UNIT 9

INTRODUCTION TO VISUAL IMAGE INTERPRETATION

Structure

9.1 INTRODUCTION

In the previous units, you have studied about remote sensing principles, sensors and platforms. We have also discussed about the remote sensing data products and formats, space programmes and image resolution. Let us read the literal meaning of visual, image and interpretation. **Visual** means the ability to see and gather information from the surroundings from the effects of visible light reaching the eye. **Image** refers to the pictorial representation regardless of wavelengths or remote sensing device it has been used to detect and record the electromagnetic energy.

Image/photographic interpretation is the process of extraction of qualitative and quantitative information of objects from aerial photographs or satellite images. In this unit, we shall introduce you to aerial photo-interpretation and visual image interpretation.

Expected Learning Outcomes

After reading this unit, you should be able to

- discuss aerial photographs, their types and advantages;
- describe historical developments in aerial photography;
- explain application potential of aerial photography;
- learn image interpretation tasks and their prerequisites;
- know the elements of aerial photo-interpretation;
- discuss image scale and its calculation; and,
- define minimum mapping unit.

9.2 WHAT ARE AERIAL PHOTOGRAPHS?

The aerial images are acquired from systems relying on the basic components common to the familiar handheld cameras that we use for photography. In the history of remote sensing, aerial images were recorded as photographs or photograph-like images. Photograph-like images are referred to as analog images because the brightness of a photograph is proportional (i.e., analogous) to the brightness in a scene. However, in contrast the digital technologies record image data as arrays of individual values that convey the pattern of brightness within an image. The digital cameras do not require film and the complex mechanisms for manipulating the film because the image is captured by the digital technology. You are familiar with the photographs taken from hand-held or normal camera where you get a horizontal perspective of the objects or scene photographed (Fig. 9.1a). However, if we have to place ourselves somewhere in the air (vertically upwards), we get a very different perspective (Fig. 9.1b).

(a)

(b)

Fig. 9.1: Lotus temple, New Delhi: a) Photograph taken from hand-held camera showing horizontal perspective (Photo credit: Ihsan Ullah Lone); **b) Aerial photograph showing vertical perspective.** (Image credit: Arindam Sarkar; Source: https://masalamug.com/wp-content/uploads/2020/07/Lotus-Temple-Body-2-1536x1405.jpg)

Aerial photograph is any photograph taken from the air. They are taken using a precision or highly-accurate camera vertically from an aircraft. There are several things you can look for to determine what makes one photograph different from another of the same area including type of film, scale, and overlap. Other important concepts used in aerial photography are stereoscopic coverage, fiducial marks, focal length, roll and frame numbers, flight lines and index maps. Aerial photography can be defined as the science of taking photographs from the air by using aircrafts mounted with special cameras for the study of the Earth's surface. The aerial image differs from the everyday photograph in the following aspects:

- overhead perspective
- beyond visible light spectrum
- unfamiliar scales and orientation

9.3 ADVANTAGES OF AERIAL PHOTOGRAPHS

Aerial photography has many applications such as cartography, urban and rural planning, environmental impact studies, resolving civil law cases and real estate evaluations. The advantages that aerial photographs offer have been listed below:

- **Synoptic viewpoint**: Aerial photographs give a bird's eye view of large areas enabling us to see surface features in their spatial context.
- **Permanent recording**: They are virtually permanent records of the existing conditions on the Earth's surface at one point in time, and are used as an

historical document. They also provide a record of the surface features at an instance of exposure.

- **Three-dimensional perspective**: It provides a stereoscopic view of the Earth's surface and makes it possible to take measurements horizontally and vertically. Aerial photographs are normally taken with uniform exposure interval. This enables in obtaining stereo pair of photographs (Fig. 9.2). Such a pair of photographs helps us in getting a three-dimensional view of the surface photographed.
- **Spectral and spatial resolution**: Aerial photographs are sensitive to radiation in wavelengths that are outside of spectral sensitivity of the human eye. They also have better spatial resolution than many ground based remote sensing methods.
- **Film sensitivity**: Our eyes observe only in the visible region of the electromagnetic spectrum, i.e., 0.4 to 0.7 µm. The sensitivity of the film ranges from 0.3 to 0.9 µm. The sensitivity of the film used in aerial photography is relatively more than the sensitivity of the human eyes.
- **Availability**: They are readily available at a range of scales for much of the world.
- **Economy**: They are much cheaper than field surveys and are often cheaper and more accurate than maps.

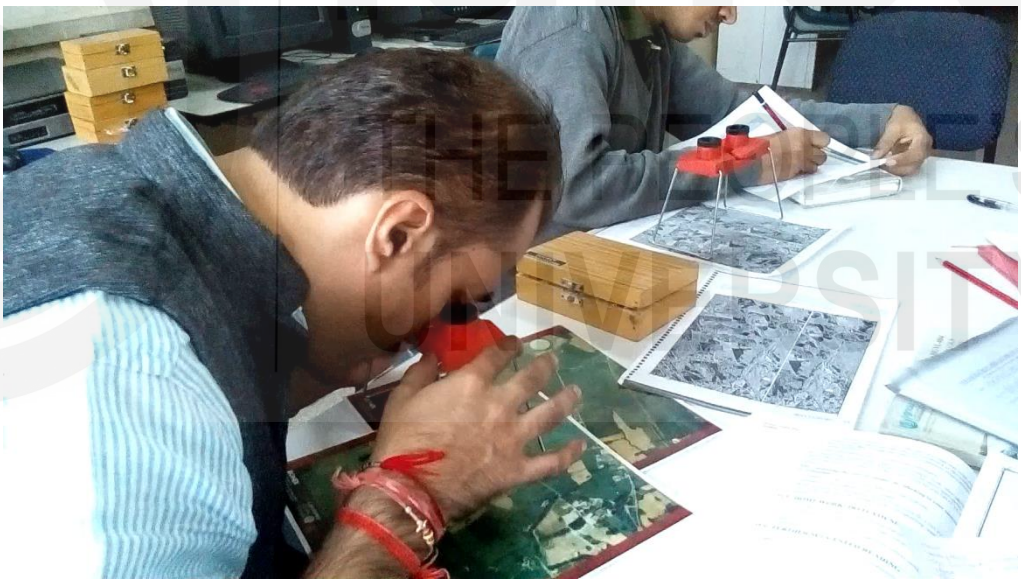


Fig. 9.2: Interpreter observing the stereo pair of aerial photographs with the help of pocket stereoscope.

9.4 TYPES OF AERIAL PHOTOGRAPHS

Aerial photographs have been classified based on many criteria such as basis on the position of the camera axis, angular extent of coverage, scale and type of film used. Let us discuss them.

9.4.1 Based on Position of Camera Axis

The aerial photographs can be classified according to the orientation of the camera in relation to the ground at the time of exposure. They are:

Vertical photographs: These photographs can be acquired by a camera aimed directly at the ground surface from above. Two distinct axes are formed from the centre of camera lens: 1) one towards the ground plane; and 2) the other towards the photo plane, while taking aerial photographs. The perpendicular dropped from the camera lens centre to the ground plane is termed as the **vertical axis**. Whereas the plumb line drawn from the lens centre to the photo plane is known as the **photographic/optical axis**. It is normally very difficult to achieve perfect parallelism between the two planes because the aircraft flies over the curved surface of the Earth (Fig. 9.3).

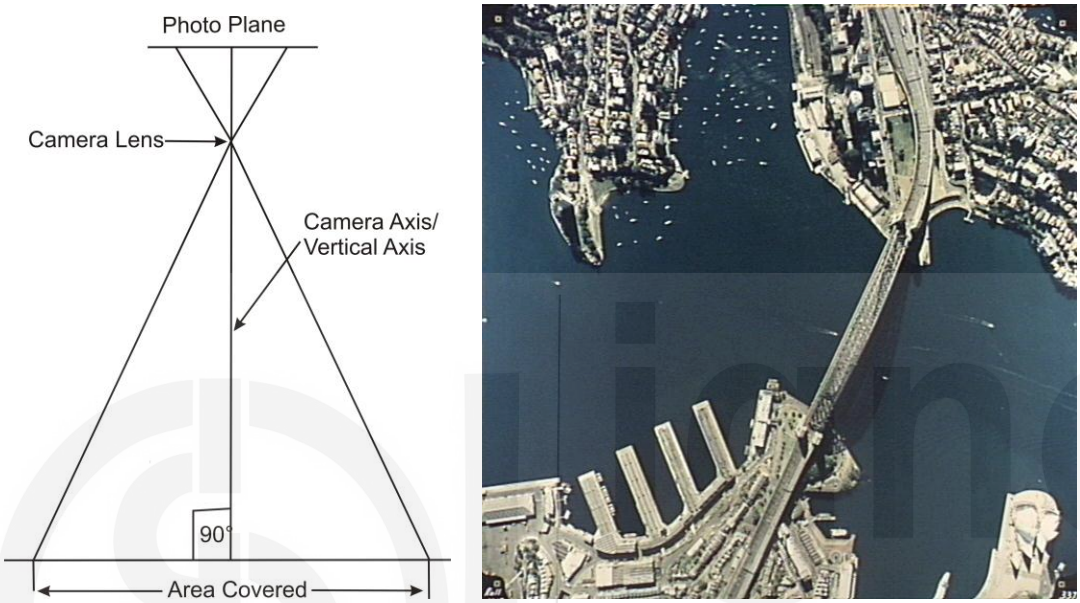
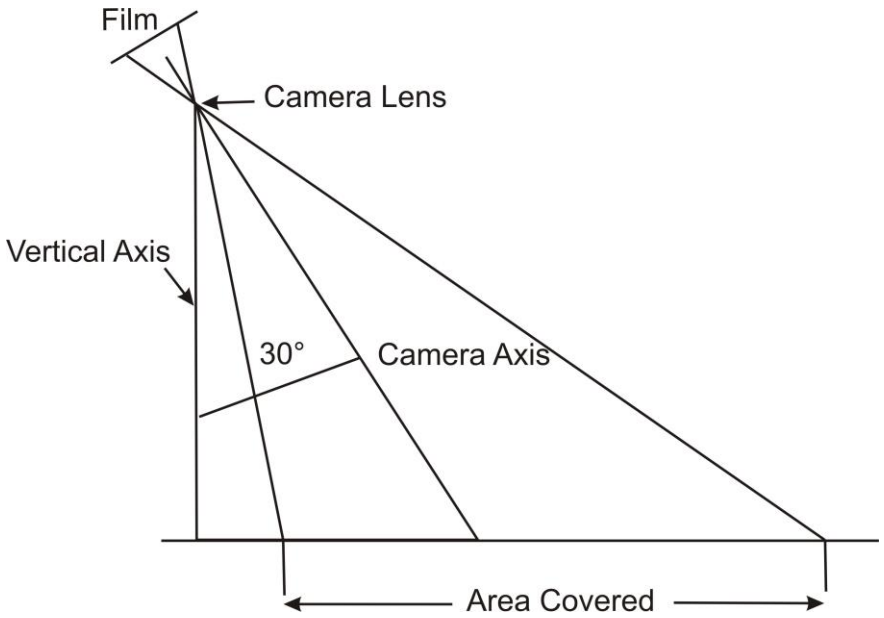
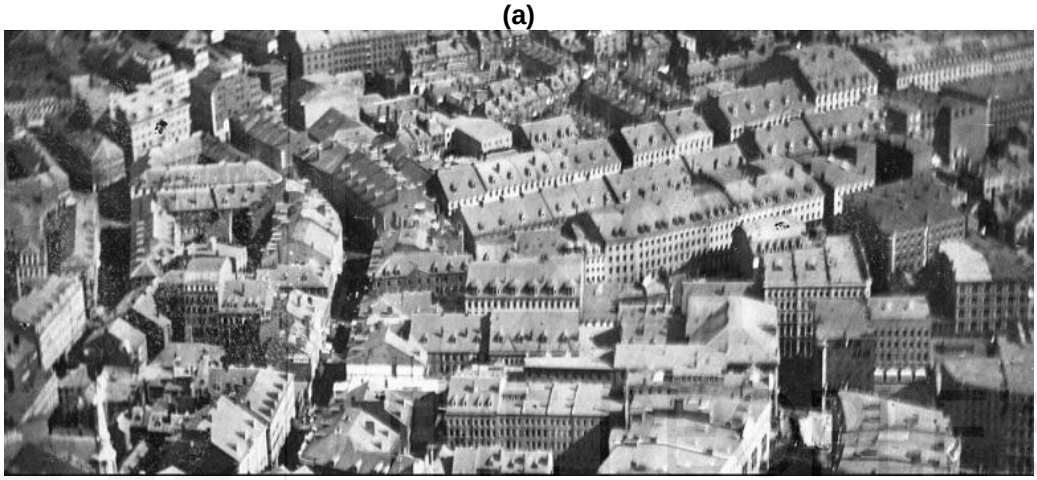


Fig. 9.3: a) Diagram showing vertical aerial photography (Source: https://sites.google.com/site/sstlearningpoint/ch-6-introduction-to-aerial-photographs); **and b) Vertical aerial photograph of Sydney area, Australia.** (Source: https://archives. cityofsydney.nsw.gov.au/assets/display/878542-max)

Low oblique photographs: They can be acquired by cameras oriented toward the side of the aircraft (Fig. 9.4). An aerial photograph taken with a planned deviation of 15° to 30° in the camera axis from the vertical axis is referred to as the low oblique photograph. This kind of photograph is often used in the exploratory surveys.



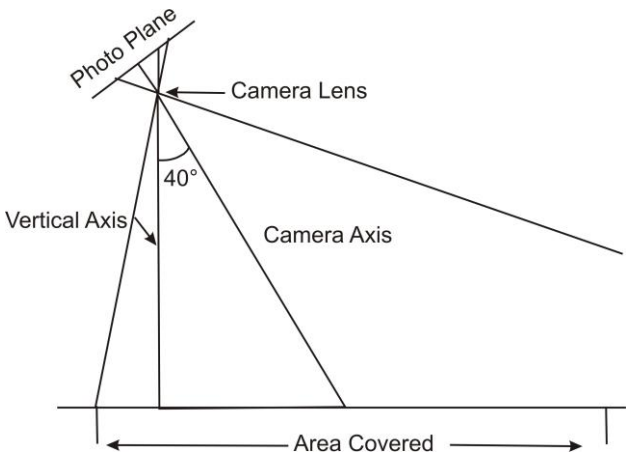
(a)



(b)

Fig. 9.4: Diagram showing low-oblique aerial photography (Source: https://sites.google.com/site/sstlearningpoint/ch-6-introduction-to-aerial-photographs); **and b) Low oblique photograph of Boston in 1860.** (Source: Boston Public Library; https://gistbok.ucgis.org/sites/default/files /DC10 Fig1. png)

High oblique photographs: These photographs show the horizon. The high oblique aerial photographs are obtained when the camera axis is purposely inclined about 60° from the vertical axis (Fig. 9.5). High oblique photography is useful in reconnaissance surveys.



(a)

(b)

Fig. 9.5: a) Diagram showing high oblique photography (Source: https://sites.google.com/site/sstlearningpoint/ch-6-introduction-to-aerial-photographs); **and b) High-oblique photograph.** (Source: San Francisco Public Library; https://gistbok.ucgis.org /sites/default/files/DC10_IAQ2.png)

9.4.2 Based on Scale

On the basis of the scale, the aerial photographs are classified into three types.

- **Large-scale aerial photographs** When the scale is 1:15,000 and larger. The large-scale photo provides more details of the ground features, but the coverage of ground area seen on the photo is less.
- **Medium-scale photographs**: When scale ranges between 1: 15,000 and 1: 30,000.
- **Small-scale photographs**: When the scale is smaller than 1:30,000. The small-scale photo gives less detail of the ground features and photo covers more area as compared to the large-scale photographs.

9.4.3 Based on Film Used

The aerial photographs are classified based on the film used into the following types:

- **Black and white film**: It may comprise black-and-white panchromatic (B/W) and black-and-white infrared (BIR) films. Black-and-white panchromatic film has good contrast and resolution with a wide exposure range and low graininess. It primarily consists of a black and white negative material with a sensitivity range comparable to that of the human eye (Fig. 9.6). Black and white infrared film is sensitive to the spectral region (0.4 μm to 0.9 μm) with some exceptions. Sometimes it is referred to as near-infrared film as it utilises only a narrow portion of the total infrared spectrum (0.7 μm to 0.9 μm).

(a) (b)

Fig. 9.6: a) Black and white panchromatic photographs; and b) Black and white infrared photographs. (Source: https://gsp.humboldt.edu/olm/Courses/GSP_216/images/black-white.JPG)

- **Colour film**: These can be natural colour (referred to as conventional or normal colour) film and colour infrared (CIR) film (Fig. 9.7). The natural colour film contains three emulsion layers which are sensitive to blue, green, and red (three primary colours of the visible spectrum). This film replicates colours as seen by the human eye. Whereas, colour infrared film, originally referred to as camouflage-detection film, is different from conventional colour film because of its emulsion layers and near-infrared radiation (0.5 μm to 0.9 μm) band/layer. This film provides sharp images and penetrates into the haze at high altitudes as it is used with a yellow filter to absorb the blue light. Colour infrared film also is referred to as false-colour film.

(a) (b)

Fig. 9.7: a) Natural colour photographs; and b) Colour infrared photographs. (Source: https://gsp.humboldt.edu/olm/Courses/GSP_216/images/color.JPG)

- **Digital photography**: In contrary to an exposure in case of conventional film, it uses charge-coupled device (CCD) or complementary metal-oxide semiconductor (CMOS) sensor to capture the image. The sensors capture light and convert it into electronic signals. The image is then digitised and stored as a computer file ready for digital processing.

9.5 INFORMATION ON AERIAL PHOTOGRAPHS

There is important information provided or mentioned on the aerial photograph (Fig. 9.8). This may include:

- Mission name and details
- Roll and frame number
- Time and date

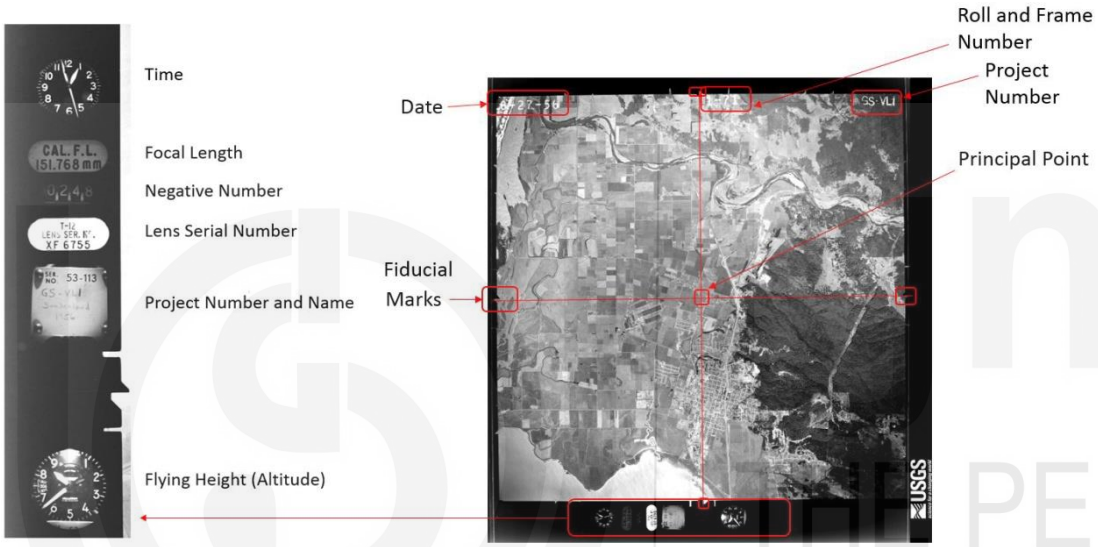


Fig. 9.8: Information on aerial photograph. (Source: https://gsp.humboldt.edu/olm/Courses/GSP_216/images/air-photo.jpg)

- Lens serial number and focal length
- Fiducial marks
- Principal point
- Altitude or flying height

Fiducial marks are the index marks, rigidly connected at the central or corner edges of the camera body but when the film is exposed, these marks appear on the film negative.

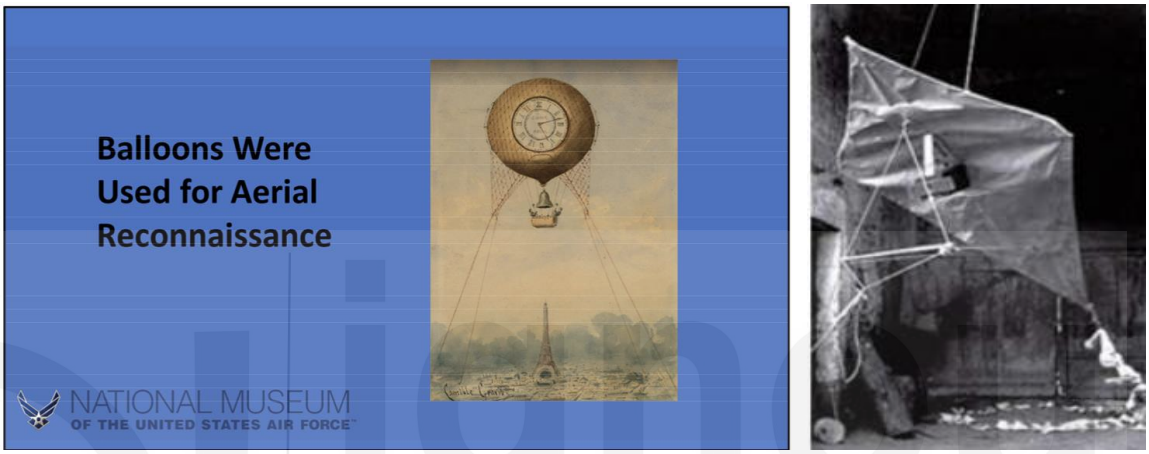
Principal point is the point on the aerial photograph where optical axis intersects the image plane.

9.6 HISTORICAL DEVELOPMENTS IN AERIAL PHOTOGRAPHY

Capturing photographs of the Earth from above in the early twentieth century required great imagination. Aerial photography was the first method of remote sensing and is even used today in the era of scanners. In the mid-1800s, aerial photographs were taken using pigeons, balloons and kites. The cameras could

be mounted on balloons and kites though with very restricted movement and speed.

The first aerial photograph was taken in the late 19th century of a French village by Gaspar Felix Tournachon, photographer and balloonist. He patented the concept of using aerial photographs to compile maps. This proved much more effective than the time-consuming ground surveys. In 1882, an English meteorologist, E. D. Archibald, was among the first to take successful photographs from kites with the attached camera. In France, Arthur Batut took an aerial photograph from a kite in 1889 (Fig. 9.9).



(a) (b)

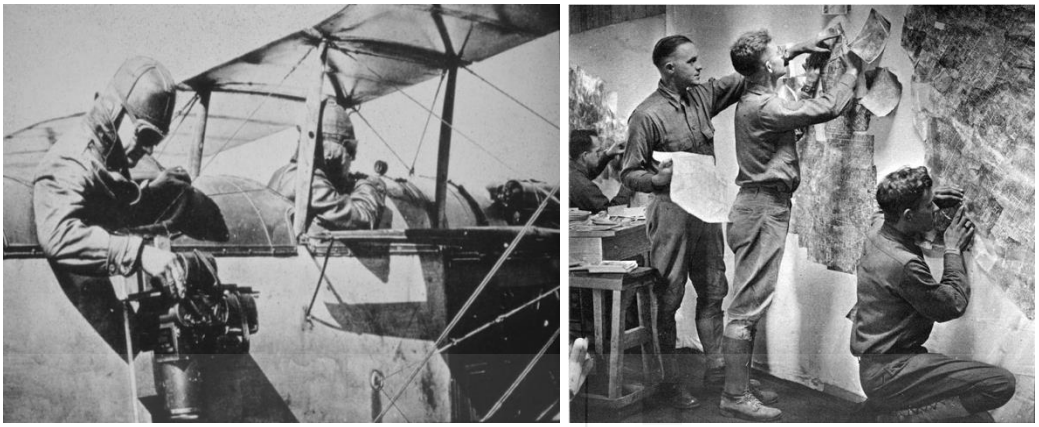
Fig. 9.9: Aerial photography: a) usage of air-balloons; and b) Batut's kite. (Source: www.nationalmuseum.af.mil/Portals/7/Remote%20Sensing%20Lesson%201.pdf)

In 1907, Julius Neubronne patented a breast-mounted camera for pigeons (Fig. 9.10), which was capable to expose automatically at 30-s (s stands for intervals). This was called as Pigeon photography. Pigeon with german miniature camera was used during the First World War to spy enemy camps. The camera weighing about 70 grams took automatic exposures every 30 seconds.

Fig. 9.10: a) Dr Julius Neubronner's Miniature Pigeon Camera (Source: https://the-public-domain-review.imgix.net/collections/dr-julius-neubronner-s-miniature-pigeon-camera/43712882935_12f88dea25_o.jpg?w=575); **and b) Photograph clicked by Pigeon camera.** (Source: https://the-public-domain-review.imgix.net/collections/dr-julius-neubronner-s-miniature-pigeon-camera/43903178774_6533ca58f2_h.jpg?fit=max&w=2400)

The military potential of aerial photography was realised with its wide usage in the World War I and II. However, not until World War I their potential for military applications was seen. Thereafter a systematic process of taking aerial

photographs became the key to the development of the method. During World War I, both the allies and Germans regularly took photographs of each other's lines and resources in order to keep up to date with the enemy movements (Fig. 9.11). After having experienced the success of this method of observation, the Britishers once again used aerial photography during World War II. Visualising the potential of application of aerial photography, the archaeologist Crawford pioneered its use for studying the English landscape.



(a) **(b)**

Fig. 9.11: a) Reconnaissance aircraft used during World War I, with the pilot trying to take vertical photographs in 1919 (Source: United States Air Force, https://gistbok.ucgis.org/sites/default/files/DC10_Fig2.png); **and b) Mosaic Mapping at U.S. School of aerial Photography in Virginia in 1930.** (Source: United States Air Force, https://gistbok.ucgis.org/sites/default/files/DC10_Fig3.png

Aerial photography expanded with advances in aeronautics. Post war period ushered the beginning of landscape studies, natural processes and archaeological features using aerial photographs. With advancement of technology, the aerial photographs were taken with the help of precision cameras mounted on aircraft or helicopter. Cameras were the simplest and oldest of sensors used for remote sensing. Advanced cameras were developed by USA and USSR. They were able to plan reconnaissance trips over important sites from thousands of feet up in the air.

You may note that there are following types of aerial cameras:

- aerial mapping camera
- reconnaissance camera
- strip camera
- panoramic camera
- multi-lens camera
- digital camera

The first non-military aerial photography programs were developed in the 1930's by the U.S. Department of Agriculture. During the Cold War and with the development of colour photography, the usage of aerial photography for wider environmental applications developed. This led to exploring infra-red photography for vegetation mapping and also for tracking and identifying diseased plants and trees. The purpose of taking landscape photographs in

different colours of the spectrum unlocked ~~up~~ a wide range of applications across the broadest possible scope of the environment. Aerial photography has numerous applications and is used by cartographers, engineers and scientists to analyse everything from urban expansion to the impacts of climate change.

In India, large-scale aerial photographs of Agra city were obtained in 1920. This marked the initiation of aerial photography. Subsequently, Air Survey Party of the Survey of India took up aerial survey of Irrawaddy Delta forests, which was completed during 1923–24. Further, several similar surveys were carried out with the advancement in technology. Today, aerial photography in India is carried out for the entire country under the overall supervision of the Directorate of Air Survey (Survey of India) New Delhi. The three flying agencies (Indian Air Force, Air Survey Company, Kolkata and National Remote Sensing Agency, Hyderabad) have been officially authorised to take aerial photographs in India. The period of aerial photography was followed by satellite reconnaissance. With the advent of satellite and space shuttles developed by national and international space agencies, the military aerial photography surveys became less important. However, the usage of aerial photography is still continued today.

9.7 APPLICATION POTENTIAL OF AERIAL PHOTOGRAPHY

The aerial images are significantly helpful for the geographers, historians, ecologists, geologists, urban planners, archaeologists and other professionals. Some of the applications of aerial photography are listed below:

- **Environmental studies**: Aerial photography has been used extensively in environmental studies, such as mapping forests and changes in vegetation over time. They have proved to be asset in environmental impact assessment, movement and glacier retreat studies.
- **Natural processes**: Tracking changes in river direction, depth and planning conservation work of river systems and changes in the landscape after the impact of natural processes such as landslides. Aerial photographs have been largely used to study the processes of natural changes, such as variations in soil and geology over time.
- **Civil law**: The legal profession has adapted techniques using aerial photography in the settlement of cases involving property disputes, riparian rights and transportation rights-of-way.
- **Cartography**: In the twentieth century aerial photography became an important component of the map making process/cartography. These photographs provide an honest depiction of the physical and cultural landscape of an area.
- **Natural resource exploration and management**: Aerial photography has proved to be landmark in natural resource management studies. Aerial photography has applications for finding mineral and fuel deposits, mapping areas, tracking geological changes and water management.
- **Landuse and Landcover**: The studies related to land use and land cover planning have been successfully carried using aerial photography.

- **Urban planning**: Aerial photography has immense application potential in urban studies. The town developers need to study the impact of expansion and development of urban centres on the landscape and environmental impact studies.
- **Climate change**: The climate change has impact on global temperatures. These changes are reflected in societies and communities and changes in their local environment are observed. Researchers keep vital records of changes incurred over seasons and years to keep track in the form of aerial photographs and evaluate the local effects of climate and risks to local ecosystems.
- **Archaeology**: In archaeological studies, aerial photography is ideal for locating lost monuments and tracking features, especially those that are not visible at ground level. This is accomplished using crop marks, parch marks, soil marks and low-profile monuments.

9.8 AERIAL PHOTO-INTERPRETATION

Aerial photo-interpretation is a process of examining and extracting useful information from aerial photographs. During this process, some features may be easily identifiable while others may not, depending on interpreter's perception and experience. The reliability of information collected from aerial photographs by the interpreter depends on the quality of aerial photographs, instruments used for interpretation, working conditions and personal experience with photo-interpretation techniques. The interpretation differs from person to person. For example, for the geological interpretation, knowledge of geomorphology, stratigraphy, structural geology, vegetation and groundwater is essential. The training in photo-interpretation and working experience of a person are very important factors, for accurate and reliable results. An excellent photo-interpreter views the aerial photographs with the help of stereoscope in order to make meaningful interpretation. We have read in the previous section that aerial photographs record all visible features on the Earth's surface from an overhead perspective. The preliminary knowledge of the area of interest comprises its geographic location, past and present climate conditions, vegetation and published literature are always useful for accurate identification of features.

SAQ 1

a) How is the aerial photograph different from an ordinary photograph?

b) What are the advantages of aerial photographs?

c) Name the types of aerial photographs based on the scale.

d) List the application potential of aerial photography.

9.9 IMAGE INTERPRETATION

Interpretation is generally called as **image interpretation** except for the case when the interpretation is carried out on aerial photographs. Interpretation of aerial photographs is known as **aerial photo-interpretation**. Image interpretation is very useful in various fields such as geography, geology, agriculture, forestry, environment, ocean studies, wetlands, conservation of

natural resources, urban and regional planning, defence and many other purposes. Interpretation techniques require extensive training and it is labour intensive. In order to translate images into information, person should be well-versed with both the subject knowledge and also the image interpretation basics. For example, interpretation of geological features requires expertise in geology along with image interpretation skill. Interpretation involves the processes of detection, identification, description and assessment of significant of an object and pattern imaged. This technology includes both aerial and satellite remote sensing.

The interpretation carried out using aerial photograph is known as **aerial photo-interpretation**. Whereas interpretation done using satellite imagery is known as **visual interpretation**. We will read about the elements and keys of visual interpretation in detail in the next unit. There are two types of extraction of information can be done from the images namely: 1) Interpretation of data by visual analysis; 2) Semi-automatic processing by computer followed by visual analysis like generation of vector layer from raster image through digitisation.

9.9.1 Image Interpretation Tasks

The image interpretation procedure is a complex task and requires several tasks to be conducted in a methodical manner (Fig. 9.12) which include:

- Classification
- Enumeration
- Mensuration
- Delineation

Classification is the assignment of object, features, or area to the classes based on their appearance on the images. Often the distinctions are made between three levels of confidence and precision namely- detection, recognition and identification. **Detection** is the determination of presence or absence of the feature. **Recognition** implies a higher level of knowledge about a feature or an object such that the object can be assigned identity. And, **identification** means that the identity of an object or feature can be specified with enough confidence and detail to place it in a specific class. Often an interpreter may assign quality of his or her confidence in an interpretation by specifying the identification as “possible” or “probable.”

Enumeration is the task of listing or counting discrete items visible on an image. For example, builtup area may be classified as “residential area” or “commercial area”. The ability to conduct enumeration task depends on an ability to accurately identify and classify items as we have discussed above. Let us read another example, housing unit can be classified as detached single family, multifamily complex, mobile home, and multistory residential and then reported as numbers present within a defined area. Clearly, the ability to conduct such an enumeration depends on an ability to accurately identify and classify items as discussed above.

Mensuration or **measurement** is an important function in many image interpretation problems. Two kinds of measurements are important, first, is the measurement of distance and height, and by extension, volumes and areas as

well. A second form of measurement is quantitative assessment of image brightness. Such measurements form the subject of **photogrammetry** as it applies only to measurements from photographs. The science of **photometry** is devoted to measurement of the intensity of light. Densitometers are used for estimation of scene brightness by examination of image tone. But if the measured radiation extends outside the visible spectrum, the term **radiometry** is applied.

Delineation deals with the task which the interpreter must delineate, or outline, regions as observed on remotely sensed images. The interpreter must be able to separate distinct units that are characterised by specific tones and textures and to identify edges or boundaries. The image analyst may apply several of these skills in examining an image. Let us read an example which includes delineation of separate classes of forest or of land use. Typical problems may include: 1) selection of appropriate levels of generalization (when boundaries are intricate, or when many tiny parcels are present), and 2) placement of boundaries when there is a gradation (rather than a sharp edge) between two units. The image analyst may simultaneously apply several of these skills in examining an image.

Recognition, delineation, and mensuration may all be required as the interpreter examines an image. Hence interpretation is the combined result of identification of feature through photo recognition elements, field verification and preparation of final thematic maps. It also requires the process of observation coupled with imagination and great deal of patience. Military photo interpretation often depends on accurate recognition and enumeration of specific items of equipment. Whereas land-use inventory highlight delineation, although other skills are obviously important. Image analysts therefore need to develop proficiency in all these skills.

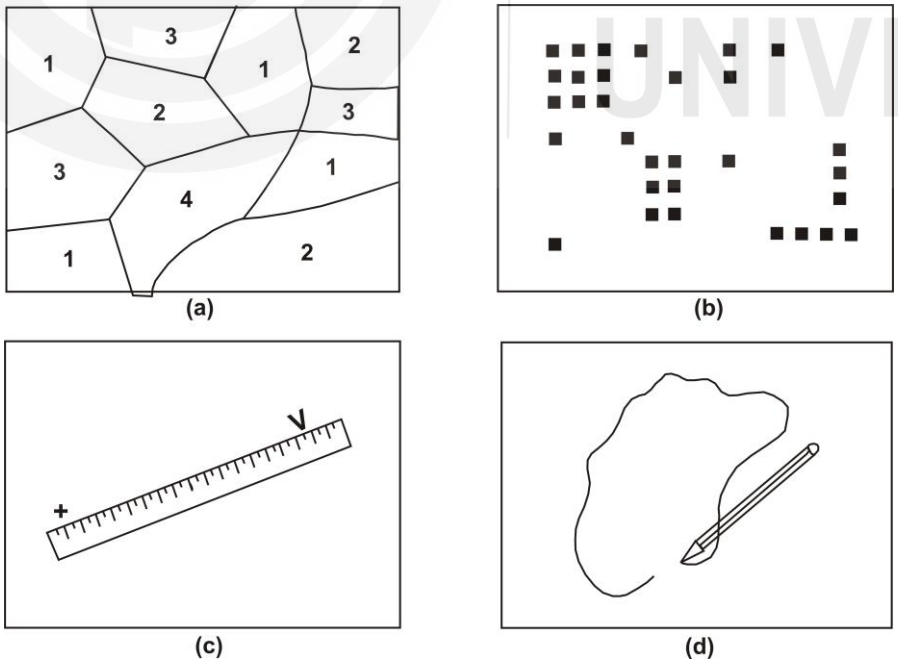


Fig. 9.12: Image interpretation tasks: a) classification; b) enumeration; c) mensuration; and d) delineation.

9.9.2 Prerequisites for Image Interpretation

Let us learn issues pertaining to image interpretation such as unfamiliar scale and resolutions, lack of understanding of physics of remote sensing and understanding proper spectral character of each object

Now you will learn about the following requirements for image interpretation:

- Remote sensing system and the knowledge of image and sensor characteristics
- Interpretation technique requires extensive training
- Interpreter should be well-versed with both the subject knowledge and also the image interpretation.
- Success in visual image interpretation varies with the training and experience on the pictorial data analysis.

9.9.3 Elements of Aerial Photo-Interpretation

The interpretation of satellite imagery and aerial photographs involves the study of various basic characters of an object with reference to spectral bands which is useful in visual analysis. The basic elements are shape, size, pattern, tone, texture, shadows, location, association and resolution. You will find that information extraction from aerial photography is based on the basic elements and characteristics of image features of aerial photographs such as tone, size, shape, texture, pattern, shadow, site and association. These eight elements are also utilized for interpretation of satellite imagery (known as visual image interpretation). We will read about these elements in detail in the next unit.

1. **Shape** refers to the general outline of objects and regular geometric shapes (Fig. 9.13). The form of an object in aerial photo helps to identify the object. Often regular uniform shapes indicate human involvement. While irregular shapes point to natural objects.

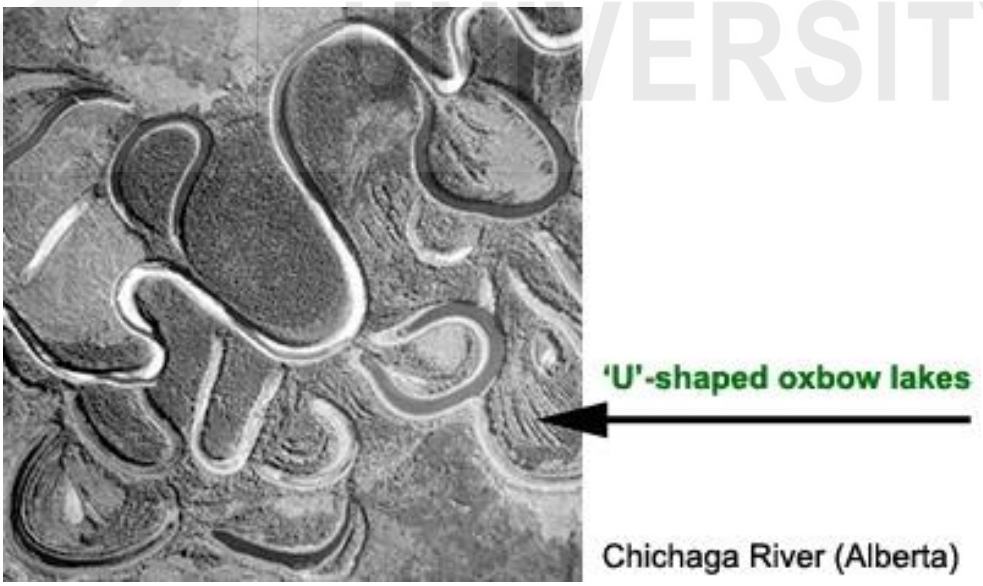


Fig. 9.13: Photograph shows the shape of meandering river surrounded on either side by many U-shaped oxbow lakes. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/photos101/images/E_Bug2451_Image1.jpg)

2. **Tone** or **colour** is the most basic interpretive element and refers to the relative brightness or colour of elements on an aerial photograph. The colour of an object is used to identify the feature, e.g., sand has a bright tone. While water usually has a dark tone (Fig. 9.14) and tree species can be determined by the colour of their leaves at particular times of the year.

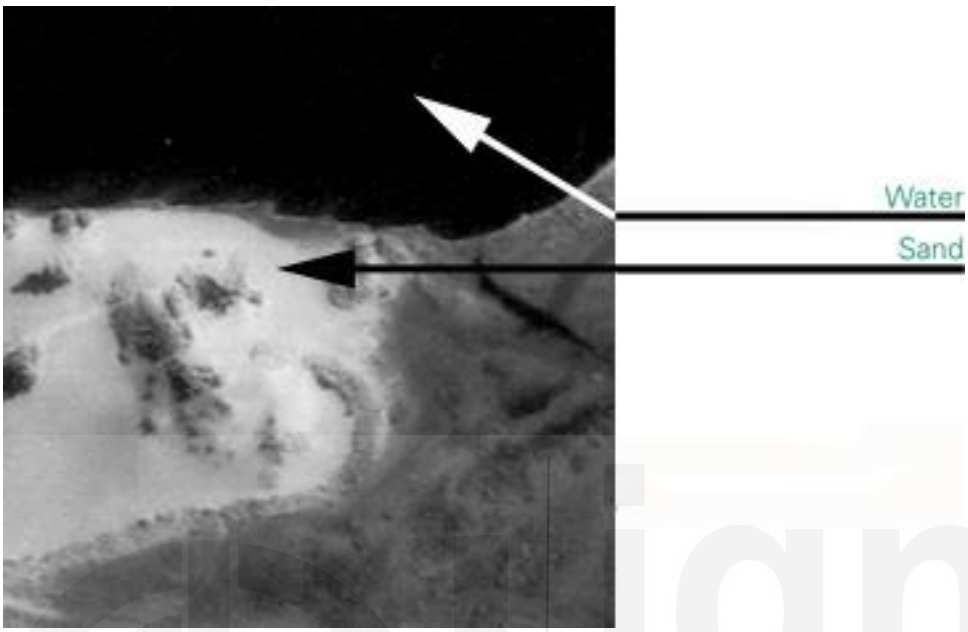


Fig. 9.14: Photograph showing the contrast between the water in black in the upper part of the picture and the light-coloured sand in the lower part. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_4_sand.jpg)

3. **Size** of objects must be considered in the context of the scale of a photograph. The scale will help you determine if a water body is a pond or lake or sea. It is a measure of the object's surface area (e.g., single-lane vs. multi-lane highways; Fig. 9.15).

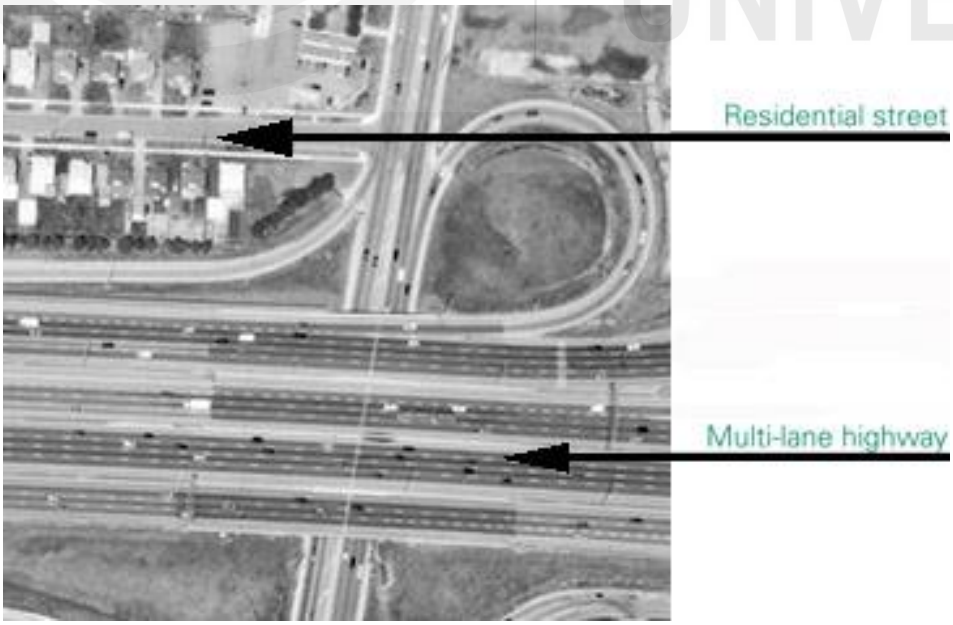


Fig. 9.15: Photograph showing a residential street; its size can be compared to the much larger multi-lane highway shown at the bottom of the picture.

(Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_3_HighWay.jpg)

4. **Texture** is the impression of smoothness or roughness of image features and is caused by the frequency of change of tone in photographs. The physical characteristics of an object will change the way they appear on a photo, e.g., calm water has a smooth texture; a forest canopy has a rough texture (Fig. 9.16).

Fig. 9.16: Photograph showing a portion of the Lake Louise, Alberta, shoreline. In the bottom right corner of the picture, calm water is characterised by a smooth appearance. On the left side of the picture, the forest shows a rough texture similar to a field of rocks. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/photos101/images/E_Bug2451_Fig6.jpg)

5. **Pattern** or spatial arrangement of the objects in a photo which can be diagnostic. The spatial arrangement of objects (e.g., row crops vs. pasture) is also useful to identify an object and its usage (Fig. 9.17).

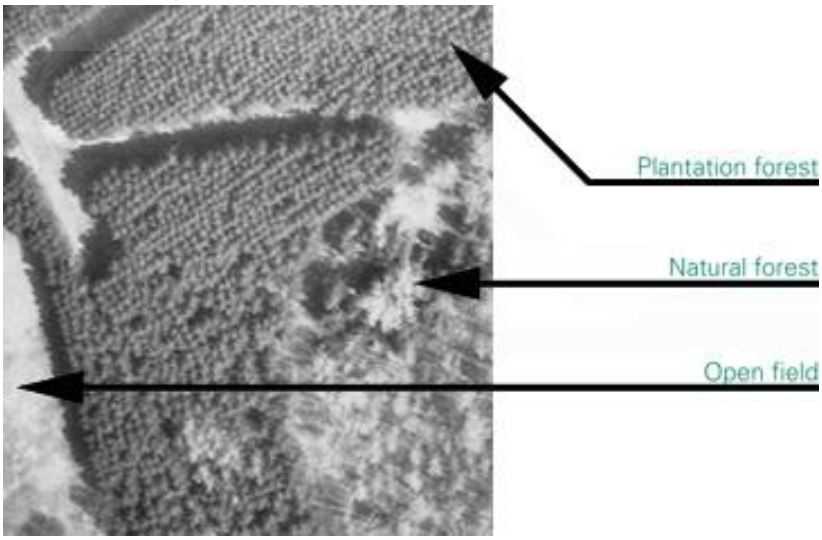


Fig. 9.17: Photograph showing three kinds of vegetation patterns. A forest plantation, shown at the top of the picture, can be identified by the straight row pattern making it look like a dark grey wool carpet. On the

right side of the picture, a natural forest can be identified by its white cloudy unstructured pattern. Finally, on the left side of the picture, a lighter coloured more uniform pattern represents an open field. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_2_forest.jpg)

6. **Shadow** helps the interpreters in determining height of objects in aerial photographs (Fig. 9.18). A shadow provides information about the object's height, shape and orientation (e.g. tree species).

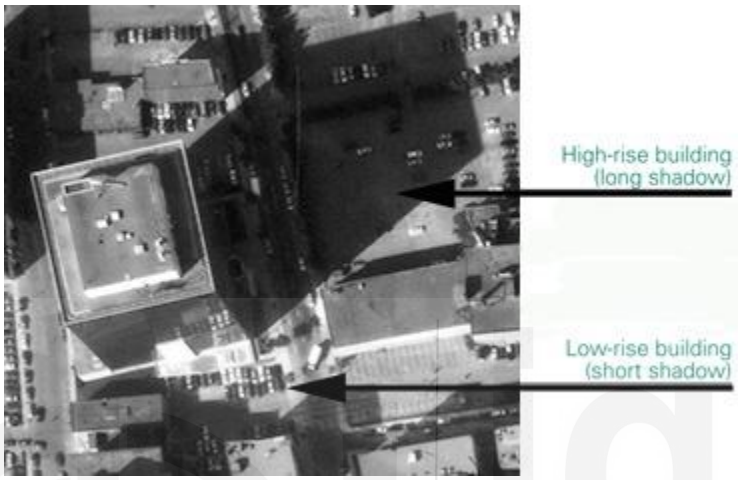


Fig. 9.18: Photograph showing two different sizes of shadows. On the left side of the picture, a large building casts a long wide shadow to its right indicating that it is a high-rise building. At the bottom left corner of the picture, smaller shadows indicate low-rise buildings. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_5_building.jpg)

7. **Association/Site** refers to topographic or geographic location of the objects of interest in relation with the other objects (Fig. 9.19). Associating the presence of one object with another, or relating it to its environment, can help the interpreter to identify the object (e.g. industrial buildings often have access to railway sidings; nuclear power plants are often located beside large bodies of water).

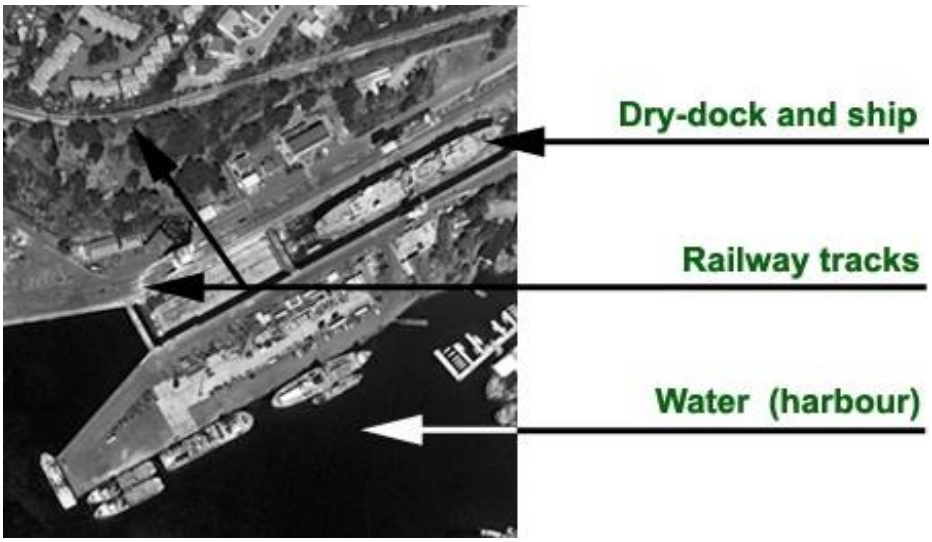


Fig. 9.19: Photograph showing Esquimalt Harbour, British Columbia. In the middle of the picture, the large wharf with ships moored a long side it

can be identified. The dry dock is identifiable by its gates and is located just above the wharf, and above the dry dock, on land, a railway line crosses the picture. (Source: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/ earthsciences/images/photos101/images/E_Bug2451_Fig7.jpg)

In order to interpret aerial photographs, a number of sophisticated instruments such as pocket stereoscope, mirror stereoscope, or plotter are used for measuring area, height and slopes of different parts of the Earth. Stereoscope is used for viewing the area in 3-D and is important for determining topographical relief of an area, as well as the height of objects such as trees and building.

Stereoscopic imagery is the result of overlap (generally 60%), which is the amount by which one photograph includes an area covered by a neighbouring photograph. For mapping, inventory and vegetation studies, for example, a survey is flown in a series of to-and-fro parallel strips with side overlaps between strips over the entire area. For non-stereoscopic coverage, used in crop sampling or pollution detection, the photographer may choose a 20% forward overlap.

SAQ II

a) List the tasks of image interpretation.

b) What is the difference between aerial photo-interpretation and visual interpretation?

c) Mention the elements of aerial photo-interpretation.

d) What are the prerequisites of image interpretation?

9.10 IMAGE SCALE AND ITS CALCULATION

Scale is a prerequisite at the time of interpretation as it effects interpretation of image features. The scale of the image is carefully chosen depending upon the observations to be made. Scale of photographs/image should be such that it will permit differentiation of objects. For regional scale mapping, we need not choose data of very high resolution. For example, mapping the forest cover of national or state level you require data which has coarse to medium spatial resolution such as the WiFS or LISS III. Similarly, for mapping at local scale you require high spatial resolution data such as Cartosat PAN, IKONOS, etc.

You should remember that the choice of an appropriate scale for a particular application depends on several factors such as level of information desired, method of analysis to be used and spatial resolution of the data. Let us read the methods to determine scale

Representative Fraction: Scale is the ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e., 1 unit on the photo equals "x" units on the ground). If a 1 km stretch of highway covers 2 cm on an aerial photo, the scale can be calculated as:

$$\frac{\text{Distance on aerial photo}}{\text{Distance on Ground}} = \frac{2\text{ cm}}{1\text{ km}} = \frac{2\text{ cm}}{100000} = \frac{1}{50000}$$ Scale: 1/50 000

Focal Length and Field of View: The scale of a photograph is determined by the focal length of the camera and the flying height above the ground (Fig. 9.20).

The **focal length** is the distance from the middle of the camera lens to the focal plane. Focal length is precisely measured when cameras are calibrated and is typically expressed in millimeters (mm). The focal length of a lens determines the magnification and the angle of the light ray. The longer the focal length, the greater is the magnification of the image.

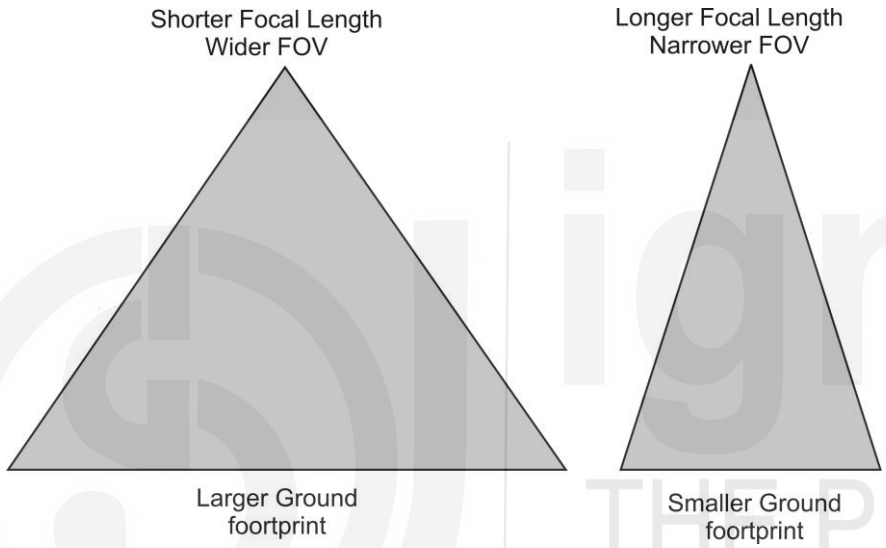
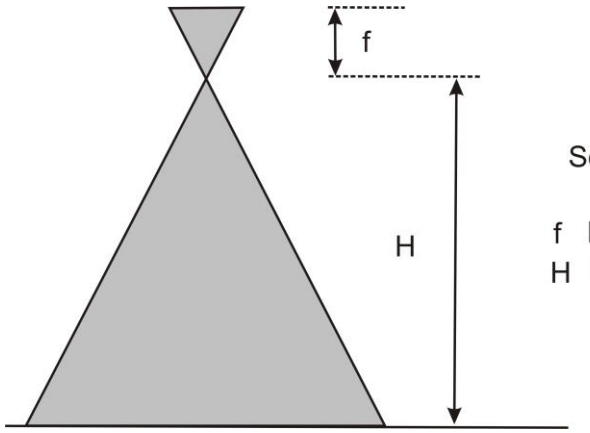


Fig. 9.20: Shorter focal lengths have wider field of views, while longer focal lengths have smaller field of views (FOV). Camera lens with a longer focal length will produce an image with a smaller footprint compared to that of a shorter focal length.

Short focal length lenses cover larger areas. The area captured by a camera is known as the **Field of View** (FOV), which is typically expressed in degrees. Field of View is a function of the focal length of the lens and the size (sometimes called format) of digital sensors (Fig. 9.21).



$$\text{Scale} = \frac{f}{H}$$

f Focal length of the camera
H Flying height above ground level

Fig. 9.21: Determination of scale using focal length.

9.11 MINIMUM MAPPING UNIT

Maps derived from remotely sensed data are often presented using a minimum mapping unit (MMU). **MMU** is defined as the smallest size areal entity on the ground that can be identified in image and mapped as a unique and discrete entity. For a given map scale, the size or dimension below the MMU, a long narrow feature is represented as a line and a small area as a point. For example, streams and rivers below the MMU will be represented as lines and a pond as a point.

A key issue when generating a map from remotely sensed data is the selection of the MMU to be employed, which determines the extent of detail conveyed by an interpreter in the map. Selection of a MMU allows reducing the visual and spatial complexity of the information contained in the map, especially when the information corresponding to the smallest patches is of little or no interest to the interpreter for the theme for which the map is being generated (Davis and Peet, 1977).

9.12 SUMMARY

Let us now summarise what has been discussed in this unit:

- Aerial photograph is any photograph taken from the air using a precision or highly-accurate camera vertically from an aircraft.
- The advantages that aerial photographs offer are: synoptic viewpoint, permanent recording, capability to stop action, three-dimensional perspective, spectral and spatial resolution, film sensitivity, availability and economy.
- The aerial photographs can be classified based on: 1) position of camera axis, 2) scale and 3) film used.
- Image interpretation is the process of extraction of information from aerial photographs and satellite images in the form of a map.
- Image interpretation is carried out either manually or with the help of computer software and are known as visual and digital interpretation, respectively.
- The information extraction from aerial data (i.e. photo interpretation) is based on the characteristics of photograph features such as size, shape, tone, texture, shadow, pattern, and association.

9.13 TERMINAL QUESTIONS

1. Discuss the advantages of aerial photographs.
2. What is the basis of classification of aerial photographs?
3. Write an essay on historical developments in aerial photography.
4. Describe in detail the application potential of aerial photography.

9.14 REFERENCES

- Bhatta, B. (2010), Remote sensing and GIS, Oxford University Press.
- Davis, W.A. and Peet, F.G. (1977), A method of smoothing digital thematic maps. Remote Sensing of Environment, Vol 6 pp 45-49.
- DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A. T., Plewe, B., and Wentz, E. (2006), Nature of aerial image data. The Geographic Information Science & Technology Body of Knowledge. Washington, DC: Association of American Geographers. (2nd Quarter 2016, first digital)
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- https://gistbok.ucgis.org/sites/default/files/DC10_Fig1.png
- https://gistbok.ucgis.org/sites/default/files/DC10_Fig2.png
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- https://the-public-domain-review.imgix.net/collections/dr-julius-neubronner-s-miniature-pigeon-camera/43712882935_12f88dea25_o.jpg?w=575
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- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/photos101/images/E_Bug2451_Image1.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_4_sand.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_3_HighWay.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/photos101/images/E_Bug2451_Fig6.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_2_forest.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/T1674_5_building.jpg
- https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/photos101/images/E_Bug2451_Fig7.jpg
- www.nationalmuseum.af.mil/Portals/7/Remote%20Sensing%20Lesson%201.pdf

The above websites were assessed between 1st and 16th August 2022.

9.15 FURTHER/SUGGESTED READINGS

- Campbell, J.B., Wynne, R. H. and Thomas, V. A. (2022), Introduction to Remote Sensing, 6th Edition, The Guilford Press, New York, 634p.
- Drury, S.A. (1990), A Guide to Remote Sensing, Oxford University Press.
- Sabins, F.F. (1987), Remote Sensing- Principles and Interpretation, 2nd Edition, W.H. Freeman and Co.

9.16 ANSWERS

SAQ I

a) The everyday photograph represents horizontal perspectives whereas aerial photograph shows vertical perspectives.

b) The advantages of aerial photography are synoptic viewpoint, permanent recording, and capability to stop action, three dimensional perspectives, spectral and spatial resolution, availability and cost effectiveness.

c) On the basis of the scale, the aerial photographs are classified into large scale photographs, medium scale photographs and small-scale photographs.

d) Environmental studies, natural processes, civil law, cartography, natural resource exploration and management, land use and landcover, urban planning, climate change and archaeology.

SAQ II

a) Classification; enumeration; mensuration and delineation.

b) Interpretation ~~is~~ carried out using aerial photograph is known as aerial photo-interpretation. Whereas interpretation done using satellite imagery is known as visual interpretation.

c) Shape; tone; size; texture; pattern; shadow; association/site.

d) Remote sensing system; knowledge of image and sensor characteristics; proficiency based on knowledge of the subject; adequate familiarity of the geographic region and locality.

Terminal Questions

1. Please refer to Section 9.3.
2. Please refer to Section 9.4.
3. Please refer to Section 9.6.
4. Please refer to Section 9.7.