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PhotoGrammetry: It is the science of making measurements from photographs.

Fundamentals of photogrammetry: The fundamental principle used by photogrammetry is triangulation. By taking photographs from at least two different locations, lines of sight can be developed from each camera to points on the object. These lines of sight are mathematically intersected to produce the 3-dimensional coordinates of the points of interest.

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

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

Stereo pair: The three-dimensional view which results when two overlapping photos , are viewed using a stereoscope. Each photograph of the stereo pair provides a slightly different view of the same area, which the brain combines and interprets as a 3-D view.

The photographs are usually taken by a series of a parallel passes called flight strip. Photographs are normally exposed in such a way that the area covered by each successive photograph along a flight strip duplicates or overlaps part of the coverage of the previous photograph.

This lapping along the flight strip is called end lap and the area of coverage common between two adjacent pairs of photographs called in a flight strip is called stereoscopic overlap (end lap).

Accuracy and Errors:

Photogrammetric accuracy depends on two main factors, the desired scale of the photography and the errors that are introduced during the photogrammetric process. The photo scale is dependent on the product specifications. The required accuracy can be met by using a small photo scale and high quality equipment or large scale photos with less accurate equipment. If one would assume that all blunders have been removed, then the remaining errors would be systematic errors and random errors.

For example when it comes to the photogrammetric product of an Orthophoto, the components that contribute errors to the product are:

- 1.Camera
- 2.Scanner
- 3.Ground control
- 4.Aerial triangulation
- 5.Rectification process

Terminologies in Aerial PhotoGrammetry

- Vertical photograph: A photograph exposed with the optical axis of the camera coinciding with the direction of gravity or optical axis of the camera held vertical.
- Tilted Photograph: A photograph taken with the optical axis unintentionally tilted from the vertical by a small amount, usually less than 30.
- Focal length: The distance from the front nodal point of the lens to the plane of photograph.
- Spatial Resolution: Spatial resolution is the quantity of data per pixel. Greater the spatial resolution, more finer will be the image/map.
- Camera Sensitivity: Camera sensitivity is defined as the amount of light required to capture a signal minus the noise floor. This means that greater the sensitivity, less light will be required to capture the same signal when compared to when the sensitivity is lower. Sensitivity is also inversely proportional to the amount of exposure time of the camera. Hence, greater sensitivity corresponds to quicker shutter speed. In Aerial Survey and Mapping, motion blur of the camera impacts the flight speed of the UAV. Since it correlates with its shutter speed, more the sensitivity, faster speed can the UAV clock as it's able to utilize the shorter exposure times of the camera.
- Temporal Resolution: Temporal resolution is the rate of change between within images/maps. Better the temporal resolution, richer and precise will be the inference across time.
- Spectral Resolution: Spectral resolution is the amount of the data collected by the sensor relating to EM waves. Better spectral resolution refers to greater ability to record minute changes in EM waves like NIR.
- Exposure Station: The space position of the front nodal point (perspective centre) at the time of exposure.
- Flying Height: The elevation of aircraft/front nodal point/exposure station at the instant of exposure above mean sea level or any reference datum.

- **Oblique:** Oblique represents a not-nadir (perpendicular FOV) angular FOV, usually between 40 to 50 degrees w.r.t the ground. It's used to capture steep images. It's however not good for photogrammetry as the scale would be inconsistent with the image being captured.
- **Overlap:** Overlap is defined as the percentage of intersection area between two photographs.
- **Principal point:** The point where the perpendicular dropped from the front nodal point meets/strikes the plane of photograph.
- **Nadir Point:** The point, where the plumb line dropped from the front nodal point meets the plane of photograph. It is the point on the photograph vertically beneath the exposure station.
- **Tilt:** The angle formed between the optical axis of the camera and the plumb line. It is also the angle which the plane of tilted photograph makes with the plane of vertical photograph.
- **Isocentre:** The point where the bisector of angle of tilt meets the plane of photograph.
- **Principal plane:** The vertical plane containing the optical axis.
- **Principal Line:** The intersection of principal plane with the plane of photograph.
- **Nadir:** Nadir represents a perpendicular FOV towards the re-spective surface/objects, thus being ideal for aerial photogrammetry.
- **Focal length:** Focal length is defined as the optical distance between the camera sensor/film to the center of the lens. It captures the angular view of the lens. Greater the focal length, more accurate will be the image because of a narrower angular view capture. It's an important intrinsic parameter of the camera during calibration.
- **Photo base:** It is the distance between the principal points of two adjoining vertical photographs.
- **Dia-positive:** A positive print (photograph) on a transparent medium (glass/film).
- **Displacement:** Any shift in the position of images on a photograph which does not alter the perspective characteristics of the photograph is called displacement (shift due to tilt of the camera and relief of the objects).
- **Emulsion:** A suspension of light sensitive silver salt (especially silver chloride or silver bromide in a colloidal medium usually in gelatin) which is used for containing photographic films, plates and paper.
- **Equivalent vertical photograph:** Theoretically, truly vertical photograph taken at same camera station with a camera whose focal length equal to that of camera taking a corresponding tilted photograph.
- **Exposure interval:** The time interval between the exposures of successive aerial

photographs.

- **Model scale:** The ratio that exists between the distances measured in a stereoscopic model and the corresponding ground distances.
- **Neat model:** The portion of the overlap of a stereo pair of photograph that is actually utilized in photographic procedures. Generally, the neat model approximates a rectangular area whose width is equal to the air base and length equal to the width between the flights.
- **Stereogram:** A set of photograph correctly oriented and mounted for stereoscopic viewing.
- **Eye base:** The distance and orientation of the line between centers of rotation of eye ball of an individual.
- **Mean Reprojection Error:** Mean reprojection error is defined as the euclidean distance between the 3D reprojected point to 2D and the original 2D point in the image. It helps determine the accuracy of estimating the 3D model, camera calibration parameters, which in-turn influences how bundle adjustment equations work.
- **Camera Distortion :** It is divided into two types- Optical Distortion and Perspective Distortion. Optical Distortion is where it bends physically straight lines and makes them appear curved in the image. It is caused due to lens error. Perspective Distortion is where when projecting a 3D space into a 2D image, closer the object is to the camera, greater will it appear distorted and bigger than it actually is compared to its background. Also the case of parallel train tracks appearing to converge at infinity.

Comparison between Oblique and Nadir.

Merging Oblique and Nadir Photogrammetry Steep topography often contains low-density regions or voids in nadir photogrammetry, while oblique photogrammetry, which is ideal for capturing steep vertical surfaces, is inefficient for large mapping projects in varied topography.

Drone Deploy

- Images need to be in jpeg format
- All images should have significant overlap
- At least 30 images for reliable map processing.