Modern Surveying Techniques

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Lecture - 10

Image Interpretation

In the previous session, I had discussed regarding the various techniques by which data regarding the earth surface can be collected from sensors placed in the space, in air or on the ground. Now, this data is to be analyzed or interpreted so that some meaningful information can be extracted by some logical means.
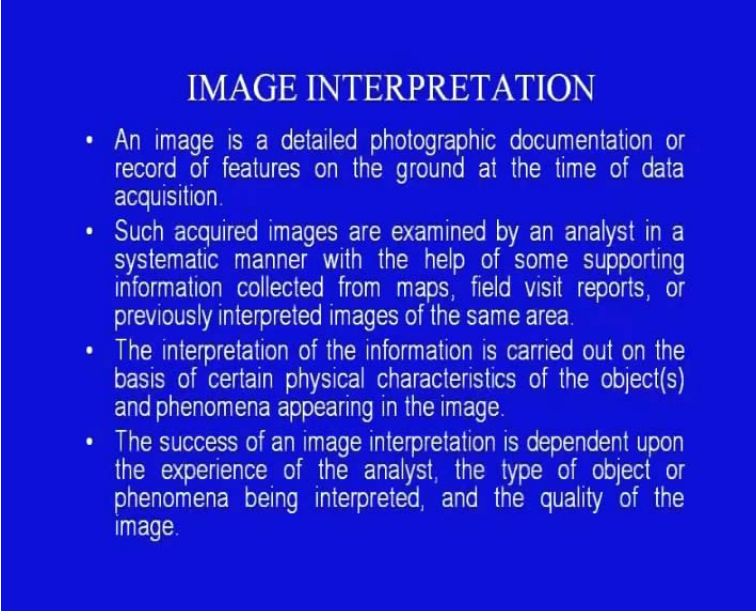
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As we know, an image is a detailed photographic documentation or record of features on the ground at the time of data acquisition. Such acquired images are examined by an analyst in a systematic manner with the help of some supporting documents collected from maps, field visit reports or previously interpreted images of the same area.

The interpretation of the information is carried out on the basis of certain physical characteristics of the objects and phenomena appearing in the image. The success of an image interpretation is dependent upon the experience of the analyst, the type of object or

phenomena being interpreted and the quality of the image itself. So, let us look at what is the definition of image interpretation.

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Photographic or image interpretation is defined as the act of examining photographic images for the purpose of identifying objects and judging their significance. The task of image interpretation procedure is a complex one and requires several tasks to be conducted in a well defined routine consisting of the processes of classification, enumeration, mensuration and delineation. So, now let us look at each of these processes one by one.

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- Classification is the first task to be performed by an interpreter, where based on the appearance of an object or feature, the analyst assigns a class or informational group.
- At this stage, the analyst first carries out the determination of presence or absence of an object or phenomena through the process of *detection*.
- This is followed by *recognition* where an object or phenomena is assigned an identity to a class or category.

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Enumeration is the next step and it relates to the listing and counting of objects or phenomena that are visible on the image. However, it is dependent upon the ability of the analyst to classify items accurately.

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Mensuration is the process of measurement wherein, an analyst makes measurements of the object in terms of length, area, volume or height. Another form of measurement could be in terms of image brightness characteristic known as densitometry.

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- Delineation which is the final task to be performed is outlining the regions of homogenous objects or areas.

- These are characterized by specific tones and textures.

- When sharp boundaries between objects occur, the delineation process becomes simpler in comparison to those areas where there is a gradual variation, *e.g.*, sandy area in the close proximity of water bodies.

Delineation which is the final task to be performed is outlining the regions of homogeneous objects or areas. These are characterized by specific tones and textures. When sharp boundaries between objects occur, the delineation process becomes simpler in comparison to those areas where there is a gradual variation.

For example; sandy areas in the closed proximity of water bodies can be identified very clearly, since sandy areas appear in whiter tones in comparison to water which would be in dark tones. Now, let us look at the various elements which assist in the whole analysis procedure.

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ELEMENTS OF PHOTOINTERPRETATION

- An object or phenomena on an image can be identified, recognized, and delineated on the basis of some of the typical characteristics of the image.
- These characteristics, which allow for a systematic and logical approach in carrying out image interpretation, are known as the elements of photo interpretation.

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SIZE

Size of objects in an image is a function of scale.
It is important to assess the size of a target relative to other objects in a scene, as well as its absolute size, to aid in the interpretation.

A quick approximation of target size can result into direct interpretation more quickly.

For example, if an interpreter has identified an area with a number of buildings, then large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

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A quick approximation of the target size can result in direct interpretation more quickly. For example; if an interpreter has identified an area with large number of buildings, then large buildings such as factories or warehouses would suggest a commercial property, whereas, small buildings would indicate residential use.

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One can see there are different sizes of objects which are there. In the top left hand portion, we find the sizes of the objects are far more bigger than the size of the objects which are on the bottom right hand side.

Even though the shape even though the shapes of these objects are very regular; on the basis of the size of the object, we can make an assessment as to what is the information class. The objects which are having bigger sizes are probably being used for some form of commercial or recreational activities.

For example; in the center portion, this the size of the objects suggest that this could be a stadium with the adjoining rectangular black box representing the stands where the spectators watch the football match. In the close vicinity, we find there are some slightly smaller objects. These could be acting as the club house where the players may be using them as changing room. However, in the bottom right corner, the string of boxes which one can see, these can be attributed to residential units or this is a residential area.

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The next element is shape. Shape normally refers to the general form of an object or outline of an individual feature. It is a very distinctive clue for interpretation. Normally, man-made features tend to have regular shape leading with defined edges leading to regular shape, while, natural objects will have irregular shape. For example; roads, buildings, canals are all man-made objects and have regular shape, while, forest areas, water bodies tend to have irregular shape.
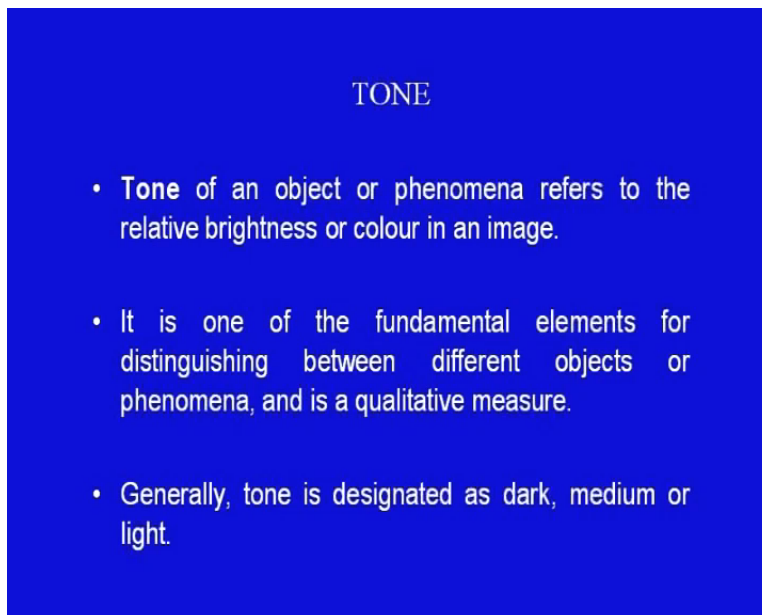
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You can see that the regular objects, on the top right left hand corner, we can see some square and rectangular objects. These objects can be constituted to be some form of building. Since they are surrounded by lot of open land, it may be constitute that these could be farm houses, agriculture, farm houses which the former may be using either to store the crop or to keep the other agriculture implements.

Similarly, on the bottom right hand corner, we can see; there are 2 very well defined structures or features which are present. Both of them have parallel long edges connected by semicircular arcs at their two ends. The presence of these 2 objects in conjunction, suggest that this could be an area which is being used for horse racing purposes.

In between these 2 regular objects, what we find is there are certain linear features which are having irregular shapes. 2 such irregular linear shapes, they join at a point and then they merge to form one irregular linear object. Basic instinct tells us that this could be natural strings. However, another interesting object can be seen which is again linear but it is a straight line and crosses the stream. Well, this can be constituted to be a road. The next element is tone.

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Tone of an object or phenomena refers to the relative brightness or color in an image. It is one of the fundamental elements for distinguishing between different objects or phenomena and is a qualitative measure. Generally, tone is designated as dark, medium or light.

In this particular image, we can see varying shades of white to dark or black color. Some areas are virtually white, whereas, some areas are represented in dark patches. This can be attributed to the color of a particular object. The white bodies or the objects can be considered to be farm houses or agriculture fields where there is no vegetation cover.

However, the adjoining area, we may have we have seen certain gray patches and these could be partially covered with vegetation. The black dots on the top left hand corner, these are nothing but representing line of trees which are there and at they are being shown in black color. Similarly, the same sort of pattern can be seen in the left bottom corner where a group of such black dots indicate that these are a patch of trees in very close distances.

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The next element is pattern. Pattern refers to the spatial arrangement of visibly discernable objects. Typically, the repetition of similar tones and texture produce a distinctive and recognizable pattern. For example; houses laid out in an orderly manner in an urban area or the trees in an orchard create different patterns.

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In this image, we can see there are 2 types of objects which are very clearly seen. One is the small rectangular or square boxes occurring at regular frequency in a repetitive manner and these are crisscrossed by some straight lines.

So, the crisscross of straight line, it depicts a road pattern, whereas, the small rectangular boxes at repetitive intervals represent house holdings in that particular area.

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Next is texture; texture is referred to as the frequency of the tonal changes in particular areas of an image. Texture is a qualitative characteristic and is normally categorized as rough or smooth. An area of dry sand will appear on an image having smooth texture, since the variation of tone for long stretches is not present. Similarly, an area covered with forest having variety of tree species with varying canopy, size, shape and density will appear with a rough texture as tone would be changing very rapidly.

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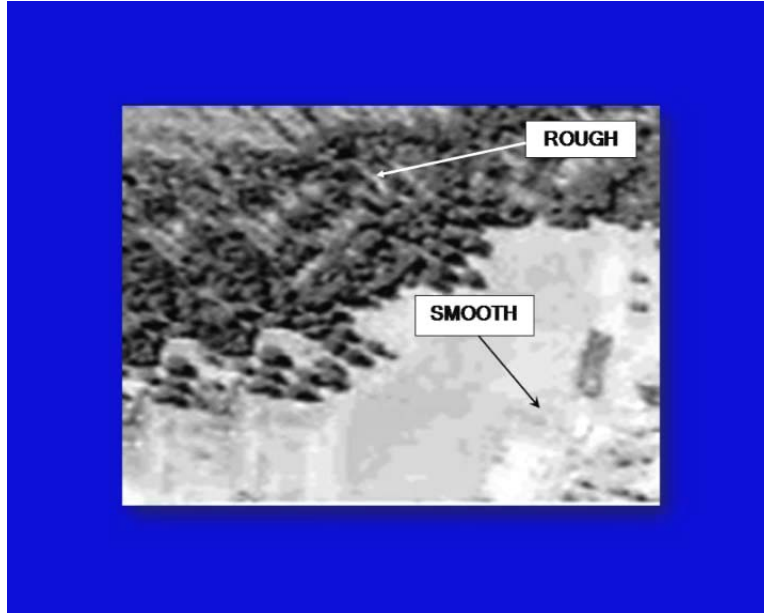
In this image, we can see two types of textures being exhibited by the objects in the lower right hand corner. We find that there is the object appears to have a very smooth representation, whereas, in the top right portion of the image, we can see the variation of black is changing very rapidly.

So, the top part of the image is having a rough texture, whereas, the bottom half of the image is having a smooth texture.

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SHADOW

- **Shadow** is an important characteristic of image interpretation.
- It gives an idea of the profile and relative height of an object, hence making identification easier.
- In mountainous areas, shadow is an important characteristic of images as it enhances the ground topography, and hence helpful for identifying variations in geological landforms.

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Next is a shadow. Shadow is an important characteristic of image interpretation. It gives an idea of the profile and relative height of an object, hence making identification easier. In mountainous areas, shadow is an important characteristic of the image as it enhances the ground topography and hence useful for identifying variation in geological landforms.

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In this particular image, we see a large number of buildings which are being collected by the camera and smaller buildings cost a very small shadow in the adjoining region depicted in black color, whereas, the tall buildings are costing a longer shadow region in the adjoining area.

By measuring the length of the shadow and if one knows the angle of the sun above the horizon at the time of data acquisition, it is possible to use this simple trigonometrical relationship of tan. That is the tangent of the angle can be correlated to the base and to the height and height can be equated to the length of the shadow multiplied by the tangent of the sun angle which will give us height of the object.

Well, this type of characteristic has now become very important. Specifically, when one is using very high spatial resolution data sets such as from ICONOS or from Quick Bird. Wherein, the objects can be seen very minutely and hence their shadow tends to play a very important role.

The role could be that it may mask out some of the important region in the adjoining area and the second could be that we could use this information to extract the height of a particular object. This information can be utilized by the aviation industry to identify what could be the possible obstructions when an aircraft departs or approaches a airport which may be in the close vicinity of urban areas.

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Next characteristic is association. Association is another important characteristic as it considers the interrelationship between objects within the close proximity of an object or phenomena. For example; white irregular patches adjacent to a river indicates the presence of dry sands of the rivers. The regular grid of lines having small regular shape box like objects is an indication of an urban area as we have already seen in a previous image.
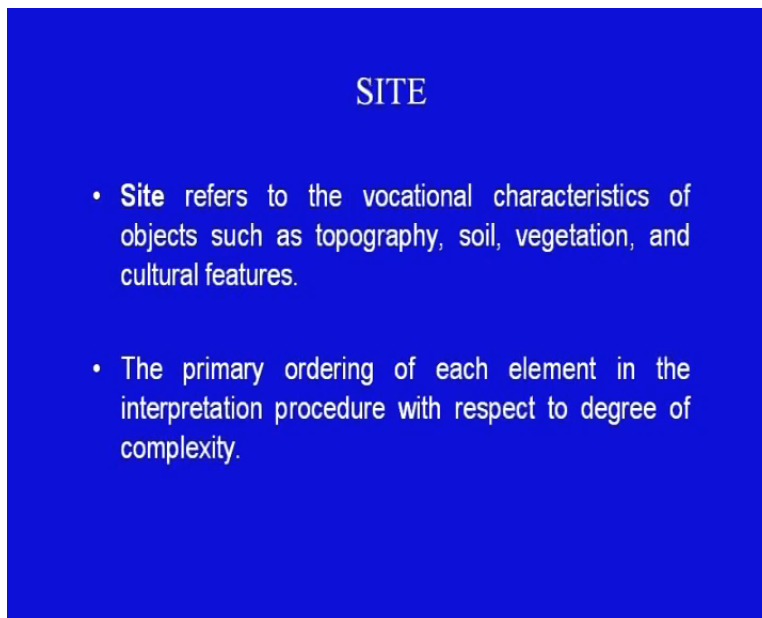
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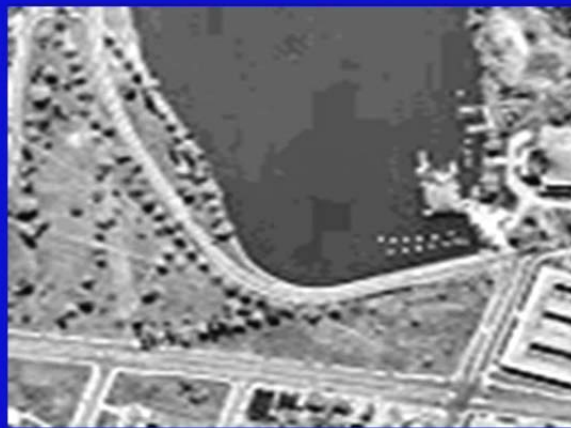
In this particular image one can see that the central portion of the image has a very dark tone. In the surrounding areas the tone is much brighter and interspaced by certain black dots. We can also see some bright lines running across in the bottom half of the image. Now, the task is to identify what could be the black region which is being represented.

Now, if one really focuses his attention within the black region we may find in the lower portion of the black area within the black region there are certain white spots. Also, in the closed vicinity, there is a white patch having a very regular shape and correlating these, one could say that the white dots are nothing but the yards which are there and the white regular patch protruding into the black region is nothing but the wharf area from where people would get into the boards or launches for taking a ride.

The white lines in the bottom region of the image indicate that this could be a major road which is passing through this particular area because it also has a rectangular offset leading to that particular area. Thus, we are now correlating the objects, there interrelationship in identifying what actually is the information. So, the role of association is very critical in identifying objects having similar tone or a texture or a pattern which they may be exhibited.

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SITE

- **Site** refers to the vocational characteristics of objects such as topography, soil, vegetation, and cultural features.

- The primary ordering of each element in the interpretation procedure with respect to degree of complexity.

Next is site; site refers to the vocational characteristics of an object such as topography, soil, vegetation and cultural features. This is very critical because depending upon the location of which the image is being examined; one may find that varying environmental and geographical locations may bring about a change in the representation of the information. Having had a look at all the important elements of photo interpretation, one now needs to understand which are the ones which are important or is there any hierarchy.

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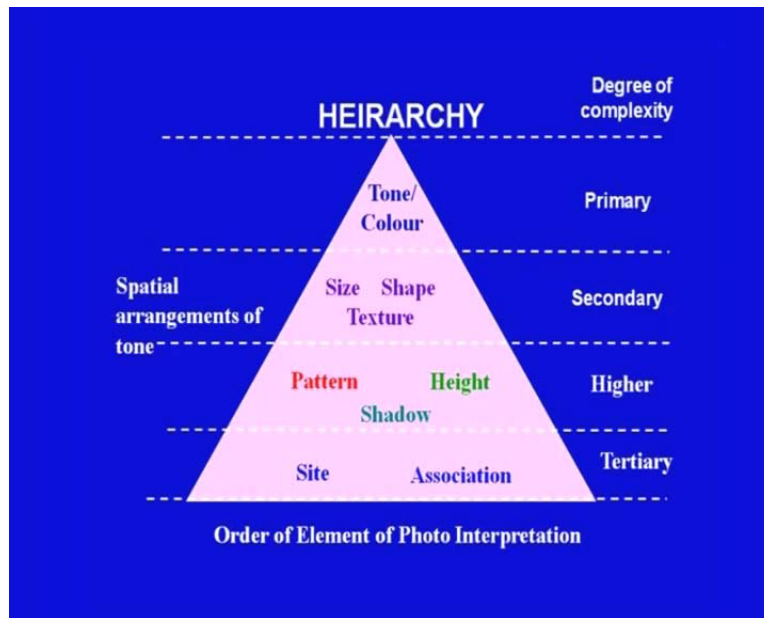
So, the next slide as a matter of fact shows the hierarchy of the photo interpretation elements. Tone and color are the primary characteristics followed by shape, size and texture which is the secondary characteristic pattern. Height and shadow, these are higher level of characteristics and tertiary are site and association. So, when we are categorizing or identifying an object in a scene or a group of objects in a scene, probably tone would be the first characteristic that the analyst may keep in his mind in identifying different groups of information classes.

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IMAGE INTERPRETATION STRATEGIES

- An image interpretation strategy can be defined as a disciplined procedure that enables the interpreter to relate geographic patterns on the ground to their appearance on the image.
- Five categories of image interpretation strategies have been defined as discussed below.
  (i) Field Observation
  (ii) Direct Recognition
  (iii) Interpretation by Inference
  (iv) Probabilistic Interpretations
  (v) Deterministic Interpretation

Having had a look at the elements, now we need to look at what could be the possible interpretation strategies. An image interpretation strategy can be defined as a disciplined procedure that enables the interpreter to relate geographic patterns on the ground to their appearance in the image.

5 categories of image interpretation strategies have been defined and these are field observation, direct recognition, interpretation by inference, probabilistic interpretations, and deterministic interpretations. So, let us look at each of these categories of image interpretation strategy one by one.

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First is field observation. Many a times, the grounds conditions as depicted on an image is complex and an on interpreter on the basis of his or her knowledge and experience is unable to correlate the relationships between the ground and the image. Hence, the analyst is forced to visit the ground to make proper identifications. Field observation is an important part of any interpretation task in order to assess the accuracy of identification.

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Next is direct recognition. Direct recognition is the application of an interpreter's experience, skill and judgment to associate the image patterns with information classes. This process is essentially a qualitative and subjective analysis of the image using the elements of image interpretation as visual and logical clues. Generally, direct recognition is an intuitive process and hence, it requires very careful and systematic examination of the image.

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The next strategy is interpretation by inference. Here, the analyst identifies the information on the basis of the presence of some other information to which it is closely related to. Such interference inference information is known as surrogate or proxy.

For example; as soil distributions are closely related to patterns of landforms and vegetation that are recorded on the image. The landforms and the vegetation form surrogates for the soil pattern and hence, the interpreter infers the invisible soil distribution from patterns that are visible. Application of this strategy requires a complete knowledge of the link between the proxy and the distribution.

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Then we come to the next strategy which is the probabilistic interpretation. Sometimes, an object or phenomena is correlated to certain specific characteristic. That is certain crops will be grown as per time or season. This non-image information or knowledge can be utilized in probabilistic interpretation. Often such knowledge can be expressed as a statement of probability.

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Finally, we have deterministic interpretation. Deterministic interpretation is the most rigorous and precise approach. Deterministic interpretations are based upon quantitative

expressions between the relationships that tie image characteristics to the ground condition.

In contrast to other methods, most information is derived from the image itself. Photogrammetric analysis of stereo pair for terrine information is a good example of deterministic interpretation.

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- Image interpreters, of course, may apply a mixture of several strategies in a given situation.

- Interpretation of soil patterns, for example, may require direct recognition to identify specific classes of vegetation, than application of interpretation by proxy to relate the vegetation pattern to the underlying soil pattern.

Image interpreters of course, may apply a mixture of several strategies in a given situation. Interpretation of soil patterns for example, may require direct recognition to identify specific classes of vegetation than application of interpretation by proxy to correlate the vegetation pattern to the underlying soil pattern.

Another form of analysis is the photomorphic analysis. Here, the interpretation of complex pattern is to identify areas of uniform appearances on the image that is search for photomorphic regions. The interpreter does not attempt to resolve the individual components within the landscape but looks for their combined influence on the image pattern. Photomorphic regions then are simply image regions of relatively uniform tone and texture.

In the first step, the interpreter delineates regions of uniform image appearance using tone, texture, shadow and the other elements of image interpretation as a means of separating regions and then tries to match photomorphic regions to useful classes of interest.

This step obviously requires field observation or collateral information because regions cannot be identified by image information alone. As the interpretation is refined, the interpreter may find that it is necessary to combine or divide photo regions to produce an acceptable interpretation.

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- Delineation of photomorphic regions is a powerful interpretation tool, but it must be applied with caution.

- Photomorphic regions do not always correspond to the categories of interest to the interpreter.

- The appearance of one region may be dominated by factors related to geology and topography, whereas that of another region in the same image may be controlled by the vegetation pattern.

Delineation of photomorphic regions is a powerful interpretation tool. But it must be applied with caution. Photomorphic regions do not always correspond to the categories of interest to the interpreter. The appearance of one region may be dominated by factors related to zoology and topography, whereas, that of the other region in the same image may be controlled by vegetation pattern.

In order to have a good knowledge, the interpreter has to acquire certain skills which means he needs to be trained and in order to be trained, he needs to have some form of guided material which we call it as image interpretation keys.

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IMAGE INTERPRETATION KEYS

- Image interpretation keys are valuable aids for summarizing complex information.
- Such keys serve either or both of the two purposes:

  (i) A means of training in experienced personnel in the interpretation of complex or unfamiliar topics.
  (ii) A reference aid for experienced interpreters to organize information and examples pertaining to specific topics.

Image interpretation keys are valuable aids for summarizing complex information. Such keys serve either or both of the two purposes as given below. A means of training in experienced personal in the interpretation of complex or unfamiliar topics. It is also a reference aid to the experienced interpreters to organize information and examples pertaining to specific topics.

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- An *image interpretation key* is simply a reference material designed to permit rapid and accurate identification of objects or features represented on aerial images.

- A key usually consists of two parts.

  (i) The first part is a collection of annotated or captioned images or stereo-grams.
  (ii) The second part is a graphic and/or word description.

So, we can now define what actually is an image interpretation key. It is simply a reference material designed to permit rapid and accurate identification of objects or features represented on an image. A key usually consists of two parts; the first part is a collection of annotated or captioned images or stereo photographs, the second part is a graphic and or word description.

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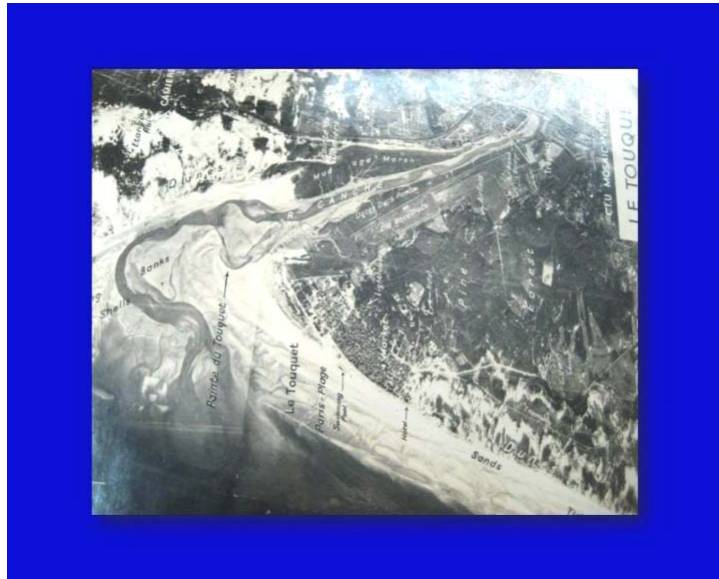
This particular slide shows the photographic annotated information wherein, where one can see that through the image center part of the image, a river is flowing and the adjoining areas which are depicted in white tones and are having a smooth texture, these are the banks of the river.

Whereas, the other areas depicted by small boxes or rectangles or squares, these indicate the urban area adjoining the sandy banks. So, this type of information is then translated into a textual or tabular information highlighting what could be its information and what could its specific photo interpretation characteristics.

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- These materials are organized in a systematic manner that permits retrieval of desired images by, for example, data, season, region, or subject.

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- It must be noted that scientific keys of all forms require a basic familiarity with the subject matter.

It may be noted that these materials are organized in a systematic manner that permits retrieval of desired images by data, by date, season, region or object. The key is a means of organizing the essential characteristics of an object or phenomena in an orderly manner. It may be noted that scientific key is of all forms require a basic familiarity within the subject matter.

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IMAGE INTERPRETATION KEYS

- A key, then, is not a substitute for experience and knowledge of an interpreter but a means of systematically ordered information to help in the interpretation process so that a user can learn quickly.
- The interpretation key forms an effective way of organizing and presenting the expert knowledge of a few individuals.
- The construction of a key tends to sharpen one's interpretation skills and encourages the interpreter to think more clearly about the interpretation process.

So, we can say a key then is not a substitute for experience and knowledge for an interpreter, but a means of systematically ordered information to help in the interpretation process so that a user can learn quickly. The interpretation keys forms an effective way of organizing and representing the experts knowledge to a few individuals. The construction of a key tends to sharpen one's interpretation skills and encourages the interpreter to think more cleanly about the interpretation process.

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The other form of interpretation could be using a digital computer. Well, this is known as digital image processing.

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COMPARISON

| Visual	Digital
It is a traditional approach based on human intuition, and its success is experienced based.	It is a recent approach and requires specialized training.
It requires simple and inexpensive equipment.	It is complex, highly mathematical and requires expensive equipment.
It uses the brightness characteristics of the object, and accounts for the spatial content of the image.	It relies heavily upon the brightness and spectral content of the object and does not use the spatial content of the image.
Usually a single band of data is used for analysis. However, colour products generated from three bands of data, can be used for analysis.	Multiple bands of data are used for analysis.
The analysis process is subjective, qualitative, and dependent on analyst bias, but deductions are concrete.	The process is objective and quantitative in nature, yet abstract in nature.

So, let us look at first of all the comparison between visual interpretation and digital interpretation. Well, visual interpretation is a traditional approach based on human intuition and its success is experience based. Whereas digital, it is a recent approach and requires specialized training. Visual interpretation is simple and it requires simple and inexpensive equipments, whereas, digital image processing, it requires complex highly mathematical and requires expensive equipments.

In the visual interpretation process, the brightness characteristics of the object and accounts for the spatial content of the image. Whereas, in digital it realize heavily upon the brightness and the spectral content of the object and does not use the spatial content of the image.

In visual interpretation, usually, a single band of data is used for analysis. However, color products generated from 3 bands of data can be used by the analyst. In digital image processing, multiple bands of data are used for analysis. At the same time, the process of visual interpretation is subjective, qualitative and dependent on the analyst bias but deductions are concrete. Whereas, in digital image processing the process is objective and quantitative in nature, however it could be abstract in nature.

So, now let us look at what is the process or the sequence of activities which are required in digital image processing.

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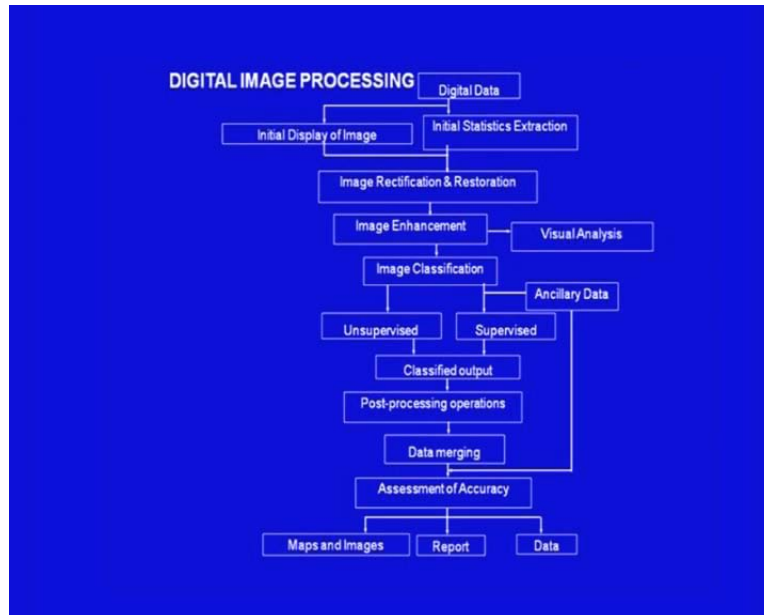
First of all the data is now going to be in digital that is it can be read by a computer.
This digital data will be displayed with the help of some software which may have certain specific options or modules which may allow either for a initial display of the image based on which we can find out what are the statistical characteristics of the image that is there.
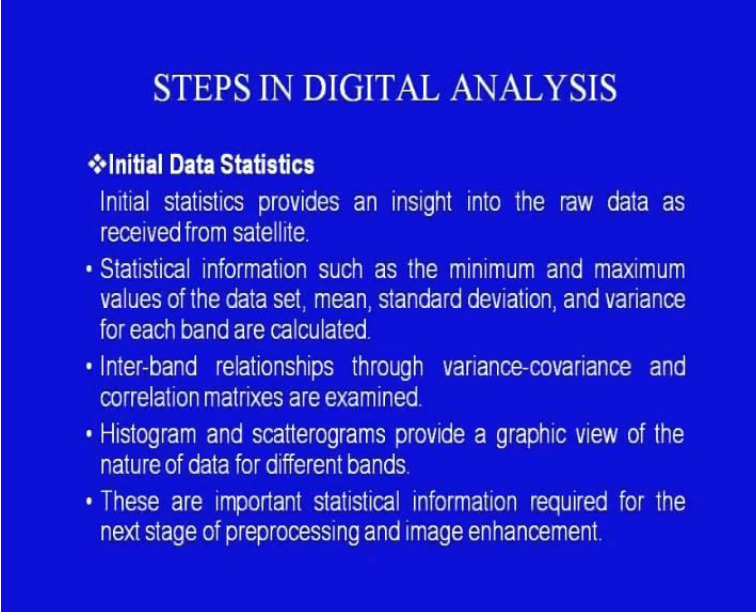
After that we may have the processes of image rectification and restoration, image enhancement and at this stage based on the image enhancement, one can carry out a visual analysis procedure or continue in the digital form for image classification. However, this will require some ancillary data to support the analyst in terms of identifying information classes.

There can be two approaches by which the image classification can be undertaken. First is the supervised classification, the other is the unsupervised classification and depending on the type of classification procedure adapted, one would get a classified output. With this classified output may have some noise that is irregularly some patches may occur which may require certain cosmetic cleaning and this is what is we call it as post processing operations so that the image appears to be smooth and uniform in terms of feature identified.

However, this data product can also be merged with some other digital data products such as we may use a digital elevation model which represents the elevation of the ground and by draping these two digital data products, one may be able to see the 3 dimensional model of the ground along with the information classes as delineated and classified through the process of digital image analysis.

No task in digital image processing is complete without making an assessment of the accuracy. If the accuracy achieved is acceptable, probably, the analyst can now embark on the final phase that is preparing of maps and images, colored images in the form of hard copy outputs, prepare a textual report, prepare tabulated information to represent the data and this would bring about an end to the digital image processing. So, let us look at the various steps in digital image processing. First is initial statistics.

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Initial statistics provide an insight into the raw data as received from the satellite. Statistical information such as the minimum and the maximum value of the data set, mean, standard deviation and variance of each band are calculated. Inter-band relationships through variance-covariance and correlation matrices are examined. Histogram and scatterograms provide a graphic view of the nature of the data for different bands. These are important statistical information required for the next stage of preprocessing and image enhancement.

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Next is image rectification and restoration. Image rectification and restoration are required to correct the distorted or degraded images to create a more faithful representation of the original image. The raw data are corrected for geometric distortions which are due to the sensor, earth geometry variations and geo-coding and registration of the image to the real world coordinate system, calibrated radiometrically for sensor irregularities and removal of noise.

Thus, the characteristic of the sensor used to acquire the image data decide the nature of the image restoration. The term preprocessing often used includes both image rectification and restoration.

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Image Enhancement

- The purpose of image enhancement is to improve the appearance of the imagery and to assist in subsequent visual interpretation and analysis.
- Normally, image enhancement involves techniques for increasing the visual distinctions between features by improving tonal distinction between various features in a scene using technique of contrast stretching.
- The enhanced images can be displayed interactively on a monitor or recorded in a hardcopy format, either in black and white or colour.

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Image Transformations

- These are operations similar in concept to image enhancement.
- Generally, image enhancement operation is carried out on a single band of data, while image transformations are usually carried on multiple bands.
- Arithmetic operations such as subtraction, addition, multiplication, and division, are performed to combine and transform the original bands into new images which display better or highlight certain features in the scene.

Next task could be image transformations. These operations are similar in concept to image enhancement. Generally, image enhancement operation is carried out on a single band of data, while image transformations are usually carried out on multiple bands. Arithmetic operations such as subtraction, addition, multiplication and division are performed to combine and transform the original bands into new images which display better or highlight certain features in the scene.

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Further, in multi-band data set when the spectral bands of range of bands are located very close to each other, repetitive information available leads to redundancy of data.
Principal component analysis helps in reducing the number of bands for analysis and hence redundancy.

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- When the decisions are based on the geometric shapes, sizes, and pattern present in the image data, the classification procedure falls into the domain of *spatial pattern recognition*.

- The categorized data may be used to produce thematic maps and/or summary of statistics on the areas covered by each land cover type.

- There are a variety of approaches to perform digital image classification; however, only two generic approaches most commonly used are **supervised** and **unsupervised** classification

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Data Merging and GIS Integration

- Data merging techniques are applied to combine data for a given geographic area with other geographically referenced data set of the same area.
- The other data sets may be image data generated on other dates by the same sensor or by other remote sensing systems.
- The data merging technique is frequently used to combine remotely sensed data with other sources of information in the context of a Geographic Information System (GIS).

Having done the classification, this particular data may have to be used in conjunction with other digital data. So, a very important task could be data merging and GIS integration. Data merging techniques are applied to combine data for a given geographic area with other geographically reference data sets of the same area.

The other data sets may be image data generated on other dates by the same sensor or by other remote sensing systems. The data merging technique is frequently used to combine remotely sensed data with other sources of information in the context of a Geographical Information System or in short known as GIS.

Having discussed in brief the various steps involved in digital image processing, in my next session I shall be discussing the various steps in digital image processing in greater details.

Thank you.