Report

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Aerial photogrammetry

Photographs of terrain in an area are taken by a precision photogrammetric camera mounted in an aircraft flying over an area.

Uses

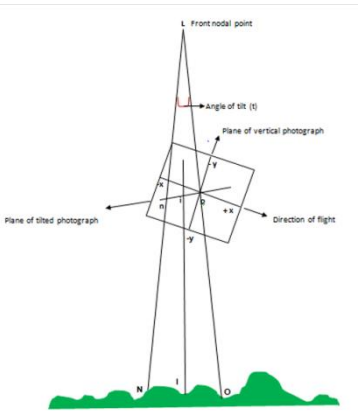
Geological investigations, soil surveys, land surveys, tax mapping, reconnaissance and military intelligence, urban and regional development, transportation system investigations, quantity estimates, shore erosion, etc.

Modern aerial cameras (Digital Camera)

- Drone Camera
- UAV
- Satellite cameras

Important Terminologies of 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 degrees.
- **Focal length:** The distance from the front nodal point of the lens to the plane of photograph, as the distance Lo in the Figure.
- **Exposure Station:** The space position of the front nodal point (perspective centre) at the time of exposure, as the point L in the Figure.
- **Flying Height:** The elevation of aircraft/front nodal point/exposure station at the instant of exposure above mean sea level or any reference datum.
- **Principal point:** The point where the perpendicular dropped from the front nodal point meets/strikes the plane of photograph, as the point O in the Figure.
- **Nadir Point:** The point, where the plumb line dropped from the front nodal point meets the plane of photograph, as the point n, in the Figure. 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, as the angle oLn in the Figure. 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, as the point i in the Figure.



- **Principal plane:** The vertical plane containing the optical axis, as the plane Lno in the Figure 1. Principal Line: The intersection of principal plane with the plane of photograph, as the line 'no' in the Figure.
- **Axis of symmetry (Isometric parallel):** The line in the plane of photograph perpendicular to the principal line and passing through the Isocentre. The axis of tilt is a horizontal line as the line perpendicular to the principal line. The other perpendicular lines are called plate parallels.
- **Crab:** The condition caused by the failure to orient the camera with respect to the track of aircraft. In vertical photograph, crab is indicated by the edged of photograph not being parallel to the air base line.
- **Drift:** The lateral shift or displacement of the aircraft from its course, due to the action of wind or other causes.
- **Floating mark:** A mark seen as occupying a position in the 3 dimensional space formed by the stereoscopic fusion of a pair of vertical photograph and used as a reference mark for examining or measuring the stereoscopic model.
- **Fiducial Mark:** Marks located in the middle of the sides of the focal plane opening. These are exposed on the negative when the picture was made
- **Fiducial centre:** The point of intersection of straight line of joining opposite Fiducial marks.
- **Air base:** The length of line joining two exposure stations.
- **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 centres of rotation of eye ball of an individual.

Vertical v/s oblique imagery

- **Vertical images:** Images taken by a camera pointing to the **nadir** direction. Pointing to the nadir means that the camera axis (in the direction of the lens) is perpendicular to the ground / object.
- **Oblique images:** Images are taken with the camera axis not perpendicular to the ground / object.

Photogrammetric techniques involve using known information to help solve other, previously unknown information. Several critical pieces of known information concern the camera used to capture the photographs, and defining those pieces in mathematical terms known as camera parameters. Photogrammetry uses the mathematics of light rays to build up knowledge of the geometry of the scene, its objects and the location of the camera when the photographs were taken. When light hits part of the scene, it is reflected toward the camera, passes through the lens, and is picked up by film or an electronic image sensor. The Most Important Camera Parameters for Aerial Imaging are

Resolution and Sensor Size

Image resolution is the detail an image holds. Ground resolution is dictated by pixel size, not megapixels. While smaller pixels provide greater ground resolution, an aircraft's speed is also dependant on the combination of pixel size, height above the ground, and the lens' focal length – where smaller pixels will limit the speed of the aircraft.

Sensitivity

A camera's sensitivity can be defined using a number of different units. EMVA 1288 defines a camera's absolute sensitivity threshold as the number of photons required to increase a pixel's value by one. This, however, does not take into account the pixel's size. If two pixels require the same number of photons to reach their absolute sensitivity threshold, and one is twice as big as the other, the larger one actually requires less light and is more sensitive than the smaller one.

Noise

The noise floor is dictated by the sum of all sources of noise in the imaging system. The two main sources of noise that are determined by the camera are read noise and dark current noise. Read noise occurs each time the camera takes an image and dark current noise is both thermal and time dependant. The longer the exposure and the hotter the camera, the more dark current noise is generated. These noise sources are listed on the datasheet in units of electrons and electrons per second, respectively. This specifies the number of electrons that can be unintentionally freed from the sensor's semiconductor lattice structure and then readout as signal.

How Sensitivity and Noise Impact Flight

The camera's sensitivity directly impacts the length of the exposure time that can be used. More sensitivity allows for faster shutter speeds. The challenge of Aerial Imaging: Achieving a Clear and Sharp Image, an aircraft's speed is limited by motion blur which is directly tied to the camera's shutter speed. Therefore, a camera with higher sensitivity allows the aircraft to travel at higher speeds because it is able to use shorter exposure times. Noise is tied to the camera's gain (multiplier circuit that is part of the camera's sensor). Since gain amplifies both signal and noise indiscriminately, lower noise allows for higher gain to be used while maintaining image data integrity. This allows for even shorter exposure times to further increase the aircraft's groundspeed.

Shutter Types

Cameras typically come with one of two types of shutters – global or rolling. A rolling shutter consists of exposing each line of the sensor one at a time and in rapid succession, whereas global shutters expose all pixels at once. Rolling shutters are subject to blurring or smearing of an object if it is moving at a high rate of speed through the frame during exposure. Global shutters eliminate these artefacts because they freeze moving objects in place by exposing every pixel at the same time.

The Ideal Shutter Type for Aerial Imaging

Global shutter cameras are the only viable option for aerial imaging if maximizing groundspeed is important. Similarly to the blur calculations, if a rolling shutter camera is used, the movement of the aircraft introduces artefacts into the image because each row of pixels is exposed with a slight delay to the neighbouring row.

Dynamic Range

A heightened dynamic range is extremely helpful for imaging shaded areas on the ground while maintaining visibility in well-lit areas. Typically measured in decibels for industrial cameras, dynamic range is easily converted into "stops" by dividing by six. Required bit depth is determined by the application. If the images are being viewed with human eyes, 8-bits of data per colour channel are sufficient. However, for applications where measurements are being made, such as NDVI and photogrammetry, higher bit depths are required.

ADDITIONAL CONSIDERATIONS IN RELIABILITY

Camera reliability is essential when capturing mission critical images, but is difficult to quantify in terms of specifications. An industrial camera with a long warranty is a good starting point. Some customization options, such as conformal coating, can also help protect against condensation forming on the electronics at high altitudes.

<u>Aerial Dataset</u>

The goal of this project was to generate the 3D model of the building taken by Asc Tec Falcon 8 UAV. The dataset has 36 images of 4592*3056 image size as given in the figure.

Location	Germany
Average Ground Sampling Distance (GSD)	1.89 cm / 0.7 in
Area covered	Undefined
Output coordinate system	WGS84 / UTM zone 32N Vertical Coordinate System: MSL egm96
Image acquisition	
UAV	AscTec Falcon 8 UAV (Ascending Technologies)
Image acquisition plan	1 flight, circular flight around the building
Camera	Sony NEX-5 (RGB)
Images	
Number of images	36
Image size	4592x3056
Image geolocation coordinate system	WGS84

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Above picture is the representation of 3D Textured Mesh.