Subject Name: **Advance surveying & remote sensing**

Subject Code: **CE-3004**

Semester: **3rd**

Unit V

Remote Sensing

Syllabus

Remote Sensing: Principle, components, classification, remote sensing data acquisition process, different types of remote sensing satellite imagery with special relevance to Indian Remote Sensing Satellites (IRS) and applications. Geographic Information Systems (GIS) : Definition, components and advantages.

Principle:

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.

Components:

1. Energy Source 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.

2. 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.

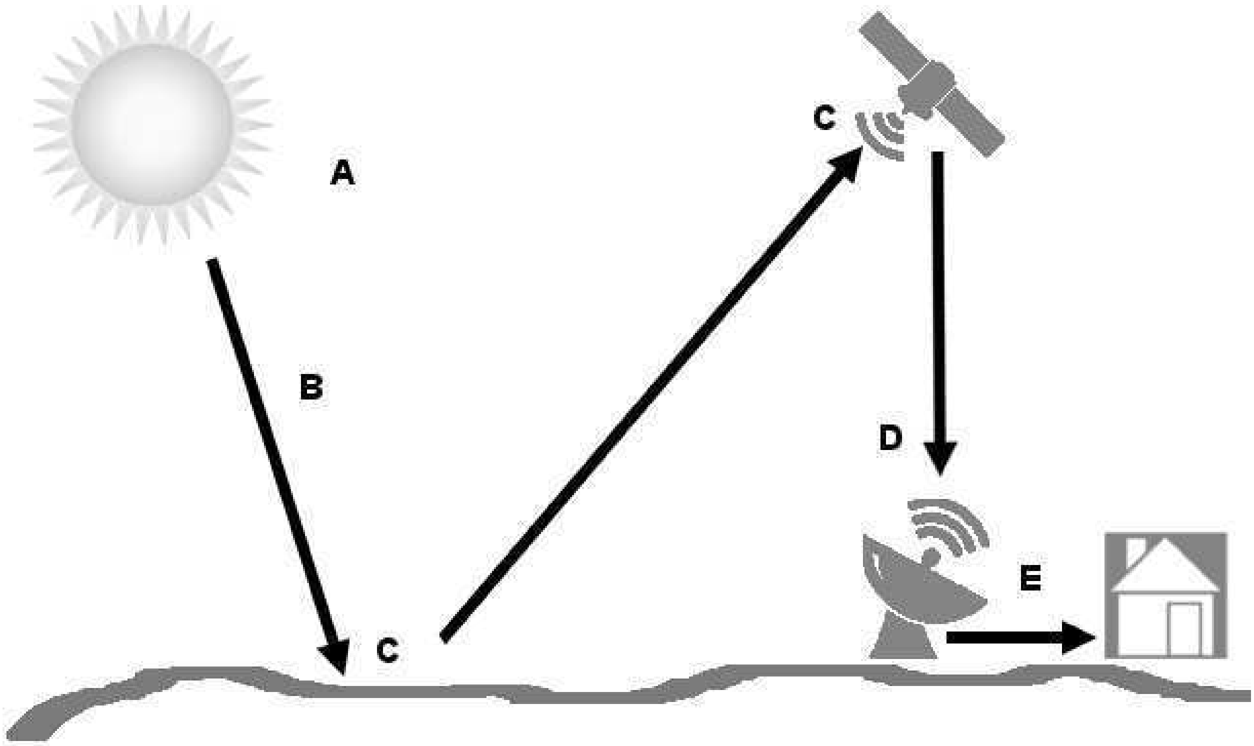
3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. 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).

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

7. 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.



Classification:

It may be split into "active" remote sensing (i.e., when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and "passive" remote sensing (i.e., when the reflection of sunlight is detected by the sensor).

*Remote sensing systems which measure energy that is naturally available are called Passive Sensors. 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. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded.

*Active sensors, on the other hand, transmit short bursts or 'pulses' of electromagnetic energy in the direction of interest and record the origin and strength of the backscatter received from objects within the system's field of view. Passive systems sense low level microwave radiation given off by all objects in the natural environment.

Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated.

Remote sensing data acquisition process:

Interpretation and analysis of remote sensing data involves the identification and measurement of various targets in an image in order to extract useful information about them. There are two main methods can be use to interpret and extract information of interpretation from images:

- Visual interpretation of images, which is based on feature tone (colour), pattern, shape, texture, shadow and association. The identification of targets performed by a human interpreter
- Digital processing and analysis may be performed using a computer (without manual intervention by a human interpreter). This method can be used to enhance data, to correct or restore the image, to automatically identify targets and extract information and to delineate different areas in an image into thematic classes.

In many case digital processing and analysis is carried out as a complete replacement for manual interpretation. Often, it is done to supplement and assist the human analyst. Applying a mix of both methods we can use manual and digital techniques advantages.

Digital processing and analysis

The most common image processing functions can be placed into the following four categories:

1. Pre-processing

2. Image Enhancement

3. Image Transformation

4. Image Classification and Analysis

Pre-processing:

Pre-processing functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections. Some standard correction procedures may be carried out in the ground station before the data is delivered to the user. These procedures include radiometric correction to correct for uneven sensor response over the whole image and geometric correction to correct for geometric distortion due to Earth's rotation and other imaging conditions (such as oblique viewing).

Radiometric corrections:

Radiometric correction is a pre-processing method to reconstruct physically calibrated values by correcting the spectral errors and distortions caused by sensors, sun angle, topography and the atmosphere.

Geometric corrections:

Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface. The systematic or predictable distortions can be corrected by accurate modelling of the sensor and platform motion and the geometric relationship of the platform with the Earth. Therefore, to correct other unsystematic or random errors we have to perform geometric registration of the imagery to a known ground coordinate system.

The geometric registration process can be made in two steps:

- identifying the image coordinates (i.e. row, column) of several clearly discernible points, called ground control points (GCPs), in the distorted image and matching them to their true positions in ground coordinates (e.g. latitude, longitude measured from a map). Polynomial equations are used to convert the source coordinates to rectified coordinates, using 1st and 2nd order transformation. The coefficients of the polynomial are calculated by the least square regression method that will help in relating any point in the map to its corresponding point in the image.
- Re-sampling: this process is used to determine the digital values to place in the new pixel locations of the corrected output image. There are three common methods for Re-sampling: nearest neighbour, bilinear interpolation, and cubic convolution.

Image Enhancement:

Image enhancement is conversion of the original imagery to a better understandable level in spectral quality for feature extraction or image interpretation. It is useful to examine the image Histograms before performing any image enhancement. The x-axis of the histogram is the range of the available digital numbers, i.e. 0 to 255. The y-axis is the number of pixels in the image having a given digital number. Examples of enhancement functions include:

- Contrast stretching to increase the tonal distinction between various features in a scene. The most common types of enhancement are: a linear contrast stretch, a linear contrast stretch with saturation (Fig. 6-13.), a histogram-equalized stretch
- Filtering is commonly used to restore imagery by avoiding noises to enhance the imagery for better interpretation and to extract features such as edges and lineaments. The most common types of filters: mean, median, low, high pass, edge detection.

Image Transformation:

Image transformations usually involve combined processing of data from multiple spectral bands. Arithmetic operations (i.e. subtraction, addition, multiplication, division) are performed to combine and transform the original bands into "new" images which better display or highlight certain features in the scene. Some of the most common transforms applied to image data are: image ratioing: this method involves the differencing of combinations of two or more bands aimed at enhancing target (i. e. vegetation, features or principal components analysis (PCA). The objective of this transformation is to reduce the dimensionality (i.e. the number of bands) in the data, and compress as much of the information in the original bands into fewer bands.

Image Classification:

Information extraction is the last step toward the final output of the image analysis. After pre-processing the remotely sensed data is subjected to quantitative analysis to assign individual pixels to specific classes. Classification of the image is based on the known and unknown identity to classify the remainder of the image consisting of those pixels of unknown identity. After classification is complete, it is necessary to evaluate its accuracy by comparing the categories on the classified images with the areas of known identity on the ground. The final result of the analysis consists of maps (or images), data and a report. These three components of the result provide the user with full information concerning the source data, the method of analysis and the outcome and its reliability.

There are two basic methods of classification: supervised and unsupervised classification. In supervised classification, the spectral features of some areas of known land cover types are extracted from the image. These areas are known as the "training areas". Every pixel in the whole image is then classified as belonging to one of the classes depending on how close its spectral features are to the spectral features of the training areas.

Segmentation

A supervised classification is based on the value of the single pixel and does not utilize the spatial information within an object. Because of the complexity of surface features and the limitation of spectral information, the results of traditional classification methods (pixel-based) are often mistaken, even confusion classification. Now a days we have some new methods based on the group of pixel. Segmentation is a process by which pixels are grouped into segments according to their spectral similarity. Segment-based classification is an approach that classifies an image based on these image segments. One of the process of segmentation employs a watershed delineation approach to partition input imagery based on their variance. A derived variance image is treated as a surface image allocating pixels to particular segments based on variance similarity (IDRISI TAIGA).The object-oriented classification produced more accurate results, than the other method.

Different types of remote sensing satellite imagery:

There are four types of resolution when discussing satellite imagery in remote sensing: spatial, spectral, temporal, and radiometric. Campbell (2002)[4] defines these as follows:

- spatial resolution is defined as the pixel size of an image representing the size of the surface area (i.e. m^2) being measured on the ground, determined by the sensors' instantaneous field of view (IFOV);
- spectral resolution is defined by the wavelength interval size (discrete segment of the Electromagnetic Spectrum) and number of intervals that the sensor is measuring;
- temporal resolution is defined by the amount of time (e.g. days) that passes between imagery collection periods for a given surface location
- Radiometric resolution is defined as the ability of an imaging system to record many levels of brightness (contrast for example) and to the effective bit-depth of the sensor (number of greyscale levels) and is typically expressed as 8-bit (0-255), 11-bit (0-2047), 12-bit (0-4095) or 16-bit (0-65,535).
- Geometric resolution refers to the satellite sensor's ability to effectively image a portion of the Earth's surface in a single pixel and is typically expressed in terms of Ground sample distance, or GSD. GSD is a term containing the overall optical and systemic noise sources and is useful for comparing how well one sensor can "see" an object on the ground within a single pixel. For example, the GSD of Land sat is ~30m, which means the smallest unit that maps to a single pixel within an image is ~30m x 30m. The latest commercial satellite (GeoEye 1) has a GSD of 0.41 m. This compares to a 0.3 m resolution obtained by some early military film based Reconnaissance satellite such as Corona.

GeoEye:

GeoEye's GeoEye-1 satellite was launched September 6, 2008. The GeoEye-1 satellite has the high resolution imaging system and is able to collect images with a ground resolution of 0.41 meters

(16 inches) in the panchromatic or black and white mode. It collects multispectral or colour imagery at 1.65-meter resolution or about 64 inches.

DigitalGlobe:

Digital Globe's WorldView-2 satellite provides high resolution commercial satellite imagery with 0.46 m spatial resolution (panchromatic only). The 0.46 meters resolution of WorldView-2's panchromatic images allows the satellite to distinguish between objects on the ground that are at least 46 cm apart. Similarly Digital Globe's Quick Bird satellite provides 0.6 meter resolution (at NADIR) panchromatic images.

Digital Globe's WorldView-3 satellite provides high resolution commercial satellite imagery with 0.31 m spatial resolution. WVIII also carries a short wave infrared sensor and an atmospheric sensor

SPOT image of Bratislava:

The 3 SPOT satellites in orbit (Spot 2, 4 and 5) provide images with a large choice of resolutions – from 2.5 m to 1 km. Spot Image also distributes multi resolution data from other optical satellites, in particular from Formosat-2 (Taiwan) and Kompsat-2 (South Korea) and from radar satellites (TerraSar-X, ERS, Envisat, Radarsat). Spot Image will also be the exclusive distributor of data from the forthcoming very-high resolution Pleiades satellites with a resolution of 0.50 meter or about 20 inches. The first launch is planned for the end of 2011. The company also offers infrastructures for receiving and processing, as well as added value options.

ASTER:

The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) is an imaging instrument onboard Terra, the flagship satellite of NASA's Earth Observing System (EOS) launched in December 1999. ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI), and Japan Space Systems (J-space systems). ASTER data is used to create detailed maps of land surface temperature, reflectance, and elevation. The coordinated system of EOS satellites, including Terra, is a major component of NASA's Science Mission Directorate and the Earth Science Division. The goal of NASA Earth Science is to develop a scientific understanding of the Earth as an integrated system, its response to change, and to better predict variability and trends in climate, weather, and natural hazards.

BlackBridge:

BlackBridge, previously known as RapidEye, operates a constellation of five satellites, launched in August 2008, the RapidEye constellation contains identical multispectral sensors which are equally calibrated. Therefore, an image from one satellite will be equivalent to an image from any of the other four, allowing for a large amount of imagery to be collected (4 million km² per day), and daily revisit to an area. Each travel in the same orbital plane at 630 km and delivers images in 5 meter pixel size. RapidEye satellite imagery is especially suited for agricultural, environmental, cartographic and disaster management applications. The company not only offers their imagery, but consults their customers to create services and solutions based on analysis of this imagery.

Image Sat International

Earth Resource Observation Satellites, better known as "EROS" satellites, are lightweight, low earth orbiting, high-resolution satellites designed for fast manoeuvring between imaging targets. In the commercial high-resolution satellite market, EROS is the smallest very high resolution satellite; it is very agile and thus enables very high performances. The satellites are deployed in a circular sun-synchronous near polar orbit at an altitude of 510 km (+/- 40 km). EROS satellites imagery applications are primarily for intelligence, homeland security and national development purposes but also employed in a wide range of civilian applications, including: mapping, border control, infrastructure planning, agricultural monitoring, environmental monitoring, disaster response, training and simulations, etc.

EROS A – a high resolution satellite with 1.9-1.2m resolution panchromatic was launched on December 5, 2000.

EROS B - the second generation of Very High Resolution satellites with 70 cm resolution panchromatic, was launched on April 25, 2006.

Meteosat

Model of a first generation Meteosat geostationary satellite

The Meteosat-2 geostationary weather satellite began operationally to supply imager data on 16 August 1981. Eumetsat has operated the Meteosats since 1987.

- The Meteosat visible and infrared imager (MVIRI), three-channel imager: visible, infrared and water vapour; It operates on the first generation Meteosat, Meteosat-7 being still active.
- The 12-channel Spinning Enhanced Visible and Infrared Imager (SEVIRI) includes similar channels to those used by MVIRI, providing continuity in climate data over three decades; Meteosat Second Generation (MSG).
- The Flexible Combined Imager (FCI) on Meteosat Third Generation (MTG) will also include similar channels, meaning that all three generations will have provided over 60 years of climate data.

Indian Remote Sensing Satellites:

Indian has the largest constellation of Remote Sensing Satellites, which are providing services both at the national and global levels. From the Indian Remote Sensing (IRS) Satellites, data is available in a variety of spatial resolutions starting from 360 metres and highest resolution being 2.5 metres. Besides, the state-of-the-art cameras of IRS spacecraft take the pictures of the Earth in several spectral bands. In future, ISRO intends to launch IRS spacecraft with better spatial resolution and capable of imaging day and night. The satellites of IRS system which are in service today are IRS-1C, IRS-ID, IRS-P3, OCEANSAT-1, Technology Experimental Satellite (TES), RESOURCESAT-1, and the recently launched CARTOSAT-1 capable of taking stereo pictures. The upcoming Remote Sensing Satellite are Cartosat-2, RISAT (Radar Imaging Satellite) and Oceansat-2.

Imagery sent by IRS spacecraft is being put to a variety of uses in India with agricultural crop acreage and yield estimation being one of the most important uses. Besides, such imagery is being used for ground and surface water harvesting, monitoring of reservoirs and irrigation command areas to optimise water use. Forest survey and management and wasteland identification and recovery are other allied uses. This apart, IRS imagery is also used for mineral prospecting and forecasting of potential fishing zones.

With regard to applications in planning and management, IRS data is being used for urban planning, flood prone area identification and the consequent suggestions for mitigation measures. Based on this experience, the concept of Integrated Mission for Sustainable Development has been evolved wherein the spacecraft image data is integrated with the socio-economic data obtained from conventional sources to achieve sustainable development.

Geographic Information Systems:

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

The major challenges we face in the world today--overpopulation, pollution, deforestation, natural disasters--have a critical geographic dimension.

Components of a GIS:

A working GIS integrates five key components: hardware, software, data, people, and methods.

Hardware
Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software
GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are

- Tools for the input and manipulation of geographic information
- A database management system (DBMS)
- Tools that support geographic query, analysis, and visualization
- A graphical user interface (GUI) for easy access to tools

Data
Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data.

People
GIS technology is of limited value without the people who manage the system and develop plans for

applying it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.

Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Advantages:

There are numbers of data that could be displayed and inventoried with the use of GIS or Geographic Information System such as from natural resources, wildlife, cultural resources, wells, springs, water lines, fire hydrants, roads, streams and also houses. The quantities and so the densities of a certain item within a given area could be displayed and calculated. But there are still many things that you could do with the use of GIS technology.

Here are some of the advantages of using GIS technology:

- It has the ability of improving the organizational integration. GIS would then integrate software, hardware and also data in order to capture, analyse, manages and so displays all forms of information being geographically referenced.
- GIS would also allow viewing, questioning, understanding, visualizing and interpreting the data into numbers of ways which will reveal relationships, trends and patterns in the form of globes, maps, charts and reports.
- Geographic Information System is to provide a help in answering questions as well as solve problems through looking at the data in a way which is easily and quickly shared.
- GIS technology could also be integrated into framework of any enterprise information system.
- And there would be numbers of employment opportunities.