RQF LEVEL 5

TRADE: LAND SURVEYING

MODULE CODE: LSVRS501

TEACHER'S GUIDE

Module name: Fundamental Principle of Remote Sensing

MODULE NAME: FUNDAMENTAL PRINCIPLES OF REMOTE SENSING

Table of content

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Acronyms

RQF: Rwanda Qualification Framework

GIS: Geographic Information System

GDA: Geospatial data acquisition

IFOV: Instantaneous Field of view

EMR: Electromagnetic radiation

RADAR: Radio Detection and Ranging

LIDAR: Light Detection and Ranging

SONAR: Sound Navigation Ranging

DMSP: Defence Meteorological Satellite Program

GPS: Global Positioning System

GDA: Geospatial Data Acquisition

Introduction

Definition of remote sensing

Remote sensing is the term composed of two words: "*remote*" and "*sensing*".

> **Remote** means not in contact with the target/object.
>
> **Sensors** are common devices used to detect a change in a physical state and quantify the measurement results in a particular scale or range.

Therefore, **remote sensing** is the science of acquiring information about the earth using instruments which are remote to the earth's surface, usually from aircraft or satellites. Instruments may use visible light, infrared or radar to obtain data from earth's surface.

Remote sensing offers the ability to observe and collect data for large areas relatively quickly, and is an important source of data for Geographic Information System.

The remotely collected data can be of many forms, including variations in force distributions, gravity, acoustic wave distribution or electromagnetic (EM) energy distributions.

(compbell 1996)

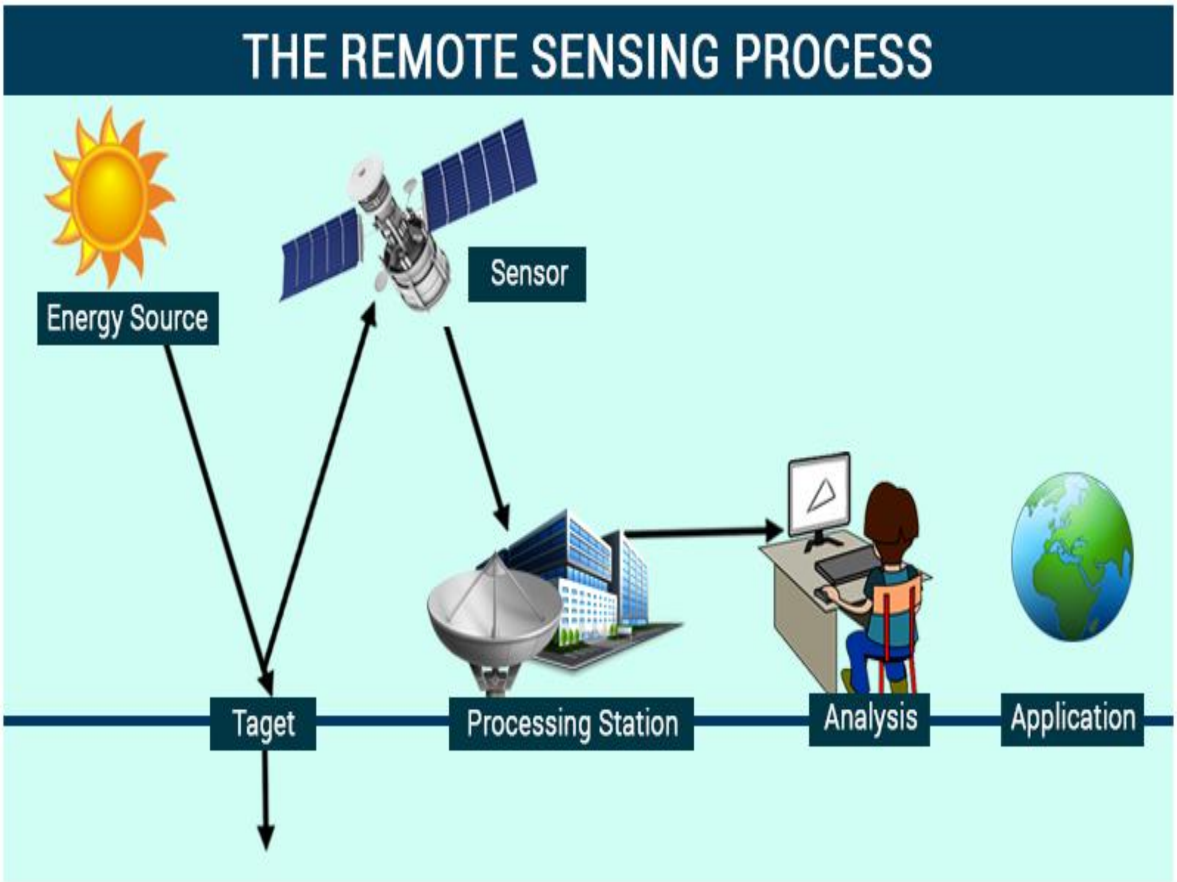
Module Code and Title: LSVRS501 501 Apply fundamental principles of remote sensing

Learning Units:

1. Identify remote sensing function and components
2. Identify Sensor and Platform system in remote sensing
3. Perform visual image interpretation
4. Apply remote sensing data in mapping

Learning Unit1: IDENTIFY REMOTE SENSING FUNCTION AND COMPONENTS

Picture/s reflecting the Learning unit 1



STRUCTURE OF LEARNING UNIT

Learning outcomes:

1.1. Identify components of remote sensing system
1.2. Identify types of remote sensing system
1.3. identify elements of remote sensing system

Learning outcome 1.1: Identify components of remote sensing system

Duration: 4hrs

Learning outcome 1.1objective:

By the end of the learning outcome, the trainees will be able to:

1. Proper Identification of components of remote sensing system according to their functions.
2. Describe clearly function of remote sensing components
3. Discuss clearly principles of remote sensing

Resources:

Equipment	**Tools**	**Materials**
➢ Computer ➢ Projector ➢ Printer	➢ White board ➢ Duster ➢ Notebook ➢ Books	➢ Maker pen ➢ Paper ➢ Pens ➢ Internet

Advance preparation:

- ✓ Hand out notes is available.
- ✓ Pictures of remote sensing sensors are available.

Content 1.1.1: Components of remote sensing

- **Sensor:** Based on their continuity of data collection, sensors are of two types of sensors: active and passive.

  An *active sensor* is a sensing device that requires an external source of power to operate. A *passive sensor* is device which doesn't use the energy from electrical source for measuring environment signals. It is a microwave instrument designed to receive and to measure natural emissions produced by constituents of the Earth's surface and its atmosphere.

- **Energy source:** It is the source of electromagnetic radiation which is incident on the target of interest.

- **Transmission path:** is the space between the electromagnetic energy source and the target, and back to the sensor. In the case of Earth observation, the transmission path is usually the atmosphere of Earth.

- **Target:** When the electromagnet radiations interact with the target, there are various possibilities in the way they behave. They can get reflected, refracted, absorbed & diffused.

- **Platform:** Platform is the arrangement or device which holds the sensor used for remote sensing process. It is defined as the carrier for **remote** sensors.

Theoretical learning Activity

- ✓ Brainstorming on remote sensing components
- ✓ In a Group of 4 , trainees discuss on components of remote sensing

Points to Remember (Take home message)

- ✓ Remote sensing components:
  - Sensor
  - Energy source
  - Transmission path
  - Target
  - Platform

Content 1.1.2: Function of remote sensing components

Remote sensing is being used very widely, to obtain information accurately, with speed and ease, about the vast stretch of land features and water bodies of the earth.

There are hundreds of applications/functions of remote sensing such as:

- *Glaciology:* measuring ice cap volumes, ice stream velocity, and sea ice distribution.
- *Geodesy:* measuring the figure of the Earth and its gravity field.
- *Botany:* forecasting crop yields.
- *Hydrology:* assessing water resources from snow, rainfall and underground aquifers.
- *Disaster warning and assessment*: monitoring of floods, landslides and volcanic activities.
- *Planning*: mapping ecological zones, monitoring deforestation and land use.
- *Oil and mineral exploration*: locating natural oil seeps and, mapping geological structures.
- *Military*: developing maps for planning and, monitoring military infrastructures.
- *Climate*: monitoring the effects of climate change
- *Sea:* Monitoring the extent of flooding
- *Rock:* Recognizing rock types
- *Space program:* is the backbone of the space program
- *Seismology:* as a premonition.

Theoretical learning Activity

- ✓ Brainstorming on function of remote sensing components
- ✓ Group discussion on function of remote sensing components

Points to Remember (Take home message

- ✓ Remote sensing applications/functions of remote sensing:
- *Glaciology*
- Geodesy
- Botany
- Hydrology
- Disaster warning and assessment
- Planning
- Oil and mineral exploration
- Military
- Climate
- Seismology

content 1.1.3: Principles of remonte sensing.

Remote sensors operate based on two principles which are detection of objects and discrimination.

- ✓ **Detection:** is the action or process of identifying the presence of something hidden.
- ✓ **Discrimination*:*** is the recognition and understanding of the difference between one detected object and another.

Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material.

Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it. This depends on the property of material (structural, chemical, and physical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy.

The Remote Sensing is basically a multi-disciplinary science which includes a combination of various disciplines such as optics, spectroscopy, photography, computer, electronics and telecommunication, satellite launching etc. All these technologies are integrated to act as one complete system in itself, known as Remote Sensing System. (CurranP.J 1985)

Theoretical learning Activity

- ✓ Brainstorming on Principles of remonte sensing
- ✓ Group discussion on Principles of remonte sensing

Points to Remember (Take home message)

- ✓ Principles of remonte sensing :
  - Detection
  - Discrimination

Learning outcome 1.1 formative assessment

Written assessment :

Q1. What do you understand by the term Discrimination?

Answer:

Discrimination: is the recognition and understanding of the difference between one detected object and another

Q2. Remote sensing is the term composed of two words, discuss about those terms

Answer:

Remote sensing is the term composed of two words: “*remote*” and “*sensing*”.

Remote means not in contact with the target/object.

Sensors are common devices used to detect a change in a physical state and quantify the measurement results in a particular scale or range.

Q3. Complete the following sentences with the words in brackets

a) ………………measuring the figure of the Earth and its gravity field. (Botany, Geodesy, Glaciology)

b) …………….. Is the act of noticing or discovering something (detection, discrimination?)

Answer

a) Geodesy
b) Detection

Learning outcome 1.2: Identify types of remote sensing system

Duration: 3hrs
Learning outcome 1.2 objectives: By the end of the learning outcome, the trainees will be able to: 1. Identify clearly types of remote sensing system according to their application
Resources:

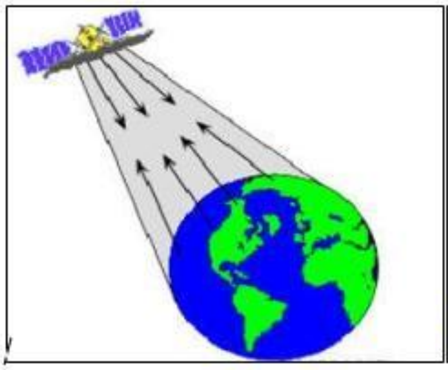
Equipment	**Tools**	**Materials**
✓ Computer ✓ Projector ✓ Printer	✓ White board ✓ Duster ✓ Notebook ✓ Books	✓ Maker pen ✓ Paper ✓ Pens ✓ Internet

Advance preparation:

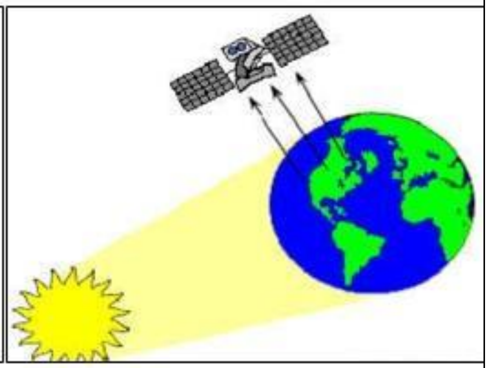
- ✓ Hand out notes is available.
- ✓ Pictures of remote sensing sensors are available.

Content 1.2.1: types of remote sensing system

There are two types of systems existing: *passive remote sensing system* and *active remote sensing system.*



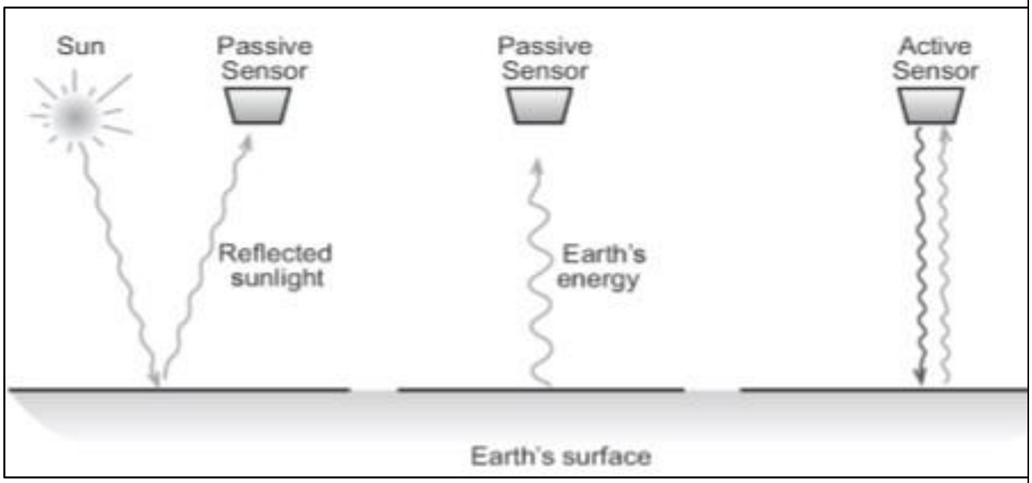
Active sensor system



Passive sensor system

- ✓ **Difference between the two types of remote sensing systems**

We do not have to rely on solar and terrestrial radiation only. We can build instruments which emit electromagnetic energy and then detect the energy returning from the target object or surface. Such instruments are called "**active sensors"** as opposed to "**passive sensors"** which measure solar or terrestrial energy.



The above figure shows that a passive sensor measures reflected or emitted energy while an active sensor has its own source of energy.

- ✓ **Advantages of active sensing system over the passive sensing system**

The main advantages of active sensors are that they can be operated day and night, are less affected by atmosphere. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night.

- ✓ **Benefit of using two types of sensor systems**

Many sensors used in earth observation detect reflected solar energy. Others detect the energy emitted by the earth itself. The sun is not always shining brightly and there are regions on the globe almost permanently under cloud cover. In this case, sensors detecting reflected solar energy are useless at night and face problems under unfavorable season and weather conditions.

Sensors detecting emitted terrestrial energy do not directly depend on the sun as a source of illumination; they can be operated any time. The earth's emission is only at longer wavelengths because of the relatively low surface temperature and long electromagnetic waves are not very energetic, thus more difficult to sense. (F.A.O 2018)

Theoretical learning Activity

- ✓ Brainstorming on types of remote sensing system

Points to Remember (Take home message)

- ✓ Types of remote sensing system:
  - passive remote sensing system
  - active remote sensing system.

Learning outcome 1.2 formative assessment

Written assessment :

Q 1. With typical examples differentiate two main types of Remote Sensing in surveying.

Answer:

- Passive sensors and Active Sensors, Passive sensors energy leading to radiation received comes from an external source, e.g : the Sun, Earth, moon
- Active energy generated from within the sensor system, beamed outward, and the fraction returned is measured other hand it provides its own energy source for illumination e. g: RADAR, LiDAR,

Q2.why is very important to use two types of remote sensing system

Answer :

- sensors detecting reflected solar energy are useless at night and face problems under unfavorable season and weather conditions.
- Sensors detecting emitted terrestrial energy do not directly depend on the sun as a source of illumination

Learning outcome 1.3: Identify elements of remote sensing system

Duration: 3hrs

Learning outcome 1.3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify elements of remote sensing system according to the stages of remote sensing process

2. Describe the stages in remote sensing process.

Resources:

Equipment	**Tools**	**Materials**
✓ Computer ✓ Projector ✓ Printer	✓ White board ✓ Duster ✓ Notebook ✓ Books	✓ Maker pen ✓ Paper ✓ Pens ✓ Internet

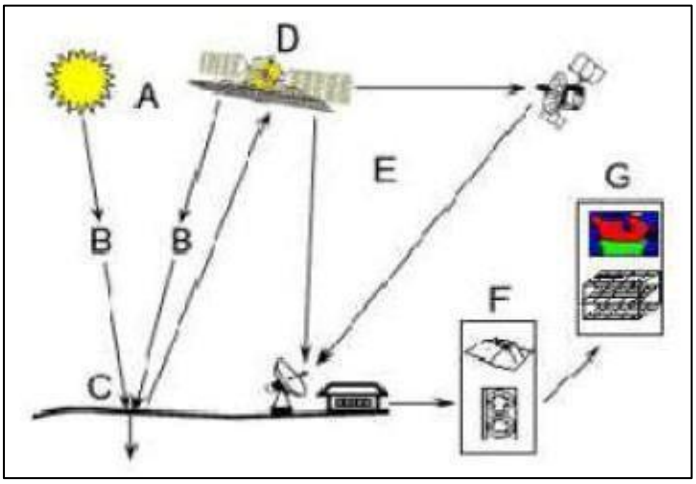
Advance preparation:

- ✓ Hand out notes is available.
- ✓ Pictures of remote sensing sensors are available.

Content 1.3.1: Identify elements of a remote sensing system

- ✓ **Identification of seven elements of a remote sensing system**
- Energy source
- Radiation and Atmosphere
- Target interaction
- Energy recording (sensor)
- Transmission, reception and processing
- Analysis and interpretation
- Applications

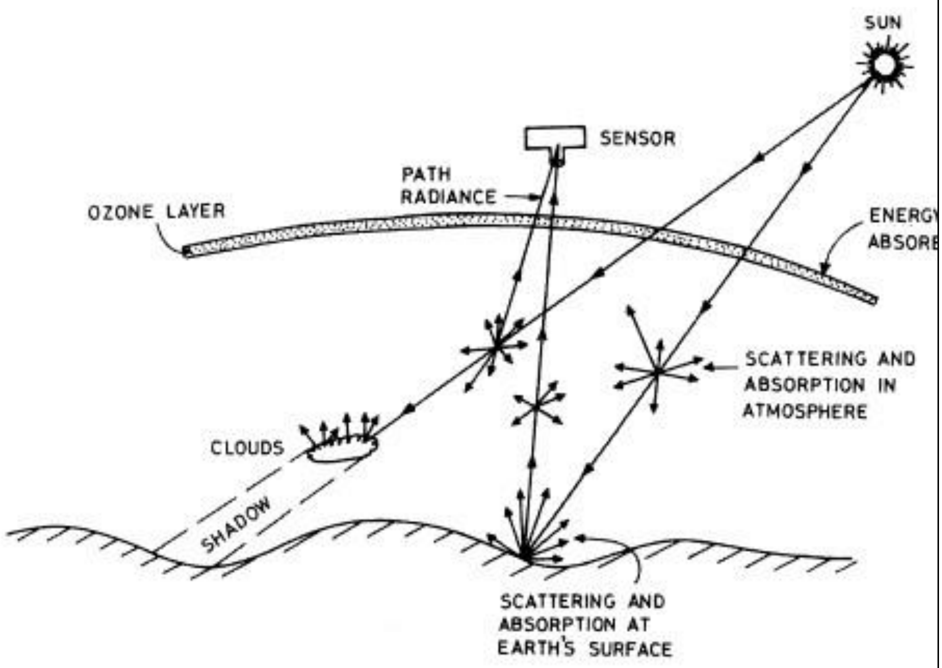
The remote sensing process involved an interaction between the targets of interest and radiation that is incident on those targets.



As illustrated on the above figure, the following elements are existing in remote sensing process:

- **Energy Sourcing or Illumination (A)**: the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

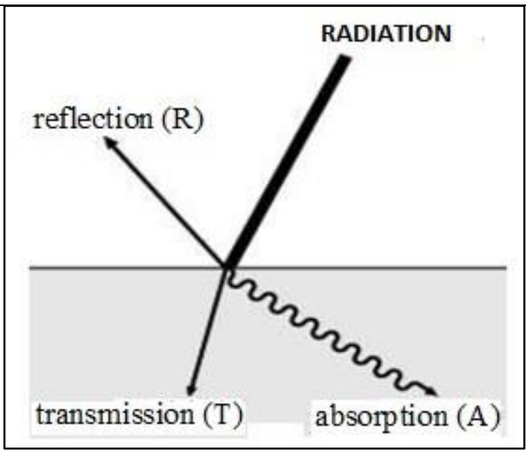
- **Radiation and the Atmosphere (B):** as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.



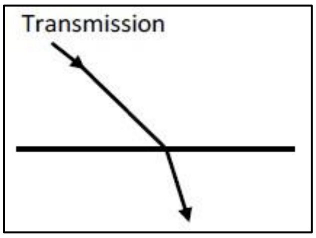
Scheme of energy flow in the solar reflection region

- **Interaction with the Target (C)**: once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation. Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface.

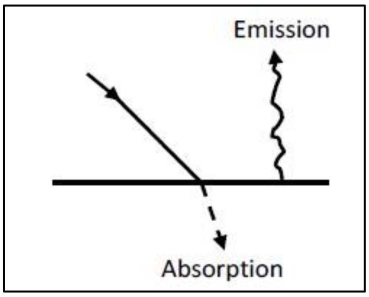
  There are three (3) forms of interaction that can take place when energy strikes. These are: absorption (A); transmission (T); and reflection (R).



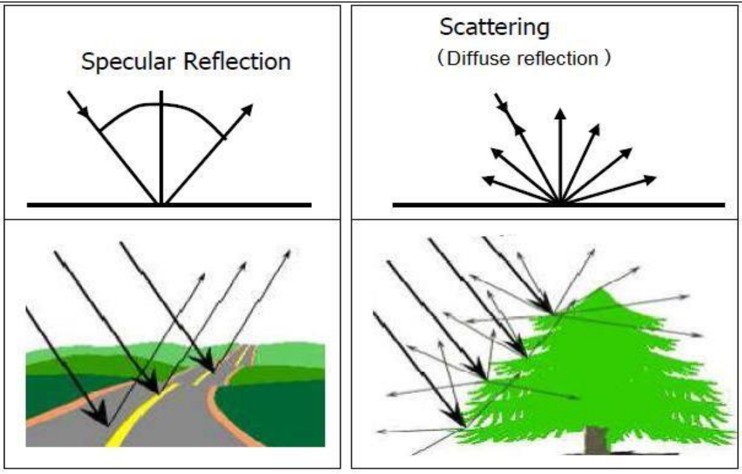
- **Transmission***:* Passes through a material (or through the boundary between two materials) with little change in intensity.



- **Absorption:** Usually wavelength-specific: that is, more energy is absorbed at some wavelengths than at others. Transformed into heat energy, which raises the material's temperature.



- **Reflection:** (depends on angle of incidence, wavelength of light and type of surface). If the surface is smooth at a scale comparable to the wavelength of the incident energy, **specular reflection** occurs: most of the energy is reflected in a single direction, at an angle equal to the angle of incidence. Rougher surfaces cause **scattering**, or **diffuse reflection** in all directions.



A chemical compound in tree's leaves called chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects *green* wavelengths. Leaves appear "greenest "to us in the summer, when chlorophyll content is at its maximum. In autumn there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear *red or yellow* (yellow is a combination of red and green wavelengths).

Longer wavelength visible and near infrared radiation is absorbed more by *water* than shorter visible wavelengths. Thus, water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at *red* or *near infrared* wavelengths.

If there is *suspended sediment* present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of the water. The apparent colour of the water will show a slight shift to longer wavelengths. Suspended sediment can be easily confused with shallow (but clear) water, since these two phenomena appear very similar.

Chlorophyll in *algae* absorbs more of the blue wavelengths and reflects the green, making the water appear *more green* in colour when algae is present. The topography of the water surface (rough, smooth, *floating materials*, etc.) can also lead to complications for water related interpretation due to potential problems of specular reflection and other influences on colour and brightness.

We can see from these examples that, depending on the complex make-up of the target that is being looked at, and the wavelengths of radiation involved, we can observe very different responses to the mechanisms of absorption, transmission, and reflection.

Scattering occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path. How much scattering takes place depends on several factors including the wavelength of the radiation, the abundance of particles or gases, and the distance the radiation travels through the atmosphere. **There are three (3) types of scattering which take place**:

Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules. Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere. The fact that the sky appears "blue" during the day is because of this phenomenon.

Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapours are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast.

Non-selective scattering occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering. Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+ green+ red light = white light).

- **Recording of Energy by the Sensor (D)**: after the energy has been scattered by, or emitted from the target, we require a sensor to collect and record the electromagnetic radiation.

- **Transmission, Reception, and Processing (E):** the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

- **Interpretation and Analysis (F)**: the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

- **Application (G)**: the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

Theoretical learning Activity

- ✓ Brainstorming on elements of a remote sensing system
- ✓ Group discussion on elements of a remote sensing system

Points to Remember (Take home message)

- ✓ Identify elements of a remote sensing system:
  - Energy source
  - Radiation and Atmosphere
  - Target interaction
  - Energy recording (sensor)
  - Transmission, reception and processing
  - Analysis and interpretation
  - Applications

Content 1.3.2: stage in remonte sensing process

Remote sensing process is done in the following five stages, from the fist to the last:

- Emission of electromagnetic radiation, or EMR (sun/self-emission)
- Transmission of energy from the source to the surface of the earth, as well as absorption and scattering
- Interaction of Electromagnetic Radiation with the earth's surface: it comprises of reflection and emission
- Transmission of energy from the surface to the remote sensor
- Sensor data output: here, we apply the information we have been able to extract n form of image, videos, sound, weather condition, etc. (Sabins 1997)

Theoretical learning Activity

- ✓ Group discussion stage in remonte sensing process
- ✓ Brain storming on stage in remonte sensing process

Points to Remember (Take home message)

- ✓ stage in remonte sensing process.

Learning outcome 1.3 formative assessment

Written assessment

Q1. Identify five (5) remote sensing components

Answers:

- ✓ Sensor
- ✓ Ennery source
- ✓ Transmission path
- ✓ Target
- ✓ Platform

Q2. Define the term

a. Remote

b. Sensors

Answer:

a. **Remote** means not in contact with the target/object.

b. **Sensors** are common devices used to detect a change in a physical state and quantify the measurement results in a particular scale or range

Q3. Answer by true (**T**) or false (**F**)

a. Remote sensing offers the ability to observe and collect data for large areas relatively quickly, and is an important source of data for Geographic Information System.

b. The remotely collected data which cannot be of many forms, including variations in force distributions, gravity, acoustic wave distribution or electromagnetic (EM) energy distributions.

c. Remote sensing is being used very widely, to obtain information accurately, with speed and ease, about the vast stretch of land features and water bodies of the earth

d. Scattering occurs when particles or large gas molecules absent in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path

Answer

a. True
b. False
c. True
d. False

Learning unit 2: Identify Sensor and Platform system in remote sensing

Picture/s reflecting the Learning unit 2

space borne platforms – satellite

Structure of Learning unit

Learning outcomes: 2.1: Identify remote sensors 2.2: Identify sensor platforms categories 2.3: Identify images resolution

Learning outcome 2.1: Identify remote sensors

Duration: 3hrs
Learning outcome 2.1objectives: By the end of the learning outcome, the trainees will be able to: 1. Identify remote sensors according to their work 2.Identify clearly remote sensing types 3.Describe remote sensor classification

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ White board ✓ Duster ✓ Notebook ✓ Books	✓ Maker pen ✓ Paper ✓ Pens ✓ Internet

Advance preparation:

- ✓ Hand out notes is available
- ✓ Pictures of remote sensing sensors are available.

Content 2.1.1: Remote sensor types

Two types of remote sensors are identified: *active* and *passive* remote sensors.

An example of an active sensor is *a large rangefinder.* Another very common active sensor is *a camera with a flash light* (operated at night). Laser and Radar are the most recognizable active sensors for geospatial data acquisition (GDA). A *camera without flash* is a passive sensor.

- **Passive** remote sensing systems record EMR that is *reflected* (e.g., blue, green, red, and near-infrared light) or *emitted* (e.g., thermal infrared energy) from the surface of the Earth.

- **Active** remote sensing systems are not dependent on the Sun's EMR or the thermal properties of the Earth. Active remote sensors create their own electromagnetic energy that:
    - is transmitted from the sensor toward the terrain
    - interacts with the terrain producing a backscatter of energy
    - is recorded by the remote sensor's receiver.

Advantages of Active Remote Sensing:

- All weather, day-and-night imaging capacity
- Sending and receiving EMR that can pass through cloud, precipitation
- Images can be obtained at user-specified times, even at night.
- Sending and receiving EMR that can penetrate tree canopy, dry surface, deposits, snow …
- Permits imaging at *shallow look angles*, resulting in different perspectives that cannot always be obtained using aerial photography.
- Providing information on surface roughness, dielectric properties, and moisture content.

The most widely used active remote sensing systems include:

1. **Active microwave** (RADAR= **Ra**dio **D**etection **a**nd **R**anging), which is based on the transmission of long wavelength microwave (e.g., 3-25 cm) through the atmosphere and then recording the amount of energy backscattered from the terrain.

2. **LIDAR (Li**ght **D**etection **And R**anging**)**, which is based on the transmission of relatively short wavelength laser light (e.g., 0.90 μm) and then recording the amount of light backscattered from the terrain;

3. **SONAR (So**und **Na**vigation and **R**anging), which is based on the transmission of sound waves through a water column and then recording the amount of energy backscattered from the bottom or from objects within the water column.

Theoretical learning Activity

- ✓ Group discussion Remote sensor types

Points to Remember (Take home message)

- ✓ Advantages of Active Remote Sensing
- ✓ Remote sensor types:
  - Passive sensor
  - Active sensor

Content 2.1.2: Remote sensor classification

We can distinguish three classes of remote sensors: altimeters, spectrometers, and radiometers.

- ✓ **Altimeter**: Laser and Radar altimeters are non-imaging sensors, providing us with information on elevation of water and land surfaces.
- ✓ **Radiometers:** they measure radiance and typically sense in one broad spectral band or in only a few bands, but with high radiometric resolution. Radiometers have a wide application range; they are used to detect forest, soil moisture and plant response, monitor ecosystem dynamics, analyse energy balance and sea surfaces, etc.
- ✓ **Spectrometers**: They measure radiance in many narrow, contiguous spectral bands, thus have a high spectral resolution. Their spatial resolution is moderate to low. The prime use of image spectrometers is identifying surface materials from mineral composition of soils to suspended matter concentration of surface water and chlorophyll contents. (J.E.conel 1987)

Theoretical learning Activity

- ✓ Brainstorming on Remote sensor classification

Points to Remember (Take home message)

- ✓ Remote sensor classification

Learning outcome 2.1formative assessment

Written assessment:

Q1. What are the Benefits of using active over passive sensor?

Answer

- All weather, day-and-night imaging capacity
- Sending and receiving EMR that can pass through cloud, precipitation
- Images can be obtained at user-specified times, even at night

Q2. The followings are types of remote sensors: LIDAR, LADAR, Sonar, X-ray, Photographic camera, Electric field sensing, Human eye, Earth classify them according to their types.

Answer:

Active sensor	**Passive sensor**
LADAR	Photographic camera
LIDAR	Electric field sensing
Sonar	Human eye
X-ray	Earth

Q3. Distinguish between the classifications of plat form according to their position

Answer:

- Space borne: 200 - 1.000 km
- (Geo-stationary) Airborne: 36.000 km
- Spaceborne :2 - 20 km
- Terrestrial : 0 km

Q4. Explain the following terms

a) Passive sensor:
Answer: Passive sensors detect energy emitted or reflected from an object, and include different types of radiometers and spectrometers

b) Active sensor:
Answer: Active remote sensing instruments operate with their own source of emission or light

Q5) Answer true or false

a) RADAR is Radiographic detection and Ranging?
b) Active remote sensors create their own electromagnetic energy?

Answer:

c) False
d) True

Q6) is human eye passive sensor? If yes justify your answer.

Answer

Yes, Human eyes are passive sensors because they collect energy (visible wave lengths) generated by the sun or another external source**.**

Learning outcomes: 2.2: Identify sensor platforms categories

Duration: 3hrs
Learning outcome 2.2 objectives: By the end of the learning outcome, the trainees will be able to: 1. Identify sensor platform categories according to their location. 2.discuss on sensors platform categories 3.Identify clearly orbit types 4.Describe satellite’s characteristics

Resources:		
Equipment	**Tools**	**Materials**
✓ Computer ✓ Projector ✓ Printer	✓ White board ✓ Duster ✓ Notebook ✓ Books	✓ Maker pen ✓ Paper ✓ Pens ✓ Internet

Advance preparation:

- ✓ Hand out notes is available.
- ✓ Video show on sensors platforms type.

Content 2.2.1: Identify sensor platforms categories

Depending on altitude (at what height a platform is located) platforms are classified into 3 types:

- ✓ Ground based sensor platforms
- ✓ Airborne sensor platforms
- ✓ Space borne sensor platforms

- **Ground Borne platforms:** A wide variety of platforms that operates being hand held or mounted on tripods, towers and cranes. These platforms are primary located on the ground. Some of these platforms are placed at certain height, however still they take the support from the ground.

If remote sensing is performed using ground borne platforms, it is called as *ground borne remote sensing.*

Examples of these platforms include *handheld cameras, cameras mounted on vehicles, towers, cranes* etc.

Cameras mounted on vehicle

As the height of photography is very less, the captured data is normally of very high resolution. Very less area is covered in a single capture. Hence, to study a large area many photographs are required. This data is very simple to understand as it directly represents the objects on the ground. More time is required for capturing a large city.

- **Air Borne Platforms:** These are platforms which are present a relatively higher altitude from the ground surface. As the name says, they are practically present in the air at the time of photography (data capture). The height of platforms used for photography or remote sensing ranges from few meters (in case of drones) to few kilometers (in case of aero-planes).

If remote sensing is performed using air borne platforms, it is called as air borne remote sensing.

Examples for airborne platforms include aerial cameras and sensors mounted on aeroplanes, helicopters, drones, etc.

As platform altitude is increased compared with ground borne platforms, here more area coverage is possible in a single instance, less time and with less number of photographs. The photographs captured can be understood by common public also, however in some instances there will be some difficulties depending on resolution of image (size of objects appearing in photos).

airborne platforms – drone camera

However, it is not possible to totally control the remote sensing process, as the sensors are present in air. It is practically not possible to maintain complete uniform velocity and smooth propagation of an aero plane (platform) during the photography. Due to wind and platform perturbations some amount distortions are observed in the aerial photographs. The distortions include crab, drift etc. The applications of this type of air borne platform based remote sensing include *reconnaissance surveys, disaster management, aerial surveys* etc.

- **Satellite or Space Borne Platforms***:* These platforms are present at a great height from the earth surface. The altitude of platforms range from few hundred kilometers to several thousand kilometers. Example for these platforms include satellites, space shuttles, rockets, etc.

space borne platforms – satellite

Polar orbiting satellites (i.e., platforms) revolve around the earth in an orbit ranging from few hundred kilometers to few thousand kilometers, whereas geo synchronous satellites used in remote sensing orbit at a height of 36,000 kilometers approximately. These satellites while moving in the orbits around the earth capture data continuously and transmits the same to ground stations.

A large area (sometimes entire city or country) can be captured in a single scene (or photo) depending on altitude and resolution of sensor. For example, geosynchronous satellites capture approximately 50% of the earth surface in a single scene.

Theoretical learning Activity

- ✓ Group discussion on sensor platforms categories

Points to Remember (Take home message)

- ✓ sensor platforms categories:
  - Ground based sensor platforms
  - Airborne sensor platforms
  - Space borne sensor platforms

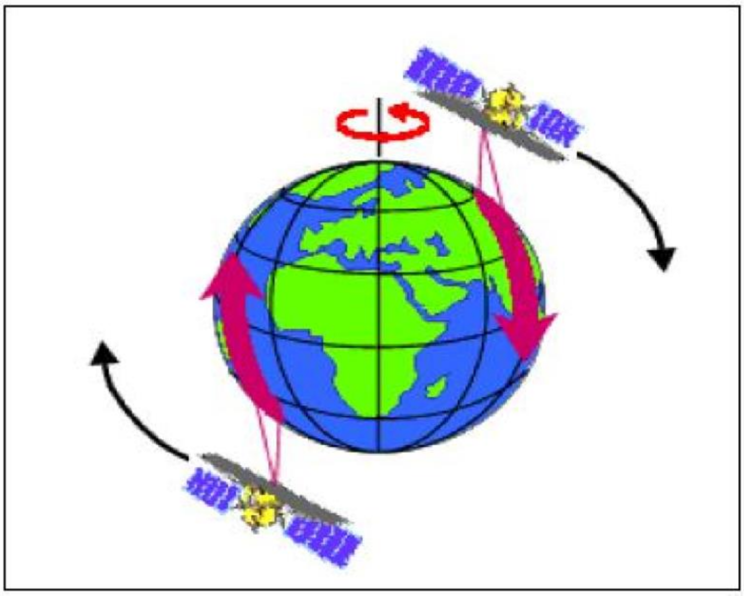
Content 2.2.2: Identification of satellite's Orbit types

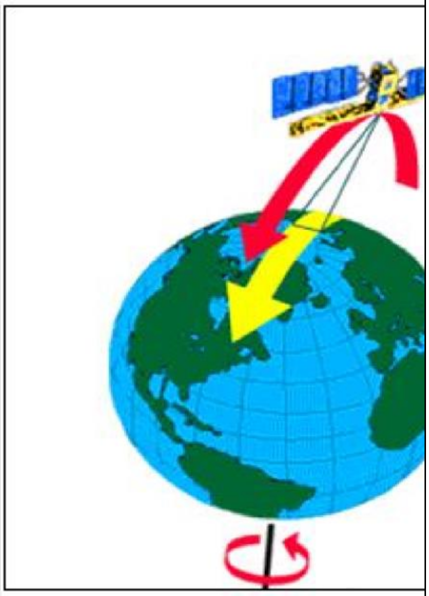
An orbit is a circular or elliptical path described by the satellite in its movement round the earth. Different types of orbits are required to achieve continuous monitoring (meteorology), global mapping (land cover mapping), or selective imaging (urban areas for example).

The following orbits are most common for remote sensing missions:

- ✓ **Polar orbit** *(*Near-polar orbit/ Sun-synchronous orbit*)*:

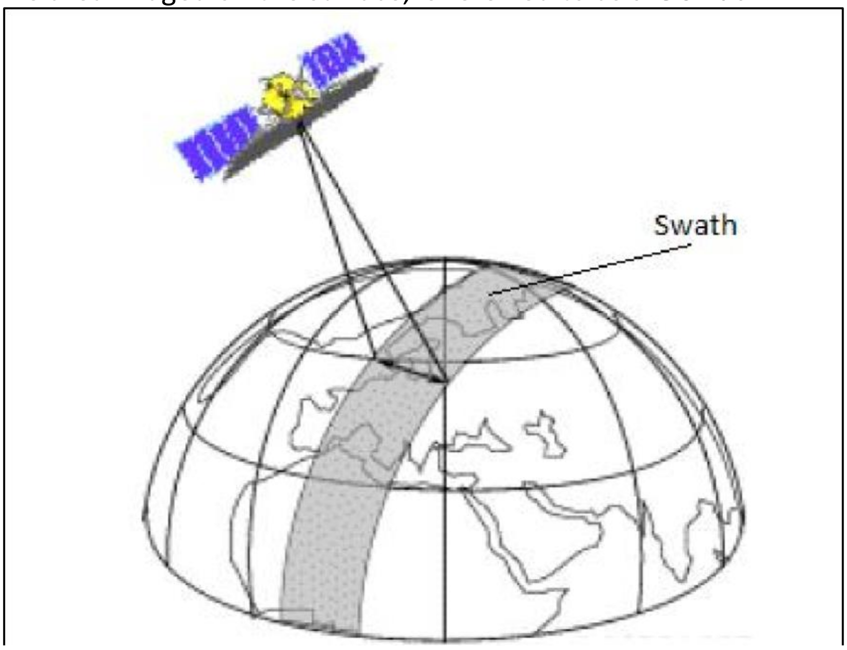
Many remote sensing platforms are designed to follow an orbit (basically north-south) which allows them to cover most of the Earth's surface over a certain period of time. These are near-polar orbits, so named for the inclination of the orbit relative to a line running between the North and South poles, with an inclination angle between 80° and 100°. The satellite is typically placed in an orbit at 600km to 1000km altitude.





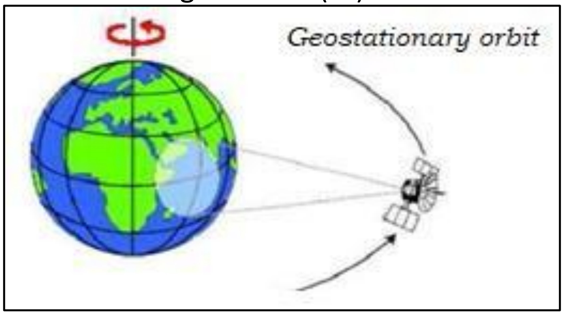
Most of the remote sensing satellite platforms today are in near-polar orbits, which means that the satellite travels northwards on one side of the Earth and then toward the southern pole on the second half of its orbit. These are called ascending and descending passes, respectively. If the orbit is also sunsynchronous, the ascending pass is most likely on the shadowed side of the Earth while the descending pass is on the sunlit side.

Sensors recording reflected solar energy only image the surface on a descending pass, when solar illumination is available. Active sensors which provide their own illumination or passive sensors that record emitted (e.g. thermal) radiation can also image the surface on ascending. As a satellite revolves around the Earth, the sensor sees a certain portion of the Earth's surface. The area imaged on the surface, is referred to as ***the swath***.



✓ **Geostationary orbit**

Imaging swaths for space borne sensors generally vary between tens and hundreds of kilometers wide. Satellites at very high altitudes, which view the same portion of the Earth's surface at all times have geostationary orbits. These **geostationary satellites**, at altitudes of approximately 36,000 kilometers, revolve at speeds which match the rotation of the Earth so they seem stationary, relative to the Earth's surface. This allows the satellites to observe and collect information continuously over specific areas. Its inclination angle is Zero (0^o).



Weather and communications satellites commonly have these types of orbits. Due to their high altitude, some geostationary weather satellites can monitor weather and cloud patterns covering an entire hemisphere of the Earth. The satellite in this orbit offers a continuous hemispherical view of almost half the Earth (45%), while the polar orbiters offer a higher spatial resolution.

Theoretical learning Activity

✓ Brainstorming on satellites orbit characteristics

Points to Remember (Take home message)

Types of orbits:

- Polar orbit
- Geostationary orbit

Content 2.2.3: satellite's Orbit characteristics

The monitoring capabilities of a satellite sensor are to a large extent determined by the parameters of the satellite's orbit. For earth observation purposes, the following orbit characteristics are relevant:

- **Altitude:** is the distance (in km) from the satellite to the surface of the earth. It influences to a large extent the area that can be viewed (means "spatial coverage") and the details that can be observed (means "spatial resolution"). In general, the higher the altitude the larger is the spatial coverage but the lower the spatial resolution.
- **Inclination angle:** is the angle (in degrees) between the orbital plane and the equatorial plane. The inclination angle of the orbit determines, together with the field of view of the sensor, the altitude up to which the earth can be observed.
- **Period:** is the time (in minutes) required to complete one full orbit.
- **Repeat time:** is the time (in days) between two successive identical orbits.
- **Revisit time:** is the time between two subsequent images of the same area.
- **Pointing capability:** is the possibility of sensor to look to the side, forward or backward, not only vertically down. Many of the modern satellites have this capability

(A 2011)

Theoretical learning Activity

- ✓ Brainstorming satellite's Orbit characteristics

Points to Remember (Take home message)

- ✓ satellite's Orbit characteristics:
  - Altitude
  - Inclination angle
  - Period
  - Repeat time
  - Revisit time

- Pointing capability

Learning outcome 2.2formative assessment

Written assessment:

Q1. Define the term orbit?

Answer: Satellites have several unique characteristics which make them particularly useful for remote sensing of the Earth's surface. The path followed by a satellite is referred to as its orbit. **Or** an orbit is a circular or elliptical path described by the satellite in its movement round the earth.

Q2. State five (5) satellite's Orbit characteristics

Answer:

a) Altitude
b) Inclination angle
c) Period
d) Repeat time
e) Repeat time

Q3) Identify three (3) sensor platforms categories

Answer

- Ground based sensor platforms
- Airborne sensor platforms
- Space borne sensor platforms

Learning outcomes: 2.3: Identify images resolution

Duration: 4hrs
Learning outcome 2.3objectives: By the end of the learning outcome, the trainees will be able to: 1.Adequate identification of images resolution according to sensor characteristics

Resources:

Equipment	**Tools**	**Materials**
✓ Computer ✓ Projector ✓ Printer	✓ White board ✓ Duster ✓ Notebook ✓ Books	✓ Maker pen ✓ Paper ✓ Pens ✓ Internet ✓ Satellite image ✓ Remote sensing image

Advance preparation:

- ✓ Hand out notes is available
- ✓ Satellite image is available

Content 2.3.1: Image Resolutions

Four types of image resolutions are identified: Spatial resolution, Spectral resolution, Radiometric resolution and Temporal resolution

- ✓ **Spatial resolution:**

Spatial resolution is the degree to which an image can differentiate spatial variation of terrain features. It is specified in "image pixel", and it depends on:

- Image scale: it decreases as the scale increases.
- Quality of optical system: higher lens quality gives better performance o

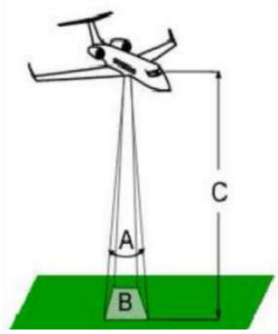
  Grain structure of film: the larger the grain the poorer the resolution

- Contrast of targeted object: the higher the target contrast, the better the resolution o Atmospheric scattering: scattering leads to loss of contrast and resolution
- Image motion: motion between camera and the ground causes blurring and loss of resolution

For some remote sensing instruments, the distance between the target being imaged and the platform, plays a large role in determining the detail of information obtained and the total area imaged by the sensor. Sensors on board platforms far away from their targets, typically view a larger area, but cannot provide great detail.

Compare what an astronaut on board the space shuttle sees of the Earth to what you can see from an airplane. The astronaut might see your whole province or country in one glance, but couldn't distinguish individual houses. Flying over a city or town, you would be able to see individual buildings and cars, but you would be viewing a much smaller area than the astronaut. There is a similar difference between satellite images and air photos.

The detail visible in an image is dependent on the spatial resolution of the sensor and refers to the size of the smallest possible feature that can be detected. Spatial resolution of passive sensors depends primarily on their Instantaneous Field of View (IFOV).



The IFOV (Instantaneous Field of View) is the angular cone of visibility of the sensor (A) and determines the area on the Earth's surface which is "seen" from a given altitude at one particular moment in time (B). The size of the area viewed is determined by multiplying the IFOV (Instantaneous Field of View) by the distance from the ground to the sensor (C). This area on the ground is called the resolution cell and determines a sensor's maximum spatial resolution. For a homogeneous feature to be detected, its size generally has to be equal to or larger than the resolution cell. If the feature is smaller than this, it may not be detectable as the average brightness of all features in that resolution cell will be recorded. However, smaller features may sometimes be detectable if their reflectance dominates within a particular resolution cell allowing subpixel or resolution cell detection.

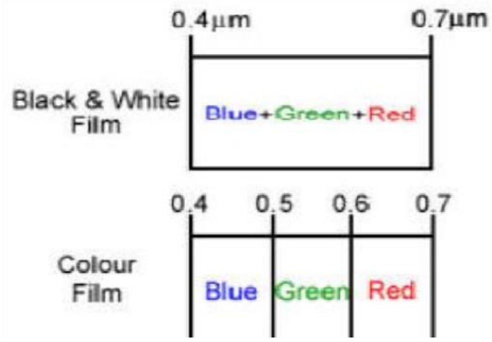
Most remote sensing images are composed of a matrix of picture elements, or **pixels**, which are the smallest units of an image. Image pixels are normally square and represent a certain area on an image. It is important to distinguish between pixel size and spatial resolution - they are not interchangeable. If a sensor has a spatial resolution of 20 meters and an image from that sensor is displayed at full resolution, each pixel represents an area of 20m x 20m on the ground. In this case the pixel size and resolution are the same. However, it is possible to display an image with a pixel size different than the resolution. Many posters of satellite images of the Earth have their pixels averaged to represent larger areas, although the original spatial resolution of the sensor that collected the imagery remains the same.

Images where only large features are visible are said to have coarse or low resolution. In fine or high resolution images, small objects can be detected. Military sensors for example, are designed to view as much detail as possible, and therefore have very fine resolution.

Commercial satellites provide imagery with resolutions varying from a few meters to several kilometers. Generally speaking, the finer the resolution, the less total ground area can be seen. The ratio of distance on an image or map, to actual ground distance is referred to as scale. If you had a map with a scale of 1:100,000, an object of 1cm length on the map would actually be an object 100,000cm (1km) long on the ground. Maps or images with small "map-to-ground ratios" are referred to as small scale (e.g. 1:100,000), and those with larger ratios (e.g. 1:5,000) are called large scale.

- ✓ **Spectral resolution:**

Spectral resolution is the degree to which the spectral response of a sensor is differentiated. It is specified as “band width”. Spectral resolution describes the ability of a sensor to define fine wavelength intervals.
The finer the spectral resolution, the narrower the wavelength ranges for a particular channel or band.



Black and white film records wavelengths extending over much, or the entire visible portion of the electromagnetic spectrum. Its spectral resolution is fairly coarse, as the various wavelengths of the visible spectrum are not individually distinguished and the overall reflectance in the entire visible portion is recorded. Color film is also sensitive to the reflected energy over the visible portion of the spectrum, but has higher spectral resolution, as it is individually sensitive to the reflected energy at the blue, green, and red wavelengths of the spectrum. Thus, it can represent features of various colors based on their reflectance in each of these distinct wavelength ranges.

Many remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions. These are referred to as multi-spectral sensors and will be described in some detail in following sections.

Advanced multi-spectral sensors called hyper spectral sensors, detect hundreds of very narrow spectral bands throughout the visible, near-infrared, and mid-infrared portions of the electromagnetic spectrum. Their very high spectral resolution facilitates fine discrimination between different targets based on their spectral response in each of the narrow bands.

- ✓ **Radiometric resolution:**

Radiometric resolution is the degree to which intensity levels of incident radiation are differentiated by the sensor. It is specified as “number of bits” used for storing a digital number (DN).
While the arrangement of pixels describes the spatial structure of an image, the radiometric characteristics describe the actual information content in an image. Every time an image is acquired on film or by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor the more sensitive it is to detecting small differences in reflected or emitted energy.
Imagery data are represented by positive digital numbers which vary from 0 to (one less than) a selected power of 2. This range corresponds to the number of bits used for coding numbers in binary format. Each bit records an exponent of power 2 (e.g. 1 bit=2 1=2). The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded. Thus, if a sensor used 8 bits to record the data, there would be 28=256 digital values available, ranging from 0 to 255. However, if only

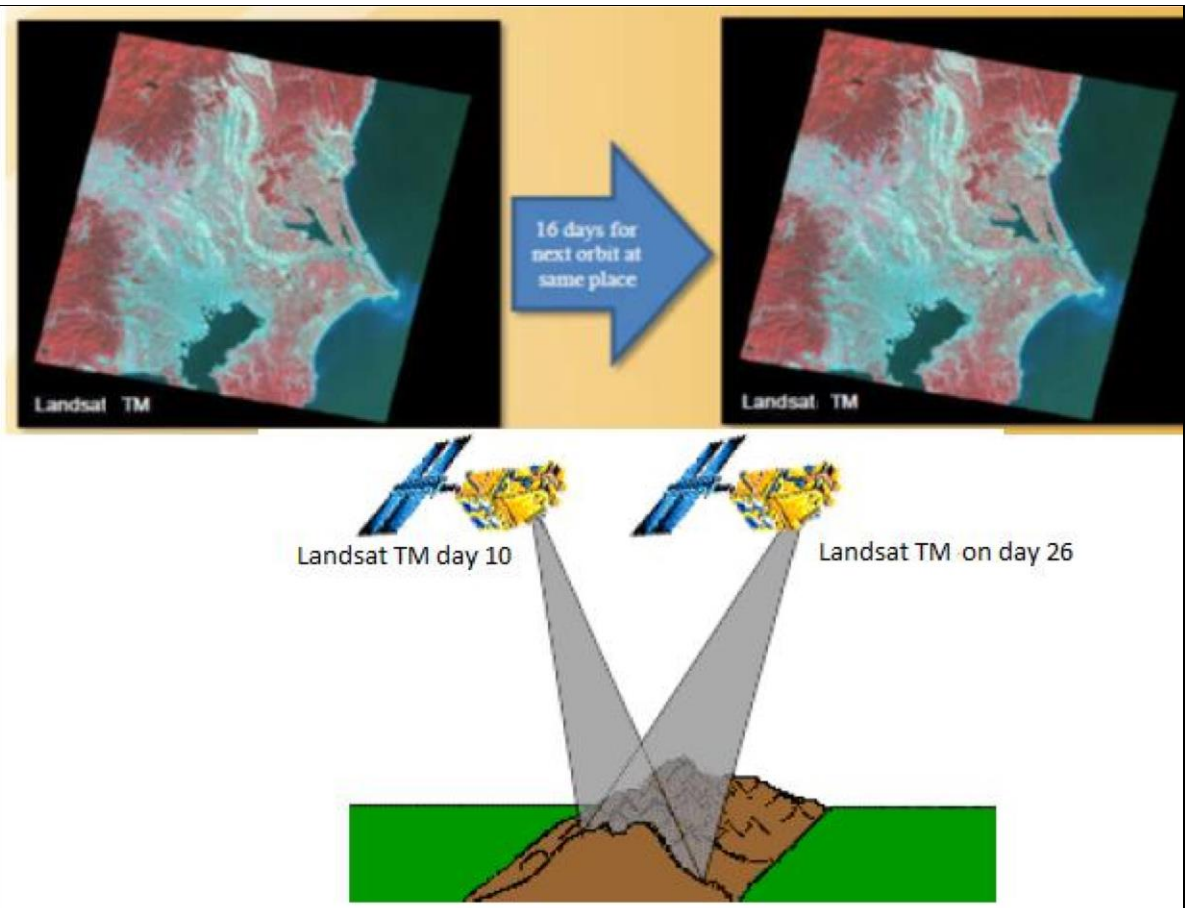
4 bits were used, then only 24=16 values ranging from 0 to 15 would be available. Thus, the radiometric resolution would be much less. Image data are generally displayed in a range of grey tones, with black representing a digital number of 0 and white representing the maximum value (for example, 255 in 8-bit data). By **comparing a 2-bit image with an 8-bit image**, we can see that there is a large difference in the level of detail discernible depending on their radiometric resolutions.

3. Temporal resolution:

The temporal resolution is the degree to which the global coverage is done. Usually expressed in number of days. The higher temporal resolution goes up to about global coverage within three days.

However, because of some degree of overlap in the imaging swaths of adjacent orbits for most satellites and the increase in this overlap with increasing latitude, some areas of the Earth tend to be re-imaged more frequently. Also, some satellite systems are able to point their sensors to image the same area between different satellite passes separated by periods from one to five days. Thus, the actual temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capabilities, the swath overlap, and latitude.

The ability to collect imagery of the same area of the Earth's surface at different periods of time is one of the most important elements for applying remote sensing data. Spectral characteristics of features may change over time and these changes can be detected by collecting and comparing multi-temporal imagery.
For example, during the growing season, most species of vegetation are in a continual state of change and our ability to monitor those subtle changes using remote sensing is dependent on when and how frequently we collect imagery.



By imaging on a continuing basis at different times we are able to monitor the changes that take place on the Earth's surface, whether they are naturally occurring (such as changes in natural vegetation cover or flooding) or induced by humans (such as urban development or deforestation).

The time factor in imaging is important when:

- Persistent clouds offer limited clear views of the Earth's surface (often in the tropics)
- Short-lived phenomena (floods, oil slicks, etc.) need to be imaged
- Multi-temporal comparisons are required (e.g. the spread of a forest disease from one year to the next)
- The changing appearance of a feature over time can be used to distinguish it from near similar features (wheat / maize) (jia. 2006)

Theoretical learning Activity

- Demonstration on different images resolution.

- Group discussion on image Characteristics.

Points to Remember (Take home message)

- ✓ Types of image resolution
  - Spatial resolution,
  - Spectral resolution,
  - Radiometric resolution and
  - Temporal resolution

Learning outcome 2.3 formative assessment

Written assessment:

Q1) the resolution of image is determined by:

a. The ration of pixels in proportion to image size

b. Pixels dimension

Respond if this statement is True or false

Answer: True

Q2) what are the factors affecting image resolution in remote sensing?

Answer:

Factors to consider when selecting remote sensing products include **spatial resolution, spectral resolution, radiometric resolution, and temporal resolution.**

Q3) how does one determine which image has more spatial resolution?

Answer

In short what spatial resolution refers to is that we cannot compare two different types of images to see that which one is clear or which one is not? If we have to compare the two images, to see which one is clearer or which has more spatial resolution, we have to

Q4) On which factor spatial resolution depends in an image

Answer

The spatial resolution of a grating spectrograph hyper spectral Imager is set by the size of the pixels of the CCD camera in the y- direction and the microscope system magnification.

Q5. Describe the merit and demerit of those types of visual image interpretation

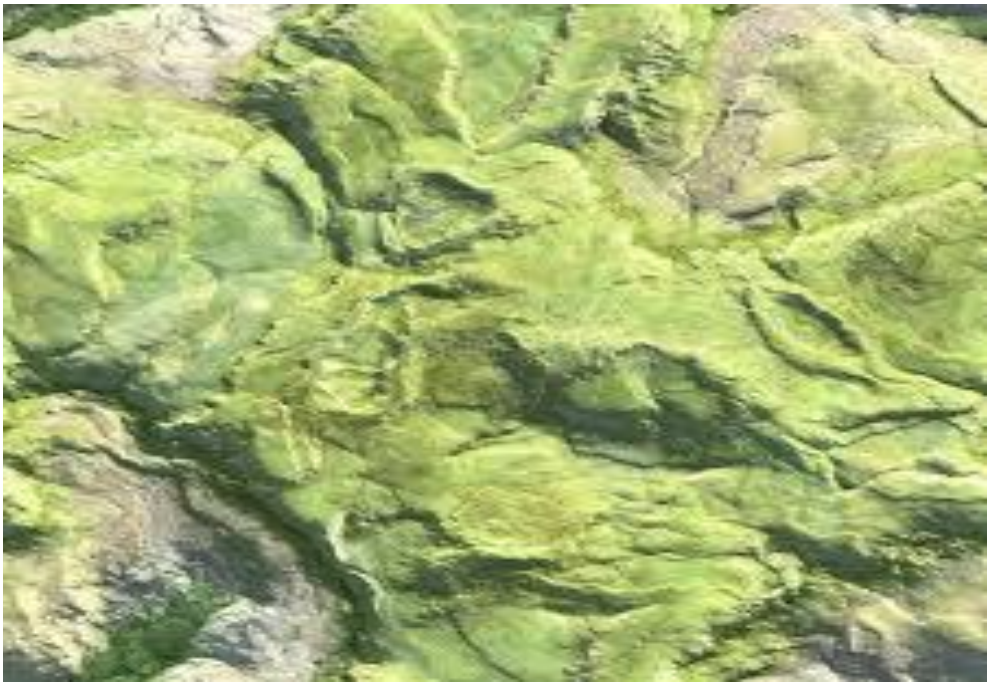
Answer:

	Visual (human) interpretation	**Digital interpretation**
Merit	• Image analyst's experience and knowledge is available • Very good for extraction of spatial information	• Time effective-requires much less time for interpretation • Results can be exactly reproduced for any number of times • Extraction of quantitative information is possible and easier
Demerit	• Time consuming • Interpretation results may vary with time and person depending upon their experience and knowledge	• Image analyst's experience and knowledge is not available • Poor in extracting spatial information

Learning unit 3: Perform visual image interpretation

Structure of learning unit

Picture/s reflecting the Learning unit 3



Learning outcomes: 3.1: Identify information needed for image interpretation 3.2: Classify images 3. 3: Interpret image 3. 4: Use stereoscope

Learning outcomes 3.1: Identify information needed for image interpretation

Duration : 4 hrs
Learning outcome 1 objectives : By the end of the learning outcome , the tnainees will be able to: 1. Identify information needed for image interpretations according to sensor type

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ Whiteboard/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ Hand out notes is available
- ✓ Remote sensing image is available

Content 3.1.1: Image interpretations information

Information needed for image interpretation are: **Physical, Semantic, Geometric, and Temporal information.**

Interpretation of remote sensing imagery involves the identification and/or measurement of various targets in an image in order to extract useful information about them.

Targets in remote sensing images may be any feature or object which can be observed in an image, and have the following characteristics:

- Targets may be a *point, line,* or *area feature*. This means that they can have any form, from a bus in a parking lot or plane on a runway, to a bridge or roadway, to a large expanse of water or a field.
- The target must be *distinguishable*; it must contrast with other features around it in the image.

Physical information involves the pattern, tone, texture, and resolution of an image. While **geometric information** relates to its size, shape and location.

Semantic information describes the visual content of an **image** by correlating low level features such as colour, gradient orientation with the content of an **image** scene. For example, correlate an extracted color such as blue with the sea or sky, white with a building, and so on. Temporal characterization occurs when you have a series of images taken at different time. The change can be identified between them. **Temporal information** therefore is a correlation between the images taken at different time at the same point.

Theoretical learning Activity

- Brainstorming on image interpretation information
- Group discussions on image interpretation information

Points to Remember (Take home message)

- ✓ Identification of Image interpretations information :
  - **Physical,**
  - **Semantic,**
  - **Geometric, and**
  - **Temporal information.**

Learning Outcome 3.2: Classify images

Duration : 4 hrs
Learning out come 3.2 objectives: By the end of the learning outcome, the trainees will be able to: 1. Classify images according to their properties.

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ Whiteboard/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ Hand out notes is available
- ✓ Remote sensing image is available

Content3.2.1 : Image classification criteria

Image classification is based on different main criteria. Some of them are: pixel value, feature space, clusters based, results validation and object oriented.

a) Pixel value: the digital number (DN) a pixel takes. It is the building cell of a digital image.

Pixel-based image classification is a powerful technique to derive thematic classes from multiband images. However, it has certain limitations that you should be aware of. The most important constraints are that:

1. it results in spectral classes; and
2. Each pixel is assigned to one class only.

Spectral classes are classes that are directly linked to the spectral bands used in the classification. In turn, these are linked to surface characteristics. In this respect, you can say that spectral classes correspond to land cover classes. Sometimes one could be interested in land use classes rather than land cover classes.
Because sometimes, a land use class may comprise several land-cover classes.

b) Feature space: The mathematical space describing the combination of observations (DN values in the different bands) of a multispectral or multiband image. A single observation is defined by a feature vector.

The mathematical space describing the combinations of observations (DN values in the different bands) of a multispectral or multi-band image. Defining clusters in image will be necessary. The objective of cluster definition is to assemble a set of statistics that describe the spectral response pattern for each land cover type that occurs in the image.

c) Cluster: The term used in the context of image classification to indicate "a concentration of observations (points in the feature space) related to a training class.

Clustering procedures are methods that have been applied in many data analysis fields to enable inherent data structures to be determined. In this technique an image is segmented into unknown classes. Clusters are defined by selecting homogeneous areas in the image and assigning a class name. Classes should be well separated from each other. Display of different sample classes in the feature space assists in the evaluation of the clusters. We use distance or cluster parameters in the feature space to accomplish classification.

d) **Result validation:** Image classification results in a raster file in which the individual raster elements are class labelled. As image classification is based on samples of the classes, the actual quality of the classification result should be checked. This is usually done by a sampling approach in which a number of raster elements of the output is selected and both the classification result and the true world class are compared.

Comparison is done by creating a correlation matrix from which different accuracy measures can be calculated. The `true world class' is preferably derived from field observations.

e) **Object oriented:** However, to distinguish for example urban from rural woodland, or a swimming pool from a natural pond, an approach similar to the visual interpretation is needed.

Object-oriented image analysis (OOA), also called segmentation-based analysis, allows us to do that. Instead of trying to classify every pixel separately and only based on their spectral information, OOA breaks down an image into spectrally homogeneous segments that correspond to fields, tree stands, buildings, etc. It is also possible to use auxiliary GIS layers, for example building footprints, to guide this segmentation.

Theoretical learning Activity

✓ Brainstorming on image classification criteria

Points to Remember (Take home message)

✓ Identification of image classification criteria :
- pixel value,
- feature space,
- clusters based,
- results validation and object oriented.

Content 3.2.2: Two approaches used in image classification

Two approaches used in image classification are: supervised and unsupervised classification.

✓ **SUPERVISED CLASSIFICATION**

An important assumption in statistical supervised classification usually adopted in remote sensing is that each spectral class can be described by a probability distribution in multispectral space: this will be a multivariable distribution with as many variables as dimensions of the space. Such a distribution describes the chance of finding a pixel belonging to that class at any given location in multispectral space.

This is not unreasonable since it would be imagined that most pixels in a distinct cluster or spectral class would lie towards the center and would decrease in density for positions away from the class center, thereby resembling a probability distribution. The distribution found to be of most value is the normal or Gaussian distribution. It gives rise to tractable mathematical descriptions of the supervised classification process, and is robust in the sense that classification accuracy is not overly sensitive to violations of the assumptions that the classes are normal.

Supervised classification is the procedure most often used for quantitative analysis of remote sensing image data. It rests upon using suitable algorithms to label the pixels in an image as representing particular ground cover types, or classes. The essential practical steps usually include:

1. **Decide the set of ground cover types into which the image is to be segmented.** These are the information classes and could, for example, be water, urban regions, croplands, rangelands, etc.

2. **Choose representative or prototype pixels from each of the desired set of classes.** These pixels are said to form *training data.* Training sets for each class can be established using site visits, maps, air photographs or even photointerpretation of a colour composite product formed from the image data. Often the training pixels for a given class will lie in a common region enclosed by a border.
   That region is then often called a *training field.*

3. **Use the training data to estimate the parameters of the particular classifier algorithm to be used**; these parameters will be the properties of the probability model used or will be equations that define partitions in the multispectral space.

The set of parameters for a given class is sometimes called the *signature* of that class.

4. **Using the trained classifier, label or classify every pixel in the image into one of the desired ground cover types (information classes).** Here the whole image segment of interest is typically classified. Whereas training in Step 2 may have required the user to identify perhaps 1% of the image pixels by other means, the computer will label the rest by classification.
5. **Produce tabular summaries or thematic (class) maps which summarize the results of the classification.**
6. **Assess the accuracy of the final product using a labelled testing data set.**

✓ **UNSUPERVISED CLASSIFICATION**

Unsupervised classification is a means by which pixels in an image are assigned to spectral classes without the user having foreknowledge of the existence or names of those classes. It is performed most often using clustering methods.

These procedures can be used to determine the number and location of the spectral classes into which the data falls and to determine the spectral class of each pixel. The analyst then identifies those classes afterwards by associating a sample of pixels in each class with available reference data, which could include maps and information from ground visits.

Clustering procedures are generally computationally expensive yet they are central to the analysis of remote sensing imagery. While the information classes for a particular exercise are known, the analyst is usually totally unaware of the spectral classes, or sub-classes as they are sometimes called.

Unsupervised classification is therefore useful for determining the spectral class composition of the data prior to detailed analysis by the methods of supervised classification.

Theoretical learning Activity

Brainstorming on image classification criteria

•

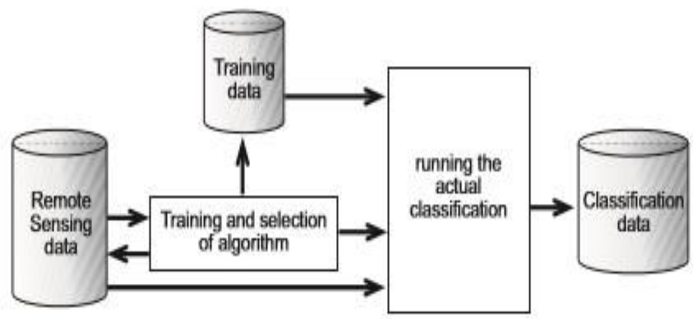
Points to Remember (Take home message)

- ✓ Two approaches used in image classification:
  - supervised classification
  - unsupervised classification.

Content 3.2.3: five steps of image classification

The process of image classification typically involves five steps:

1. **Selection and preparation of remote sensing images:** Depending on the land cover types or whatever needs to be classified, the most appropriate sensor, the most appropriate date(s) of acquisition and the most appropriate wavelength bands should be selected.



2. **Definition of the clusters in the feature space:** Here, two approaches are possible: supervised and unsupervised classification. In the supervised classification, the operator defines the clusters during the training process while in an unsupervised classification a clustering algorithm automatically finds and defines a number of clusters in the feature space.

3. **Selection of classification algorithm:** Once the spectral classes have been defined in the feature space, the operator needs to decide on how the pixel are assigned to the classes.

4. **Running the actual classification:** Once the training data have been established and the classifier algorithm selected, the actual classification can be carried out. Based on its DNs, each "multiband pixel" (cell) in the image is assigned to one of the predefined classes.

5. **Validation of the result:** the quality is assessed by comparing it to reference data (ground truth). This requires selection of a sampling technique, generation of an error matrix, and the calculation of error parameters.

Theoretical learning Activity

✓ Group discussion on images classification process

Practical learning Activity

✓ Practical exercises on images classification process

Points to Remember (Take home message)

✓ five steps of image classification:
1. Selection and preparation of remote sensing images
2. Definition of the clusters in the feature space
3. Selection of classification algorithm
4. Running the actual classification
5. Validation of the result

Learning outcome 3.2 formative assessment

Written assessment

Q1. The followings are five steps of image classification except:

1. Selection and preparation of remote sensing images
2. results Definition of the clusters in the feature space
3. Selection of classification algorithm
4. Running the actual classification
5. Validation of the result
6. Produce image results

Answer: Produce image results

Q2. how many approaches used in image classification and list them?

Answer: there two approaches used in image classification which are:

supervised and **unsupervised** classification

Learning Outcome3.3: Interpret image

Duration : 4 hrs
Learning outcome 3.3 objectives: By the end of the learning outcome, the trainees will be able to: 1. Proper identification of information needed for image interpretations according to sensor type

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ White board/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ Hand out notes is available
- ✓ Remote sensing image is available

Content 3.3.1: visual interpretation elements

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.

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 seven visual interpretation elements which are: tone/hue, shape, size, pattern, texture, shadow, and association/location.

1. **Tone** refers to the relative brightness or color 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.

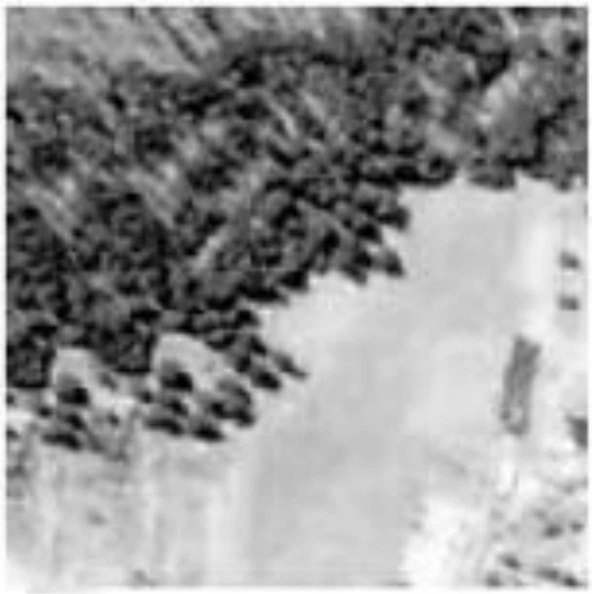
2. **Shape** refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

3. **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 the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly. For example, if an interpreter

had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

4. **Pattern** refers to the spatial arrangement of visibly discernible objects. Typically, an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Below, Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern.

5.Texture refers to the arrangement and frequency of tonal variation in particular areas of an image. 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. 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. Texture is one of the most important elements for distinguishing features in radar imagery.



6.Shadow/Height/Elevation: shadow is also helpful 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, particularly in radar imagery.

Height differences are important for distinguishing between different vegetation types, building types, etc. *Elevation* differences provide us with cues in geomorphological mapping. We need a ***stereoscopic viewing*** to observe height and elevation. It facilitates interpretation of both natural and manmade features.

7.Association/Location: association 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.

In the example given above, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields. In our example, a lake is associated with boats, a marina, and adjacent recreational land.

Theoretical learning Activity

- ✓ Group discussion on images interpretation using visual elements

Practical learning Activity

- ✓ Practical exercises on images interpretation using visual elements

Points to Remember (Take home message)

- ✓ **visual interpretation elements:**
  - tone/hue,
  - shape,
  - size,
  - pattern,
  - texture,
  - shadow, and
  - association/location.

ntent 3.3.2. Methods of extraction information from remote

In general, the information extraction methods from Remote sensing images form two groups:

- ➢ information extraction based on visual **image interpretation** (e.g. for land use or soil mapping and acquisition of data for topographic mapping from aerial photographs);
- ➢ **Image classification** based on semi-automatic processing by the computer (e.g. digital image classification and calculation of surface parameters).

1. Image interpretation

The most intuitive way to extract information from remote sensing images is by visual image inspection and interpretation**,** which is based on the human ability to relate colors and patterns in an image and to real world features.

We can interpret images displayed on a computer monitor or images given in a hardcopy form.

Explanation can be done:

- on a transparency overlaid on an aerial photograph or hardcopy of the satellite image; or
- by digitizing either on-screen, or using a digitizer tablet when we have a hardcopy image.

Instead of interpreting and digitizing on a single image, we can use a stereo-image pair**.** The interpretation process is the same, we only need special devices for stereoscopic display and viewing, and equipment that allows us to properly measure in a stereogram.

Visual image interpretation is not as easy as it may seem; it requires training. Yet the human eye-brain system
is well capable of doing the job. In analyzing an image, typically you can be somewhere between the following two situations:

- ✓ Direct and spontaneous recognition**:** Direct and spontaneous recognition, refers to the ability of an interpreter to identify objects or features at first glance. Agronomists will immediately recognize the pivot irrigation systems with their circular shape. They are able to do so because of earlier (professional) experience. Similarly, most people can directly relate what they see on an aerial photo to the terrain features of their place of living (because of 'scene knowledge').

The quote from people that are shown an aerial photograph for the first time "I see because I know" refers to this spontaneous recognition.

- ✓ Logical inference: Logical inference, needing several clues to draw conclusions through a reasoning process. Logical inference means that the interpreter applies reasoning.

In the reasoning, the interpreter uses acquired professional knowledge and experience. What is the white rectangle? Based on the connecting white line (probably track) from another straight line (probably road) the conclusion can be that it is a house or a building.

With visual image interpretation we consider each element in terms of its spectral appearance but also in terms of its shape and texture, and within its environment. The use of all seven image interpretation elements (tone, shape, size, location, pattern, …) is the strength of visual image interpretation. In standard digital image classification, only color is utilized, which explains the limitations of automated methods compared to visual image interpretation.

2. Image classification

Image classification uses the differences in spectral characteristics of materials of the Earth's surface. Multispectral image data captures some of those differences. Here you will focus on the classification of multispectral data.

The principle of image classification is that a pixel is assigned to a class on the basis of its combination of spectral band values. Doing so for all pixels will result in a classified image.
The crucial point of image classification is in comparing the pixel values to predefined clusters, which requires definition of the clusters and methods for comparison.

The image classification may be done any of the following technique. Some were explained in previous learning outcomes: Classification using Feature space, Classification using result validation, Classification with Pixel-based, classification based on algorithms, and Classification by object-oriented

Theoretical learning Activity

- Group discussion methods of extraction information from remote.

Points to Remember (Take home message)

- ✓ Methods of extraction information from remote

Learning Outcome 3.4: Use stereoscope

Duration : 4 hrs
Learning outcome3. 4 objectives: By the end of the learning outcome, the trainees will be able to: 1. Efficient use of stereoscope according to their working principles

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ White board/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ Hand out notes is available
- ✓ Satellite image is available

content 3.4.1 types of stereoscope

A **stereoscope** is a device consisting of a binocular and two mirrors so that we can put two images next to each other to achieve stereoscopic vision. We can also use it to view paper prints of stereo photographs. **Stereo** (Short for stereoscopic) viewing gives a three-dimensional impression.

Stereoscopy is the science of producing three-dimensional visual models using two-dimensional images.

We can make use of stereoscopy to make 3D measurements of objects.

a. Types of stereoscope:

Two types of stereoscope are existing: **Lens stereoscope** and **Reflecting (Mirror) stereoscope**

Lens Stereoscope

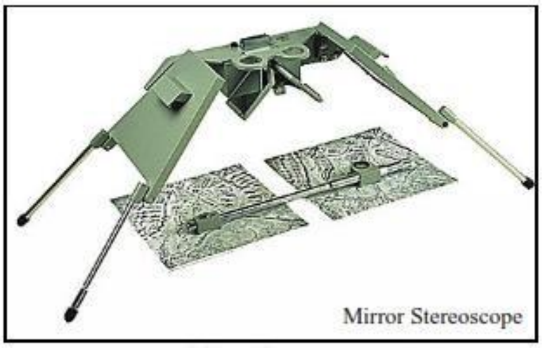
The simple and least expensive equipment for viewing the three-dimensional image from aerial photography is the lens stereoscope. It consists of a pair of lenses mounted on a frame, which is supported over the photographs by a thin metal leg.

Lens or Pocket Stereoscope

The lens separation may be fixed for the average human eye separation, but more usually, the separation may be varied to suit the eye base of the user. When the lens stereoscope is set up, the distance from the lens to the photograph will be equal to the focal length of the lenses, so that the photographic image will appear sharp in the focal plane of the lenses.
The user has to arrange the photographs below the lenses, so that the appropriate eye is viewing the same detail in the appropriate photograph at the same time. It is necessary to place one photograph on top of the other, so that the separation of corresponding images is about the same as the lens separation. The limitation of a lens stereoscope is that only a limited portion of the photograph can be viewed at a time, and the photographs have to be readjusted often if the whole overlap area is to be viewed stereoscopically.

Reflecting or Mirror Stereoscope

Almost all limitations of the lens stereoscope are overcome in the mirror stereoscope.


Mirror Stereoscope

This stereoscope consists of two pairs of parallel mirrors, one large and one small mirror in each pair arranged, so that the outer larger mirrors are inclined at 45º to the horizontal, one over each photograph.

The image on each photograph is reflected from the large mirror and that image is directed to the small mirror and the image, which appears as two separate images, is seen through the lenses placed vertically over the small mirror. The small viewing lenses can be replaced by a binocular attachment, to permit magnification of the images. Apart from the increased magnification, the mirror stereoscope has an advantage that the optical paths from each photograph are physically separated.

Practical learning Activity

- ✓ Practical exercises on images interpretation using stereoscope

Points to Remember (Take home message)

- ✓ Types of stereoscope:
  - Lens stereoscope and
  - Reflecting (Mirror) stereoscope

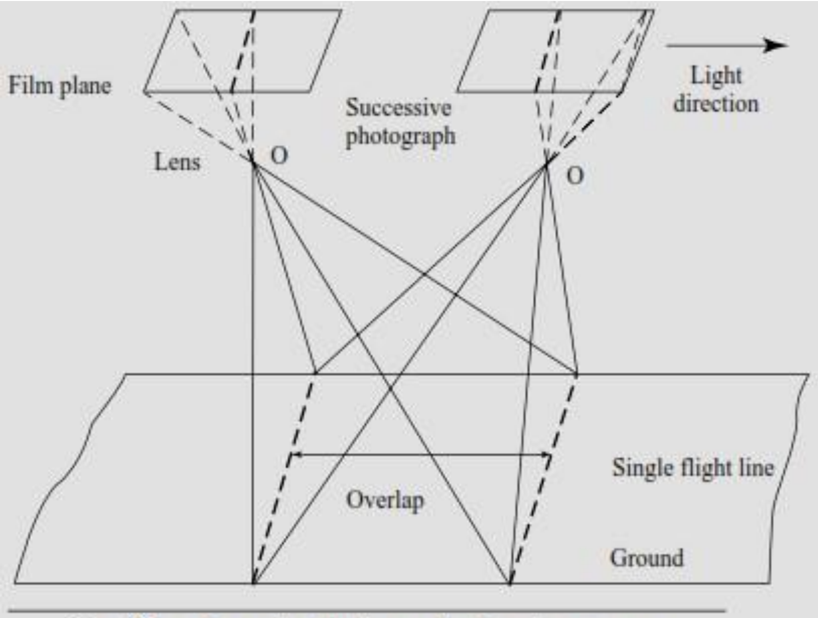
Content 3.4.2. principles of stereoscope

Stereoscope operates based on two principles: stereo pair and stereo model.

a) **Stereo model:** a 3D relief model observed through stereoscopic vision of a stereo pair.

b) **Stereo pair:** a pair of overlapping photos or images that (partially) cover the same area from a different position. When appropriately taken, stereo pairs form a stereo model.

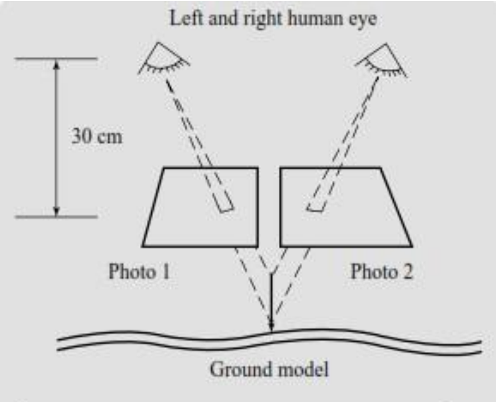
The human ability to see three dimensions is the result of having two eyes that record slightly different images of an object around him. These slightly different images are fused by the brain to give the impression of the third dimension, that is, depth. The prime motive of aerial photography is that it must be possible to view an optical model of the terrain in three dimensions. This is made possible if the geometrical condition is similar to natural binocular vision. At successive exposures, the aerial camera positions are analogous to the separation of the eyes in normal vision (see Figure below).



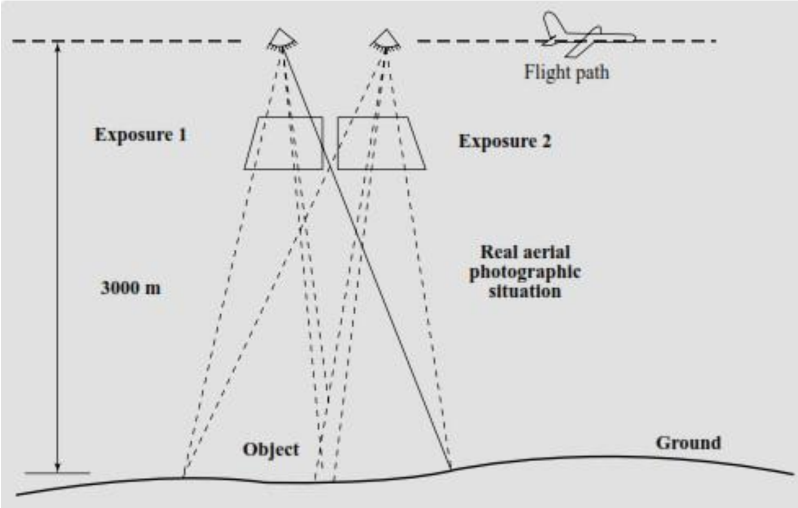
Conditions for aerial photography for stereoscopy

If the photographic sequence is arranged so that a portion of terrain between the two camera stations is recorded on successive exposures, two slightly different views of the same area of terrain, called **the overlap**, are recorded on the photographic film.

If the pair of photographs are viewed under suitable conditions, an optical model of the area of overlap will be seen in relief. The condition to be satisfied is for each eye to have a slightly different view of the same area of terrain. This can be achieved if the left eye views only the left photograph and the right eye views only the right photograph (see the two figures below).



Stereo viewing principle



Visualising the concept of stereo viewing in a real situation

The dimension of height not only enhances the interpretation of many features, but also allows the possibility of measuring heights within the stereoscopic model using only a minimal amount of ground derived information normally four height points for one overlap.

Practical learning Activity

- ✓ Practical exercises on images interpretation using stereoscope

Points to Remember (Take home message)

- ✓ principles of stereoscope:
  - stereo pair and
  - stereo model.

content 3.4.3. Three – Dimension view

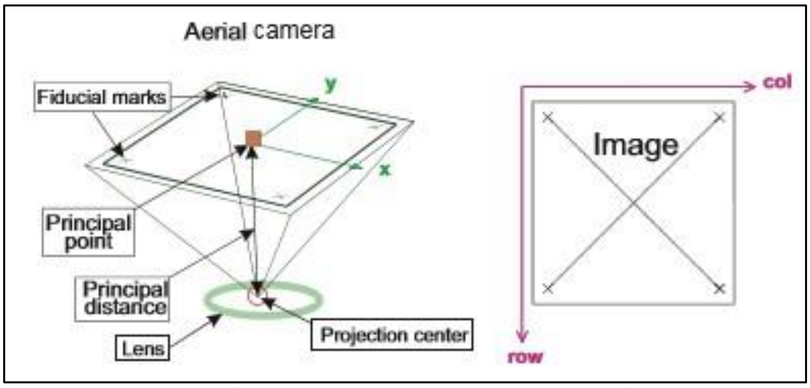
In mapping terrain, we want 2D geospatial data, describing the horizontal position of terrain features, but the terrain under considerations has large elevation differences. Elevation differences in the scene cause relief displacement in the image. Digitizing image features without taking into account relief displacement causes errors in computed map coordinates. We want 3D data.

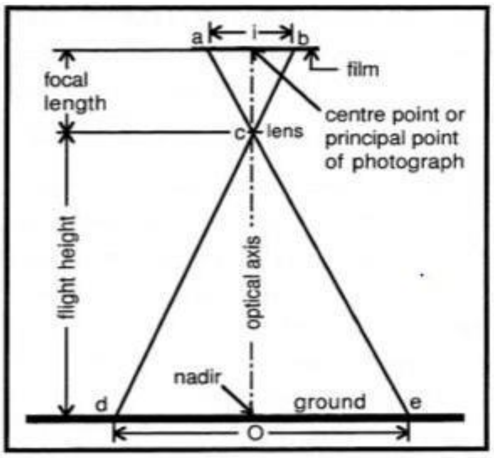
We refer to land cover, topographic objects, etc as *terrain features;* we show them on a 2D map as areas (polygon), lines, and point symbols. We refer to the shape of the ground surface as *terrain relief;* we show it on a topographic map by contour lines and/or a relief shades.

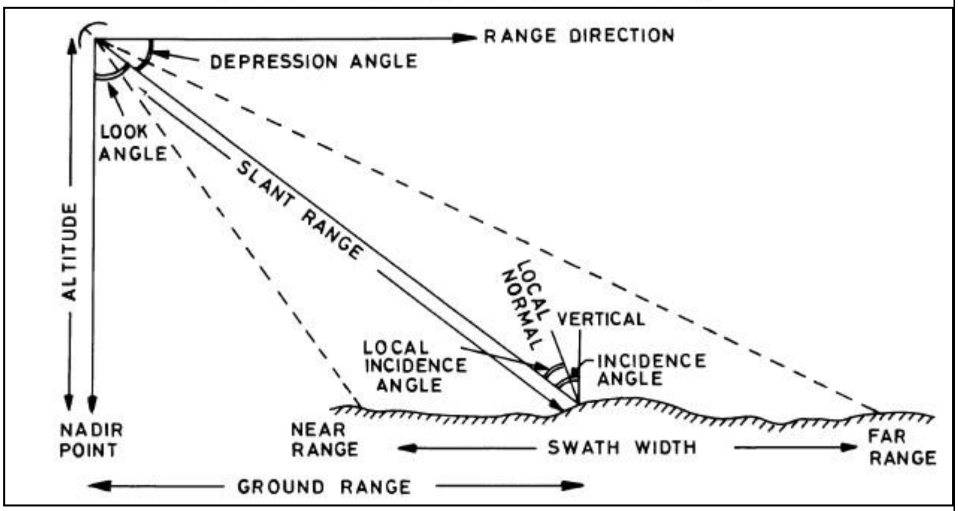
A contour line on a topographic map is a line of constant elevation. Given contour lines, we can determine the elevation at any arbitrary point by interpolating between contour lines.

A DTM (Digital Terrain Model) is a digital representation of terrain relief, a model of the shape of the ground surface. We have a variety of sensors at our disposal that can provide us with 3D data: line cameras and frame cameras, laser scanners, and microwave radar instruments. They all can produce (X,Y,Z) coordinates of terrain points, but not all of the terrain points will be points on the ground surface.

Camera orientation







After relative orientation of a stereo pair, we can exploit the 3D impression gained from the stereo model to make measurements in 3D. The measurements made in a stereo model make use of the phenomenon called "*parallax". Parallax refers to the fact that an object photographed from different camera locations (*e.g:* from a moving aircraft) has different relative positions in the two images. In other words, there is an apparent displacement of an object as it is observed from different locations.

A true 3D view is that of stereo-plotting, which makes use of parallax differences as observed in stereo images to measure the vertical dimension and obtain correct horizontal coordinates of terrain points

In mapping terrain, we want 2D geospatial data, describing the horizontal position of terrain features, but the terrain under considerations has large elevation differences. Elevation differences in the scene cause relief displacement in the image. Digitizing image features without taking into account relief displacement causes errors in computed map coordinates. We want 3D data.

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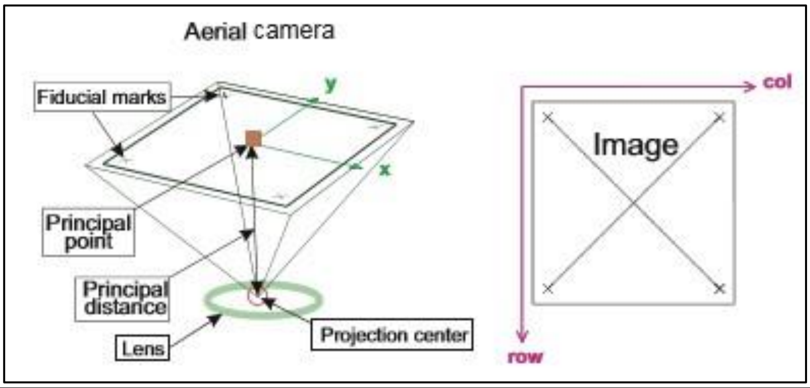
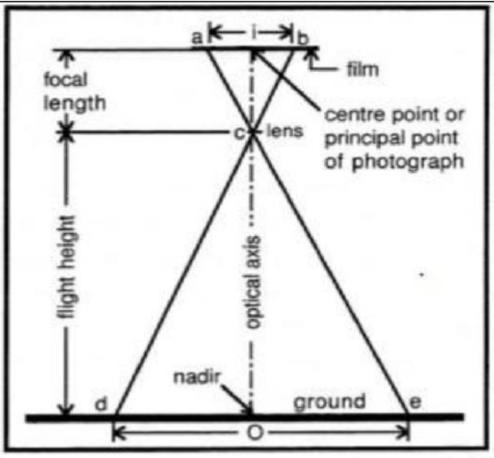
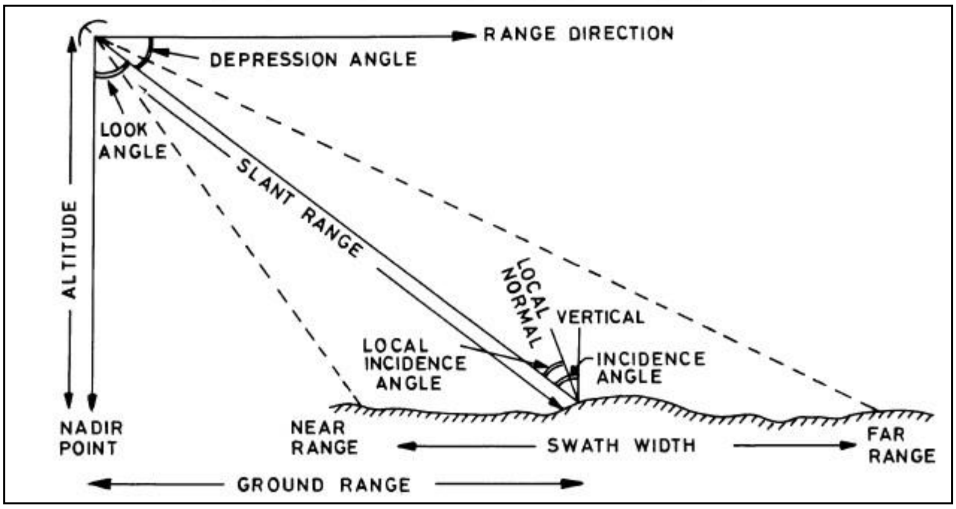
Camera orientation







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A true 3D view is that of stereo-plotting, which makes use of parallax differences as observed in stereo images to measure the vertical dimension and obtain correct horizontal coordinates of terrain points.

Practical learning Activity

- Practical exercises on images interpretation using stereoscope

Points to Remember (Take home message)

✓ Three – Dimension view

Learning outcome 3.4 formative assessment

Written Assessment :

Q1. Ex plain the two types of stereoscope

Answer

Two types of stereoscope are existing: Lens stereoscope and Reflecting (Mirror) stereoscope

Q2. Answer true or false

a) A contour line on a topographic map is a line of constant elevation.
b) After relative orientation of a stereo pair, we can exploit the 3D impression gained from the stereo model to make measurements in 2D.
c) Stereoscopy is the science of producing three-dimensional visual models using two-dimensional images.

Answer

a) True
b) False
c) True

Q3. Stereoscope operates based on two principles explain them

a) **Stereo model:** a 3D relief model observed through stereoscopic vision of a stereo pair.
b) **Stereo pair:** a pair of overlapping photos or images that (partially) cover the same area from a different position. When appropriately taken, stereo pairs form a stereo mode

Q4. Mention all elements to be based if you want to interpret any image

Answer

a) tone/hue
b) shape
c) size,
d) pattern,
e) texture,
f) shadow, and
g) association/location

Learning unit 4: Apply remote sensing data in mapping

STRUCTURE OF LEARNING UNIT

Picture/s reflecting the Learning unit 4

Learning out Comes : 1. Identify main application areas of remote sensing 2. Identifyremote sensing data 3. Use remote sensing data

Learning outcome 4.1: **Identify main application areas of remote sensing**

Duration : 5 hrs
Learning outcome 4.1 objectives: By the end of the learning outcome , the trainees will be able to: **1**. Appropriately identify main areas of applications of remote sensing according to the use

Resources:

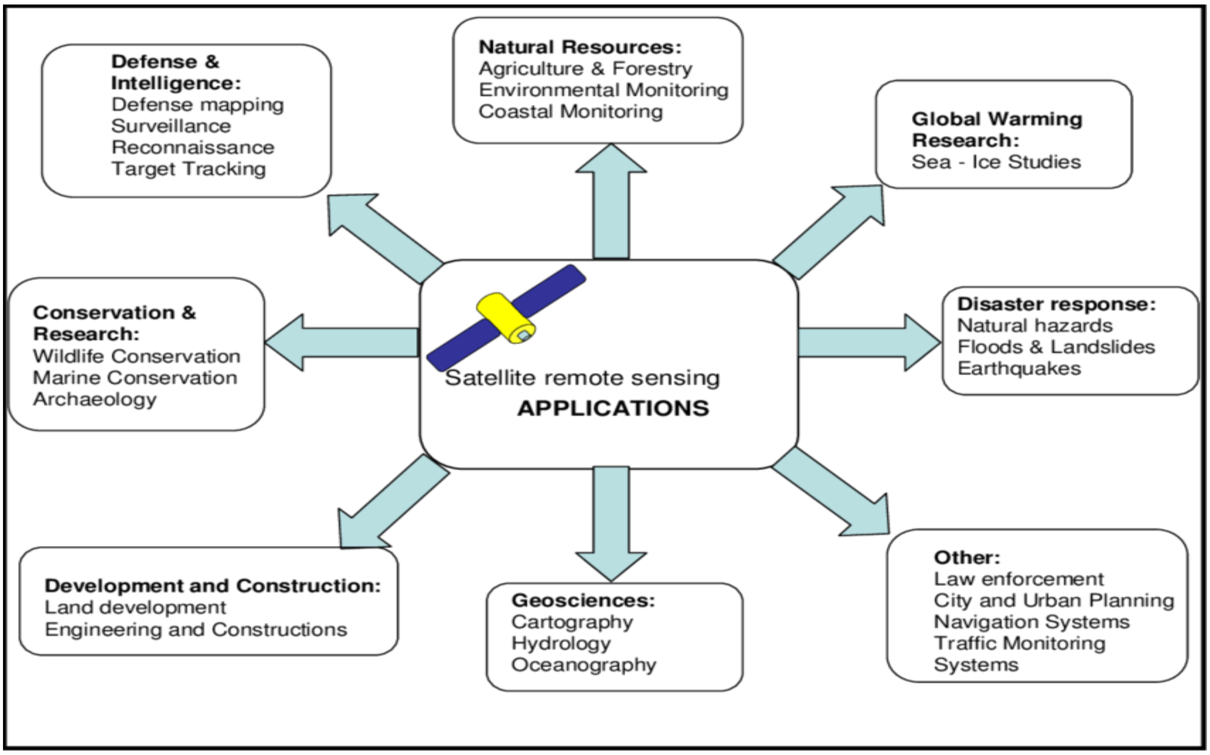
Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ White board/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ hand out notes is available
- ✓ equipment, tools and materials are available.

Content 4.1.1. Remote sensing application

Application of remote sensing



Main applications of remote sensing are: topographical survey, geology survey, route location, soil analysis, soil mapping, urban environments protection, forestry inventory, terrain evaluation, land use and land cover assessment, agriculture production, water resources, environmental studies including flood damage studies, property boundary mapping, forecasting the overall agricultural product of large area, and pollutants of waste disposal sites.

Above various applications of remote sensing may be grouped into the following headings:

- ✓ Resource exploration
- ✓ Environmental study
- ✓ Land use
- ✓ Site investigation
- ✓ Archaeological investigation
- ✓ Natural hazards study.

1. Resource Exploration: Geologists use remote sensing to study the formation of sedimentary rocks and identify deposits of various minerals, detect oil fields and identify underground storage of water.

Remote sensing is used for identifying potential fishing zone, and to find other wealth from ocean.

2. Environmental Study*:* Remote sensing is used to study cloud motion and predict rains. With satellite data it is possible to study water discharge from various industries to find out dispersion and harmful effects, if any, on living animals. Oil leakage and oil greasy can be studied using remote sensing.

3. Land Use: By remote sensing, mapping of larger areas is possible in short time. Forest area, agricultural area, residential and industrial area can be measured regularly and monitored. It is possible to find out areas of different crops.

4. *Site Investigation:* Remote sensing is used extensively in site investigations for dams, bridges, pipelines.

It can be used to locate construction materials like sand and gravel for the new projects.

5. Archaeological Investigation: Many structures of old era are now buried under the ground and are not known. But by studying changes in moisture content and other characteristics of the buried objects and upper new layer, remote sensors are able to recognize the buried structures of archaeological importance.

6. *Natural Hazard Study:* Using remote sensing the following natural hazards can be predicted to some extent and hazards minimized:

- Earthquake
- Volcanoes
- Landslides
- Floods
- Hurricane (storm) and cyclones.

Theoretical learning Activity

- ✓ Group discussions on remote sensing applications and uses
- ✓ Video aid showing use of remote sensing
- ✓ Brainstorming on remote sensing applications and uses

Points to Remember (Take home message)

- ✓ Remote sensing application:
  - Resource exploration
  - Land use
  - Site investigation
  - Archaeological investigation
  - Natural hazards study.

Content 4.1.2. Remote sensing use

The followings are uses of remote sensing

- ✓ Property boundary mapping
- ✓ Forecasting the overall agricultural product of large area
- ✓ Pollutants of waste disposal sites
- ✓ Route location
- ✓ Forest mapping
- ✓ Land use mapping
- ✓ Water resources mapping
- ✓ Soil mapping
- ✓ Geology mapping overall agricultural product of large area

Theoretical learning Activity

- ✓ Group discussions on remote sensing uses
- ✓ Video aid showing use of remote sensing

Points to Remember (Take home message)

✓ Uses of remote sensing

Learning outcome 4.2: **Identify remote sensing data**

Duration : 5 hrs
Learning out come 4.2 objectives : By the end of the learning outcome, the tnainees will be able to: **1**. Appropriately identify of remote sensing data according to their method of acquisition

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ Printer	✓ White board/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ hand out notes is available
- ✓ equipment, tool and materials are available

Content 4.2.1. Remote sensing data

Typical products derived from geospatial data are orthophoto maps, "satellite image maps", topographic maps, thematic maps such as land use maps, land use change statistics, etc.

A small scale of images provides data useful for regional studies, and applications have included mapping remote areas, geological surveys, and land use monitoring.
Advantages of remotely sensed data for GIS applications in the area of natural resource management are:

1. Low cost relative to other data sources
2. Currency of images
3. Accuracy
4. Completeness of data
5. Uniform standards across an area of interest

Theoretical learning Activity

- ✓ Group discussions on remote sensing data source
- ✓ Individual assignment use of remote sensing date

Points to Remember (Take home message)

- ✓ remote sensing data:
  - orthophoto maps
  - satellite image maps
  - topographic maps,
  - thematic maps

Content 4.2.2. Remote sensing data acquisition techniques

Remote sensing data acquisition techniques

Data acquisition or data input of geospatial data in digital format is more expensive and procedures are time consuming in a GIS, the data sources for data acquisitions should be carefully selected for specific purposes.

For GIS, data sources such as analog maps, aerial photographs, satellite imagery, GPS surveying, digitizers, scanners, and reports and publications are widely used.

- ✓ **Data acquisition from Analog Maps**

Topographic maps with contours and other terrain features, and thematic maps with respect to defined object classes are digitized manually by digitizers, or semi-automatically by scanners. Problems of analog maps are lack of availability, inconsistency in map production time, outdated maps, and inaccuracy.

- ✓ **Acquisition from Aerial Photographs**

An aerial photograph is a snapshot of the earth at a particular instant of time. It contains a mass of data and it is necessary to carry out some form of interpretation to make effective use of the information photographed. Aerial photographs are useful for monitoring changes, since repeated photographs of the same area are relatively cheap.
Aerial photographs may be used in GIS as a background for other data, to give those data spatial context and to aid interpretation. Hence the user can abstract information on land use, vegetation type, moisture or heat levels, or other aspects of the landscape from the photograph.
Interpretation of a sequence of photographs allows in ascertaining events such as major floods, which cause changes to the landscape.
The six characteristics of aerial photographs, which make them of immense value as a data source for GIS, are:

- Low cost compared with remote sensed satellite images
- Wide availability
- Three-dimensional perspective
- Time-freezing abilities
- High spectral and spatial resolution
- Wide area views

Also, aerial photographs can be used to obtain data that is not available from other secondary sources, such as the location and extent of new housing estates and the extent of forest fires. Aerial photographs do not provide spatially referenced data. Spatial referencing has to be added to features on the image by reference to other sources such as paper maps.

- ✓ **Satellite Imagery**

Satellite images are collected by sensors on board a satellite and then relayed to earth as a series of electronic signals, which are processed by computers to produce an image. These data can be processed in a variety of ways, each giving a different digital version of the image. Satellite imagery can also be used as a raster backdrop to vector GIS data. There are large numbers of satellites orbiting the earth continuously, collecting data and returning them to ground stations all over the world.

- ✓ **Ground Survey**

There are several methods of collecting raw data in the field for direct input into the GIS. These are most often used when the required data do not exist in any other readily available format such as a map or satellite image.

Traditional manual surveying techniques using chains, plane tables, levels, and theodolites are example of direct field measurement. For the above methods, the data are collected and are recorded manually. Modern digital instruments have replaced these manual methods, and data collected are stored in digital formats that are ready for direct input into GIS.

- ✓ **Global Positioning System**

A relatively new technique for field data collection, which has found particular favour with GIS users, is the use of the satellite navigation system of GPS, which comprises a series of approximately 20 Department of Defence satellites, which orbit the earth. These satellites send location information back to earth. Commercially available receivers can capture that data from a minimum of three satellites at any one time, to give the GPS receiver operator a coordinate location.

- ✓ **Acquisition from Reports and Publications**

Social economic data are usually listed in the reports of statistics and census with respect to administration units. Census and survey are a collection of related information. Examples are population census, employment data, agricultural census data and marketing data.

- ✓ **Acquisition from Digitizers (for Vector Data Input)**

Digitizing is the process of tracing maps into computer format. Most of the vector GIS data is collected by this method. Digitization is a simplification process that converts all spatial data to either a point (e.g. a well), a line (e.g. a stream), a polygon formed by a closed, complex line (e.g. a lake), or a grid cell.

- ✓ **Acquisition from Scanners (for Raster Data Input)**

Scanners are used to convert analog maps or photographs to digital image data in raster format.

- ✓ **Advanced Technologies for Primary Data Acquisition**

Several advanced technologies have become available for primary data acquisition of geospatial data as well as digital elevation model (DEM). The following advanced technologies will be useful for future GIS.

- **Electronic Plane Surveying System**: An integrated system of total station with automated tracking function, kinematic global positioning system (GPS) and a pen computer will replace the conventional plane surveying. Direct data acquisition in digital form, at the field site, will be very useful for large scale GIS data set, for example in the application to cadastral surveys, utility facilities, and urban structures.
- **Mobile Mapping System**: Different sensors such as GPS, INS (inertia navigation system), more than two digital cameras, and voice recorder is fixed on a vehicle in order to map objects in close range.
- **Laser Scanner:** Airborne laser scanner, together with GPS and INS, will directly measure the terrain relief or DEM, with the height accuracy of 10 cm up to the altitude of 1,000 m.
- **SAR Interferometry:** SAR (Synthetic Aperture Radar) interferometry is a new technology to produce DEM automatically by special interferometric processing of a pair of SAR images. Airborne and space borne SAR interferometry are now available if the interferometric condition meets the standard.

Theoretical learning Activity

- ✓ Group discussions on Remote sensing data acquisition techniques

Practical learning Activity

- ✓ Practical exercises on remote sensing data acquisition techniques

Points to Remember (Take home message)

- Remote sensing data acquisition techniques:
  - Satellite Imagery
  - Data acquisition from Analog Maps
  - Global Positioning System
  - Acquisition from Scanners
  - Acquisition from Digitizers

Content 4.2.3. Remote sensing data instruments

a) Camera *and* Airplane

A **camera** is an optical instrument for recording or capturing images, which may be stored locally, transmitted to another location, or both. The images may be individual still photographs or sequences of images constituting videos or movies. The camera is a remote sensing device as it senses subjects without any contact.

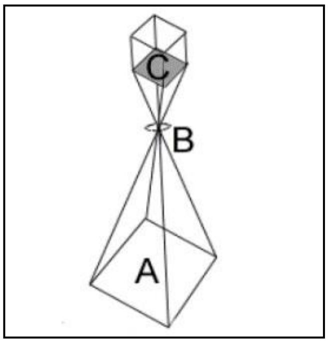
Depending upon the film format (i.e. size), four types of cameras are distinguished:

- small-format (35 mm),
- medium-format (70 mm),
- medium to large-format (126/140 mm) large-format (240 mm).

Four types of cameras can be distinguished, depending upon their construction, objective and working:

- single-lens frame cameras,
- panoramic cameras,
- strip cameras, and
- multiband cameras.

Cameras and their use for aerial photography are the simplest and oldest of sensors used for remote sensing of the Earth's surface.



Cameras are **framing systems** which acquire a near-instantaneous "snapshot" of an **area (A)**, of the surface. Camera systems are passive optical sensors that use a **lens (B)** (or system of lenses collectively referred to as the optics) to form an image at the focal plane (C), the plane at which an image is sharply defined.

Colour and false colour (or colour infrared, CIR) photography involves the use of a three layers film with each layer sensitive to different ranges of light. For a **normal colour photograph**, the layers are sensitive to blue, green, and red light - the same as our eyes. These photos appear to us the same way that our eyes see the environment, as the colours resemble those which would appear to us as "normal" (i.e. trees appear green, etc.).

Cameras can be used on a variety of platforms including ground-based stages, helicopters, aircraft, and spacecraft. Very detailed photographs taken from aircraft are useful for many applications where identification of detail or small targets is required.

Most aerial photographs are classified as either **oblique** or **vertical**, depending on the orientation of the camera relative to the ground during acquisition. **Oblique aerial photographs** are taken with the camera pointed to the side of the aircraft. High oblique photographs usually include the horizon while low oblique photographs do not. Oblique photographs can be useful for covering very large areas in a single image and for depicting terrain relief and scale. However, they are not widely used for mapping as distortions in scale from the foreground to the background preclude easy measurements of distance, area, and elevation.

Vertical photographs taken with a ***single-lens frame camera*** is the most common use of aerial photography for remote sensing and mapping purposes. These cameras are specifically built for capturing a rapid sequence of photographs while limiting geometric distortion.

Multiband photography uses multi-lens systems with different film-filter combinations to acquire photos simultaneously in a number of different spectral ranges. It is the case of ***digital cameras***. The advantage of these types of cameras is their ability to record reflected energy separately in discrete wavelength ranges, thus providing potentially better separation and identification of various features. The digital format of the output image is amenable to digital analysis and archiving in a computer environment, as well as output as a hardcopy product similar to regular photos. Digital cameras also provide quicker turn-around for acquisition and retrieval of data and allow greater control of the spectral resolution.

b) Satellites

Weather monitoring and forecasting was one of the first applications of satellite remote sensing. The **DMSP** (Defense Meteorological Satellite Program) series of satellites (from USA) are used for weather monitoring. These are near-polar orbiting satellites whose Operational Line scan System (OLS) sensor provides twice daily coverage with a swath width of 3000 km at a spatial resolution of 2.7 km.

There are several meteorological satellites in orbit, launched and operated by different countries, or groups of countries. These include Japan, with the **GMS** satellite series, and the consortium of European communities, with the **Meteosat** satellites. Both are geostationary satellites situated above the equator over Japan and Europe, respectively.

Many of the weather satellite systems are also used for monitoring the Earth's surface, they are not optimized for detailed mapping of the land surface. Example is **Landsat-1.** The Earth's oceans cover more than two-thirds of the Earth's surface and play an important role in the global climate system. They also contain an abundance of living organisms and natural resources which are susceptible to pollution and other man-induced hazards.
The meteorological and land observations satellites/sensors can be used for monitoring the oceans of the planet, but there are other satellite/sensor systems which have been designed specifically for this purpose. Example is the **Coastal Zone Colour Scanner (CZCS)**, specifically intended for monitoring the Earth's oceans and water bodies. They were optimized to allow detailed discrimination of differences in water reflectance due to **phytoplankton concentrations** and other suspended particulates in the water.

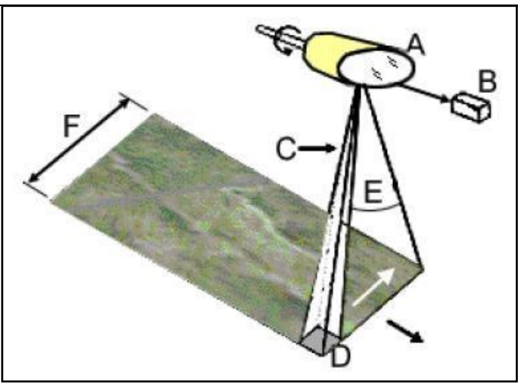
c) Thermal Scanner (Laser scanner)

Laser scanning, in a terrestrial or airborne form, is a relatively new and powerful surveying technique. The system provides 3D location of features and surfaces quickly and accurately, in real time if necessary.

Many electronic (as opposed to photographic) remote sensors acquire data using **scanning systems**, and produce a two-dimensional image of the surface. Scanning systems can be used on both aircraft and satellite platforms and have essentially the same operating principles. A scanning system used to collect data over a variety of different wavelength ranges is called a **multispectral scanner (MSS)**, and is the most commonly used scanning system.

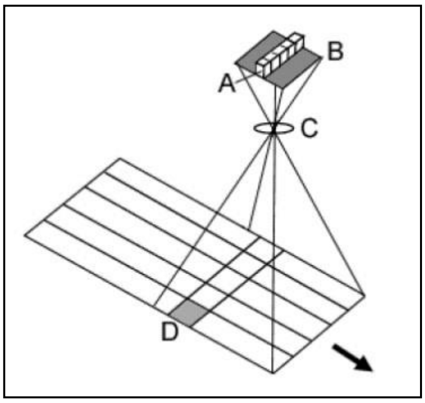
There are two main modes or methods of scanning employed to acquire multispectral image data: across track scanning, and along-track scanning:

- **Across-track scanners** scan the Earth in a series of lines. The lines are oriented perpendicular to the direction of motion of the sensor platform (i.e. across the swath). Each line is scanned from one side of the sensor to the other, using a **rotating mirror (A)**. As the platform moves forward over the Earth, successive scans build up a two-dimensional image of the Earth´s surface. The incoming reflected or emitted radiation is separated into several spectral components that are detected independently.



The Ultra-Violent, visible, near-infrared, and thermal radiation are dispersed into their constituent wavelengths. A bank of internal **detectors (B)**, each sensitive to a specific range of wavelengths, detects and measures the energy for each spectral band and then, as an electrical signal, they are converted to digital data and recorded for subsequent computer processing. The **IFOV (C)** of the sensor and the altitude of the platform determine the **ground resolution cell viewed (D)**, and thus the spatial resolution. The **angular field of view (E)** is the sweep of the mirror, measured in degrees, used to record a scan line, and determines the width of the imaged **swath (F)**.

- **Along-track scanners** also use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction.



However, instead of a scanning mirror, they use a linear array of detectors (A) located at the focal plane of the image (B) formed by lens systems (C), which are "pushed" along in the flight track direction (i.e. along track). These systems are also referred to as **push-broom scanners**, as the motion of the detector array is analogous to the bristles of a broom being pushed along a floor. Each individual detector measures the energy for a single ground resolution cell (D) and thus the size and IFOV of the detectors determines the spatial resolution of the system.

Advantages and disadvantages of the two types of scanners**:**

Along-track scanners with linear arrays have several advantages over across-track mirror scanners. The array of detectors combined with the push-broom motion allows each detector to "see" and measure the energy from each ground resolution cell for a longer period of time (dwell time). This allows more energy to be detected and improves the radiometric resolution.

The increased dwell time also facilitates smaller IFOVs and narrower bandwidths for each detector. Thus, finer spatial and spectral resolution can be achieved without impacting radiometric resolution. Because detectors are usually solid-state microelectronic devices, they are generally smaller, lighter, require less power, and are more reliable and last longer because they have no moving parts.

On the other hand, cross-calibrating thousands of detectors to achieve uniform sensitivity across the array is necessary and complicated.

Theoretical learning Activity

- ✓ Individual assignent on Remote sensing data instrument

Practical learning Activity

- ✓ Practical exercises on uses of remote sensing data instrument

Points to Remember (Take home message)

- ✓ Remote sensing data instrument

Learning out come 4.3: **Use of satellite images**

Duration : 5 hrs
Learning out come 4.3 objectives: By the end of the learning outcome, the trainees will be able to: **1**. Relevant use of remote sensing data according to their applications

Resources:

Equipment	Tools	Materials
✓ Computer ✓ Projector ✓ - Printer	✓ White board/blackboard ✓ Duster ✓ Workshop	✓ Marker pen ✓ Notebook ✓ Pen/pencil ✓ Internet

Advance preparation:

- ✓ hand out notes is available

Content 4.3.1. Use of satellite images

Satellite images are mainly used in three areas: Digital mapping, Agriculture, and Land use mapping

- ✓ Digital mapping: High resolution satellite imagery is expected to reduce cost for medium and small scale topographic mapping
- ✓ Agriculture, and Land use mapping: Remote sensed images are also used in agriculture sector for crop identification and estimation, crop diseases detection, forest cover mapping and deforestation. Use of satellite images increase the speed, quality and variety of products and services available to farmers. These include:
  - Real-time updates on current field, soil and crop conditions
  - Real-time decision support (eg. When to irrigate)
  - Precision profit mapping
  - Disease and pest identification
  - Immediate alerts to canopy conditional change (eg. Water stress)
  - Harvest forecasting
  - Hyper-localized weather
  - Fleet management and performance tracking
  - Animal tracking and monitoring
  - Enhanced field planning – e.g. field profiling and variety selection

Google earth images can be primarily used for *housing* and *locating infrastructure.*

The use of **aerial photos** or **orthophotos** is concentrated generally in land demarcation, land consolidation and in GIS operations.

The important fields in which remotely-sensed data are used are given below for an appreciation of the technique of remote sensing.

1) **Geology**. To identify rock types, earth lineaments (fault lines) and landslides, remote sensing is being used.
2) **Hazard Control**. To measure the natural and man-made hazards like storms, landslides, floods and pollution and to control such hazards.
3) **Land Survey and Cartography**. Aerial photographs are widely used for updating the existing maps and to measure heights. Both aerial and satellite

data products are used to renew the existing transportation routes and planning.

4) **Land Use, Agriculture and Forestry**.
5) **Meteorological Research**. To study various components of meteorology such as cloud cover, intensities and variations in weather elements, global climate change, …
6) **Oceanography**. To study various elements of oceanography such as surface temperatures, ocean currents, sea erosion, wave patterns and marine resources.
7) **Water and Land Resources**. Remote sensing is highly useful in identifying water bodies such as lakes, ponds and rivers, their aerial extent and quality, snowmelt, runoff, surface flow, irrigation, land suitability, soil type and moisture capacity of soil.

Practical learning Activity

✓ Practical exercises on uses of remote sensing data

Points to Remember (Take home message)

✓ Uses Remote sensing data:
  - Digital mapping,
  - Agriculture, and
  - Land use mapping

Learning outcome 4.3 formative assessment

Written Assessment:

Q1. State Remote sensing data instruments.

Answer:

- Camera
- Airplane
- Satellites

Q2. State types of remote sensing data in surveying.

Answers:

- Satellites images
- Aerial photo/orthophotos
- Google Earth images

Q3. List ten (10) uses and applications of remote sensing.

- ✓ Remote sensing applications
- Topographical survey,
- Geology survey
- Soil analysis,
- Urban environments protection
- Forestry inventory
- Terrain evaluation,
- Land use/Land cover assessment
- Agriculture production
- Water resources, and
- Environmental studies/flood damage studies

- ✓ Remote sensing uses
- Property boundary mapping
- Forecasting the overall agricultural product of large area
- Pollutants of waste disposal sites
- Route location
- Forest mapping
- Land use mapping
- Water resources mapping
- Soil mapping
- Geology mapping overall agricultural product of large area
- Pollutants of waste disposal sites
- Route location

Q4. Aerial photo projects for all mapping and most image analyses require that a Series of exposures be made along each of the multiple flight lines. To guarantee Stereoscopic coverage throughout the site, the photographs must overlap in two Directions: in the line of flight and between adjacent flights. Differentiate types of photo overlap.

Answer: **Side lap**, sometimes called side overlap, encompasses the overlapping areas of photographs between adjacent flight lines. It is designed so that there are no gaps

Usually, side lap ranges between 20 and 40% of the width of a photo, with a nominal average of 30%

End lap, also known as forward overlap, is the common image area on consecutive

photographs along a flight strip. This overlapping portion of two successive aerial

photos, which creates the three-dimensional effect necessary for mapping, is known as a stereo model or more commonly as a “model

Normally, end lap ranges between 55 and 65% of the length of a photo, with a

nominal average of 60% for most mapping project

Q5. Answer true or false the following statement

a) Aerial images are images taken an aerial cameras properties, this the same as aerial photographs which is taken by an aerial cameras
b) Can ‘’remote sensing ‘’ employ anything otherthan electromagnetic radiation

Answer

a) **True**
b) **True,** some types of remote sensing use mechanical waves like sound waves instead of electromagnetic waves, Example include active and passive sonar, ultrasound sensing, and seismographs.

Q6. Make the simple summary of angular coverage in photogrammetric image properties.

Answer:

	super-wide	wide-angle	inter-Mediate	normal-angle	narrow-angle
focal length [mm]	85.	157.	210.	305.	610.
angular coverage [o]	119.	82.	64.	46.	24.

Q7. How do you measure objects on google earth?

a) On your computer, open google earth
b) Search for place, or select location on the globe
c) On the left, click measure
d) Click the map to set measurement points
e) To remove a point, on the right, click undo
f) To complete your line measurement, double click on your last point, or click done.

Q8. Suppose you have digital image which has a radiometric resolution of 6bits.What is the maximum value of the digital number which could be represented in that image?

Answer

The number of values in a 6-bit image would be equal to 26 = 2 x 2 x 2 x 2 x 2 x 2 = 64.

Practical Assessment:

Rwanda Housing Authority (RHA) and MINAGRI through MUHANGA District would like to know total area occupied by housing and agriculture activities in MUHANGA district urban area (limited to SHYOGWE, NYAMABUYE and sectors) that will help to implement and guide the new housing policy and agriculture development in mentioned sectors.

Based on this, Spatial Ltd Company specialized in mapping signed a service agreement with the MUHANGA district to conduct that consultancy duty. The conceptual land use map report should include built up land, agriculture land and other land use with target to get total land occupied by housing and agriculture activities.

All data needed to perform the task are available in GIS and remote sensing department at RHA. In tender notice, remote sensing data of 1m of resolution taken after September 2018 with Rwanda coordinate system based on ITRF 2005 spatial reference for Rwanda were stated for mapping. The conceptual land use map will be printed to A0 paper coloured in three copies at scale of 1:25000. Both hard and soft copy must be submitted.

As a GIS and remote sensing technician from Spatial Ltd Company Ltd, you are requested to perform the task by mapping using ArcGIS 10.1 and providing total area (Ha) occupied by housing and agriculture activities in 6hour as specified

Assesment Criterion 1: Quality of Process

Checklist	Score	
	Yes	No
Indicator: tools/materials are selected		
ArcGIS software		
Satellites images		
Google earth images		
Orthophotos		
Rwanda Administrative boundary shapefile		
Indicator: updated Data are respected		
Satellites images September 2018		
Orthophotos September 2018		
Google earth images October 2018		
Indicator: software isrespected		
ArcGIS 10.1		
Professional Google earth		
Indicator: data processing is used		
ArcGIS 10.1		

Spatial reference ITRF2005		
Images Resolution 1m		
Indicator: land use mapping respected		
Housing area		
Agriculture area		
Other land area		
Indicator: image visual interpretation element		
Tone /Hue		
Texture		
Pattern		
Shape		
Size		
Location/association		
Shadow		
Observation		

Assesment Criterion 2: Quality of product

Checklist	Score	
	Yes	No
Indicator:Land use map well produced		
Agriculture land use		
Housing land use		
Other land use		
Indicator: Area well computed		
Agriculture area in Ha		
Housing area in Ha		
Other land use area in Ha		
Total area (Agriculture and Housing) in Ha		
Indicator: documents well submitted		
Hard copy		

Soft copy		
A0 Paper		
Scale : 1:25000		
Three colored copies		
Observation		

Assessment Criterion 3: Relevance

Checklist	Score	
	Yes	No
Indicator: time well respected		
Time: 6hour		
Indicator: updated data well applied		
After September 2018		
Images resolution 1m		
Indicator:Unit well respected		
Ha	Ha	Ha
Observation		

Reference(s):