate photos in a strip are taken
- ➔ Their borders only are trimmed
- ➔ Used without rectification or ratioing
- ➔ Strips are laid in a soft board
- ➔ Multiple strips are assembled and pinned on the board and used.

7. Orthophoto Mosaic:

An assembly of two or more orthophotos to form a continuous picture of the terrain. Ortho photos are derived from vertical aerial photographs using a differential rectification instrument.

- ➔ **Have had no image displacements due to relief and tilt – they are removed**
- ➔ **So that they show features in their true planimetric positions**
- ➔ **Distances, angles and areas can therefore be measured directly**
- ➔ **They have the pictorial advantages of aerial mosaics and the geometric correctness of maps.**
- ➔ **They can usually be prepared more rapidly and economically than line and symbol maps.**