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Efficient Handling of Images in Satellites by Photogrammetry

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ABSTRACT: This paper is about to explain the concept of photogrammetry which satellite uses to capture the images in the ground. This is to be done with the help of camera which is installed in the satellites which captures ground image in two dimension and later by applying the processing technique called photogrammetry satellite connects it into three-dimension image.
This paper also explains errors occur due to relief (height) of the ground image becomes boon in the depth perception of the objects in the ground.
Keywords: Nadir, Off- Nadir, Parallactic, 2D,3D

I. INTRODUCTION:

To understand photogrammetry, one should have clear understanding about the maps and its different types

Map:

Map gives the information of the area as seen vertically from above. A map is made up by using different notations, symbols & colours which represent various objects on a map.
The map is broadly classified into two different types

- Topographic Maps
- Thematic Maps

Topographic Maps:

All the information of the ground where represented on the basis of certain scale.

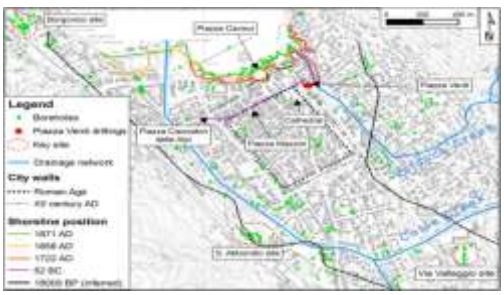

Fig.1: Topographic map

Thematic Maps:

Thematic map is the type of maps where theme wise information is available and information related to particular theme will be available in such maps.
For e.g.: A map of coal or iron belt in the particular region.

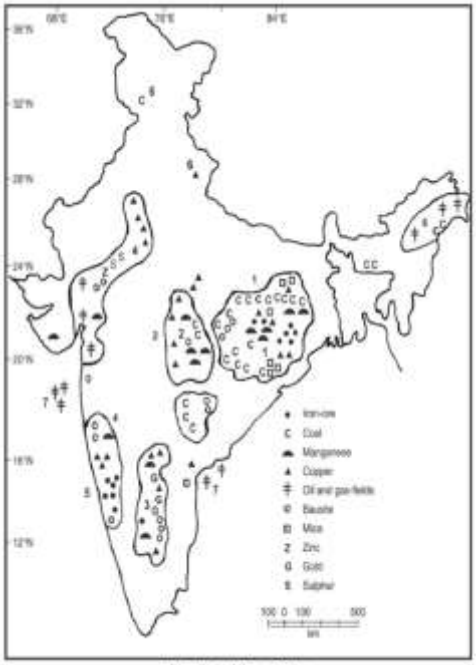

Fig. 7.1 Mineral Belts

Fig. 2: Major mineral belts of India

Aerial Photograph:

These types of photograph generally taken at the high altitude usually from the aircraft. Aerial photograph can be further subdivided into vertical aerial photograph and oblique photo graph and so on.

Though both topographic map & aerial photograph can reprint certain features of the ground. But when we compare the topographic Map and aerial Photograph, we can see certain basics differences which we can explain as follows:

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- **Nature of projection**

Topographic maps contain the information of the ground in the form of orthogonal projection (all the features of the ground are projected at 90 degree) and due to this kind of projection there is no distortion in a map.

While in aerial photograph all the features of the ground are sent to high altitude comes in the form of ray and they meet at specific point which is generally a lens of the camera from where it again diverges and form a negative in the focal plane. So as all the ray going and meeting at a central point so in aerial photograph the nature of projection is central projection.

- **Type of scale:**

Topographic map has a uniform scale. It is printed on the map as (1 is to 500), means one measure in the map is equivalent to 500 measure on the ground. On the other hand, aerial photograph the scale can vary it is not constant. Scale can vary point to point.

- **Distortion based on Relief(height)**

In Topographic map as there is no height so no relief distortion while in aerial photograph there is distortion due to height.

- **Types of representation**

Maps are the abstract representation means suppose at the ground there is the school so we use only some sign/symbol for that while aerial photograph is a real representation.

Table 1: Comparison between topographic image and aerial photograph

Map	Aerial Photo
Orthogonal projection	Central projection
Uniform scale	Variable scale
Terrain relief without distortion	Relief displacement
All objects represented on a particular scale	Only objects that are visible
Abstract representation	Real representation
Representation geometrically correct	Distortions in geometry

So thus, all the discussion above we can easily understand that aerial photograph or satellite images directly cannot be taken as photomap because of distortion due to relief, seals is not uniform. So, this makes us to certain processing, so that the photograph can be used as photomap and this entire processing involved in it is called photogrammetry.

Photogrammetry is the science of quantitative analysis of measurements from photographs. Photogrammetry word is comprised of
Photos- means light
Gamma- means to draw
Metron- means to measure
So we can also say that photogrammetry is the precise 3D measurement of the photograph.

Procedure to get 3D measurement from 2D photograph

This is made possible by looking the same photograph/ image from different view directions. We can also say that principle of photogrammetry is same as the principle of working of eye.As with eyes we are able to distinguish the depths the object because we 2 eyes and these 2 eyes can focus on an object.

So, both eyes on object by making some parallactic Angle. Now with the second object eye makes 2nd parallactic angle. So, this difference in parallactic Angle gives us the impression about the actual depth of the objects.

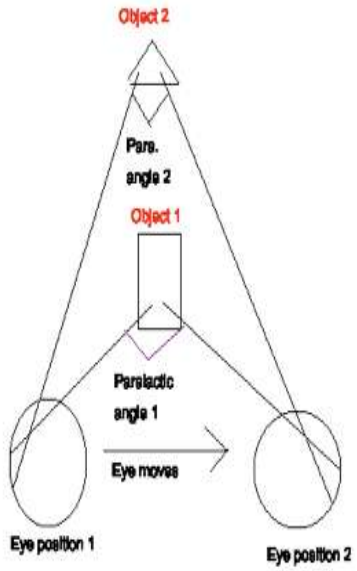

Fig 3: Eye detecting the depth of object

The same concept is used in photogrammetry in which instead of two eyes we two camera which takes the images of the same object at two different angles thereby converting a 2D image to 3D image by doing certain processing.

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Fig 4: Photogrammetry

Theoretically photogrammetry is subdivided into:

- Metric Photogrammetry
- Interpretative photogrammetry

Metric Photogrammetry:

When we do measurements from photograph called as metric photogrammetry. By doing such measurements we determine the location(relative) on some points on the ground. It uses stereo photogrammetric concepts.

For e.g.: Finding shapes and sizes of the object, distances, volume etc.

Application of metric photogrammetry:

- Used in making topographic maps.
- Military intelligence etc.

Interpretative Photogrammetry:

When we take interpretation from the photograph like identifying objects and identifying their existence through careful and systematic analysis. It is generally done by the aerial photograph or done by the remote sensing images also. But only metric photogrammetry is used in satellite photogrammetry.

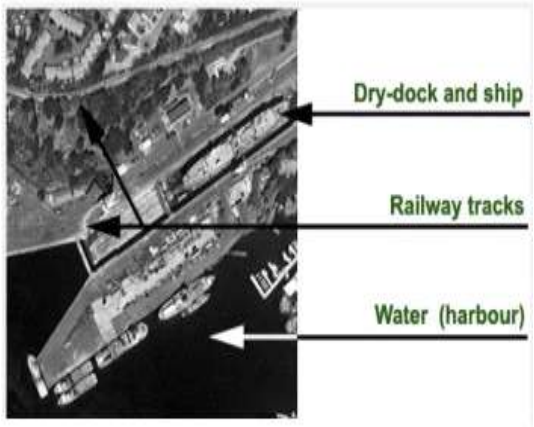

Fig 5: Interpretative photogrammetry

Branches of photogrammetry on the basis of processing technique

- Analog system
- Analytical system
- Digital system

Analog system:

In this type optical or mechanical instruments were used to reconstruct 3D geometry from the overlapping photograph. The main product of this phase was topographic images.

Fig 6: Setup of analog system

Analytical system:

In this computer replaces some expensive optical and mechanical components. Analog / Digital hybrid types of devices used in this system. Main development of this system is Orthogonal projectors. In this system output can be digital map or topographic maps also.

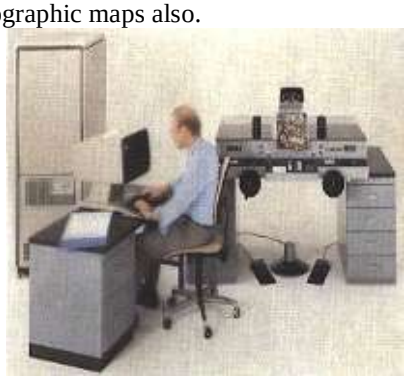

Fig 7: Setup of analytical system

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Digital system:

It is the most advanced form of photogrammetry that is widely used in the present era. They are generally applied to digital images where images can be aerial digital photograph or satellite images. It is also called by another name of soft copy photogrammetry. Output is in the digital forms such as digital maps. Inputs and outputs are in digital formats in this system.

Fig 8: Setup of digital system

Principle of photogrammetry:

Photogrammetry is carried out by viewing the same area from two different angle thereby recreating the same condition as it is existed at the time of photography.

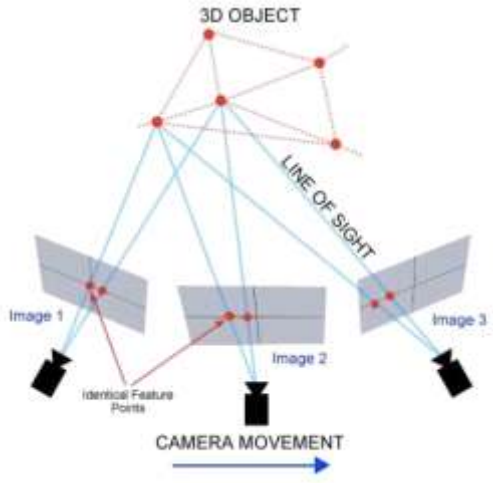

Fig. 9: Satellite camera taking the image 3D object at different angle

Photogrammetry combines images that contain same point on the ground from multiple points to yield detailed 2D and 3D maps. As in photogrammetry images are generally captured from satellites or aircraft in which at least 60% forward overlap is there when taking two pictures. To generate the 3D model from the 2D photo this overlap should must be maintained.

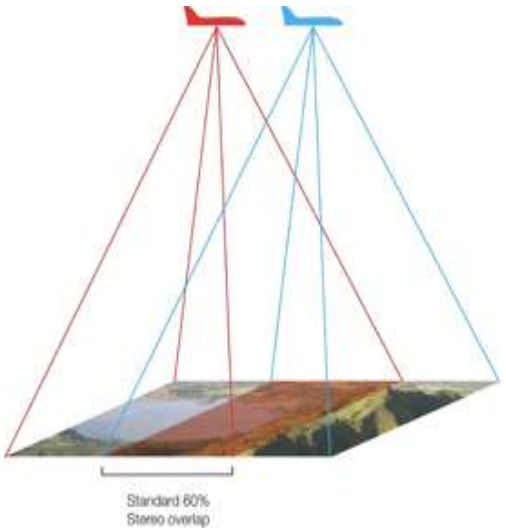

Fig. 10: Forward overlap in aerial photograph.

Method to determine the height of the object in the ground from satellite

This is to be done with the use of relief distortion. Relief distortion is the shift or dipole cement in the photographic position of an image caused by the relief (height) of the object. The amount of relief dipole cement is directly correlated with the height or depth of the object and the distance of the object from the Nadir. While this displacement is inversely correlated with the flying altitude of the aircraft above the datum and the focal length used.

Even though relief displacement is source of error in measuring the horizontal distances on vertical aerial photograph. But this error becomes advantage in the determining the height of the object and to see 3D image.

Fig. 11: Relief displacements

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Satellite Photogrammetry:

In satellite photogrammetry all the concepts of photogrammetry remain same only one thing is fixing this time that image must be captured by the satellites rather than aircraft. The images which are captured by the satellite we generally call it as stereo image.

The stereo image is captured in two configurations:

- Along the track imaging technique.
- Across the track imaging technique.

Along track imaging technique:

In this technique images captured by a single satellite along the same orbit within few seconds. Stereo coverage is obtained during the flight along the same orbit either by using at least two sensors oriented off-nadir in the along track direction with different angles of view -i.e. fore and aft or by changing the pointing angle of one sensor along the orbit.

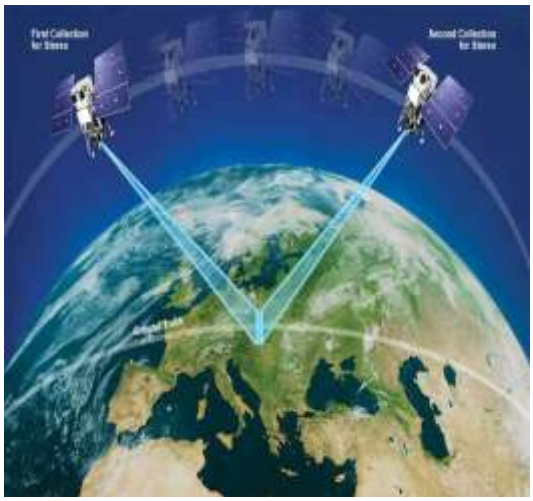

Fig. 12: Along track technique

Across track imaging technique:

In this technique image is captured by the same satellite (or different satellite) from different orbits in different dates.

The pointing of the imaging sensor is oriented off-nadir in the across track direction.

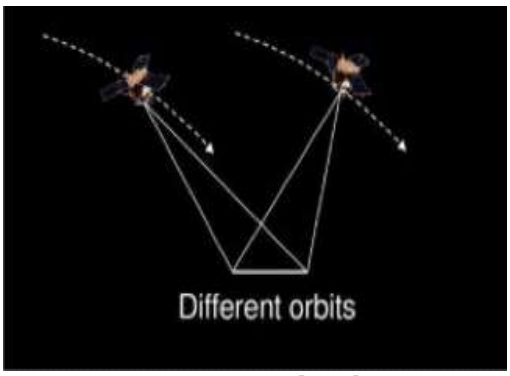

Fig. 13: Across track technique

II CONCLUSION:

The satellite captures the images which are in two dimensions, these images have distortions, non-uniform scale so thus these images directly cannot be processed by satellite as photomap so by the use of photogrammetry we convert these two-dimension images to three-dimensional photomap to obtain the information of the ground points.

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