Fundamental of Visual Image Interpretation & Its Keys

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1. Introduction

The analysis of remote sensing imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features which consist of points, lines, or areas. Targets may be defined in terms of the way they reflect or emit radiation. This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an air photo or a satellite image.

Image interpretation

Visual interpretation and digital image processing techniques are two important techniques of data analysis to extract resource related information either independently or in combination with other data. Visual interpretation methods have been the traditional methods for extracting information, based on the target characteristics on aerial photograph or satellite imagery. A human interpreter uses various parameters of object recognition and interpret objects/ phenomena, spatial and spectral patterns etc.

Image interpretation is defined as 'the art of examining images for the purpose of identifying objects and judging their significance. Interpreters study remotely sensed data and attempt through logical processes in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural object, their patterns and spatial relationships. Image interpretation is a complex process of physical, physiological activities occurring in a sequence begins with the detection and identification of images and later by their measurements. Different aspects of image interpretation (Vink 1964) are listed below in a simpler form most of these have overlapping function.

The most basic of these principles are the elements of image interpretation. They are: location, size, shape, shadow, tone/color, texture, pattern, height/depth and site/ situation/ association. These are routinely used when interpreting an aerial photo or analyzing satellite image. Aerial photographs as well as imagery, obtained by remote sensing using aircraft or spacecraft as platforms, have applicability in various fields. By studying the qualitative as well as quantitative aspects of images recorded by various sensor systems, like aerial photographs (black-and-white, black-and-white infrared, colour and colour infrared), multiband photographs, satellite data (both pictorial and digital) including thermal and radar imagery, an interpreter well experienced in his field can derive lot of information. The primary task of the interpreter is the detection and identification of objects, features, phenomena and processes. This is primarily a stimulus and response activity. The interpreter conveys his or her response by labelling. These labels are often expressed in qualitative terms, e.g. likely, possible, probable, or certain. Therefore, it is a process of 'picking out' object element from the photo or image through interpretation techniques. It may be detection of point, line or polygons viz. forest land, agricultural fields, settlement patterns, road network, tube wells, dug wells etc.

Detection and Identification:

An interpreter studies remotely sensed data and attempts through logical process to detect, identify, measure and evaluate the significance of environmental and cultural objects, patterns and spatial relationships. It is an information extraction process. Anyone who looks at a photograph or imagery in order to recognize an image is an interpreter. A soil scientist, a geologist or a hydro geologist, a forester or a planner, trained in image interpretation can recognize the vertical view presented by the ground objects on an aerial photograph or a satellite image, which enables him or her to detect many small or subtle features. An interpreter is, therefore, a specialist trained in the study of photograph or imagery, in addition to his or her own discipline. The present discussion mainly pertains to the techniques of visual interpretation, the application of various instruments and the extraction of information.

Recognition

It is a process of classification or trying to distinguish an object by its characteristics or patterns which are familiar on the image. It preceded the process of detection. Sometimes it is also termed as photo reading e.g. vegetation, water bodies, built-up land etc.

Analysis

It is a process of resolving or separating a set of objects or features having similar set of characteristics. In analysis 'lines of separation' are drawn between groups of objects and the degree of reliability of these lines can also be indicated e.g. vegetation as that of built-up land, water bodies with that of waste lands etc.

Classification

It is a process of identification and grouping of objects or features resolved by analysis. It arranges 'features of recurrence' in the same class or group to which the feature belongs. Any wrong identification and analysis may often lead to misclassification.

Deduction

Deduction may be directed to the separation of different groups of objects or elements and deducing their significance based on covering evidence. The evidence is derived from mainly visible objects or from invisible elements, which give only partial information on the nature of certain correlative indications. Deduction as regard to the identification of objects made without proper pre-interpretation checks in the field, may often be misleading and result in wrong classification. For complicated interpretation, therefore, it is advisable to affect the separation under this process and leave the deduction of the identity till after the clarification.

Idealization

It is a process of drawing ideal or standard representation from what is actually identified and interpreted from the image or map with standard symbols and colors.

2. Elements of Visual Interpretation

Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of tone, shape, size, pattern, texture, shadow, location, association and height. Some of these elements are interconnected and are classified into three orders viz. Basic or First order elements (Tone), Second order (Texture, shape, size, pattern) and Third order (Location, Association, Shadow and Height). Visual interpretation using these elements is often a part of our daily lives, whether we are conscious of it or not. Examining satellite images on the weather report, or following high speed chases by views from a helicopter are all familiar examples of visual image interpretation. Identifying targets in remotely sensed images based on these visual elements allows us to further interpret and analyze. The nature of each of these interpretation elements is described below, along with an image example of each.

A. Basic, first order elements of image interpretation

1. Tone/Colour - Tone refers to the relative brightness of objects in an image. Generally, tone is the fundamental element for distinguishing between different targets or features. Variations in tone also allow the elements of shape, texture, and pattern of objects to be distinguished. Colour may be defined as each distinguishable variation on an image produced by a multitude of combinations of hue, value and chroma. Therefore tone refers to the relative brightness or colour of objects on an image. (Figure 1).

Fig.1: Colour Variations

Fig.2: Tonal variations

Many factors influence the tone or colour of objects or features recorded on photographic emulsions. Human interpreter can distinguish between ten to twenty shades of grey, but can distinguish many more colours (figure 2). Some authors state that interpreters can distinguish at least 100 times more variations of colour on colour photography than shades of gray on black and white photography.

B. Second order -- Geometric Arrangements of Objects

1. Size –The size of objects can be important in discrimination of objects and features (single family vs. multi-family residences, scrubs vs. trees, etc.). In the use of size as a diagnostic characteristic both the relative and absolute sizes of objects can be important. Size can also be used in judging the significance of objects and features (size of trees related to board feet which may be cut; size of agricultural fields related to water use in arid areas, or amount of fertilizers used; size of runways gives an indication of the types of aircraft that can be accommodated) as shown in figure 3. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target.

Fig.3: Size as parameter for visual interpretation

2. **Shape** - Shape refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Similarly, roads can have right angle turns, rail lines do not. play grounds, large buildings, parks etc. have specific shapes and can easily be identified shown in figure 4.

Fig.4: Shape as parameter for visual interpretation

3. Texture: It refers to the arrangement and frequency of tonal variation in particular areas of an image. The visual impression of smoothness or roughness of an area can often be a valuable clue in image interpretation. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation as shown in figure 5. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Similarly, various density of scrub vegetation shows different texture. Uniform fields of crops, water bodies etc gives smooth texture.

Fig.5: Textural variations

4. **Pattern**: Pattern is the spatial arrangement of objects. Pattern can be either man-made or natural. Pattern is a macro image characteristic. It is the regular arrangement of objects that can be diagnostic of features on the landscape. Arrangements of complex drainage in the form of ravines can be identified easily. Likewise, the network or grid of streets in a sub- division or urban area can aid identification and aid in problem solving such as the growth patterns of a city. Pattern can also be very important in geological or geomorphologolical analysis. Drainage pattern can tell the trained observer a great deal about the lithology and structural patterns in an area (figure 6). Dendritic drainage patterns develop on flat bedded sediments; radial on/over domes; linear or trellis in areas with faults or other structural controls.

Fig.6: Pattern variations

C. Third order -- Location or Positional Elements

1. Shadow: It is useful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms (figure 7).

Fig.7 Shadow used for identifying topography in imagery

2. Location: How objects are arranged with respect to one another; or with respect to various terrain features, can be an aid in interpretation. Aspect, topography, geology, soil, vegetation and cultural features such as salt pans, settlements, industrial establishments etc. on the landscape are distinctive factors that the interpreter should use when examining a site. The relative importance of each of these factors will vary with local conditions, but all are important. Just as some vegetation grows in swamps others grow on sandy ridges. Agricultural crops may like certain conditions. Man made features may also be found on rivers (e.g. power plant) or on a hill top (observatory or radar facility).

3. Association: It takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. Some objects are so commonly associated with one another that identification of one tends to indicate or confirm the existence of another. Smoke stacks, step buildings, cooling ponds, transformer yards, coal piles, railroad tracks = coal fired power plant. Arid terrain, basin bottom location, highly reflective surface, sparse vegetation = playa. water body surrounded by salt pond and saline patches = salt production units (figure 8). Association is one of the most helpful clues in identifying man made installations. Aluminium manufacture requires large amounts of electrical energy. Absence of a power supply may rule out this industry. Cement plants have rotary kilns. Schools at different levels typically have characteristic playing fields, parking lot and cluster of building in urban area

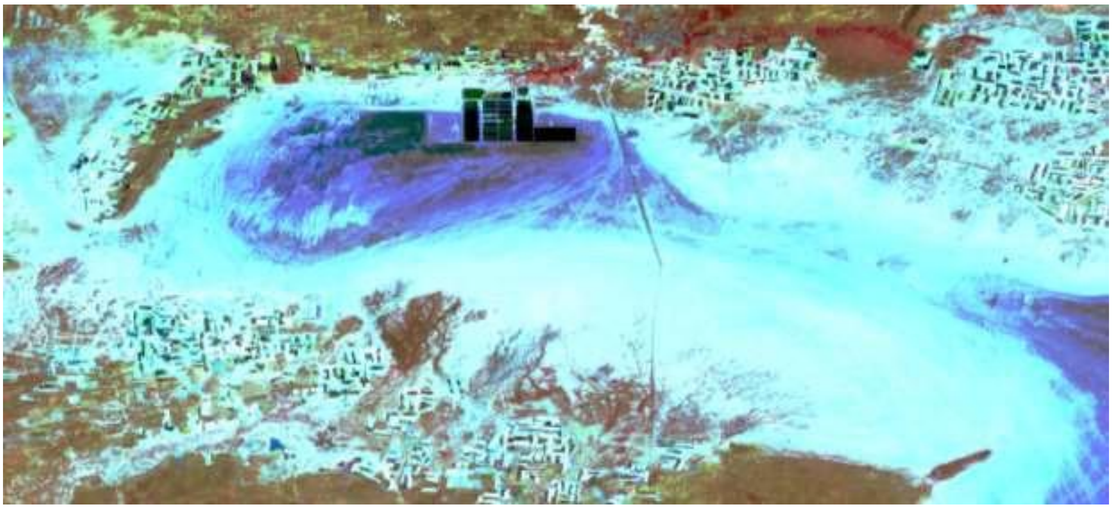

Fig.8 salt patches and salt production unit

4. Height: Height can add significant information in many types of interpretation tasks; particularly those that deal with the analysis of man-made features. How tall a tree is can tell something about board feet. How deep an excavation can tell something about the amount of material that was removed (in some mining operations excavators are paid on the basis of material removed as determined by photogrammetric analysis). High rise buildings with symmetry of windows and parking arrangements shows residential (figure 9).

Fig.9 High rise buildings with parking arrangements

3. Steps to prepare thematic maps using visual interpretation

Step 1: Acquisition of data

i. Standard false color composite made of green, red and infrared bands of RS data of two seasons Kharif (June-September) and Rabi (October - March)

ii. Ancillary data – Topographical maps (As per the requirement i.e. 1:250,000 or 1:50,000 scale).

Step 2 : Preliminary Interpretation

i. Check the area to be interpreted is covered on RS data.

ii. Spread the satellite imagery on a light table and fix it firmly.

iii. Orient the imagery with respect to SOI map corresponding to the scene, with reference to latitudes and longitudes marked on the imagery and physical and cultural features.

iv. Cut to the size of the imagery the artian tracing sheet or polyester tracing sheet (rough surface

facing top) or acetate base film and fix it on the scene with transparent tape.

v. For interpretation use ordinary pencil (HB or H)

vi. At the bottom corner, note latitude, longitude from scene, date and year of scene,

vii. scene path-row number, name of district, state etc.

Step 3: Final Interpretation

i. Identify and recognise the different land use / land cover, on the imagery based on image characteristics, for correct classification of land use, refer classification system.

ii. Considering the general interpretation key for land use land cover, develop a separate interpretation key for the specific area under study.

iii. After identification of a category, delineate and map it on transparent over lay, for better clarity and discernibility, use magnifying lens.

iv. To minimize doubtful area, use other satellite images, information from topographical maps, forest maps or any other maps available.

v. Use numerical or alphabetical notation or colours to each of the land use / land cover classes delineated.

vi. Land use / land cover categories having similar spectral signature, appearing side by side require detail ground verification.

vii. Minimum mapping unit is 3 mm x 3 mm, all details less than the minimum mapping unit are excluded from mapping, for better visual separation and cartographic representation.

Step 4: Transfer of details on to the base map

i. Transfer the interpreted details on to a base map prepared from topographic map. Transfer notified forest boundaries on to the base map.

ii. Finalise the map after incorporating post field data.

Step 5: Area Calculation

i. Calculate area of different land use / land cover categories either using a millimeter Polythene graph sheet and / or a planimeter.

ii. For better consistency and accuracy of area calculation, repeat the operation at least thrice and select the average of the two nearest values.

iii. Compute the area both in square km and in hectares, also calculate percentage.

Generation of Cartographic Quality map

i. Retrace the map on a new transparent sheet using appropriate rotring pens.

ii. Prepare the fair drawing original, with proper legend, scale, north arrow etc.

4. Interpretation aids

On the basis of tasks to be carried out, visual interpretation aids can be classified into three categories viz. Aids for viewing including enhancement, transfer of detail and measurement. Interpretation aids can also be classified as equipment for monoscopic viewing and stereo viewing. It should however be pointed out that the categorisation is not rigid as certain equipment can be classified into more than one category particularly some of the projection devices which can be used for both viewing and transfer of details. Some of the equipments have become obsolete due to availability of high quality and cost effective FCC data products. In context of land use/cover the aids used only for transferring of details have been discussed here. Basically the equipment in this category are meant for delineating the details from image to a map on the same scale or different scale. These devices employ the means for simultaneous viewing of both the image and the map. There are following three types of equipments which are commonly used for mapping i.e. HME, LFOE, PROCOM and light tables. First two types come under the optical projection types instruments. The schematic presentation if interpretation process is shown in figure 10.

High magnification enlarger (HME):

HME is developed at SAC is a versatile aid for visual interpretation of remotely sensed data in the form of transparencies. i.e. B/W or FCC diapositives. Enlargements upto 20 times are possible in this instrument thus enabling a 1:1million dia-positives such as LANDSAT TM transparency to be enlarged up to the scale of 1:50 000 corresponding to SOI topographic sheets. Even high magnifications have also been attempted with this equipment comparison. Projection of the image is carried out on a table attached to the equipment on which a map can be fixed for registration with image and also a tracing film for the preparation of a thematic map.

Large format optical enlarger (LFOE):

Large format optical enlarger has also been developed at SAC. It is used for two and four times enlargement of 240mm diapstives.1:1M scale images such as LANDSAT TM and MSS data can be enlarged upto the scale of 1:250 000 scale corresponding to SOI topographical scale at this scale. IRS LISS II images at 1:500 000 scale can be enlarged to a scale of 1:250 000 using a LFOE having capability of two times enlargements. It can also project multi-spectral images in 70 mm format for easy comparison.

Light tables: In addition to the instruments used for optical projection an interpretation aid used for delineation of features from hardcopy paper prints are light tables. Interpretation corresponding to the scale of paper print can be carried out. Handling of images for interpretation is relatively easier using light tables.

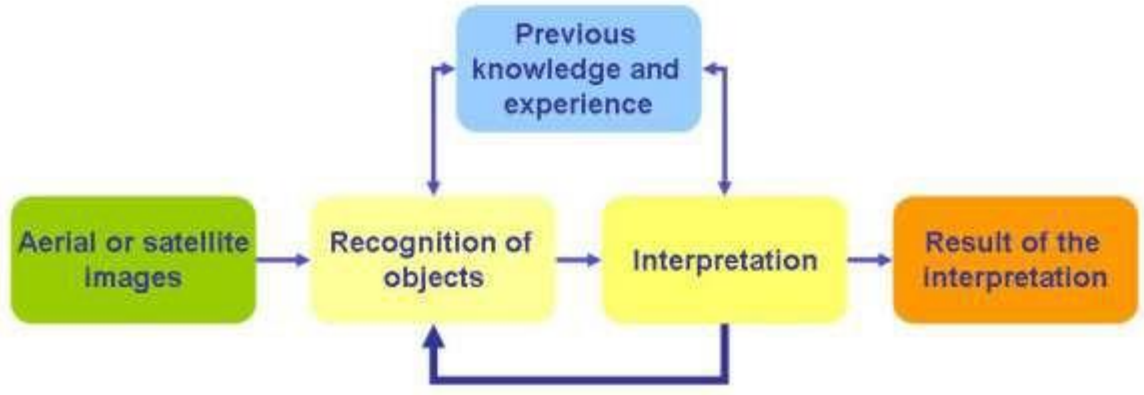

Fig.10: Schematic Presentation of the Interpretation Process.

5. Techniques of Photographic/Image Interpretation

2.1 Collateral Material

A review of all existing source material that pertains to a given area, process, type of facility or object, can aid in the interpretation process. The use of collateral material may also result in a better definition of the scope, objectives and problems associated with a given project. Also called "ancillary data", collateral material may come in the form of text, tables, maps, graphs, or image metadata. Census data, a map or description of the flora of a given area, a land use map, meteorological statistics, or agricultural crop reports can all be used in support of a given interpretation. Basically, collateral material represents data/information that an interpreter may use to aid in the interpretation process. Material contained within a Geographic Information System (GIS) that is used to assist an interpreter in an analysis task can be considered collateral data. Two classes of collateral materials deserve special mention: interpretation keys and field verification.

2.2 Interpretation Keys

An interpretation key is a set of guidelines used to assist interpreters in rapidly identifying features. Determination of the type of key and the method of presentation to be employed will depend upon,

a) The number of objects or conditions to be identified; and,

b) The variability typically encountered within each class of features or objects within the key

Some authors say that as a general rule, keys are more easily constructed and used for the identification of man-made objects and features than for natural vegetation and landforms. For analysis of natural features, training and field experience are often essential to achieve consistent results. Basically, an interpretation key helps the interpreter organize the information present in image form and guides him/her to the correct identification of unknown objects. Keys can be used in conjunction with any type of remotely sensed data. Such keys can differ from those employed in other disciplines in that they can consist largely of illustrations, e.g. landforms, industrial facilities, military installations. Many types of keys are already available, if you can find or get your hands on them. This can often be very difficult and a reason why people develop their own keys. Depending upon the manner in which the diagnostic features are organized, two types of keys are generally recognized. 1) Selective keys and 2) Elimination keys. Selective keys are arranged in such a way that an interpreter simply selects that example that most closely corresponds to the object they are trying to identify, e.g. industries, landforms etc. Elimination Keys are arranged so that the interpreter follows a precise step-wise process that leads to the elimination of all items except the one(s) that they are is trying to identify. Dichotomous keys are essentially a class of elimination key. Most interpreters prefer to use elimination keys in their analyses (Colwell, 1997; Olson, 1960).

2.3 Field Verification

Field verification can be considered as form of collateral material because it is typically conducted to assist in the analysis process. Essentially, this is the process of familiarizing the interpreter with the area or type of feature. This type of verification is done prior to the interpretation to develop a visual "signature" of how the feature(s) of interest appear on the ground. After an interpretation is made field verification can be conducted to verify accuracy. The nature, amount, timing, method of acquisition, and data integration procedures should be carefully thought out.