

**VISVESVARAYA
TECHNOLOGICAL UNIVERSITY
BELGAUM**



ENGINEERING GEOLOGY

(Subject Code: BCV303)

LECTURE NOTES

(MODULE-5)

III-SEMESTER

Ms. Pooja D

Assistant Professor



AJIET

**A J INSTITUTE OF ENGINEERING
& TECHNOLOGY**

**DEPARTMENT OF INFORMATION SCIENCE
AND ENGINEERING**

(A unit of Laxmi Memorial Education Trust. (R))

NH - 66, KottaraChowki, Kodical Cross - 575 006

tools and techniques for civil Engineering Applications

TOPOGRAPHICAL AND GEOLOGICAL MAP

Geo-

Maps are representation of three dimensional views on two dimensions. Thus the relief of the ground such as depressions and elevations are shown by:

1. Shading : Different colours to indicate different altitude with reference to mean sea level.
2. Hachuring : Only one colour is employed and lines are drawn in the direction of the slope of the ground.
3. Contour : Lines joining all points of equal elevation with some constant intervals.

7.1 Topographic maps

A map of a small area drawn on a large scale depicting detailed surface features both natural and manmade. Relief in this map is shown by contours. A topographic map indicates the ground features like hills, valleys, river courses, roads, railway lines, forests, villages, town, lakes etc.

The topographical maps of India are prepared on 1 : 10,00,000, 1 : 250,000, 1 : 1,25,000, 1 : 50,000 and 1 : 25,000 scale providing a latitudinal and longitudinal coverage of 4° x 4°, 1° x 1°, 30' x 30', 15' x 15' and 7' 30" x 7' 30", respectively.

Reading of Topographical Maps: The study of topographical maps is simple. It requires the reader to get acquainted with the legend, conventional sign and the colours shown on the sheets.

Map Scale:

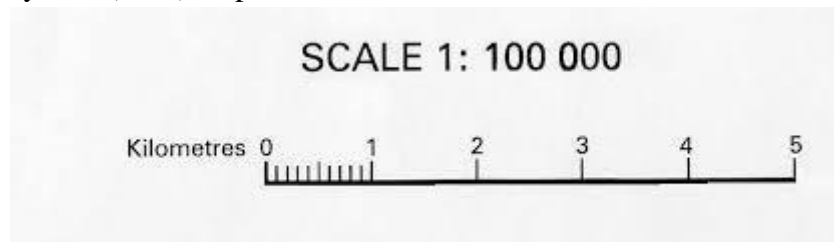
Maps are made to scale. In each case, the scale represents the ratio of a distance on the map to the actual distance on the ground.

$$\frac{\text{MAP DISTANCE}}{\text{GROUND DISTANCE}} = \frac{2 \text{ cm}}{1 \text{ km}} = \frac{2 \text{ cm}}{100\,000 \text{ cm}} = \frac{1}{50\,000}$$

Scale 1:50 000



Medium-scale maps (e.g. 1:50 000) cover smaller areas in greater detail, whereas small-scale maps (e.g. 1:250 000) cover large areas in less detail. A 1:250 000 scale national topographic system (NTS) map covers the same area as sixteen 1:50 000 scale NTS maps.



Map Grid:

A grid is a regular pattern of parallel lines intersecting at right angles and forming squares; it is used to identify precise positions. To help to locate any position accurately on the surface of the Earth (or map sheet), topographic maps have two kinds of referencing systems:

- Universal transverse Mercator (UTM) projection (easting/northing)
- Geographic: degrees and minutes (longitude/latitude)

The projection used for topographic maps is UTM. The UTM grid is a square grid system of lines depicted on maps and based on the transverse Mercator projection. It can be used to accurately locate the position of features on the map by distance or direction.

Contours:

Contours are imaginary lines joining places having the same elevation above mean sea level. A map showing the landform of an area by contours is called a contour map. The method of showing relief features through contour is very useful and versatile. The contour lines on a map provide a useful insight into the topography of an area.

Contours are drawn at different vertical intervals (VI), like 20, 50, 100 metres above the mean sea level. It is known as contour interval. It is usually constant on a given map. It is generally expressed in metres. While the vertical interval between the two successive contour lines remains constant, the horizontal distance varies from place to place depending upon the nature of slope. The horizontal distance, also known as the horizontal equivalent (HE), is large when the slope is gentler and decreases with increasing slope gradient.

The following steps may be followed to draw cross-sections of various relief features from their contours:

1. Draw a straight line cutting across the contours on the map and mark it as AB.
2. Take a strip of white paper or graph and place its edge along the AB line.
3. Mark the position and value of every contour that cuts the line AB.
4. Choose a suitable vertical scale, e.g. $\frac{1}{2}$ cm = 100 metres, to draw horizontal lines parallel to each other and equal to the length of AB. The number of such lines should be equal or more than the total contour lines.
5. Mark the appropriate values corresponding to the contour values along the vertical of the cross-section. The numbering may be started with the lowest value represented by the contours.
6. Now place the edge of the marked paper along the horizontal line at the bottom line of the cross-section in such a way that AB of the paper corresponds to the AB of the map and mark the contour points.
7. Draw perpendiculars from AB line, intersecting contour lines, to the corresponding line at the cross-section base.
8. Smoothly join all the points marked on different lines at the cross section base.

Stream Ordering

Streams may be categorized according to their position--order or magnitude--within a drainage network. Stream order can be used to describe a stream and to conveniently divide a stream network into component parts that may be quantified and compared. For instance, streams that do not possess a tributary are designated as '1st order' or 'magnitude 1' streams. The number and length of 1st order streams in a basin can be measured and compared to those in a separate basin. Such procedures lend themselves to statistical treatment and are therefore extremely useful for comparing different drainage basins.

Two principal stream order schemes are in use today. The Strahler Order system designates 1st order streams as those that lack a tributary. Second order streams are formed at the junction of 1st order streams (Figure 8). Third order streams are formed at the junction of 2nd order streams, fourth at the junction of 3rd order streams, and so forth. Note that stream order only increases when two streams of the same order join. Therefore, where a 2nd order stream joins a 3rd stream there is no change in stream order; the 3rd order stream remains 3rd order.

The Shreve Magnitude system designates streams that lack a tributary as magnitude 1. Where streams join, their magnitudes are added together. Therefore unlike the Strahler system, magnitudes increase at all junctions in the Shreve system. For instance, where a magnitude 2 stream joins a magnitude 3 stream, the magnitudes are added to form a magnitude 5 stream. Note that in such a case there is no magnitude 4 stream. A convenient component of the Shreve system is that a stream's magnitude corresponds to the number of magnitude 1 or 1st order streams contributing to the channel.

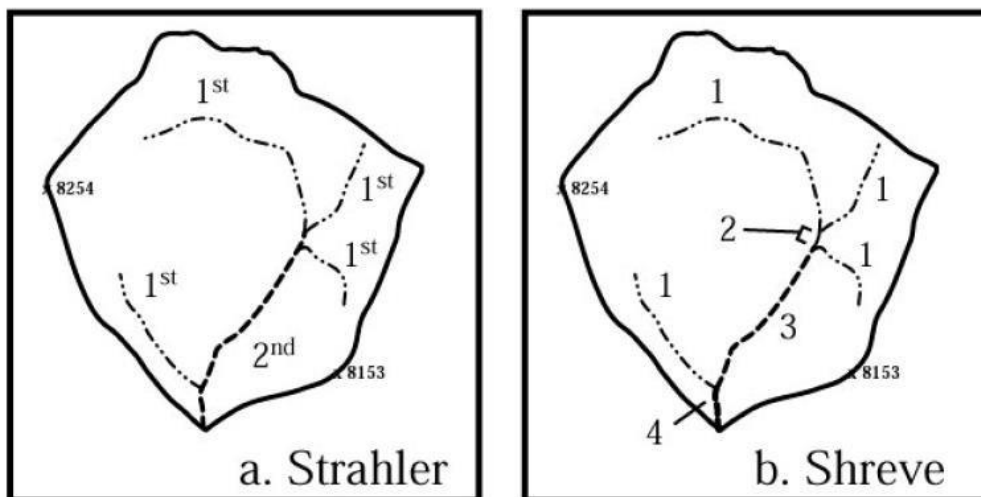


Figure 8: Stream order. Orders increase in the Strahler stream order system where two streams of equal order meet. In the Shreve magnitude system, magnitudes increase through addition at all stream junctions. Using the Shreve system, the number of magnitude 1 streams in a basin is equal to the basin's magnitude.

The number of 1st order streams in a basin of a given size is dependent upon a variety of climatic, geologic, and hydrologic factors. For instance, holding all other variables constant we would expect that a drainage basin in an arid climate would have more 1st order streams than a watershed in a more humid climate. Similarly, increasing relief is associated with increasing stream densities. Although the number of streams in a given order is a crude measure of drainage density, we define **drainage density (D)** much more explicitly as,

$$D = \frac{\sum L_i}{A_b}$$

where L_i denotes stream lengths and A_b is drainage basin area

Measuring stream lengths is accomplished using a map wheel or digitizing table. During this exercise, we will measure the length of all streams in each order. Drainage density will be calculated by summing the lengths of all orders and dividing by basin area. Prior to measuring the stream lengths you should pause and predict which stream order will have the greatest length. Why is this relationship important?

Not only are the numbers and lengths of particular stream orders important, but their ratios are quite instructive as well. Consider a dendritic drainage pattern versus trellis. In an ideal dendritic drainage pattern, the number of 1st order tributaries would be exactly twice the number of 2nd order streams. Thus, the number of 1st order streams will be exactly twice that of 2nd order streams. In a trellis network, long main stem streams are fed by many low order streams. As a result, 1st order streams typically outnumber 2nd order streams by 3 to 5 times. The relationship between the number of streams in successive stream orders is called the bifurcation ratio (R_b). The ratio can be mathematically defined as follows,

$$R_b = \frac{S_{o-1}}{S_o}$$

where S_o is the number of streams in any given order and S_{o-1} is the number of streams in the next lowest order.

For Figure 8a, note that the bifurcation ratio between the 1st and 2nd order streams can be computed as follows,

$$R_b = \frac{S_{o-1}}{S_o} = \frac{S_{1st}}{S_{2nd}} = \frac{4}{1} = 4$$

The utility of the bifurcation ratio lies in its ability to succinctly express the organization of a drainage basin and allow statistical tests. As a mental exercise, you might consider two streams with similar areas, relief, and so forth. Their drainage patterns differ with one

possessing a 1st/2nd bifurcation ratio of 2.4 and a 2nd/3rd ratio of 2.2. The other stream possesses values of 4.7 and 4.1. Using logic, can you accurately predict which watershed has the flashiest hydrograph at its mouth? The solution is, perhaps, more complex than it appears.

Identification of cultural features from topographical sheets:

Settlements, buildings, roads and railways are important cultural features shown on topographical sheets through conventional signs, symbols and colours. The location and pattern of distribution of different features help in understanding the area shown on the map.

Distribution of Settlements:

It can be seen in the map through its site, location pattern, alignment and density. The nature and causes of various settlement patterns may be clearly understood by comparing the settlement map with the contour map.

Four types of rural settlements may be identified on the map

- (a) Compact (b) Scattered (c) Linear (d) Circular

Similarly, urban centres may also be distinguished as

- (a) Cross-road town (b) Nodal point (c) Market centre (d) Hill station
(e) Coastal resort centre (f) Port (g) Religious centre (h) Capital

(i) Manufacturing centre with suburban villages or satellite towns

Various factors determine the site of settlements like

- (a) Source of water (b) Provision of food (c) Nature of relief (d) Nature and character of occupation
(e) Defence

Site of settlements should be closely examined with reference to the contour and drainage map. Density of settlement is directly related to food supply. Sometimes, village settlements form alignments, i.e. they are spread along a river valley, road, embankment, coastline – these are called linear settlements. In the case of an urban settlement, a cross-road town assumes a fan-shaped pattern, the houses being arranged along the roadside and the crossing being at the heart of the town and the main market place. In a nodal town, the roads radiate in all directions.

Transport and Communication Pattern:

Relief, population, size and resource development pattern of an area directly influence the means of transport and communication and their density. These are depicted through conventional signs and symbols. Means of transport and communication provide useful information about the area shown on the map.

Interpretation of topographical maps:

Knowledge of map language and sense of direction are essential in reading and interpreting topo-sheets. All topo-sheets contain a table showing conventional signs and symbols used in the map. Conventional signs and symbols are internationally accepted; so, anyone can read any map anywhere in the world without knowing the language of that particular country.

A topographic sheet is usually interpreted under the following heads:

- (a) Marginal information
- (b) Relief and Drainage
- (c) Land Use
- (d) Means of Transport and Communication
- (e) Human settlement

Marginal information: It includes the topographical sheet number, its location, grid references, its extent in degrees and minutes, scale, the districts covered, etc.

Find out from the index number of the topographical sheet, the location of the area in India. This would give an idea of the general characteristics of the major and minor physiographic divisions of the area. Note the scale of the map and the contour interval, which will give the extent and general landform of the area.

Relief of the Area: The general topography of the area is studied to identify the plains, plateaus, hills or mountains along with peaks, ridges, spur and the general direction of the slope. These features are studied under the following heads:

- Hill: With concave, convex, steep or gentle slope and shape.
- Plateau: Whether it is broad, narrow, flat, undulating or dissected.
- Plain: Its types, i.e. alluvial, glacial, karst, coastal, marshy, etc.
- Mountain: General elevation, peak, passes, etc.

Drainage of the Area: The important rivers and their tributaries and the type and extent of valleys formed by them, the types of drainage pattern, i.e. dendritic, radial, ring, trellis, internal, etc.

Land Use: It includes the use of land under different categories like:

- Natural vegetation and forest (which part of the area is forested, whether it is dense forest or thin, and the categories of forest found there like Reserved, Protected, Classified / Unclassified).
- Agricultural, orchard, wasteland, industrial, etc.
- Facilities and Services such as schools, colleges, hospitals, parks, airports, electric substations, etc.

Transport and Communication: The means of transportation include national or state highways, district roads, cart tracks, camel tracks, footpaths, railways, waterways, major communication lines, post offices, etc.

Settlement: Settlements are studied under the following heads:

- Rural Settlements: The types and patterns of rural settlements, i.e. compact, semi-compact, dispersed, linear, etc.
- Urban Settlements: Type of urban settlements and their functions, i.e. capital cities, administrative towns, religious towns, port towns, hill stations, etc.

Occupation: The general occupation of the people of the area may be identified with the help of land use and the type of settlement. For example, in rural areas the main occupation of majority of the people is agriculture; in tribal regions, lumbering and primitive agriculture dominates and in coastal areas, fishing is practised. Similarly, in cities and towns, services and business appear to be the major occupations of the people.

Lineament mapping:

A lineament is an interpreted line (“one dimensional”) drawn in relation to linear to semi-linear terrain forms, e.g. valleys and slopes and reflect subsurface phenomenon. It can be derived from remotely sensed data, geological and geophysical maps. Lineaments can be natural features such as fault, joint, line weakness, cliffs, terraces, and linear valleys or artificial features such as road, tracks, and buildings. Lineaments are one of the most important topographic features used in exploration of resources such as minerals, hydrocarbons, hydrogeological researches and hot spring detection as well as to solve certain problems in the area for instance, in site selection for construction a dams, bridges, roads, etc., for seismic and landslide risk assessment etc.

While mapping conducting lineament mapping all linear features are to be interpreted from the map. The cultural features like road, railway line, high tension lines etc. are to be excluded. The lineament may not be a single continuous line, rather it has to be shown as discontinuous line segments. Lineaments from topographic map can be identified mainly based on their linear nature, alignment of vegetation, alignment of ponds, straight stream segments, etc. However, interpretation of lineaments is to be done in conjunction with other diagnostic criteria such as channel offset, bank erosion and down-cutting of channel along lineament, warping and displacement of sediment layer, anabranching of river course, abrupt change of river course, presence of dry channel in an active river course, channel rejuvenation and land subsidence, linear ridges, scarp surface, linear alignment of water bodies and straight channel segments.

Classification of lineaments

The following two types of lineaments are to be interpreted from the topographic map.

A. Geomorphic lineaments

1. Scarp parallel
2. Drainage parallel

3. Ridge parallel
4. Parallel to shoreline
5. Gorge / trench parallel
6. Break-in slope

B. Structural lineaments

1. Fault,
2. Joint/Fracture
3. Shear Zone,
4. Axial trace of fold
5. Dyke

Magnitude of lineament

All lineaments are to classified based on their length into the following two types.

- A. Micro lineaments - Very small (magnitude) linear features frequently observed in the map. They correspond to minor faults, fractures, joints and bedding traces in the rock. Geomorphologically they are expressed as linear alignments of local depressions/ ponds. For quantification purpose, lineament length < 3 km is classified as micro lineaments.
- B. Mega lineaments - Large linear features. Adjacent/coincides with regional trends/ structural features. It cuts across various geomorphic units both in time and space. Lineament length > 3 km is classified as mega lineaments.

7.2 Geological map

A geological map always represents the distribution and association of rock types, ores and other economic mineral deposits. The map is usually super imposed on a topographic map of an area. It represents the way in which the beds would appear. Geological sections are useful for solving both Stratigraphy and structural problems.

Drawing a geological section:

From a geological map a section along a suitable line is constructed to show the geological information in a concise form. The procedure of drawing a section consists of three steps:

- i) Drawing a topographic profile
 - ii) Determination of dip and strike
 - iii) Construction of geologic structures
- i) **Drawing a topographic profile:** Suppose it is required to draw a topographic profile along a XY line on the geological map. The map is first folded along the XY line on the drawing paper. A horizontal line equal to the XY line is drawn, which serves as a baseline to the geological sections to be made over this line. The folded map is

placed and the positions of the various contour lines along XY lines are marked. From these points vertical lines are drawn their length being proportional to the values of corresponding contours as per the scale of the map. Then a free hand curve joins their tops. The vertical lines drawn above the base line are not desired and therefore should be removed.

- ii) **Determination of dip and strike:** Generally on geological maps both the contour lines as well as boundaries of rock beds are shown. To determine the dip of a rock bed by graphical method, such a contour is selected which cuts the particular rock boundary at two points. A line called strike lines joins these points. Two strike lines from contours of different values are drawn for the same boundary. Then the distance between them along XY line is measured. And a line having the same length is drawn on the drawing paper somewhere below the profile already made. From one end a perpendicular of length equal to the strike of interval is constructed as per the scale of the map. The angle formed by joining its top with the other end of the line will be the dip angle. And its direction will be from the strike line of higher value to the one that has the lower value. In this way dip of various rock beds shown on the map are determined.
- iii) **Construction of geologic structures:** Now the map is folded along the XY line and is placed over the base line of the profile. The points of intersection of the boundary lines between different beds and the XY line are transferred. These points are then projected to the surface profile. From these points lines are drawn according to the dip of the respective boundary surfaces. This is usually done by drawing angles of dip first at the base line and then drawing parallel lines from the corresponding points at the surface profile. In the section thus constructed, the various structures present are completed as follows:
 - a) If unconformity is present, an undulating line shows its plane.
 - b) If fold is present, anticline or syncline structures are made accordingly.
 - c) If fault is present, strata must be shown dislocated along it.
 - d) Dykes are shown running vertically. Sills are shown running parallel to the bedding planes.

REMOTE SENSING AND IMAGE INTERPRETATION

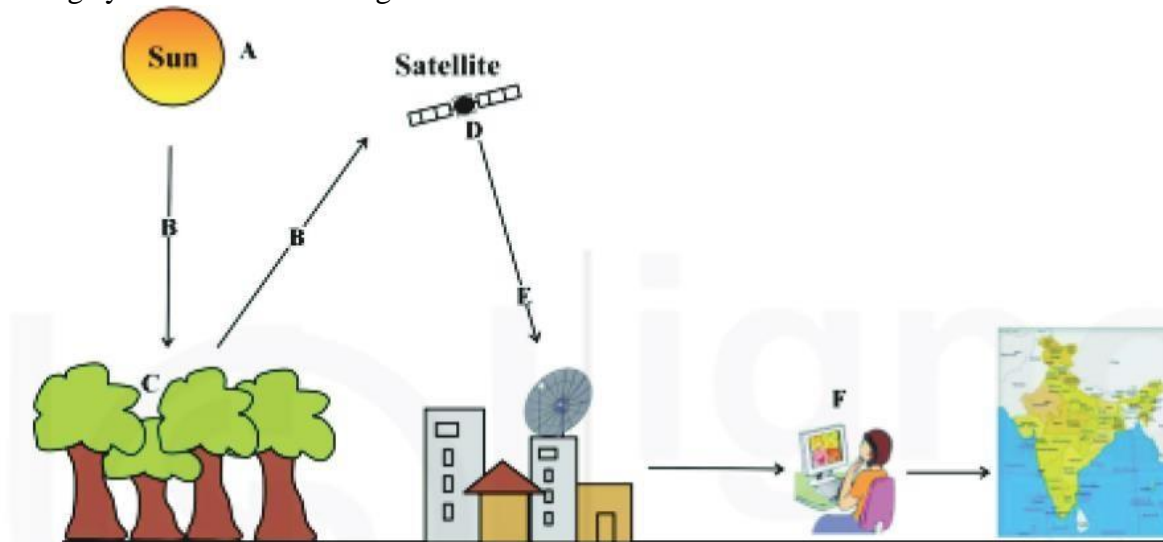
Remote sensing and image interpretation are relatively new fields. Remote sensing is defined as a science and method of acquiring information about Earth materials without coming in direct contact with the objects. This can be done with the help of cameras/sensors mounted in the aircrafts or satellites.

Through remote sensing technique we can acquire data about characteristics of the Earth in an almost continuous and two-dimensional fashion. Remote sensors are designed in such a way that they record interaction between Earth materials and electromagnetic radiation (EMR). Thus, it is useful for acquiring information about Earth not only in visible light but also in other regions of the spectrum that extend from gamma rays to microwaves. Each Earth object has its own unique spectral characteristic (i.e. signature), which can help us to discern them

from others in remote sensing images. Process of extracting information from remote sensing images is known as image interpretation.

6.1.1 Remote Sensing System

You now know that remote sensing is a tool for gathering information about objects at a distance. However, it is not just about a sensor or platform. There are several steps in remote sensing system as shown in Fig. 1.1.



Source of Energy (A): The first and very important requirement for remote sensing is an energy source which provides electromagnetic energy to the Earth. It may be either from natural (e.g. solar radiation) or artificial (e.g. RADAR) sources. For remote sensing, Sun's radiations are commonly used as a source of energy.

Interaction of energy with the atmosphere (B): When energy travels from its source to the Earth surface, it comes in contact with the Earth's atmosphere where it interacts with atmospheric constituents. The energy reflected from Earth's surface is received by remote sensors. In this process the energy once again interacts with atmosphere.

Interaction with Earth surface features (C): Energy reaching the Earth surface through the atmosphere interacts with the Earth surface features. The interaction and its outcome depend on the characteristics of the features and the energy.

Recording of energy by the sensor (D): After interacting with Earth surface features the reflected and emitted energy travels to the sensor. And, the sensor records the reflected and emitted energy.

Transmission, reception, and processing of the recorded signals (E):

The energy recorded by the sensor is transmitted in the form of signals to receiving and processing station on the Earth. The signals are in electronic form and are processed and converted into an image.

Utilisation of the data (F): The processed image is interpreted and analysed to extract information about the object of interest. The above mentioned components comprise the remote sensing system and underline the importance of energy and its interaction with atmosphere and Earth features.

6.1.2 Interpretation of Satellite Data

Interpretation is the process of extraction of qualitative and quantitative information of objects from aerial photographs or satellite images. Interpretation is generally called *image interpretation* except for the case when the interpretation is carried out on aerial photographs. Based on the mode of the interpretation, interpretation can be categorized into visual and digital interpretation. *Visual interpretation* involves visual analysis of aerial photographs and satellite images. When the interpretation is carried out with the help of computer software, it is known as *digital interpretation*. *Visual image interpretation* is a process of identifying features seen on the images by an analyst/interpreter and communication of information obtained from these images to others for evaluating their significance. This process, however, is not restricted to making decisions concerning what objects appear in images but it also includes determination of their relative locations and extents. Success in visual image interpretation varies with the training and experience on the pictorial data analysis. If the interpreter has an artistic and photographic sense then information derived from the interpretation process may be more authentic and reliable. Visual interpretation of satellite images are applied successfully in many fields including geology, geography, agriculture, water resources and forestry.

6.1.3 Image Interpretation Tasks

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

- classification**
- enumeration**
- mensuration and**
- 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.

Enumeration is the task of listing or counting discrete items visible on an image.

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.

Finally, the interpreter must **delineate, or outline**, regions as observed on remotely sensed images. The interpreter must be able to separate distinct aerial units that are characterized by specific tones and textures and to identify edges or boundaries. 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.

6.1.4 ELEMENTS OF VISUAL IMAGE INTERPRETATION

Visual interpretation of aerial photographs involves the study of various basic characteristics of an object. In case of interpretation of satellite images, these characteristics of objects are studied with reference to a single or multiple spectral bands because there are generally more than one images acquired in different spectral regions of electromagnetic spectrum. However, the basic elements are tone, texture, shape, size, pattern, shadow, location and association, similar to those used in aerial photo interpretation. Image interpretations employ combination of the following eight elements (Fig. 7.4):

- tone**
- size**
- shape**
- texture**
- association**
- shadow**
- site and**
- pattern**

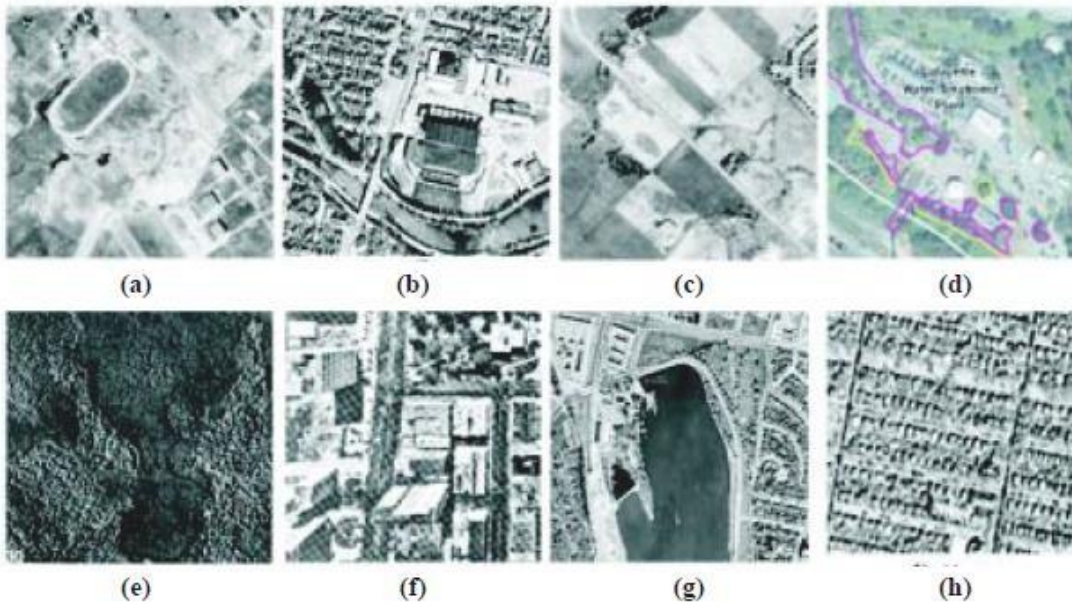


Fig. 7.4: Representative examples of the eight elements of visual image interpretation.
 (a) Shape, (b) size, (c) tone, (d) site, (e) texture, (f) shadow, (g) association and
 (h) pattern (source: <http://ccrs.nrcan.gc.ca>)

A systematic study and visual interpretation of satellite images usually involves consideration of two basic elements, namely *image elements* and *terrain elements*. Out of the eight elements listed above, the first seven elements comprise image elements and the 8th element; pattern is the terrain element such as drainage, landform, erosion, soil, vegetation and land-use patterns. These elements are shown in the order of their complexity in Fig. 7.5.

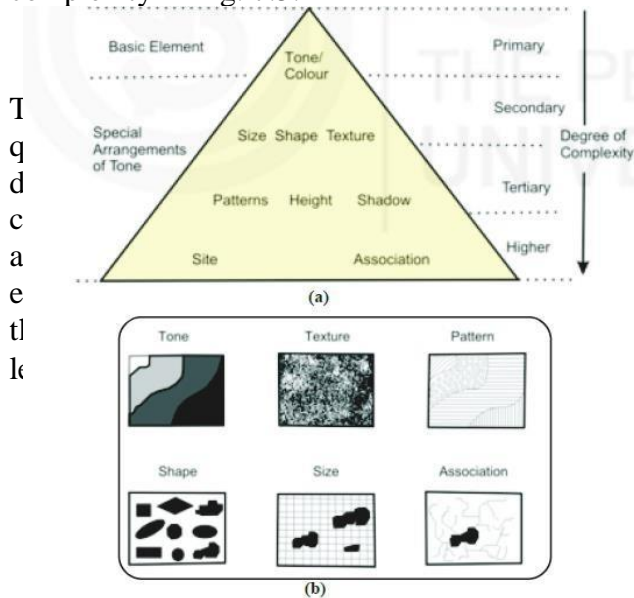


Fig. 7.5: (a) Ternary plot showing the primary ordering of image elements that are fundamental to the image analysis process and (b) diagrammatic representation of elements of visual image interpretation (source: <http://rst.gsfc.nasa.gov>)

subject in colour image and the relative and . As studied earlier, the tonal variation is or absorption object to another and from one band to because it is difficult to discern other th surface tends to have high reflectance

ced by the following factors:

- light transmission of filters and
- photographic processing.

Strong tonal contrasts on satellite imageries are always desirable for better image interpretation. Similarly, in thermal imagery, objects at higher temperature are recorded in lighter tone compared to objects at lower temperature, which appear of medium to darker tone. Similarly, top soil gives dark tone compared to soil containing quartz (silica) sand. In Figs. 7.6 and 7.7, which show colour and gray scale images, respectively, you can observe different tones for different features.



Fig. 7.6: Satellite imagery of Indira Gandhi National Open University campus at New Delhi. Place mark shows the New Academic Complex (source: www.earth.google.com)



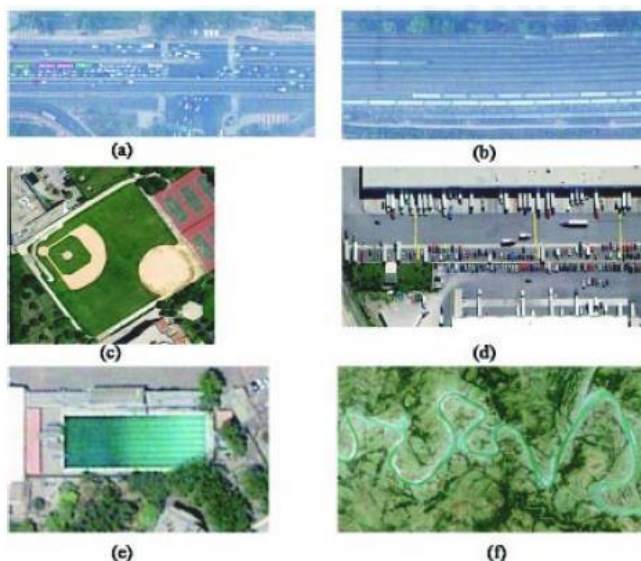
Fig. 7.7: Satellite image showing Doon valley and surroundings. The drainage patterns and lithological differences can be clearly observed (source: Rao, 2002)

Size

Objects can be misinterpreted if their sizes are not evaluated properly. Size of objects in an image is a function of scale hence, the size of objects must be considered in the context of the scale of a photograph/image. Although, the third dimension, which comprises of height of the objects is not readily measurable on satellite images but valuable information can be derived from the shadows of the objects.

Size of an object can be important tool for its identification, in two ways. First, the size of an object or feature is relative in relation to other objects on the image. This is probably the most direct and important function of size, as it provides the interpreter with an intuitive notion of the scale and resolution of an image even though no measurements or calculations may have been made. This role is achieved by recognition of familiar objects like dwellings, highways and rivers as shown in Fig. 7.8. Second, absolute measurement can be equally valuable as interpretation aids. You should remember that size of an object in an image depends on the scale and resolution of the image.

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1 individual object. Shape is one m images (Fig. 7.8a-e). Regular use. Similarly, irregular shapes

Fig. 7.8: Variation in size and shapes in the images provides clue for different objects. (a) Automobiles, (b) railway track, (c) baseball court, (d) trailer, (e) swimming pool and (f) a meandering river (source: www.earth.google.com)

usually indicators of natural objects as shown in Fig. 7.8f. Some objects can be identified almost solely on the basis of their shapes. For example, a railway line is usually readily distinguished from a highway or an unmetalled road because its shape consists of long straight tangents and gentle curves as opposed to the shape of highway as shown in Fig. 7.8b. You should remember that shape of an object viewed from above may be quite different from its profile view. For planar objects, it is easier to calculate the areal dimensions on imagery e.g., river as shown in Fig. 7.8f. Features in nature often have such distinctive shapes that shape alone might be sufficient to provide clear identification e.g., beach, ponds, lakes and rivers occur in specific shapes unlike others found in nature.

Texture

Texture is an expression of roughness or smoothness as exhibited by the images. It is the rate of change of tonal values (frequency of tonal changes). Texture signifies the frequency of change and arrangement of tones in an image and is produced by an aggregate of unit features too small to be clearly recognised individually on an image. Texture can be expressed qualitatively as coarse, moderate, fine, very fine, smooth, rough, rippled and mottled. It is rather easier to distinguish various textural classes visually than in the digital oriented techniques. Texture is, thus, dependent upon tone, shape, size, pattern, and scale of the imagery, and, is produced by a mixture of features that are too small to be seen individually. For example, grass and water generally appear 'smooth' while trees or a forest canopy may appear 'rough' as shown in Fig. 7.8e.

Association

Association is occurrence of features in relation to its surroundings. Sometimes a single feature by itself may not be distinctive enough to permit its identification. It specifies the occurrence of certain objects or features in association of a particular object or feature. Many features can be easily identified by examining the associated features. For example, a primary school and a high school may be similar flat roofed building structures but it may be possible to identify the high school by its association with an adjacent football field.

Shadow

Shadow is an especially important clue in the interpretation of objects in the following twoways: the outline or shape of a shadow provides a profile view of objects, which aids in image interpretation and objects within shadow reflect little light and are difficult to discern on image, which hinders interpretation. Taller features cast larger shadows than shorter features as observed in Fig. 7.9. Military image interpreters are often primarily interested in identification of individual items of equipment. Shadow is significant in distinguishing subtle differences that might not be otherwise visible.

Site

Site refers to the tonographic position for example sewage treatment facilities are positioned a



Fig. 7.9: Taller objects such as the Qutub Minar cast larger shadow than smaller objects such as buildings and trees (source:earth.google.com)

rivers to collect waste flowing through the system from higher locations. The relationship of feature to the surrounding features provides clues towards its identity. You can also consider the example of certain tree species located in areas of specific altitudes. Similarly, identification of landforms can help in deciphering the underlying geology. Often many of the rock types have distinct topographic expressions, for example, some kinds of sedimentary rocks are typically exposed in the form of alternating ridge and valley topography.

Pattern

You have read about the seven image elements. It is now time to discuss about the terrain element which is also a significant element in image interpretation. The terrain elements include drainage, topography/landform, soil, vegetation and land use planning patterns. Pattern develops in an image due to spatial arrangement of objects. Hence, pattern can be defined as the spatial arrangement of objects in an image. Certain objects can be easily identified because of their pattern. A particular pattern may have its genetic relation with several factors of its origin. For example, urban and rural settlement areas can be easily identified based on the patterns created by the rows of houses or buildings. Similarly, drainage patterns have orderly association with the underlying lithology, structure, soil texture and hydrological characteristics of the ground and hence provide clues about them (Fig. 7.7).

The drainage patterns and texture seen on images are good indicators of landform and bedrock type and also suggest soil characteristics and drainage condition. For example, dendritic drainage is most common drainage pattern found in nature which is developed in regions of homogeneous rocks. Landform patterns may be regional, for example, long ridges and valleys correspond to resistant and non-resistant rocks which together develop into ridge and valley patterns. Soils also have a distinct pattern. Generally, fine textured, poorly drained soils are dark in colour due to higher water content whereas coarse textured soils, which are well drained are light in colour. Similarly, vegetation correlated to certain rock types could help in determining the lithology in an area. The changes brought about in land use planning and pattern with time can be carefully monitored which can provide information about the land use pattern. Images of different years mentioned in Fig. 7.10 give you information about the land use planning in the area. You can observe the effects of urbanization in this figure and evaluate the agricultural fields that have been converted to human settlements.

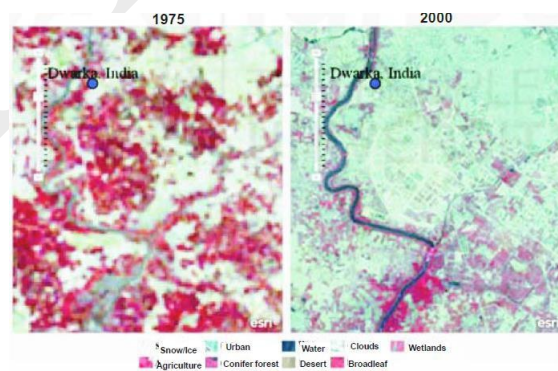


Fig. 7.10: Monitoring land cover change over time. Here you can see agricultural field as observed in the image of year 1975 has been converted to human settlements in 2000 (source: <http://changematters.esri.com/compare>)

GIS

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships.

GIS is an acronym for “Geographic Information System.” A GIS system uses computers and software to gather, manage and analyze data based on geography, and visualizes the data on a map. GIS mapping software uses spatial data to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data. Many industries and government data analytics agencies use GIS to better communicate complex information and solve problems associated with geographic locations.

How GIS Works

GIS systems generally consist of the following elements:

- Maps — Shareable maps that contain geographic data layers.
- Data — Spreadsheets, tables and imagery with a geographic component that ties data to a particular location.
- Analysis — Spatial analysis enhances decision-making process by providing insights that give users more confidence when interpreting and predicting situations.
- Apps — GIS is no longer tied to a desktop. Mobile apps allow GIS data to be used anywhere, at any time.

While each application is different, Geographic Information Systems are broadly similar in the way they work. All GIS tools analyze and visualize spatial data, which includes location information like address, latitude or longitude.

Geographic Information Systems generally perform these tasks in three steps:

- Visualize data — Geographic data is displayed in GIS software.
- Combine data — Layers of data are combined to form maps.
- Query data — Geographic queries search for values in layered data.

What is the Purpose of Geographic Information Systems?

Geographic Information Systems, or GIS, overlay data on a map. By connecting data with geography, GIS programming helps people understand how data relates to a specific location. Visualizing data geographically can help people spot patterns that would have been difficult or impossible to detect in a huge spreadsheet.

GIS maps are used in a variety of ways, from tracking climate change to analyzing crime patterns. Many companies use Geographic Information Systems, and GIS technology is integrated into nearly every industry and government organization. Environmentalists were some of the earliest adopters, using GIS to track melting glaciers and deforestation. The agricultural industry relies on GIS to map crop and soil types.

Businesses use GIS to pick store sites, manage their supply chain and profile their customers. GIS applications help real estate companies and land planners compare locations and parcels. Journalists use GIS to illustrate concepts for their audience. GIS data can also effectively target ad campaigns.

Today, GIS continues to expand into diverse areas including archaeology, education and transportation.

Benefits of GIS (Geographic Information Systems)

GIS benefits businesses and governments by giving them the ability to ask complex questions about location-based data.

GIS analysis uses spatiotemporal data to provide visual clues that help people discover deeper insights than they could with a paper map or traditional spreadsheet.

This is important when dealing with big issues like climate change, population dynamics and natural disasters.

Types of Geographic Information Systems

The types of data in Geographic Information Systems, or GIS, include:

- **Numeric data** — Statistical data collected with a geographic component and displayed as a layer on a map. US Census demographics are an example of numeric data.
- **Vector data** — Consisting of X and Y coordinates, vector data can describe points, lines or polygons connected to a geographic space. Vector formats are best for data with strict borders, like a street or political district.
- **Raster data** — Typically digital images in JPEG, TIF or GIF format, raster data is formed from grids of cells or pixels. Satellite imagery is a good example of raster data.
- **Linear networks** — A layered line that can represent multiple elements, such as a road that is also the boundary of a city or political district.

PHOTOGRAMMETRY

Photogrammetry is the science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena.

Steps to Create a Photogrammetric Model

Creating a photogrammetric model requires the following:

1. **TIE POINTS:** Tie points link coordinates from two or more overlapping images. In general, you assign tie points for features that are visually apparent in two or more photographs. When you have overlap, tie points adjust photos together through common feature coordinates.

2. **GROUND CONTROL POINTS (GCP):** Establishing ground control orientates and positions images to known geographic coordinates on Earth's surface. By adding ground control points, you give photogrammetric products a spatial reference to the real world.
3. **BUNDLE ADJUSTMENT:** Running a block bundle adjustment removes geometric distortion from a set of images of three-dimensional points at different viewpoints. This process minimizes the error between observed and predicted image points during reprojection.

GPR

Ground penetrating radar (GPR) is a non-destructive detection and imaging method which identifies subsurface elements either underground or within a surface such as concrete. According to the New York State Museum, GPR was invented in the 1930s as a tool for measuring the thickness of glaciers. It wasn't until the mid-1980s that the technology advanced to a stage where it became affordable for widespread use. GPR can detect both metallic and non-metallic objects, giving it a wide range of applications. It reveals all types of utilities, including electrical conduit, steam pipes, telecommunications lines, gas & oil lines, water lines, and sewer & storm pipes. GPR can locate the presence of voids, rebar, conduit, post tension cables, and other structural elements hidden within concrete.

In short, GPR works by sending a radio signal into a structure and reading the "bounce." The radio wave bounces off any material it encounters and creates a reading that displays those bounces as parabolas. An experienced GPR technician interprets this reading to determine the type of material located. GPR is extremely accurate. However, external factors such as ground and soil conditions, proper use of equipment, and correct interpretation of readings can affect accuracy. In cases where GPR may not be the appropriate tool for the job, GPRS will use complimentary underground imaging technology such as electromagnetic (EM) locating to identify subsurface obstructions.

As stated above, the uses for ground penetrating radar are many and varied. GPRS uses GPR to map underground utilities and other findings, and to scan for materials in concrete. We do this to help our clients avoid the costly and dangerous repercussions of striking any of these subsurface objects during construction activities. Scanning and locating services enable contractors or homeowners to get a clear picture of what lies beneath before continuing with a project.

GPS

GPS (Global Positioning System) is a satellite-based navigation system which was created by U.S. Department of Defence as a part of NAVSTAR satellite program. It gives geolocation and time information to a GPS receiver in all climate conditions, anywhere on or close to the Earth where there is an unobstructed line of sight to four or more GPS satellites.

GPS has three segments:

1. Space segment
2. Control segment
3. User segment

The space segment is made up of at least 24 satellites with are placed on six circular orbital planes (Four satellites per one orbit). Each orbit is inclined at an angle of 55° relative to equator plus they are separated by 60° . Satellites are at an altitude of approximately 20,200km (12,600 mi).

The control segment handles synchronizing satellite's atomic clocks and adjusts the ephemeris of each and every satellite's inner orbital model. It is maintained by U.S. Air Force.

User segment is for typical users (like civil, commercial, scientific, military users, etc.) that want to make use of GPS receivers to estimate their position.

What is GPS used for ?

At present, GPS is a multi-use, space-based radio navigation system belonging to the united states government and controlled by the US Air Force to meet national defense, homeland security, civil, commercial, and scientific requirements.

How Global Positioning System Works ?

GPS satellites circle the Earth 2 times a day in a precise orbit. GPS position is determined using data coming from satellites. GPS receiver computes distance to satellites and using theirs position calculate its own.

To find out the distance to satellites receiver will need to have very precise clock. This is the primary reason why each satellite comes with an atomic clock and all those clocks should be synchronized. In this system the weakest part is the GPS receiver since it has only the quartz clock and require time synchronization.

DRONE AND ITS APPLICATIONS

What is a drone?

A drone is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, that work in conjunction with onboard sensors and a global positioning system (GPS).

UAVs were most often associated with the military. They were initially used for anti-aircraft target practice, intelligence gathering and, more controversially, as weapons platforms.

Drones are now also used in a range of civilian roles, including the following:

- search and rescue
- surveillance

- traffic monitoring
- weather monitoring
- firefighting
- personal use
- drone-based photography
- videography
- agriculture
- delivery services

How do drones work?

Drones have two basic functions: flight mode and navigation.

To fly, drones must have a power source, such as battery or fuel. They also have rotors, propellers and a frame. The frame of a drone is typically made of a lightweight, composite material to reduce weight and increase maneuverability.

Drones require a controller, which lets the operator use remote controls to launch, navigate and land the aircraft. Controllers communicate with the drone using radio waves, such as Wi-Fi.

Drones have a large number of components, including:

- electronic speed controllers, which control a motor's speed and direction;
- flight controller;
- GPS module;
- battery;
- antenna;
- receiver;
- cameras;
- sensors, including ultrasonic sensors and collision avoidance sensors;
- accelerometer, which measures speed; and
- altimeter, which measures altitude.

Drone features vary based on the use it is put to. Examples of features include:

- various types of cameras with high-performance, zoom and gimbal steadycam and tilt capabilities;
- artificial intelligence (AI) that enables the drone to follow objects;
- augmented reality features that superimpose virtual objects on the drone's camera feed;
- media storage format;
- maximum flight time, which determines how long the drone can remain in the air;
- maximum speeds, including ascent and descent;
- hover accuracy;
- obstacle sensory range;
- altitude hold, which keeps the drone at a fixed altitude;
- live video feed; and
- flight logs.

✓ **Applications of DRONE**

- ✓ Aerial photography for journalism and film.
- ✓ Express shipping and delivery.
- ✓ Gathering information or supplying essentials for disaster management.
- ✓ Thermal sensor drones for search and rescue operations.
- ✓ Geographic mapping of inaccessible terrain and locations.
- ✓ Building safety inspections.

QUESTION BANK

1. Short notes on GPS
2. Explain briefly about topo sheets and topography
3. Write short notes on drone and its applications
4. What is photogrammetry
5. Explain GIS