Chapter 7 Image Interpretation

7.1 Information Extraction in Remote Sensing

Information extraction in remote sensing can be categorized into five types as shown in Table 7.1.1. **Classification** is a type of categorization of image data using spectral, spatial and temporal information. **Change detection** is the extraction of change between multi-date images. **Extraction of physical quantities** corresponds to the measurement of temperature, atmospheric constitutients, elevation and so on, from spectral or stereo information. **Extraction of indices** is the computation of a newly defined index, for example, the vegetation index (see 10.6) from satellite data. **Identification of specific features** is the identification, for example, of disaster, lineament, archaeological and other features, etc.

Information extraction can be made by human or computer methods. **Information extraction by human** interpretation will be described in the next sections, while **information extraction by computer** will be explained in chapter 8.

Table 7.1.2 provides a comparison between human and computer information extraction. As seen in the table, human and computer methods supplement each other, so that they both may offer better results when combined. For example in geology, computers will produce an enhanced image, from which humans can interpret the geological features.

A computer system with an interactive graphic display through which humans and computers can interactively work together is called "a **man-machine interactive system**".

Because human interpretation is time consuming, as well as expensive, a special computer technique, with the ability of human interpretation, is being developed. For example, an **expert system** is a computer software system with a training ability to use the interpreter's knowledge for information extraction.

Table 7.1.1 Types of information extraction by remote sensing

Types	Example
Classification	Land cover, Vegetation
Change detection	Land cover change
Extraction of physical quality	Temperature, Atmospheric component, Elevation
Extraction of indices	Vegetation index, Turbidity index
Identification of specific features	Identification of disasters like forest fire or flood, Extraction of linearment Detection of archaeological feature

Table 7.1.2 Comparison between human and computer information extraction

Method	Merit	Demerit
Human (Image interpretation)	*Interpreter's knowledge are available *Excellent in spatial information extraction	*Time consuming *Individual difference
Computer (Image processing)	*Short processing time Reproductivity *Extraction of physical quantities or indices is possible	*Human knowledge is unavailable *Spatial information extraction is poor

7.2 Image Interpretation

Image interpretation is defined as the extraction of qualitative and quantitative information in the form of a map, about the shape, location, structure, function, quality, condition, relationship of and between objects, etc. by using human knowledge or experience. As a narrow definition, " **photo-interpretation** " is sometimes used as a synonym of image interpretation.

Image interpretation in satellite remote sensing can be made using a single scene of a satellite image, while usually a pair of stereoscopic aerial photographs are used in photo-interpretation to provide stereoscopic vision using, for example, a mirror stereoscope. Such a single photo-interpretation is discriminated from stereo photo-interpretation (see 7.3).

Figure 7.2.1 shows a typical flow of the image interpretation process.

Image reading is an elemental form of image interpretation. It corresponds to simple identification of objects using such elements as shape, size, pattern, tone, texture, color, shadow and other associated relationships. Image reading is usually implemented with interpretation keys with respect to each object, as explained in 7.4 and 7.5.

Image measurement is the extraction of physical quantities, such as length, location, height, density, temperature and so on, by using reference data or calibration data deductively or inductively.

Image analysis is the understanding of the relationship between interpreted information and the actual status or phenomenon, and to evaluate the situation.

Extracted information will be finally represented in a map form called an interpretation map or a thematic map.

Generally the accuracy of image interpretation is not adequate without some ground investigation. Ground investigations are necessary, first when the keys are established and then when the preliminary map is checked.

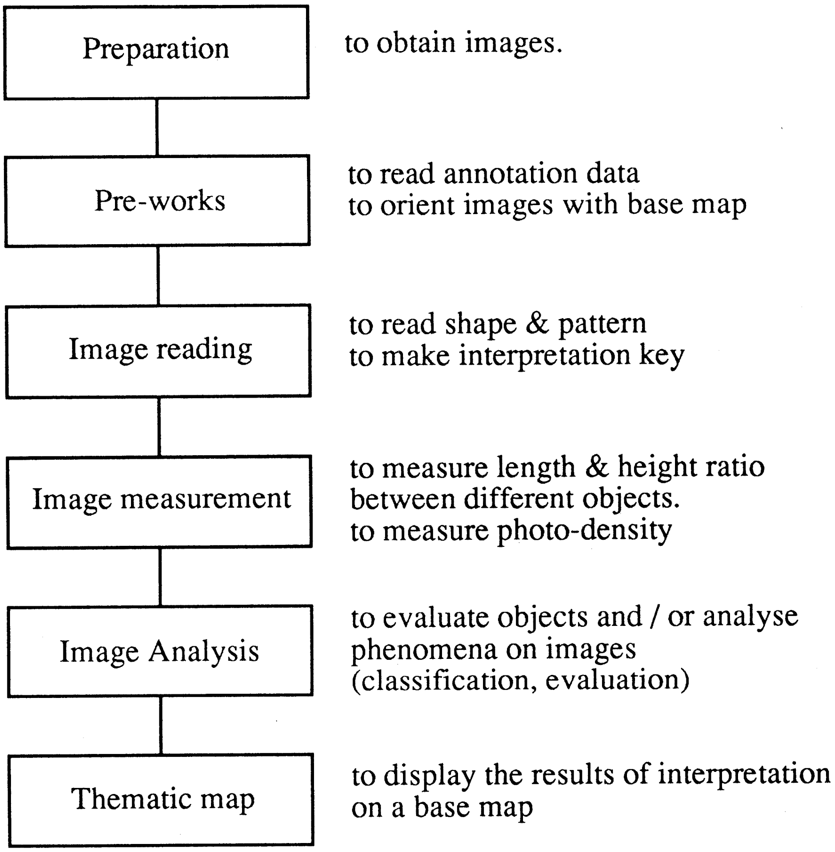


Figure 7.2.1 The image interpretation processing

7.3 Stereoscopy

A pair of stereoscopic photographs or images can be viewed stereoscopically by looking at the left image with the left eye and the right image with the right eye. This is called **stereoscopy**. Stereoscopy is based on Porro-Koppe's Principle that the same light path will be generated through an optical system if a light source is projected onto the image taken by an optical system. The principle will be realized in a **stereo model** if a pair of stereoscopic images are reconstructed using the relative location or tilt at the time the photography was taken. Such an adjustment is called relative orientation in photogrammetric terms. The eye-base and the photo-base must be parallel in order to view at a stereoscopic model, as shown in Figure 7.3.1.

Usually a stereoscope is used for image interpretation. There are several types of stereoscope, for example, portable lens stereoscope, stereo mirror scope (see Figure 7.3.2), stereo zoom transfer scope etc.

The process of stereoscopy for aerial photographs is as follows. At first the center of both aerial photographs, called the **principal point,** should be marked. Secondly the principal point of the right image should be plotted in its position on the left image. At the same time the principal point of the left image should be also plotted on the right image. These principal points and transferred points should be aligned along a straight line, called the base line, with an appropriate separation (normally 25-30 cm in the case of a stereo mirror scope) as shown in Figure 7.3.3. By viewing through the binoculars a stereoscopic model can now be seen.

The advantage of stereoscopy is the ability to extract three dimensional information, for example, classification between tall trees and low trees, terrestrial features such as height of terraces, slope gradient, detailed geomorphology in flood plains, dip of geological layers and so on.

The principle of height measurement by stereoscopic vision is based on the use of **parallax,** which corresponds to the distance between image points, of the same object on the ground, on the left and right image. The height difference can be computed if the **parallax difference** is measured between two points of different height, using a parallax bar, as shown in Figure 7.3.3.

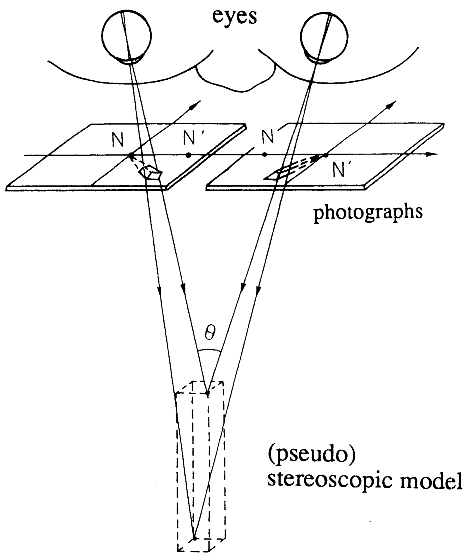


Fig. 7.3.1 Schematic diagram of stereoscopic vision

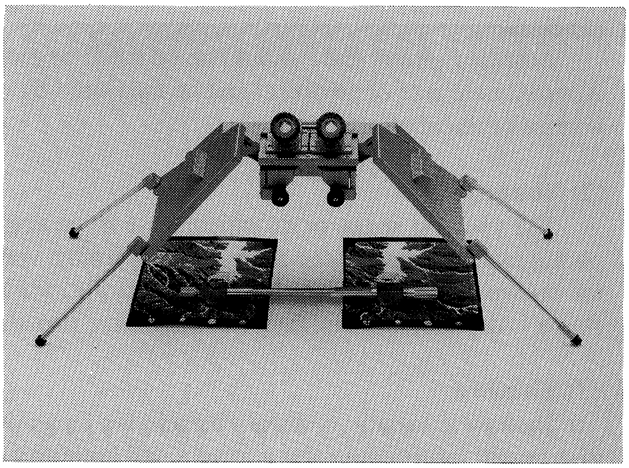
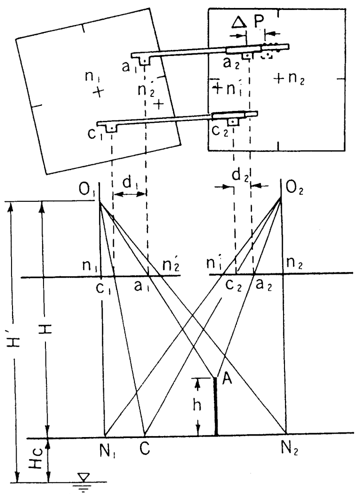


Figure 7.3.2 Stereoscopic viewer



Hc : flight height

c : control point

Hc : height of control point

H : H' - Hc

$\overline{n_1 \cdot n_2}$: principal points on a pair of stereo photos

$\overline{n_1 \cdot n_2}$: transferred points from each principal point of the photos

$\overline{n_1 \cdot n_2}$: principal distance

$\overline{c_1 \cdot c_2}$: distance between point c on a pair of stereo photos

$\overline{a_1 \cdot a_2}$: distance between point a on a pair of stereo photos

parallax at point c : $P = \overline{n_1 \cdot n_2} - \overline{c_1 \cdot c_2}$

parallax difference between point a & c : $\Delta P = \overline{c_1 \cdot c_2} - \overline{a_1 \cdot a_2}$

obtained height : $h = H \cdot \Delta P / (P + \Delta P)$

Fig. 7.3.3 Principle of height measurement

7.4 Interpretation Elements

The following eight elements are mostly used in image interpretation; size, shape, shadow, tone, color, texture, pattern and associated relationship or context.

(1) **Size**:

A proper photo-scale should be selected depending on the purpose of the interpretation. Approximate size of an object can be measured by multiplying the length on the image by the inverse of the photo-scale.

(2) **Shape:**

The specific shape of an object as it is viewed from above will be imaged on a vertical photograph. Therefore the shape looking from a vertical view should be known. For example, the crown of a conifer tree looks like a circle, while that of a deciduous tree has an irregular shape. Airports, harbors, factories and so on, can also be identified by their shape.

(3) **Shadow**:

Shadow is usually a visual obstacle for image interpretation. However, shadow can also give height information about towers, tall buildings etc., as well as shape information from the non-vertical perspective-such as the shape of a bridge.

(4) **Tone**:

The continuous gray scale varying from white to black is called tone. In panchromatic photographs, any object will reflect its unique tone according to the reflectance. For example dry sand reflects white, while wet sand reflects black.In black and white near infrared infrared photographs, water is black and healthy vegetation white to light gray.

(5) **Color:**

Color is more convenient for the identification of object details. For example, vegetation types and species can be more easily interpreted by less experienced interpreters using color information. Sometimes color infrared photographs or false color images will give more specific information, depending on the emulsion of the film or the filter used and the object being imaged.

(6) **Texture**:

Texture is a group of repeated small patterns. For example homogeneous grassland exhibits a smooth texture, coniferous forests usually show a coarse texture. However this will depend on the scale of the photograph or image.

(7) **Pattern**:

Pattern is a regular usually repeated shape with respect to an object. For example, rows of houses or apartments, regularly spaced rice fields, interchanges of highways, orchards etc., can provide information from their unique patterns.

(8) **Associated relationships or context**:

A specific combination of elements, geographic characteristics, configuration of the surroundings or the context of an object can provide the user with specific information for image interpretation.

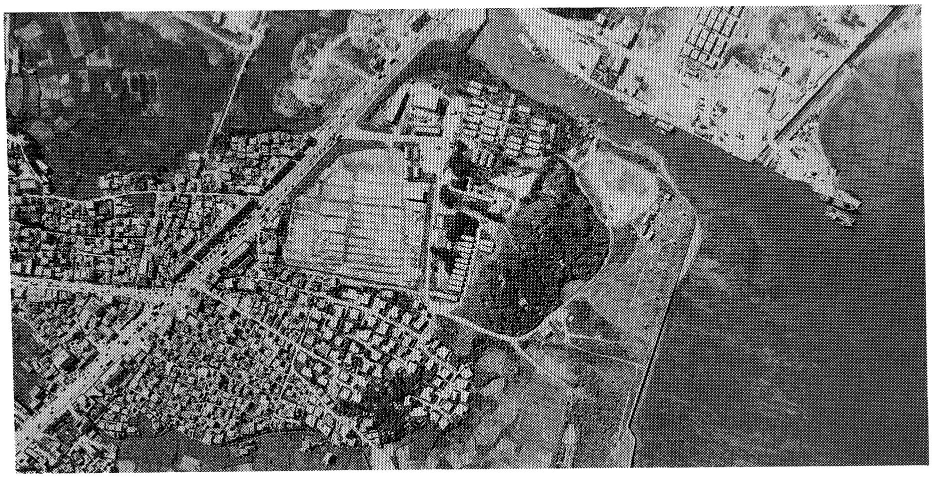


Figure 7.4.1 A sample of aerial photograph at Naha-city in Okinawa pref. (scale about 1/13,000)

[Size] Small fishery boats &large working ships
[Shape] square apartment houses & irregular low old houses
[Shadow] high buildings along the main street
[Tone] dark forest & light cultivated field, lighter coral reef & darker deep sea

Figure 7.4.2 A sample of aerial photograph at a part of Ibaragi Pref. (scale about 1/10,000)

[Texture] coarse forest area & fine young re-forest area
[Pattern] shaped housing vegetation, linearly road, meandering river and quadrangulation cultivated fields

7.5 Interpretation Keys

The criteria for identification of an object with interpretation elements is called an **interpretation key**. The image interpretation depends on the interpretation keys which an experienced interpreter has established from prior knowledge and the study of the current images. Generally, standardized keys must be established to eliminate the differences between different interpreters.

The eight interpretation elements (size, shape, shadow, tone, color, texture, pattern and associated relationship), as well as the time the photograph is taken, season, film type and photo-scale should be carefully considered when developing interpretation keys. Keys usually include both a written and image component.

Table 7.5.1 shows an example of interpretation keys for forestry mapping which have been standardized by the Japan Association for Forestry.

The keys are specified with respect to the crown's shape, rim shape of the crown, tone, shadow, projected tree shape, pattern, texture and other factors.

Table 7.5.2 shows an example of an interpretation key for land cover mapping with Landsat MSS images in the case of single band and false color images.

Table 7.5.1 Interpretation keys for forestry

species	crown shape	edge of crown	tone	pattern	texture
ceder	conical with sharp spear	circular and sharp	dark	spotted grain	hard and coarse
cypress	conical with round crown	circular but not sharp	dark but lighter than ceder	spotted	lard and fine
pine	cylindrical with shapeless crown	circular but unclear	light and unclear	irregularly spotted	soft but coarse
larch	conical with unclear crown	circular with unclear edge	lighter than cypress	spotted	soft and fine
fir/spruce	conical with wider crown	circular with zigzag edge	dark and clear	irregular	coarse
deciduous	irregular shapes	unclear	lighter	irregular	coarse

(by country of Japan Association of Forestry

Table 7.5.2 A sample of LANDSAT image's interpretation key

	band 4	band 5	band 6	band 7	457(BGR)	457(RGB)
Snow	PW	PW	PW	PW	PW	PW
Cloud	W	W	W	W	W	W
Haze	W	W	-	-	W	W
Forest	DGR	BL	W	W	R	G
Grass	GR	DG	W	W	P	BY
Bare land	GR	W	W	W	W	W
Wet land	GR	W	GR	DGR	LB	RP
Urban	GR	W	GR	DGR	LB	RP
Water	DGR	BL	BL	BL	B	BP
Shadow	BL	BL	BL	BL	BL	BL

PW: pure white W: white DGR: dark gray GR: gray BL: black
R: red G: green B: blue P: pink BY: brandish yellow
LB: light blue RP: reddish purple BP: blueish purple

7.6 Generation of Thematic Maps

An **image interpretation** map is usually produced by transferring the interpreted information to a base map which has been prepared in advance. The requirements of the **base map** should be as follows.

(1) Proper map scale to enable appropriate presentation of interpreted information
(2) Geographic coordinate system to establish the geographic reference
(3) Basic map information to be printed in light tones as background which results in enhancement of interpreted information

Normally a topographic map, plan map or orthophotomap is used as a base map.

A topographic map with a scale of 1:50,000, 1:100,000 or 1:250,000 is usually the preferable base map for higher resolution satellite image interpretation.

For oceanographic purposes or marine science, charts with a scale of 1:50,000 to 1:500,000 should be used as the base map.

Orthophotomaps are more easily used by cartographers for the transfer of interpreted information, particularly in the case of forest classification.

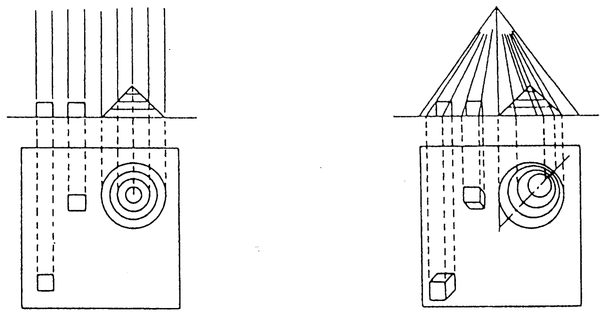
The methods of transfer of information to a base map, are as follows.

(1) Tracing
The interpreted image is traced on to a base map by overlaying on a light table.

(2) Optical projection
The interpreted image is projected via a lens and a mirror onto a base map. The optical zoom transferscope or mirror projector is very useful for image interpretation. (see Figure 7.6.1)

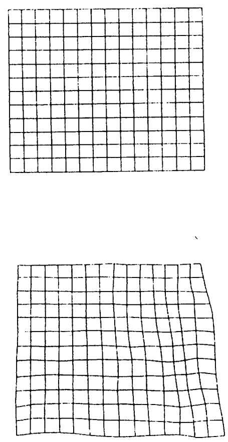
(3) Grid system
Grid lines are drawn on both an image and a base map. Then the interpreted information in a grid on the image is transferred to the corresponding grid on the map.

(4) Photogrammetric plotting
Aerial photographs are interpreted into a thematic map using a photogrammetric plotter. (see Figure 7.6.2)



a) Ortho Graphic Projection b) Central Projection

Figure 7.6.1 Method for the Projections



(1) Grid on the Map

(2) Grid on the Aerial-photo corresponding (1)

Figure 7.6.2 Grid to grid method for editing

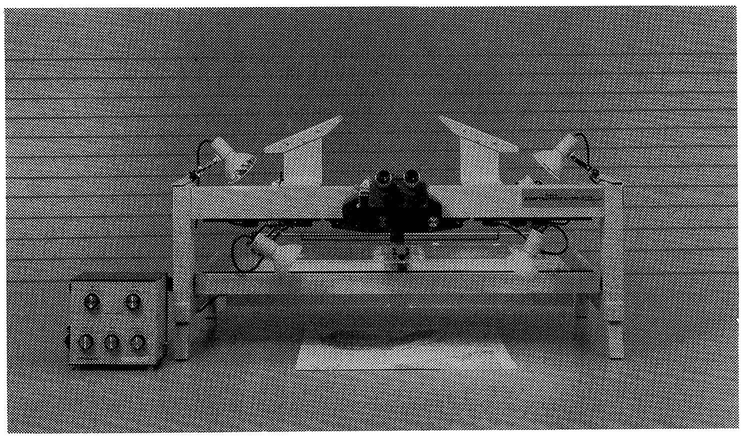


Figure 7.6.3 Instrument for optical editing