23 November 2001

TERRESTRIAL AND NUMERICAL PHOTOGRAMMETRY

1. MID -TERM EXAM – Question 4

Two-camera stations are located at the ends of a base, which are 191.46m long, measured horizontally. Photographs have been taken in the normal case photography. The height of each camera is 177.82 m. The camera focal length is 172.20 mm. The coordinates of the points A and B are measured on the left and right photographs.

Image coordinates measured on the left hand photograph are;

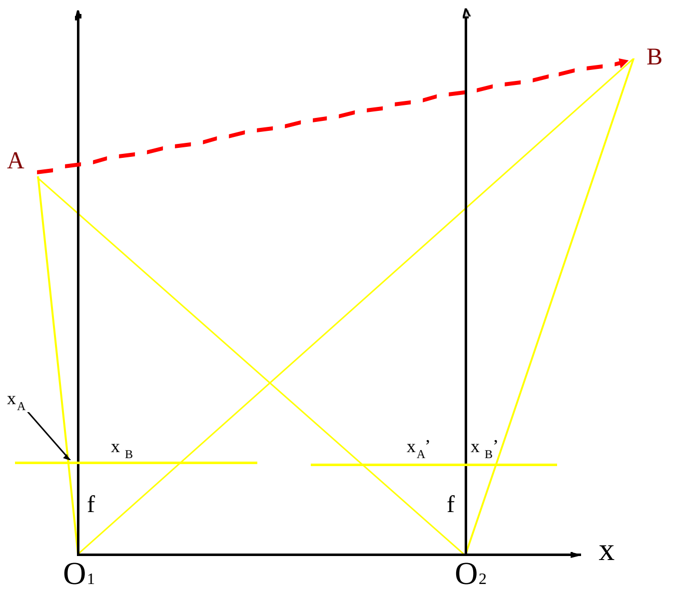
x_a = -27.21 mm. x_b = 91.22mm.

z_a = 8.95 mm. z_b= -21.80 mm.

The coordinates of the points A and B measured on the right hand photograph are;

x_a'= -81.70 mm. x_b'= 50.20 mm.

Determine the ground coordinates and elevation of A and B. Calculate the distance between these two points. (40 p)



Results of Question:

X_A = -95.607 m X_B = 425.767 m

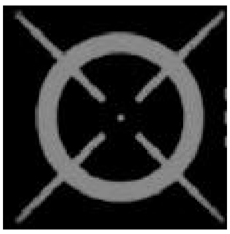
Y_A = 605.054 m Y_B = 803.740 m

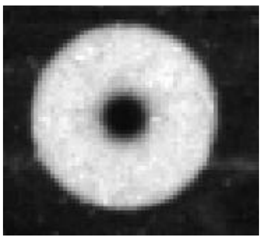
H_A = 31.447 m H_B = 76.069 m

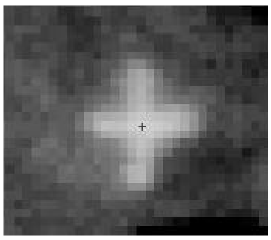
Distance between A and B is = 557.95 m

Fiducial Marks

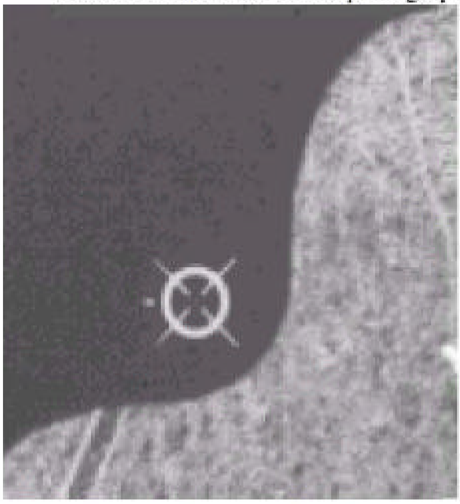
Fiducial marks are small targets on the body of metric cameras. Their positions relative to the camera body are calibrated. Thus, they define the image co-ordinate system; in that system, the position of the projection centre is known. Form as well as distribution of fiducial marks depend on the manufacturer. If amateur cameras are used, the images of corners of the camera frame on the negatives can be used instead of fiducial marks.







Example of a fiducial mark, In this case found in each corner of the photograph



Fiducial Marks

- There are many varieties of fiducial mark employed by different cameras and manufacturers. They all provide a means of precisely identifying the location of the principle point

Corner Fiducials

Side Fiducials

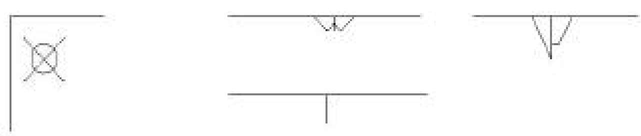
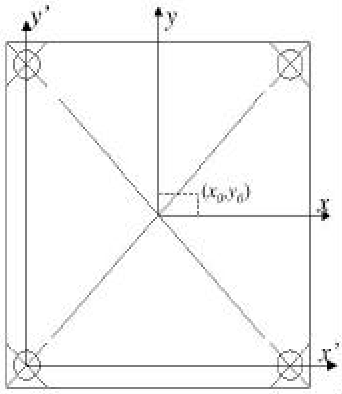


Photo Coordinate System

- A Photo coordinate system is defined in reference to the fiducial marks, and the position of the PP given in the defined coordinate system, as (x_0, y_0).
- Positive x is defined as the direction of flight



Metric Cameras

They have stable and precisely known internal geometries and very low lens distortions. Therefore, they are very expensive devices. The principal distance is constant, which means, that the lens cannot be sharpened when taking photographs. As a result, metric cameras are only usable within a limited range of distances towards the object. The image coordinate system is defined by (mostly) four fiducial marks, which are mounted on the frame of the camera. Terrestrial cameras can be combined with tripods and theodolites. Aerial metric cameras are built into aeroplanes mostly looking straight downwards. Today, all of them have an image format of 23 by 23 centimeters.

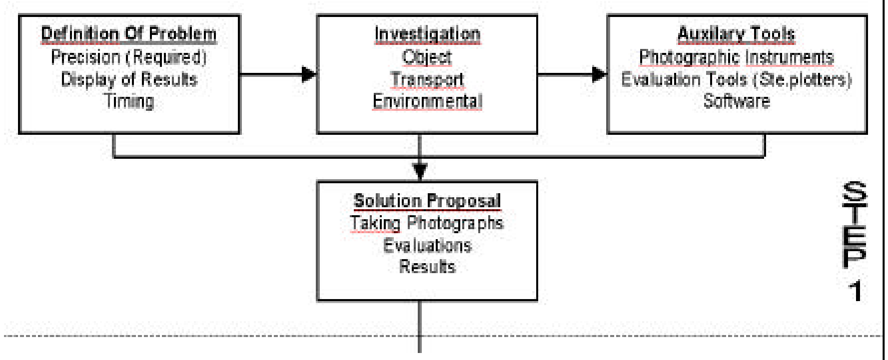
CAMERAS IN TERRESTRIAL PHOTOGRAMMETRY

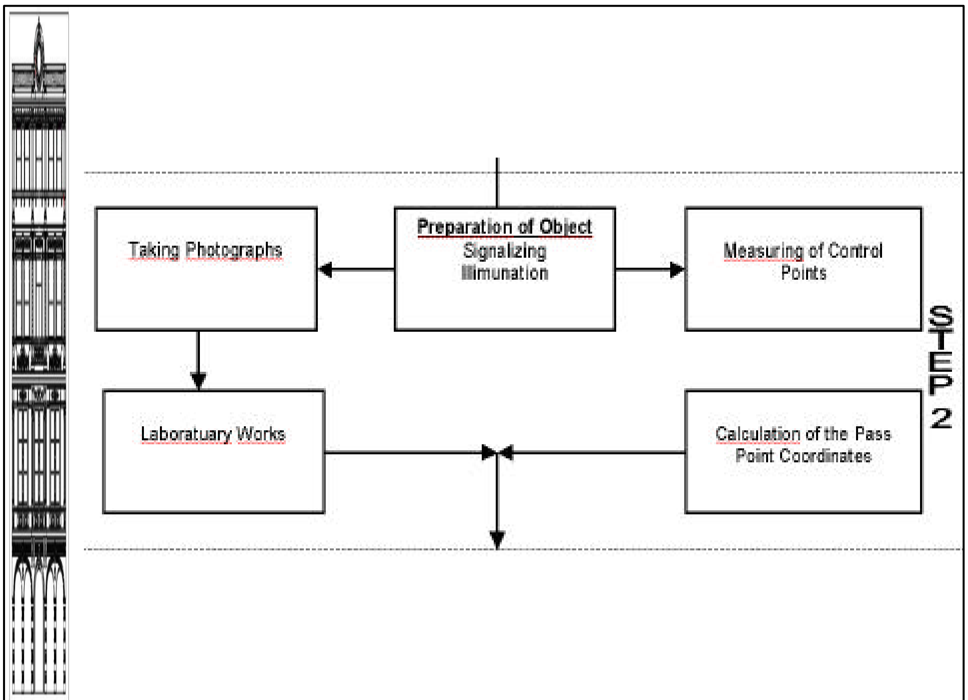
Two basic camera types are employed in terrestrial photogrammetry. These are; metric cameras and non metric cameras.

Metric cameras are designed and calibrated specifically for photogrammetric measurement. It has a known and stable interior orientation and is usually a fixed-focus camera. They also contains fidicual marks with which to recover the interior orientation.

Nonmetric cameras are represented by a variety of fairly high-quality hand-held cameras used by amateur and professional photographers to take good pictorial quality.

STEPS OF A TERRESTRIAL PHOTOGRAMMETRIC APPLICATION





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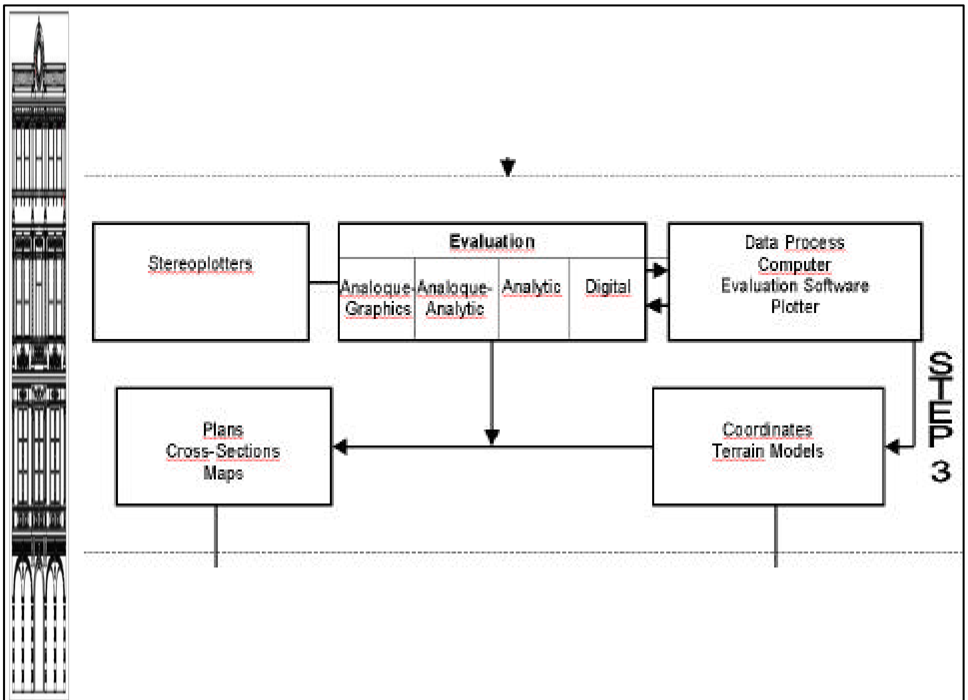

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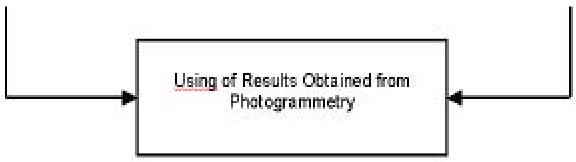
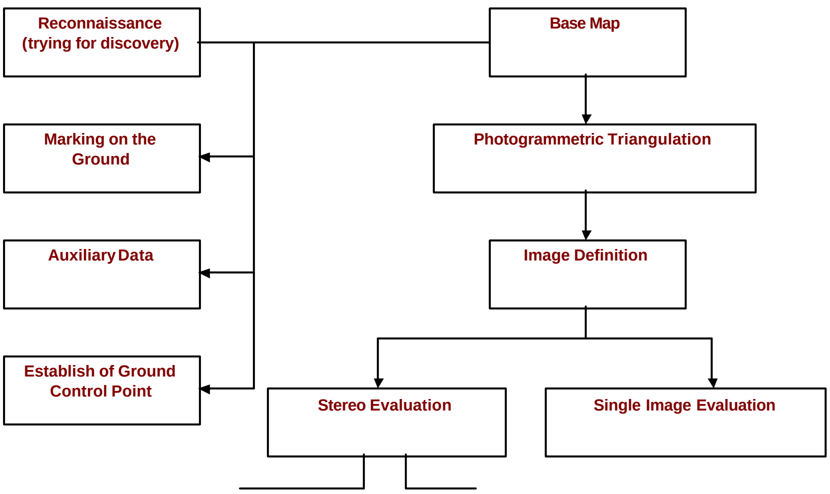
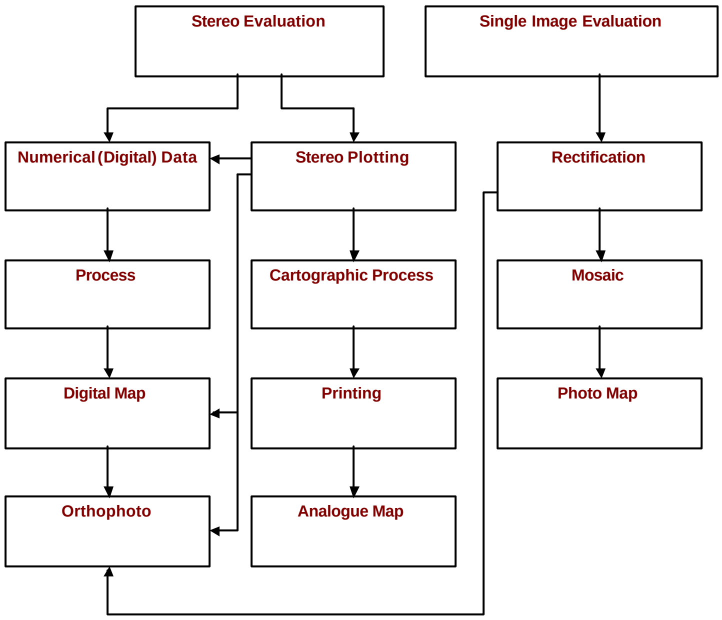


STEP 4

Question 3. FLOWCHART OF PHOTOGRAMMETRIC MAP PRODUCTION





Restitution and Rectification Equipment Comparators

Description

- simple coordinate measurement instruments similar in principle to a tablet digitiser
- measure only x-y image coordinates in the plane of the photograph, therefore can be mechanically simple and more precise/accurate than stereoplotters
- minimal orientation parameters, usually only a kappa rotation for operator convenience
- optical train viewing system with ability to vary magnification
- x-y position controlled by hand wheels connected to lead screws which translate the rotations into linear motions of the photograph carriers
- **mono**comparators have a single photograph carrier with only x-y motions
- viewing system is similar to a simple microscope with a measuring mark
- **stereo**comparators have two photograph carriers with common x-y motions and differential movements of one photograph which are analogous to x- and y-parallax

the four motions may be controlled by hand wheels, or a combination of hand wheels for the x and y motions and foot wheels for the px and py motions

- the viewing system is binocular based on half marks on conjugate images to form a floating mark
- the measurement process for a point observation is similar to that of a stereoplotter, except that y-parallax is always present
- so first x- and y-parallaxes are removed, the floating mark is placed over the point to be observed and then the parallaxes are adjusted again if necessary
- x- and y-parallaxes will vary continuously throughout the overlap area due to tilt and height distortions the lead screws are fitted with rotary encoders, and encoded counts are transmitted to a digitiser
- the digitiser transmits accumulated counts to computer via an interface or the system back plane
- transmission of data may be "on command" or continuous

Applications

- comparators are generally used for two principal applications, namely aerotriangulation observations and precise mapping
- for aerotriangulation the comparator is used essentially as an image measurement device, either in mono using targetted points, or in stereo using either targetted or non-targetted points (for example pass or tie points placed by a point transfer device)
- although the computer system may be used for some on-line checking of the observations as they are acquired, in general the observations are simply compiled and processed at a later time within an aerotriangulation LSE solution
- for precise mapping, usually in stereo, observations to fiducials/reseau points, control and parallax points and finally the points of detail are recorded
- typical applications of precise mapping have been (most are now done on analytical or digital stereoplotters) stock pile surveys, DEM creation and engineering project work
- the map data acquisition uses a fully analytical approach and the observations and transformations are based on digital data throughout

the first transformation may be for the calibration of the comparator (to correct for non-orthogonality or non-linearities of the coordinate axes)

- the second transformation is for the interior orientation, for example by a similarity transformation using observations to two or more fiducial marks or reseau points
- the third transformation is for the exterior orientation, for example by collinearity using observations to three or more control points
- in all cases the transformations should use an adjustment by least squares estimation to utilise any redundant data
- data points are then observed and transformed:

comparator coordinates camera coordinates object space coordinates

- these transformations may be carried out on line or post-processed off line, the advantage of on line processing is of course the possibility of error checking as there are four observables, three unknowns and therefore one redundancy (vector solution or LSE of the collinearity equations)
- in either on line or off line processing the data may be numerically corrected for the calibration of the camera, including PP offset and radial and decentring distortions
- stream data must be acquired and filtered by time, distance or chord tolerance modes

Precision and Accuracy

- precision or repeatability of mono and stereocomparators is generally around ±0.002 to 0.003mm
- monocomparators may have slightly better precision due to simpler mechanics, that is ±0.001mm or better
- precision should not be confused with the least count of the measuring system, generally 0.001mm to 0.0001mm, as it is a function of the encoder resolution, whereas the repeatability is a function of the mechanical parts and lead screws of the instrument
- the accuracy can be determined by a grid plate test where grid intersections are observed and compared to the expected locations, the significant parameters are likely to be coordinate axis scales and rectangularity, possibly with some minor non-linear scale terms
- there are often mechanical adjustments provided to correct for non-rectangularity and/or non-parallelism of the x, y, p_x and p_y axes
- the subsequent observations can be corrected by a high order two dimensional transformation or by simple linear interpolation within each grid cell, the calibration correction becomes the first transformation in the data processing path
- the level of accuracy depends on age and wear, but is generally similar to the precision of a single coordinate observation

Advanced Features of Digital Systems

- digital stereoplotters will become more and more common because they have the distinct advantage that there are no mechanical or moving parts, except for the scanner
- a further advantage is that image processing techniques can be used to enhance or otherwise manipulate the digital images either prior to or after photogrammetric analysis
- for example, single photographs or satellite images can be rectified to fit ground control, combined into a mosaic or used to "drape" a digital elevation model (DEM) for realistic surface rendering
- also, digital stereoplotters may have the capability for image correlation to assist the operator in point measurement and to automatically generate DEMs for the entire overlap area
- DEM generation is limited to areas of good detail, required for the matching process to be effective, and will not work where there are discontinuities in the surface (cliffs, steep valleys, man-made structures)
- these areas can be excluded from the DEM or break lines can be manually recorded to isolate the discontinuities
- once the DEM is formed it can be used

- once the DEM is formed it can be used

o to generate contours and sections automatically

o as the surface on which a scanned photograph or satellite image is draped

o as a visualisation tool

o to produce an orthophotomap (differentially rectified image)

- in addition, digital systems may have the ability to "lock" the measuring mark to the surface of the DEM, so that the operator can concentrate on capturing detail whilst the computer system controls the height
- the current disadvantage of digital stereoplotters is the large size of high resolution digital images (224Mb for a monochrome aerial photograph scanned at a resolution of 0.015mm or 1.3Gb for a full colour stereopair!), but computer technology is rapidly reducing this problem
- compression algorithms such as JPEG and TIFF/LZW can be used to reduce files sizes by ratios between 2 and 100