Program : **B.Tech**

Subject Name: **Remote Sensing and GIS**

Subject Code: **CE-504**

Semester: **5th**

Unit II

Remote Sensing& GIS

Syllabus

Remote Sensing Platforms and Sensors: Indian Satellites and Sensors characteristics, Remote Sensing Platforms, Sensors and Properties of Digital Data, Data Formats: Introduction, platforms- IRS, Land sat, SPOT, Cartosat, Ikonos, Envisat etc. sensors, sensor resolutions (spatial, spectral, radiometric and temporal). Basics of digital image processing- introduction to digital data, systematic errors (Scan Skew, Mirror-Scan Velocity, Panoramic Distortion, Platform Velocity, Earth Rotation) and non-systematic [random] errors (Altitude, Attitude), Image enhancements (Gray Level Thresholding, level slicing, contrast stretching), image filtering.

Principle

Remote sensing is the acquisition of information about an object without coming in physical contact of that object. And 'sensor' is a device that helps in gathering of information (amount of EMR emitted or reflected by the object). In other words, 'sensor' is the remote sensing device that records wavelengths of energy. Generally, these sensors are mounted or fixed with a 'platform'. Therefore, 'platform' is termed as a vehicle that carries remote sensing device.

Indian Satellites and Sensors characteristics:

IRS satellite program Indian Remote Sensing (IRS) satellite system is one of the largest civilian remote sensing satellite constellations in the world used for earth observation. Objective of the program is to provide a long-term space-borne operational capability for the observation and management of the natural resources. IRS satellite data have been widely used in studies related to agriculture, hydrology, geology, drought and flood monitoring, marine studies and land use analyses. The first satellite of the mission IRS-1A was launched in 1988.

IRS satellites orbit the Earth in sun-synchronous, near-polar orbits at low altitude. Various missions in the IRS satellite program employ various sensors viz., LISS-1, LISS-2, LISS-3, WiFS, AWiFS etc.

A list of the sensors that have been used in Indian Remote Sensing satellites Follows.

Satellite Microwave Radiometer (SAMIR)

SAMIR was the payload for BHASKAR I and II satellites launched in 1979 and 1981. They successfully provided data on the sea surface temperature, ocean winds, moisture content over the land and sea. It was a dicke type radiometer with a temperature resolution better than 1 degree kelvin.

Two Band T.V. Payload

The Bhaskara satellites I and II had a two band TV payload for land applications. It gave images of earth from a height of 525 Km. The data were used in meteorology, hydrology, and forestry.

Smart Sensor: Rohini Rs-D2, (the successor to the failed Rs-D1) was launched on Apr. 1983. It carried a Smart sensor, which was a 2-Band solid-state device. It had the first CCD camera developed in house.

LISS-I, II and III

LISS-I (Linear Imaging self Scanner) was a payload for the IRS-1A satellite. This camera operated in four spectral bands. It operated in a push-broom scanning mode using a CCD array. Each band used 2 CCD's which were staggered in the focal plane. It was again used in IRS-1B. It used 7 bit quantization, and had a swath of 148 Kms. Images of LISS-I was extensively used in forestry, crop acreage, yeild estimation, drought monitoring, flood monitoring etc.

LISS-II was similar to LISS-I, but with higher spatial resolution and smaller swath. it was on payload in three satellites : IRS-1A, IRS-1B, IRS-P2.

LISS-III is onboard two satellites IRS-1C and IRS-1D. This is a multi-spectral camera which operates in four bands. It provides color images. Its images were used widely in the area of agriculture, mapping, crop acreage etc.

The Panchromatic Camera:

This was carried by IRS-1c and IRS-1D satellites. Pan camera enables the acquisition of images at the resolution of 5.8m, which was the highest resolution offered by a civilian satellite until recently, when American satellite Ikonos with a resolution of 1m surpassed it. The Pan camera uses CCD's to capture images.

Wide Field Sensor:

IRS-1C, IRS-1D, IRS-P3, which are all second generation Indian remote sensing satellites, carried the WIFS sensor. The WIFS camera uses an 8 element refractive optics like in LISS-III. Two such cameras are mounted with overlapping pixels of imaging. WIFS data was used in assessment of rabi cropped area, crop inventory, observation of crop phenology etc.

Ocean Colour Monitor:

IRS-P4, also called Ocean sat, carried the ocean color monitor, launched on board PSLV-C1. This payload is meant for oceanographic applications. The OCM is a solid state camera operating in the push-broom scanning mode, using linear array CCD'S as detectors for generating ocean biological parameters.

Very High Resolution Radiometer:

All the INSAT-1 and the INSAT-2, INSAT-3 series communications satellites carry the VHRR to provide various remote sensing applications. Since INSAT satellites are geostationary, VHRR provides round the clock meteorological earth observations, disaster warning signals.

Remote sensing platforms:

Remote sensing platforms can be defined as the structures or vehicles on which remote sensing instruments (sensors) are mounted. For remote sensing applications, sensors should be mounted on

suitable stable platforms. These platforms can be ground based air borne or space borne based. As the platform height increases the spatial resolution and observational area increases. Thus, higher the sensor is mounted; larger the spatial resolution and synoptic view is obtained. The types or characteristics of platform depend on the type of sensor to be attached and its application. Platforms for remote sensors may be situated on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere.

Typical platforms are satellites and aircraft, but they can also include radio-controlled aeroplanes, balloons kits for low altitude remote sensing, as well as ladder trucks or 'cherry pickers' for ground investigations.

Types of platforms

1.Ground-borne platforms:

Ground borne platforms are used to record detailed information about the surface which is compared with information collected from aircraft or satellite sensors i.e. for ground observation. Ground observation includes both the laboratory and field study, used for both in designing sensors and identification and characterization of land features Ground observation platforms include – handheld platform, cherry picker, towers, portable masts and vehicles etc. Portable handheld photographic cameras and spectroradiometers are largely used in laboratory and field experiments as a reference data and ground truth verification.

2. Air-borne platforms: Airborne platforms are used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time. Airborne platforms were the sole non-ground-based platforms for early remote sensing work.

Balloon

Balloons are used for remote sensing observation (aerial photography) and nature conservation studies. The first aerial images were acquired with a camera carried aloft by a balloon in 1859. Balloon floats at a constant height of about 30 km. The balloon is governed by the wind at the floating altitude. Balloons are rarely used today because they are not very stable and the course of flight is not always predictable, although small balloons carrying expendable probes are still used for some meteorological research.

Drone

Drone is a miniature remotely piloted aircraft. It is designed to fulfil requirements for a low cost platform, with long endurance, moderate payload capacity and capability to operate without a runway or small runway. Drone includes equipment of photography, infrared detection, radar observation and TV surveillance. It uses satellite communication link.

An onboard computer controls the payload and stores data from different sensors and instruments. Drone was developed in Britain during World War-II, is the short sky spy which was originally conceived as a military reconnaissance. Now it plays important role in remote sensing. The unique advantage is that it could be accurately located above the area for which data was required and capable to provide both night and day data.

Aircraft:

Special aircraft with cameras and sensors on vibration less platforms are traditionally used to acquire aerial photographs and images of land surface features. While low altitude aerial photography results in large scale images providing detailed information on the terrain, the high altitude smaller scale images offer advantage to cover a larger study area with low spatial resolution. Beside aerial photography multi spectral, hyper spectral and microwave imaging is also carried out by aircraft. Aircraft platforms offer an economical method of remote sensing data collection for small to large study areas with cameras, electronic imagers, across- track and along-track scanners, and radar and microwave scanners. AVIRIS hyper spectral imaging is famous aircraft aerial photographic operation of USGS.

High Altitude Sounding Rockets:

High altitude sounding rocket platforms are useful in assessing the reliability of the remote sensing techniques as regards their dependence on the distance from the target is concerned. Balloons have a maximum altitude of approximately 37 km, while satellites cannot orbit below 120 km. High altitude sounding rockets can be used to a moderate altitude above terrain. Imageries with moderate synoptic view can be obtained from such rockets for areas of some 500,000 square kilometres per frame. The high altitude sounding rocket is fired from a mobile launcher. During the flight its scanning work is done from a stable altitude, the payload and the spent motor are returned to the ground gently by parachute enabling the recovery of the data. One most important limitations of this system is to ensure that the descending rocket not going to cause damage.

3. Space-borne platforms: In space-borne remote sensing, sensors are mounted on-board a spacecraft (space shuttle or satellite) orbiting the earth. Space-borne or satellite platform are onetime cost effected but relatively lower cost per unit area of coverage, can acquire imagery of entire earth without taking permission. Space borne imaging ranges from altitude 250 km to 36000 km.

Space borne remote sensing provides the following advantages:

• Large area coverage;

• Frequent and repetitive coverage of an area of interest;

• Quantitative measurement of ground features using radio metrically calibrated sensors;

• Semi-automated computerized processing and analysis;

• Relatively lower cost per unit area of coverage.

There are two types of well recognized satellite platforms- manned satellite platform and unmanned satellite platform.

Manned Satellite Platforms:

Manned satellite platforms are used as the last step, for rigorous testing of the remote sensors on board so that they can be finally incorporated in the unmanned satellites. This multi- level remote sensing concept is already presented. Crew in the manned satellites operates the sensors as per the program schedule.

Unmanned Satellite Platforms

Landsat series, SPOT series and IRS series of remote sensing satellite, NOAA series of meteorological satellites, the entire constellation of the GPS satellites and the GOES and INSAT series of geostationary environmental, communication, television broadcast, weather and earth observation satellites etc are examples of unmanned satellite category.

Cartosat-1 PAN Sensor

1. 2.5 m resolution
2. Two Pan cameras - fore with 26 deg. and aft with -5 deg. Tilt(500 nm- 850 nm)
3. Swath 27.5 km for stereo
4. 8 km overlap between adjacent paths
5. 10 bits
6. Facility for across track tilt to give better revisit

IKONOS

IKONOS was a commercial Earth observation satellite, and was the first to collect publicly available high-resolution imagery at 1- and 4-meter resolution. It collected multispectral (MS) and panchromatic (PAN) imagery. The capability to observe Earth via space-based telescope has been called "one of the most significant developments in the history of the space age", and IKONOS brought imagery rivalling that of military spy satellites to the commercial market.[4] IKONOS imagery began being sold on 1 January 2000, and the spacecraft was retired in 2015.

Envisat ("Environmental Satellite")

Envisat ("Environmental Satellite") is a large inactive Earth-observing satellite which is still in orbit. Operated by the European Space Agency (ESA), it was the world's largest civilian Earth observation satellite.

It was launched on 1 March 2002 aboard an Ariane 5 from the Guyana Space Centre in Kourou, French Guiana, into a Sun synchronous polar orbit at an altitude of 790 ± 10 km. It orbits the Earth in about 101 minutes, with a repeat cycle of 35 days. After losing contact with the satellite on 8 April 2012, ESA formally announced the end of Envisat's mission on 9 May 2012.

Envisat cost 2.3 billion Euro (including 300 million Euro for 5 years of operations) to develop and launch.[4] The mission is due to be replaced by the Sentinel series of satellites. The first of these, Sentinel 1, has taken over the radar duties of Envisat since its launch in 2014.

Remote sensing data:

Remote sensing data from two satellite-borne sensors was used;

1) SEVIRI, a meteorological sensor on MSG2, a geostationary platform, and

2) MODIS, an ocean colour sensor on the polar-orbiting Aqua satellite.

SEVIRI provides data at a high temporal resolution (every fifteen minutes), while MODIS has an approximately daily revisit time at this latitude (52°N). Two SEVIRI bands were used: one at 635 nm (VIS0.6) and one at 810 nm (VIS0.8). Both have a spatial resolution of 3 × 3 km at the sub-satellite point, but due to the latitude of the study area the pixels are elongated to approximately 6 × 3 km. A twenty month dataset (January 2008 to mid-September 2009) of SEVIRI data was obtained from the Royal Meteorological Institute of Belgium (RMIB) and cropped to the southern North Sea region (130 × 240 pixels). To derive the marine reflectance in the VIS0.6 band, ρwSEV, SEVIRI imagery was corrected for 1) atmospheric gas absorption, 2) Rayleigh scattering, and 3) scattering by aerosols (details in Neukermans et al., 2009, Neukermans et al., 2012).

MODIS-Aqua marine reflectance, ρwMOD, with a spatial resolution of approximately 1 × 1 km was computed by multiplying the remote sensing reflectance at 645 nm (Rrs_645) by π. Rrs_645 was extracted from the level 2 products distributed by the Ocean Biology Processing Group (http://oceancolor.gsfc.nasa.gov/), using the R2009.1 reprocessing (http://oceancolor.gsfc.nasa.gov/WIKI/OCReproc20091.html) and the flagging described in Vanhellemont, Nechad, and Ruddick (2011).

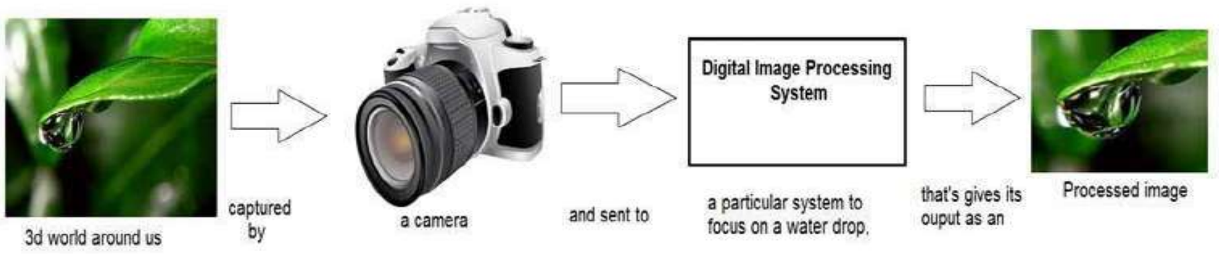
MODIS reflectance was wavelength-shifted to the SEVIRI band (factor 1.02, see Fig. 4.13 in Neukermans, 2012). The low resolution (LR) SEVIRI grid was subdivided into 6 × 3 pixels, to obtain a high resolution grid (HR) with spatial resolution comparable to that of MODIS.MODIS and SEVIRI marine reflectance's were collocated on the HR grid, using nearest neighbour re projection.

Basics of digital image processing:

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and

the system process that image using efficient algorithms, and gives an image as an output. The most common example is Adobe Photoshop. It is one of the widely used applications for processing digital images.

How it works.



Digital Image Processing means processing digital image by means of a digital computer. We can also say that it is a use of computer algorithms, in order to get enhanced image either to extract some useful information.

Image processing mainly include the following steps:

1. Importing the image via image acquisition tools;

2. Analysing and manipulating the image;

3. Output in which result can be altered image or a report which is based on analysing that image.

An image is defined as a two-dimensional function, F(x, y), where x and y are spatial coordinates, and the amplitude of F at any pair of coordinates (x, y) is called the intensity of that image at that point. When x, y, and amplitude values of F are finite, we call it a digital image.

In other words, an image can be defined by a two-dimensional array specifically arranged in rows and columns.

Digital Image is composed of a finite number of elements, each of which elements have a particular value at a particular location. These elements are referred to as picture Elements, image elements, and pixels. A Pixel is most widely used to denote the elements of a Digital Image.

Types of an image:

1. **BINARY IMAGE– The binary image as its name suggests, contain only two pixel elements i.e 0 & 1,where 0 refers to black and 1 refers to white. This image is also known as Monochrome.**
2. **BLACK AND WHITE IMAGE– The image which consists of only black and white colour is called BLACK AND WHITE IMAGE.**
3. **8 bit COLOR FORMAT– It is the most famous image format. It has 256 different shades of colours in it and commonly known as Greyscale Image. In this format, 0 stands for Black, and 255 stands for white, and 127 stands for gray.**
4. **16 bit COLOR FORMAT– It is a colour image format. It has 65,536 different colours in it. It is also known as High Colour Format. In this format the distribution of colour is not as same as Greyscale image.**

A 16 bit format is actually divided into three further formats which are Red, Green and Blue. That famous RGB format.

PHASES OF IMAGE PROCESSING:

1. **ACQUISITION– It could be as simple as being given an image which is in digital form. The main work involves:**
   a) Scaling
   b) Colour conversion (RGB to Gray or vice-versa)

2. IMAGE ENHANCEMENT– It is amongst the simplest and most appealing in areas of Image Processing it is also used to extract some hidden details from an image and is subjective.

3. IMAGE RESTORATION– It also deals with appealing of an image but it is objective(Restoration is based On mathematical or probabilistic model or image degradation).

4. COLOR IMAGE PROCESSING– It deals with pseudocolor and full colour image processing color models are applicable to digital image processing.

5. WAVELETS AND MULTI-RESOLUTION PROCESSING– It is foundation of representing images in various degrees.

6. IMAGE COMPRESSION-It involves in developing some functions to perform this operation. It mainly deals with image size or resolution.

7. MORPHOLOGICAL PROCESSING-It deals with tools for extracting image components that are useful in the representation & description of shape.

8. SEGMENTATION PROCEDURE-It includes partitioning an image into its constituent parts or objects. Autonomous segmentation is the most difficult task in Image Processing.

9. REPRESENTATION& DESCRIPTION-It follows output of segmentation stage, choosing a representation is only the part of solution for transforming raw data into processed data.

10. OBJECT DETECTION AND RECOGNITION-It is a process that assigns a label to an object based on its descriptor. Systematic errors (Scan Skew, Mirror-Scan Velocity, Panoramic Distortion, Platform Velocity, Earth Rotation)

Systematic Errors

Generally caused by Scan skew, mirror scans, velocity variance, panoramic distortion, platform velocity and, earth rotation. These errors can correct through analysis of system characteristics and ephemeris.

Non-systematic Errors

Generally caused by altitude variance and varied platform attitude. These errors can correct with the use of ground control points. Geometric distortions can also categorize as internal distortions and external distortions. Internal distortions are generally occurs due to platform or observer's movement, while external distortions are due to observed object. Following figure shows the various effects generated during image distortions.

Image Enhancement

Enhancements are used to make it easier for visual interpretation and understanding of imagery. The advantage of digital imagery is that it allows us to manipulate the digital pixel values in an image. Although radiometric corrections for illumination, atmospheric influences, and sensor characteristics may be done prior to distribution of data to the user, the image may still not be optimized for visual interpretation. Remote sensing devices, particularly those operated from satellite platforms, must be designed to cope with levels of target/background energy which are typical of all conditions likely to be encountered in routine use. With large variations in spectral response from a diverse range of targets (e.g. forest, deserts, snowfields, water, etc.) no generic radiometric correction could optimally account for and display the optimum brightness range and contrast for all targets. Thus, for each application and each image, a custom adjustment of the range and distribution of brightness values is usually necessary.

An image 'enhancement' is basically anything that makes it easier or better to visually interpret an image. In some cases, like 'low-pass filtering', the enhanced image can actually look worse than the original, but such an enhancement was likely performed to help the interpreter see low spatial frequency features among the usual high frequency clutter found in an image. Also, an enhancement is performed for a specific application. This enhancement may be inappropriate for another purpose, which would demand a different type of enhancement.

Image filtering

If a vertical or horizontal section is taken across a digital image and the image values are plotted against distance, a complex curve is produced. An examination of this curve would show sections where the gradients are low (corresponding to smooth tonal variations on the image) and sections where the gradients are high (locations where the digital numbers change by large amounts over short distances). Filtering is the process by which the tonal variations in an image, in selected ranges or frequencies of the pixel values, are enhanced or suppressed. Or in other words, filtering is the process that selectively enhances or suppresses particular wavelengths or pixel DN values within an image. Two widely used approaches to digitally filter images are convolution filtering in the spatial domain and Fourier analysis in the frequency domain. This lecture explains the filtering techniques with special reference only to the spatial domain.

