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LECTURE-1

REMOTE SENSING- AN INTRODUCTION

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Remote sensing is used in numerous fields, including geography and most Earth Science disciplines (for example, hydrology, ecology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning, and humanitarian applications. In current usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation).

CONCEPT OF REMOTE SENSING

Remote Sensing is the latest tool of study in earth sciences in general and geographical studies in particular. While remote sensing is the technology of obtaining information about the earth and its environment, GIS is the technique or system of managing, storing, interpreting and analyzing this information.

- Remote sensing is the science of obtaining and interpreting information from a distance, using sensors that are not in physical contact with the object being observed.

- "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."

- The science of remote sensing in its broadest sense includes aerial, satellite, and spacecraft observations of the surfaces and atmospheres of the planets in our solar system.

- According to American Society for Photogrammetry and Remote Sensing (ASPRS): *" the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study"* (Colwell, 1983)

- In 1988, ASPRS adopted a combined definition of Photogrammetry and Remote Sensing:

  Photogrammetry and Remote Sensing are the art, science and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery and digital interpretations of energy patterns derived from non-contact sensor systems(Colwell, 1997)

OVERVIEW OF REMOTE SENSING

Remote sensing of the Earth has many purposes, including making and updating planimetric maps, weather forecasting, and gathering military intelligence.

- The period from 1960 to 2010 has experienced some major changes in the field of remote sensing. The background for many of these changes occurred in the 1960s and 1970s. Some of these changes are outlined below.

- First, the term "remote sensing" was initially introduced in 1960. Before 1960 the term used was generally aerial photography. However, new methods and technologies for sensing of the Earth's surface were moving beyond the traditional black and white aerial photograph, requiring a new, more comprehensive term be established.

- Second, the 1960s and 1970s saw the primary platform used to carry remotely sensed instruments shift from air planes to satellites. Satellites can cover much more land space than planes and can monitor areas on a regular basis.
- Third, imagery became digital in format rather than analog. The digital format made it possible to display and analyze imagery using computers, a technology that was also undergoing rapid change during this period. Computer technology was moving from large mainframe machines to small microcomputers and providing information more in graphic form rather than numerical output.
- Fourth, sensors were becoming available that recorded the Earth's surface simultaneously in several different portions of the electro-magnetic spectrum. One could now view an area by looking at several different images, some in portions of the spectrum beyond what the human eye could view. This technology made it possible to see things occurring on the Earth's surface that looking at a normal aerial photograph one could not detect.
- Finally, the turbulent social movements of the 1960s and 1970s awakened a new and continuing concern about the changes in the Earth's physical environment. Remotely sensed imagery from satellites - analyzed and enhanced with computers - made it possible to detect and monitor these changes. Thus, societal support was and continues to remain strong for this

technology, even though very few people are familiar with the term, remote sensing.

Today, many satellites, with various remote sensing instruments, monitor the Earth's surface. These satellites and their respective remote sensing programs can trace their origins back to the CORONA and Landsat programs. CORONA was a secretive military program that continues to the present time through the advanced Keyhole satellites and Landatwas an open Earth resources program that also continues through more advanced Landsats and other satellite resource monitoring programs.

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LECTURE-2

TYPES OF REMOTE SENSING

Remote sensing can be defined as the collection of data about an object from a distance. Humans and many other types of animals accomplish this task with aid of eyes or by the sense of smell or hearing. Geographers use the technique of remote sensing to monitor or measure phenomena found in the Earth's lithosphere, biosphere, hydrosphere, and atmosphere. Remote sensing of the environment by geographers is usually done with the help of mechanical devices known as remote sensors. These gadgets have a greatly improved ability to receive and record information about an object without any physical contact. Often, these sensors are positioned away from the object of interest by using helicopters, planes, and satellites. Most sensing devices record information about an object by measuring an object's transmission of electromagnetic energyfrom reflecting and radiating surfaces. It may be split into active remote sensing (when a signal is first emitted from aircraft or satellites) or passive (e.g. sunlight) when information is merely recorded.

Remote sensing Type-Based on Source of energy

The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelength or absorbed and then re-emitted (for thermal infrared wavelength).

Remote sensing systems, which measure this naturally available energy, are called *passive sensors*. This can only take place when the sun is illuminating the earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted can be detected day and night provided that the amount of energy is large enough to be recorded.

Remote sensing systems, which provide their own source of energy for illumination, are known as *active sensors*. These sensors have the advantage of obtaining data any time of day or season. Solar energy and radiant heat are examples of passive energy sources. Synthetic Aperture Radar (SAR) is an example of active sensor.

Remote sensing Type - Based on Range of Electromagnetic Spectrum

Optical Remote Sensing:

The optical remote sensing devices operate in the visible, near infrared, middle infrared and short wave infrared portion of the electromagnetic spectrum. These devices are sensitive to the wavelengths ranging from 300 nm to 3000 nm. Most of the remote sensors record the EMR in this range, e.g., bands of IRS P6 LISS IV sensor are in optical range of EMR.

Thermal Remote Sensing

The sensors, which operate in thermal range of electromagnetic spectrum record, the energy emitted from the earth features in the wavelength range of 3000 nm to 5000 nm and 8000 nm to 14000 nm. The previous range is related to high temperature phenomenon like forest fire, and later with the general earth features having lower temperatures. Hence thermal remote sensing is very useful for fire detection and thermal pollution. e.g., the last five bands of ASTER and band 6 of Landsat ETM+ operates in thermal range.

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Microwave Remote Sensing

A microwave remote sensor records the backscattered microwaves in the wavelength range of 1 mm to 1 m of electromagnetic spectrum. Most of the microwave sensors are active sensors, having their own sources of energy, e.g., RADARSAT.These sensors have edge over other type of sensors, as these are independent of weather and solar radiations.

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LECTURE-3

REMOTE SENSING AS A TOOL FOR DATA GENERATION AND MAPPING

Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them. This process involves making observations using sensors (cameras, scanners, radiometer, radar etc.) mounted on platforms (aircraft and satellites), which are at a considerable height from the earth surface and recording the observations on a suitable medium (images on photographic films and videotapes or digital data on magnetic tapes).

When electromagnetic radiation falls upon a surface, some of its energy is absorbed, some is transmitted through the surface, and the rest is reflected. Surfaces also naturally emit radiation, mostly in the form of heat. It is that reflected and emitted radiation which is recorded either on the photographic film or digital sensor. Since the intensity and wavelengths of this radiation are a function of the surface in question, each surface is described as processing a characteristic ″Spectral Signature″. If an instrument can identify and distinguish between different spectral signatures, then it will be possible to map the extent of surfaces using remote sensing. Satellite remote sensing is widely used as a tool in many parts of the world for the management of the resources and activities within the continental shelf containing reefs, islands, mangroves, shoals and nutrient rich waters associated with major estuaries.

Satellites & Sensors

The mode can be geostationary, permitting continuous sensing of a portion of the earth or sun-synchronous with polar orbit covering the entire earth at the same equator crossing time. The Landsat series of satellites have a repeat period ranging from 16 – 18 days, whereas in the case of IRS, it is 22 days. Satellites cover the same area and provide continuous coverage of a fixed area. The sun-synchronous satellites have a synoptic coverage. The ground area covered by the satellite's passes can be obtained by referring to its path and row. Sensors are devices used for making observations. They consist of mechanisms usually sophisticated lenses with filter coatings to focus the area observed onto a plane in which detectors are placed. These detectors are sensitive to a particular region in which the sensor is designed to operate and produce outputs, which are either representative of the observed area as in the case of the camera or produce electrical signals proportionate to radiation intensity.

Spatial resolution

It is a measure of the smallest angular or linear separation between two objects that can be resolved by the sensor. The greater the sensor's resolution, the greater the data volume and smaller the area covered. In fact, the area coverage and resolution are inter-dependant and these factors determine the scale of the imagery.

Spectral resolution

It refers to the dimension and number of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive. Narrow bandwidths in certain regions of the electromagnetic spectrum allow the discrimination of various features more easily.

Temporal resolution

It refers to how often a given sensor obtains imagery of a particular area. Ideally, the sensor obtains data repetitively to capture unique discriminating characteristics of the phenomena of interest.

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Radiometric sensitivity

It is the capability to differentiate the spectral reflectance/ emittance from various targets. This depends on the number of quantization levels within the spectral band. In other words, the number of bits of digital data in the spectral band will decide the sensitivity of the sensor.

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LECTURE- 4

APPLICATIONS OF REMOTE SENSING

- Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Doppler radar is used by local law enforcements' monitoring of speed limits and in enhanced meteorological collection such as wind speed and direction within weather systems in addition to precipitation location and intensity. Other types of active collection includes plasmas in the ionosphere. Interferometric synthetic aperture radar is used to produce precise digital elevation models of large scale terrain
- Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so. By measuring the height and wavelength of ocean waves, the altimeters measure wind speeds and direction, and surface ocean currents and directions.
- Ultrasound (acoustic) and radar tide gauges measure sea level, tides and wave direction in coastal and offshore tide gauges.
- Light detection and ranging (LIDAR) is well known in examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology. Vegetation remote sensing is a principal application of LIDAR.

- Radiometers and photometers are the most common instrument in use, collecting reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors, followed by microwave, gamma ray and rarely, ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere.
- Stereographic pairs of aerial photographs have often been used to make topographic maps by imagery and terrain analysts in trafficability and highway departments for potential routes, in addition to modelling terrestrial habitat features.
- Simultaneous multi-spectral platforms such as Landsat have been in use since the 70's. These thematic mappers take images in multiple wavelengths of electro-magnetic radiation (multi-spectral) and are usually found on Earth observation satellites, including (for example) the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, detect invasive vegetation, deforestation, and examine the health of indigenous plants and crops, including entire farming regions or forests.[3] Landsat images are used by regulatory agencies such as KYDOW to indicate water quality parameters including Secchi depth, chlorophyll a density and total phosphorus content. Weather satellites are used in meteorology and climatology.
- Hyper spectral imaging produces an image where each pixel has full spectral information with imaging narrow spectral bands over a contiguous spectral range. Hyper-spectral images are used in various applications including mineralogy, biology, defense, and environmental measurements.

- Within the scope of the combat against desertification, remote sensing allows to follow up and monitor risk areas in the long term, to determine desertification factors, to support decision-makers in defining relevant measures of environmental management, and to assess their impacts.

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LECTURE 5

IMPORTANCE OF REMOTE SENSING IN GEOGRAPHY

Geography has evolved from a descriptive discipline to a highly developed analytical science which studies the spatial patterns of interrelationships between man and his environment. It is, hence, considered as the science of spatial distributions dealing with the space occupying processes and events. Besides, it also concerns with the nature of distributions, networks and interactions which all manifest some spatial patterns. Geography, thus, integrates the knowledge of processes and phenomena of the real world in a meaningful way.

The advent of electronic data processing and remote sensing have greatly improved both the techniques of analysis and quality of data whereas the electronic data processing is being used increasingly to analyse the large volume of spatio-temporal data. Remote sensing techniques have proved to be greatly useful in the quantitation geographical works for reasons of providing accurate and precise data about spatial phenomena.

The technology of land remote sensing has advanced rapidly. Beginning in the 19th century with the photographic reproduction of landscapes obtained through a variety of devices that enabled overhead photography, the field expanded rapidly in the 1930s and 1940s with the development of airborne photography. The commercial firms that obtained these photographic images were generally small and operated on a local rather than a national scale. With the launch of the first civilian land remote sensing satellite in 1972 and the beginning of global-scale remote sensing, there was an expectation that state, county, and local governments would rapidly create applications for this new source of information, but for a number of reasons public sector applications were slow to develop. There were limitations on what could be accomplished with satellite data in urban areas because the resolution of the satellite imagery was lower than that of the airborne imagery upon which many cities had depended for so long. Few people who had technical experience with remote sensing data worked in the public sector, which in any case had established nontechnical means of obtaining the necessary information. In short, for many jurisdictions, there was no compelling reason to incur the added institutional and budgetary expense of introducing a new technology into their operations—a technology perceived as having limited practical applications.

There have since been changes in both the institutional and the technical capabilities of state and local governments. Management of spatial (geographical) data on terrains, land ownership, land use, and soils collected by state and local governments has become far more sophisticated in recent years. GIS software has become more flexible, powerful, and easy to use. Layers of digital data can be combined to form new information products. Many state and local governments now employ staff with geographic information science expertise and use GIS databases routinely.

Global positioning system (GPS) technologies also contribute to the geospatial resources available to the public sector. GIS and GPS technologies are particularly useful in urban applications and management. One of the advantages of these technologies is that they can easily be used in conjunction with remote sensing. Because remote sensing data can be geo-referenced, they can be combined with topographic, land use, or tax data in a GIS database to provide information not previously available.

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LECTURE 6

APPLICATIONS OF REMOTE SENSING IN GEOMORPHOLOGY AND NATURAL HAZARDS

Remote sensing is the science of obtaining information about an object and its surrounding area, point and its surrounding phenomenon and its interaction with each other through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Geographical applications include monitoring of deforestation, agro ecologic zonation, ozone layer depletion, early flood warning systems, monitoring of large atmospheric oceanic anomalies such as EL Nino, climate and weather prediction, ocean mapping and monitoring, wetland degradation, vegetation and soil mapping, natural disaster and hazard assessment and mapping and land cover maps for input to global climate models. The application of remote sensing techniques for geographical studies can be outlined as follows:

1. **Geomorphological studies**

   Remote sensing provides the three dimensional modal of the area which provides a means for describing, delimiting, inventory and monitoring of relief and structure. Quantitative analysis of slope, drainage, texture and other physiography studies are carried out using remote sensing.Remotely sensed imagery has been used extensively in geomorphology since the availability of early Landsat data, with its value measurable by the extent to which it can meet the investigative requirements of geomorphologists. Geomorphology focuses upon landform description/classification, process characterization and the association between landforms and processes, while remote sensing is able to provide information on the location/distribution of landforms, surface/subsurface composition and surface elevation. The application of remote sensing in geomorphology is very wide as it enabled the introduction of high end technology in the subject. The wide availability of digital elevation models and the introduction of hyper-spectral imaging, radio-metrics and electromagnetics are few latest techniques of landform analysis. Remote sensing is also beginning to offer capacity in terms of close-range (<200 m) techniques for very high-resolution imaging.

2. **Natural hazards**

The use of remote sensing is becoming increasingly frequent in environmental studies. Recently, there has been almost no serious research of the environment performed without advanced image processing and analysis. One of the most important applications of remote sensing can be found in the case of natural disasters, where satellite imagery can be a valuable data source used in order to support rescue operations and damage estimation. With advanced studies, remote sensing can also be used to predict catastrophic events and to determine hazardous areas. This paper commences with a review of the remote sensing applications in natural hazard monitoring. Several case studies are presented, ranging from the El Nino devastation analysis and inundation area determination to forest fire detection and landslide observation. The Mount Mangart landslide case study is then described in greater detail. Some general remarks on landslide development are depicted and its consequences are described. A short outline of the 'Space and Major Disasters' Charter, which presented the framework for the remote sensing application to the event, is also given. Details on processing optical (SPOT, Landsat) and radar (ERS, RADARSAT) satellite imagery are presented. Both basic image interpretation and advanced GIS integration and analysis are described. The paper ends with a few general remarks on the usability of remote sensing in hazard studies and the 'Space and Major Disasters' Charter.

The potential threat of natural hazards is always difficult to predict accurately. However the advent of remote sensing has made great strides in the field of hazard prediction and monitoring. Remote sensing techniques are now used extensively to monitor natural hazards through the analysis of timely satellite data. The loss to life and property due to natural hazards like floods, draughts, tsunami and the like has been reduced considerably by the early warning systems and management plans formulated through the use of remote sensing.

LECTURE 7

APPLICATIONS OF REMOTE SENSING IN LAND USE

Land use/Land cover studies

Land use land cover studies and other resource surveys and inventories are main contribution of image interpretation. Geographers who are interested to conduct land use and inventory studies are involved in the development studies based on remote sensing. In fact, geographers are regarded as valuable member of the resource surrey team for the mapping of soil, vegetation and other resources. Remotely sensed images are most valuable to supplement the field work. It is possible to cover large areas at less cost and less time. Spatial stratification on the basis of soil, hydrological, vegetation or land use phenomena interpretation can be carried out quickly and an overview idea of various physical and cultural phenomenon of the area can be collected through the imagery.

Cartography: cartography is certainly the oldest and probably the most widely used application of remote sensing data. Formerly the purpose of aerial photography was the production of topographic mapping but the advent of new sources of remote sensing data has opened up new possibilities for the production of useful small scale maps.

Integrated surveys: During the time of integrated studies, geographers were more involved and remote sensing become irreplaceable basis for integrated surrey and study of the region.

Agricultural studies: Geographers are using remote sensing for agricultural survey ranging from very general land use information to very specific information such as location of certain insects and or diseases, total acreage and yields of major crops etc.

Settlement studies: Settlement type, pattern, growth etc can be overviewed on the remotely sensed imagery. Image interpretation techniques are very useful tool for urban land use survey and mapping, morphological study, house type and quality analysis, population estimation, slum clearance, CBD survey study, urban growth and development.

Biogeography: Remote sensing has been used extensively by bio-geographers for vegetation type identification, assessing environmental pollution and forecasting of natural disasters and their management.

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LECTURE-8

COMPUTER CARTOGRAPHY- AN INTRODUCTION

A map can be simply defined as a graphic representation of the real world. This representation is always an abstraction of reality. Because of the infinite nature of our Universe it is impossible to capture all of the complexity found in the real world. For example, topographic maps abstract the three-dimensional real world at a reduced scale on a two-dimensional plane of paper. The art of map construction is called cartography. People who work in this field of knowledge are called cartographers. The construction and use of maps has a long history. Some academics believe that the earliest maps date back to the fifth or sixth century BC. Even in these early maps, the main goal of this tool was to communicate information. Early maps were quite subjective in their presentation of spatial information. However, the introduction of Computer based cartography has revolutionized this art of map making. The application of computers into cartography made maps more ordered and accurate. Today, the art of map making is quite a sophisticated science employing methods from cartography, engineering, computer science, mathematics, and psychology.

Maps are used to display both cultural and physical features of the environment. Standard topographic maps show a variety of information including roads, land-use classification, elevation, rivers and other water bodies, political boundaries, and the identification of houses and other types of buildings. Some maps are created with very specific goals in mind. Cartographers classify maps into two broad categories: reference maps and thematic maps. Reference maps normally show natural and human-made objects from the geographical environment with an emphasis on location.

Examples of general reference maps include maps found in atlases and topographic maps. Thematic maps are used to display the geographical distribution of one phenomenon or the spatial associations that occur between a number of phenomena.

The art and science of cartography has now advanced as geographers, researchers, software companies, and various user organisations have realised the importance of Information Technology. The advantages offered by computers in this field of geography are numerous and find useful application in a number of areas like mining, earthquake zone detection, defense, cultivation, irrigation, roads construction, town planning, under water exploration and mountain expeditions. Yet another career prospect awaits you even though you may not be a student of science or mathematics. This is the field of computer cartography. The experts in this field develop maps and images with the help of specific software and hardware. The cartographic software keeps into account various mathematical formulae, principles of applied and physical sciences, geographical features like elevations and time zones. The specialised software also makes use of fundamentals of astronomy and relevant rules of measurement or geological data for determining and displaying size, shapes and topography.

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LECTURE- 9

RELEVANCE OF DIGITAL CARTOGRAPHY

Computer-proficient cartographers play a significant role in mapping as well as surveying. Almost all leading universities in the West, especially USA and UK are conducting curriculum on computer-aided cartography techniques. These are University of Texas, Oklahoma, Oregon State and California State. Besides, there are professional organisations like the Society of Cartographers, Association of American Geographers, Mapping Science Institute and British Cartographic Society. Software firms like Microsoft and Sun, have developed software that is used specifically for map-making. These are MapArt, Map Point 2000 and ARC view.

Computer cartographers are involved in acquisition and management of geographical information with the help of computer software and other IT hardware like digital cameras. They develop electronic mapping systems for automobiles, prepare forests inventories, suggest and prepare improvement plan for navigation system. These professionals are also required in related areas like remote sensing, photogrammetry, spatial analysis, surveying, GPS, Geodesy, etc. In remote sensing or photogrammetry cartographers make use of satellite or camera images and process them through computer programs to prepare maps. These techniques are used where human being cannot reach physically or areas that are environmentally hazardous. The data or maps are stored in spatial analysis system and used in land planning, telecommunication, geological surveys, medical research, power distribution and irrigation. With the help of electronic theodolites, cartographers produce maps, plans and digital model of areas that are of extreme relevance in defense. They also provide support in railways, bridge and roads construction, natural and mineral resource management etc.

As the Internet is spreading its reach, more Web-based software are coming up to transport cartographic data from one end to another and thus more avenues exist for professionals who will generate and work on Web-based cartographic data. Software professionals have opportunity to develop more user friendly, affordable and application specific packages for cartography. The enormous data so collected is compiled in a computer and then vector-based maps, specific to user requirement are prepared. Computer cartographers are also required to convert old print maps into digitized ones and to make them more accurate with the help of latest data collection and imaging techniques.

Some of the leading IT companies like Microsoft and Oracle offer software as well as hardware specific to cartography. Thus vast career avenues exist in these firms for professionals to develop programs or prepare database. Indian geographers are also not lagging behind their Western counterpart as far as IT-based cartographic education, training and career prospects are concerned. De Beers, a leading company in diamond exploration and mining, has its exploration office in Bangalore where it offers opportunity for cartographers who could prepare maps to guide the exploration and mining staff. Endoxon, a Delhi-based geo solution company in cartography, Web-based geo applications and marketing, employ project executives for its cartography-related projects. Those who have experience in vector graphic software like Freehand, Corel Draw Illustrator are desired for the position. Knowledge of Photoshop, scanning and printing techniques are also essential for a computer cartographer.

SGS Infotech, a Delhi-based company providing software-based mapping solutions, data processing and digitising services employs professionals for development of mapping software. More avenues for computer cartographers shall arise in department like Forest Research Institute and Geological Survey of India.

Computer cartography course conducted by some of the foreign universities expose students to thematic and terrain surface mapping, programming languages, computer-assisted cartographic techniques, map projection, interpretation and use of the Internet. Professionals employed in Forest Survey of India, located at places like Dehra Dun, Shimla and Bangalore are engaged in thematic and vegetation mapping using satellite and aerial imagery, electronic processing of inventory data and data banking, providing training on cartographic techniques, designing of methodology related to forest surveys.

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LECTURE 10

EVOLUTION OF GEOGRAPHIC INFORMATION SYSTEM (GIS)

Definitions

Some of the important definitions of Geographical Information System (GIS) are:

A GIS is

"*a computer system capable of assembling, storing, Manu plating and displaying geographically referenced information*."

"*a decision support system involving the integration of spatially referenced data in a problem solving environment.*"

"*a set of computer based systems for managing geographic data to solve spatial problems.*"

Introduction and Brief History

The advent of cheap and powerful computers over the last few decades has allowed for the development of innovative software applications for the storage, analysis, and display of geographic data. Many of these applications belong to a group of software known as Geographic Information Systems (GIS). Many definitions have been proposed for what constitutes a GIS. Each of these definitions conforms to the particular task that is being performed. Instead of repeating each of these definitions, I would like to broadly define GIS according to what it does. Thus, the activities normally carried out on a GIS include:

- The measurement of natural and human made phenomena and processes from a spatial perspective. These measurements emphasize three types of properties commonly associated with these types of systems: elements, attributes, and relationships.

- The storage of measurements in digital form in a computer database. These measurements are often linked to features on a digital map. The features can be of three types: points, lines, or areas (polygons).
- The analysis of collected measurements to produce more data and to discover new relationships by numerically manipulating and modeling different pieces of data.
- The depiction of the measured or analyzed data in some type of display - maps, graphs, lists, or summary statistics.

The first computerized GIS began its life in 1964 as a project of the Rehabilitation and Development Agency Program within the government of Canada. The *Canada Geographic Information System* (CGIS) was designed to analyze Canada's national land inventory data to aid in the development of land for agriculture. The CGIS project was completed in 1971 and the software is still in use today. The CGIS project also involved a number of key innovations that have found their way into the feature set of many subsequent software developments.

From the mid-1960s to 1970s, developments in GIS were mainly occurring at government agencies and at universities. In 1964, Howard Fisher established the *Harvard Lab for Computer Graphics* where many of the industries early leaders studied. The Harvard Lab produced a number of mainframe GIS applications including: SYMAP (Synagraphic Mapping System),CALFORM, SYMVU, GRID, POLYVRT, and ODYSSEY. ODYSSEY was first modern vector GIS and many of its features would form the basis for future commercial applications. Automatic Mapping System was developed by the United States

Central Intelligence Agency (CIA) in the late 1960s. This project then spawned the CIA's *World Data Bank*, a collection of coastlines, rivers, and political boundaries, and the *CAM* software package that created maps at different scales from this data. This development was one of the first systematic map databases. In 1969, Jack Dangermond, who studied at the Harvard Lab for Computer Graphics, co-founded Environmental Systems Research Institute (ESRI) with his wife Laura. ESRI would become in a few years the dominate force in the GIS marketplace and create ArcInfo and ArcView software. The first conference dealing with GIS took place in 1970 and was organized by Roger Tomlinson (key individual in the development of CGIS) and Duane Marble (professor at Northwestern University and early GIS innovator). Today, numerous conferences dealing with GIS run every year attracting thousands of attendants.

In the 1980s and 1990s, many GIS applications underwent substantial evolution in terms of features and analysis power. Many of these packages were being refined by private companies who could see the future commercial potential of this software. Some of the popular commercial applications launched during this period include: ArcInfo, ArcView, MapInfo, SPANS GIS, PAMAP GIS, INTERGRAPH, and SMALLWORLD. It was also during this period that many GIS applications moved from expensive minicomputer workstations to personal computer hardware.

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LECTURE 11

COMPONENTS AND FUNCTIONS OF GIS

Component of GIS

GIS has four component. All the components need to be in balance as one single perfectly synchronized unit for the system to function satisfactorily. These are:

1. Hardware
2. Software
3. Brain ware/live ware/ human ware
4. Geographic data

Hardware: It refers to the computer components and includes devices for storing, analysis and creating output. They include CPU, monitor, key board, scanner, hard disk, CD rom, printers, plotters etc.

Software: Software package for GIS consists of five basic technical modules which are subsystems for:

- **a.** Data input and verification
- **b.** Data storage and management
- **c.** Data output and presentation
- **d.** Data transformation and
- **e.** Interaction with the user.

  The different GIS software packages are MAP INFO, Arc info, Arc View, Arc GIS etc.

Functions of GIS

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GIS performs five main functions. These are:

1. **Data input and acquisition:** Acquisition of data from maps, aerial photographs, satellite images and field survey
2. **Pre-processing:** It involves manipulation of data for permanent storages in GIS database. It includes format conversion, data merging, data registration and photo-interpretation and data storage.
3. **Data Management:** A data base may be thought of as a collection of logically linked data files. A database management system allows the user to work efficiently with the data. It provides the means for creating data files, specifying their names, field type, sorting them, setting relations between them, editing and addition and deletion of data.
4. **Manipulation and analysis:** It is often called geo-processing. It is concerned with the analytical operations that process the database contents with different algorithms to derive information as per the users need and choice. It includes spatial operations, measurements, statistical analysis, manipulation and reclassification, aggregation and modelling.
5. **Product Generation:** A GIS programme provides facilities to display the derived information in the form of maps, graphs and tables on a variety of output media both in black and white and in colour.