Remote Sensing and GIS

Unit 5

Remote Sensing

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it.

This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

Electro Magnetic Spectrum

speed of light

frequency
(Greek letter, nu)

$$c = \lambda \nu$$

wavelength

Elements or Components of Remote Sensing

1. Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Target (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception, and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)

Types of Sensing

1. Passive sensing is a collection of energy that is reflected or emitted from the surface of the earth

2. Active sensing system sends the energy towards the object then measure and detect the radiation that is reflected or backscattered from the object

Remote Sensing observables

- Synoptic scale observation is done by sensing and recording **reflected, emitted and scattered energy** and processing, analyzing, and applying that information."

Platforms

Platforms are:

- Ground based
- Airborne
- Spaceborne

Sensing from 1 meter to 36,000 km height

Sensor-platform characteristics

- **Spatial Resolution** - Spatial Resolution of the sensor and refers to the size of the smallest possible feature that can be detected .
- **Spectral Resolution** - It refers to the EMR wavelengths to which remote sensing system is sensitive.
- **Radiometric Resolution** – Radiometric resolution is the smallest difference in the radiant energy that can be detected by the sensor.
- **Temporal Resolution** – Time frequency of data collection.

Spectral Resolution

Spatial Resolution

Radiometric Resolution

Temporal Resolution

Year of Acquisition - 2000

Year of Acquisition - 2005

FCC (False Color Composite)

FCC (False Color Composite)

Sensor	Optical Sensor System		Antenna System
Wavelength Region	Visible – Reflective IR	Thermal Infrared	Microwave
Source	Sun	Object	Transmitted by Remote sensing System
Object	Reflectance	Thermal radiation (temperature, emissivity)	Backscattering coefficient
Electro-magnetic Spectrum	Visible – Reflective infrared	Thermal infrared	Microwave

Microwave Remote Sensing

Active microwave sensors provide their own energy source for illumination.

Cloud Cover is a major problem in many optical remote sensing applications

Microwave radiation can penetrate through Clouds

Optical

Microwave

Microwave Remote Sensing

- Radar is an active remote sensing system because it provides its own source of energy. The system “illuminates” the terrain with longer electromagnetic energy, detects the backscattering energy returning from the terrain (called radar turn), and then records it as an image.

ROLE OF REMOTE SENSING: *IN* ***CYCLONE:***

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED:
Risk modelling; vulnerability analysis.	Early warning; long-range climate modelling	Identifying escape routes; crisis mapping; impact assessment; cyclone monitoring; storm surge predictions.	Damage assessment; spatial planning.	KALPANA-1; INSAT-3A; QuikScat radar; Meteosat **SCATSAT-1**

Example:

Cyclone Lehar by KALPANA 1

Cyclone Helen by Mangalayan

ROLE OF REMOTE SENSING: *IN* ***EARTHQUAKES:***

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED
Building stock assessment; hazard mapping.	Measuring strain accumulation.	Planning routes for search and rescue; damage assessment; evacuation planning; deformation mapping.	Damage assessment; identifying sites for rehabilitation.	PALSAR; IKONOS 2; InSAR; SPOT; IRS

The **World Agency of Planetary Monitoring and Earthquake Risk Reduction** (WAPMERR) uses remote sensing to improve knowledge of building stocks — for example the number and height of buildings. High resolution imagery can also help hazard mapping to guide building codes and disaster preparedness strategies.

ROLE OF REMOTE SENSING: *IN FLOODS:*

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED
Mapping flood-prone areas; delineating flood-plains; land-use mapping.	Flood detection; early warning; rainfall mapping.	Flood mapping; evacuation planning; damage assessment.	Damage assessment; spatial planning.	Tropical Rainfall Monitoring Mission; AMSR-E; KALPANA I;

Sentinel Asia — a team of 51 organisations from 18 countries — delivers remote sensing data via the Internet as easy-to-interpret information for both early warning and flood damage assessment across Asia.
It uses the **Dartmouth Flood Observatory's** (DFO's) River Watch flood detection and measurement system, based on AMSR-E data, to map flood hazards and warn disaster managers and residents in flood-prone areas when rivers are likely to burst their banks.

Flood In Uttarakhand

Flood In Assam

ROLE OF REMOTE SENSING: *IN OTHER DISASTERS:*

DISASTER	MITIGATION	PREPAREDNESS	RECOVERY	RESCUE	SATELLITES USED
DROUGHT	Risk modelling; vulnerability analysis; land and water management planning.	Weather forecasting; vegetation monitoring; crop water requirement mapping; early warning.	Monitoring vegetation; damage assessment.	Informing drought mitigation.	FEWS NET; AVHRR; MODIS; SPOT
VOLCANO	Risk modelling; hazard mapping; digital elevation models.	Emissions monitoring; thermal alerts.	Mapping lava flows; evacuation planning.	Damage assessment; spatial planning.	MODIS and AVHRR; Hyperion
FIRE	Mapping fire-prone areas; monitoring fuel load; risk modelling.	Fire detection; predicting spread/direction of fire; early warning.	Coordinating fire fighting efforts.	Damage assessment.	MODIS; SERVIR; Sentinel Asia; AFIS
LANDSLIDE	Risk modelling; hazard mapping; digital elevation models.	Monitoring rainfall and slope stability.	Mapping affected areas;	Damage assessment; spatial planning; suggesting management practices.	PALSAR; IKONOS 2; InSAR; SPOT; IRS

Microwave Remote Sensing Technologies

- Scatterometry – Cyclones
- Polarimetry – Drought, Flood
- Interferometry – Landslide

CASE STUDY :
USE OF REMOTE SENSING & GIS in PHAILIN CYCLONE

8th October

10th October

11th October

12th October

7th October, 2013: Indian Meteorological Department received information from KALPANA I, OCEANSAT and INSAT 3A Doppler radars deployed at vulnerable places, with over-lap, sensors in the sea and through the ships, about a cyclone forming in the gulf between Andaman Nicobar and Thailand named PHAILIN (Thai for "Sapphire").

8th October, 2013: IMD confirmed cyclone formation and predicted it as "severe cyclone" and its effects would be felt from Kalingapatnam in Andhra Pradesh to Paradeep in Odisha, and that it would probably first strikethe port of Gopalpur in Ganjam district at about 5 pm on 12 October. The wind speed could touch 200(km/h).

10th October, 2013: IMD prediction of a severe cyclone was converted to a "very severe cyclonic storm" with wind speeds up to 220 kmph. the US Navy's Joint Typhoon Warning Centre predicted it would have wind speeds up to 315 km/h.

12th October, 2013: The "very severe" cyclonic storm had its landfall at Gopalpur port at about 9 pm with a wind speed of 200 km/h.

CASE STUDY :
USE OF REMOTE SENSING & GIS in PHAILIN CYCLONE

MITIGATION	PREPAREDNESS	RESPONSE	RECOVERY
GIS: Risk modelling; vulnerability analysis; Strengthening EWS; Disaster Response Infrastructures; Disaster Drills	Early Warning System; Constant updates from ISRO, IMD and USNJTWC etc.; Distribution of Satellite Phones , VHF and HAMRADIO to DMs, BDO's, Sarpanch etc.; Mass Evacuation on the basis of cyclone's path over the state.	Google Crisis Map; Google People Finder; ODRAF & NDRF Deployment;	Relief Operations coordinated by Navy & Air Force; Disaster Assessment; Logistics Coordinated by Centrally Operated Units; Spatial planning;

GIS – Geographical information System

- GEO:- Earth.
- Geography:- Study of earth and where things are.
- Information:- For capturing, managing, analyzing and understanding information.
- System:- A set of Software , hardware and Data.

GIS is capable to collect, map, analyze and model the Vector and Raster data

GIS (Geographical Information System)

- Geographic Information System (GIS) is a computer based application of technology involving spatial and attributes information to act as a decision support tool. It keeps information in different layers and generates various combinations pertaining to the requirement of the decision making.
- The data required for disaster management is coming from different scientific disciplines, and should be integrated.
  - ❖ Data integration is one of the strongest points of GIS. In general the following types of data are required:
  - ❖ Data on the disastrous phenomena (e.g. landslides, floods, earthquakes), their location, frequency, magnitude etc.
  - ❖ Data on the environment in which the disastrous events might take place: topography, geology, geo-morphology, soils, hydrology, land use, vegetation etc.
  - ❖ Data on the elements that might be destroyed if the event takes place: infrastructure, settlements , population, socio-economic data etc.
  - ❖ Data on the emergency relief resources, such as hospitals, fire brigades, police stations, warehouses etc.

Spatial and Non-spatial Products of GIS

- Vector Data - Spaghetti model – represented by point, line and polygon.
- Raster Data – composed of pixels.
- DEM (Digital Elevation Model) is a raster product (satellite data product) used to extract the slope and aspect map of the surface- useful in forest fire and landslide applications.

- Attribute data

Application of GIS in Disaster Management

- Identification of cyclone shelters location.
- Use in Automated Weather Stations (AWS)
- Preparation of the district vulnerability maps.
- Strengthening of embankment.
- Repair of roads.
- Identification of weak points in the embankments.
- Preparing the base map indicating location.

ArcGIS : The Complete Enterprise GIS

esri India

- Arc GIS is a complete GIS system for authoring, serving and using geographic information.
- It is an integrated collection of GIS software products for building and deploying a complete GIS wherever it is needed – on desktops, servers or custom applications, over the web or in the field

Role of GIS in Disaster Management Cycle

Why GIS ?

- **Integrate** many different types of data
  - Spatial data + Non-spatial data (statistical, texts,..)

- With GIS we can easily:
  - Draw maps and visualize spatial distributions
  - Edit and alter existing data
  - **Map where things are?**
  - Map Quantities & Densities
  - Accurately measure distances and areas
  - Simulate scenario's for better planning

& much more

Using GIS for Emergency Management

The Geographic Approach

How GIS can be leveraged for Disaster Management

esri India

GIS is the most complete information system for analyzing, modeling, and displaying community vulnerability

GIS aids in quickly establishing full situational awareness by linking people, processes, and information together using geography. It provides the map interface into getting a handle on an emergency and nimbly adjusting to change.

Accurate cataloging of GIS data and services, combined with your organization's existing investments, gives you an edge for turning raw data into useful information.

Getting accurate information from field operations back to the command center can be a difficult challenge. Mobile GIS gives you the advantage.

Where are My Assets

esri India

Field enablement

esri India

- Collect and Use Information Remotely
- Coordinate and Prioritize Response
- Optimize Operational Efficiency

Improving work in remote environments

Response and Recovery

Where?

Who?

How Long?

- GIS helps in creating Common Operational View
- GIS uses include:
  - *Mass Evacuation*
  - *Emergency Vehicle Dispatch and Tracking*
  - *System Restoration Monitoring*
  - *Damage Assessment*
  - *Infra availability assessment*

Assessment and Preparedness

- GIS uses include:
  - *Emergency Management Planning*
  - *Modeling Events*
  - *Mapping Critical Asset Locations Infrastructure Inventory*
  - Placement scenarios for motion detectors or cameras

Flood Modeling

Motion Detection

Planning/Mapping Critical Infra

Building a common operating environment

Case studies

Indian Ocean Tsunami

Operationalized Data and the Web

Supporting Pacific Data Centre

INCOIS

Collected, Processed & Provided Data & Images

Fukushima Radiation Exposure

Earthquake - Haiti

http://www.directrelief.org/Flash/Haiti_Aid_Distribution/Index.html

Case Study – Maharashtra DMIS

Case Study – Earthquake, Kutch District

esri India

Gulf of Mexico Spill

Data Management and the Cloud

esri India

- Response tracking/time series
- Shoreline cleanup
- Environmental sampling
- Boom retrieval
- Field observations
- Overflight photos
- Before and after photos
- Wildlife

GPS in emergency management

Satellite based positioning– 3D positioning (Latitude, longitude & Altitude or x, y & z)

SATELLITE-BASED RADIO NAVIGATION SYSTEM

- WORLD-WIDE COVERAGE
- ALL WEATHER OPERATION
- CONTINUOUS SIGNAL

- *NAVIGATION*
- *POSITIONING*
- *PRECISE TIME*

Global Navigation Satellite System (GNSS)

- Satellite based navigation system that provide **autonomous geospatial positioning** with Global coverage.
- **GNSS** is a network of satellites that continuously **transmit coded information** to identify the locations on the earth by measuring the distance from the satellites.

➨ GNSS involves **satellites, ground stations** and **user equipment.**

Galileo
EU/ESA

GPS
USA

GLONASS
Russia

QZSS - Japan

Compass
China

Design Objectives of GPS

- **Suitable for different platforms**: aircraft, ship, land-based and space (missiles and satellites),
- **Real-time positioning, velocity and time determination** capability to an appropriate accuracy,
- Single global geodetic datum (reference system) (**WGS 84**) for defining position,
- **Differential accuracy standards**: highest accuracy to be restricted to a certain class of authorized users,
- **Resistant to jamming** (intentional and unintentional),
- **Redundancy provisions** to ensure the survivability of the system,
- **Passive positioning system** that does not require the transmission of signals from the user to the satellite(s),
- Ability to provide the **service to an unlimited number of users** and **world-wide coverage**
- **Low cost, low power, therefore highly complex satellite segment**,

Global Positioning System

- GPS is a type of Global Navigation Satellite Systems.
- A very precise positioning system.
- Developed and maintained by the US Department of Defense(DOD).
- Satellite Based
  - 24 satellite in 6 constallations
  - 20,200 km high orbit.

Functional Segments of GPS

Space Segment

- Higher altitudes are made to have larger area coverage.
- **At least 4 of the satellites are visible above the horizon** to GPS receivers on the ground at any time.

GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

- **Satellites travel** at a speed of **3870 m/s**, which allows them to complete one revolution every **12h**. The satellites are **Geostationary** as well as **non-geostationary**. There are **12 satellites** on either side of the hemisphere at any time. Very high accurate **Atomic clocks** are used in **Satellites.**

Space Segment

- **Main Functions of a GPS Satellites are**

1. It **receives** and **stores** data and other **corrections from the control segment.**
2. It maintains a very **precise time**.
3. It transmits the coded signals to user receivers through two Frequencies **L1 and L2.**

Space Segment

- Each satellite contains **at least 3 high precision Atomic clocks** which constantly transmits radio signals using its own identification code.
- These signals travels in the 'Line of Sight'.
- Each signals contains ***pseudorandom codes (***which contain the information about the **time** and **orbital path** of the satellite***)*** through which the signal-travel time is calculated.

Control Segment (Ground Segment)

- It controls the GPS Satellites by tracking and providing them with correct **orbital and clock information**.

- Monitoring Stations are also called **Operational Control Segment (OCS)** monitor Station.
- 10 other National Geospatial Agency (NGA) stations are also deployed since 2005.

Main functions of the Control Segment

- **Monitor** the satellites.
- Estimate the **on-board clock state** and define the corresponding parameters to be broadcast.
- **Define the orbit** of each **satellite** to predict the ephemeris with almanac.
- **Determine the location and altitude** of the satellite in order to determine the parameters to be sent for **correcting** their orbits.
- **Uploading** the derived **clock correction** parameters, **ephemeris, almanac, and orbit correction** commands to the satellites.

User Segment

- Ground-based devices read and interpret the radio signals from several of the NAVSTAR satellites at once.
- Geographic position is determined using the time it takes signals from the satellites to reach the GPS receiver.
- Calculations result in varying degrees of accuracy that depend on:
  - Quality of the receiver
  - User operation of the receiver (e.g., skill of user and receiver settings)
  - Atmospheric conditions
  - Local conditions (i.e., objects that block or reflect the signals)
  - Current status of system

BASED ON FREQUENCIES

***Single frequency Receivers**

***Dual Frequency Receivers**

Application of GPS

- Location
- Navigation
- Tracking
- Mapping
- Timing

Applications of GPS in Disaster Management.

- GPS APPLICATION IN DISASTER EVENT.
- Landslide Study Using GPS Technologies
- GPS Application in Landslide Monitoring
- Application of GPS in Earth Quake
- GPS Application in Forest fire management
- Application of GPS in Flood Management

Applications of GPS in Disaster Management(contd.).

Characteristics of GPS

- Free
- Precise
- Reliable
- All weather
- Anytime & anywhere.
- Unlimited user capacity.