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Department of Employment and Training

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BASICS OF GEOSPATIAL TECHNOLOGY

Introduction:

Geography has developed a number of methods and tools to investigate and identify the spatial structures and patterns. Besides, it also lends or borrows some methods and tools to measure and investigate precise understanding of the spatial locations and patterns.

- a) ***Mathematical Geography*** deals with the study of earth's size and shape, motions of the earth, concept of time and the time zones.
- b) ***Statistical Geography*** is concerned with the practice of collecting, analysing and presenting data that has a geographic or areal dimension, such as census data.
- c) ***Cartography*** is the study of making maps of various scales using authentic information.
- d) ***Remote Sensing*** is the art, science and technique of capturing the earth surface features using sensors or cameras in airplanes or satellites, processing and presenting the spatial information to users.
- e) ***Geographic Information System (GIS)*** is a computer-based tool of the recent decades for geographical studies. It is used for storing, retrieving, transforming, analysing, and displaying data to prepare useful thematic maps.
- f) ***Global Navigation Satellite System (GNSS)*** is used to pinpoint the geographic location of a user anywhere in the world. Airlines, shipping, travel agencies and automobile drivers use the system to track the vehicles and follow the best routes to reach the destination in the shortest possible time.

Geography is undergoing frequent changes to tackle the challenges of the dynamic world. The subject is more flexible and accommodates many principles of related subjects. At the same time, it lends concepts and knowledge to many related disciplines. Owing to these changes, the subject is attaining more refinement, accuracy, precision, depth and scientific rationale.

◆.....◆ **Geographical Information System (GIS)**

- The Geographic information systems have emerged in the past two decades as an essential tool for urban and resource planning and management. It includes the functions of data entry, data display, data management, information retrieval and analysis.
- While GIS deals with entire geography of the earth including land, ocean and atmosphere, the art, science and technology dealing with the acquisition, storage, processing, production, presentation and dissemination of the earth's information is called the Geoinformatics.
- It is the popular means of studies in recent decades which cater the real and useful information to the field of Geography, Environmental Studies, Town planning, Rural development studies, and Defense and Agricultural promotion.

Generation of the computers

1940 – 1956: First Generation – Vacuum Tubes
1956 – 1963: Second Generation – Transistors
1964 – 1971: Third Generation – Integrated Circuits
1972 – 2010: Fourth Generation – Microprocessors
2010 – Fifth Generation – Artificial Intelligence

Components of GIS

The components of GIS can be broadly classified into five types. They are mentioned below.

A. Hardware

Hardware is Computer on which GIS software runs. Nowadays there are a different range of computer, it might be Desktop or server based. ArcGIS Server is server-based computer where GIS software runs on network computer or cloud based. For computer to perform well all hardware components must have high capacity. Some of the hardware components are: Motherboard, Hard driver, processor, graphics card, printer and so on. These all component function together to run GIS software smoothly.

B. Software

Next component is GIS software which provides tools to run and edit spatial information. It helps to query, edit, run and display GIS data. It uses RDBMS (Relational Database Management System) to store the data. Few GIS software list: ArcGIS, ArcView 3.2, QGIS, SAGA GIS. Software Components: GIS Tools, RDBMS, Query Tools, GUI and Layout.

C. Data

Geographic data and related tabular data can be collected in-house compiled to custom specifications and requirements (or) purchased from a commercial data provider. A GIS can integrate spatial data with other existing data resources often stored in a corporate data base management System. The data can be broadly classified as

- Attribute data
- Spatial data
- Remote sensing data
- Global data base.
- You will learn in detail about each of the above classification of data in higher studies.

D. People

The GIS technology is used by a huge number of industrialists and agencies to help plan, design, engineer, build and maintain information infrastructures that affects our everyday lives

E. Methods or Procedures

Methods here refer to well-defined, consistent procedures that are required to produce accurate, reproducible result. A neatly conceived implementation plan and business rules are the models and operating practices are unique to each organization. There is need to properly integrate the sophisticated tool through bringing out well-defined procedures in well documented form into the entire business strategy and

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operation to make the technology effective. Meta data i.e., (data about the data) is the key for documenting these processes.

Functions of GIS

The functions of GIS describe the steps that have to be taken to implement a GIS. These steps have to be followed in order to obtain a systematic and efficient system. The steps involved are data capture, data storage (GIS Data Models), manipulation and analysis.

Data Capture

- The input of data into a GIS can be achieved through many different methods of gathering.
- For example, aerial photography, scanning, digitizing, GNSS is just a few of the ways a GIS user could obtain data. Digitization: A conversion process which converts paper maps into numerical digits that can be stored in the computer.
- Digitizing simplifies map data into sets of points, lines or cells that can be stored in the GIS computer. In this stage, digitization is carried out. There are two basic methods of digitization: Manual digitizing & scanning.

Data Storage

- Some data is stored such as a map in a drawer, while others, such as digital data, can be as a hardcopy, stored on CD or on your hard drive. Once the data have been digitally compiled, digital map files in the GIS are stored on magnetic or other digital media. Data storage is based on a Generic Data Model that is used to convert map data into a digital form.
- The two most common types of data models are Raster and Vector. Both types are used to simplify the data shown on a map into a more basic form that can be easily and efficiently stored in the computer.

Data Manipulation

- The digital geographical data can be edited, this allows for many attributes to be added, edited, or deleted to the specification of the project. Once data are stored in a GIS, many manipulation options are available to users.

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- These functions are often available in the form of “Toolkits.” A toolkit is a set of generic functions that a GIS user can employ to manipulate and analyse geographical data. Toolkits provide processing functions such as data retrieval measuring area and perimeter, overlaying maps, performing map algebra, and reclassifying map data.
 - Data manipulation tools include coordinate change, projections, and edge matching, which allow a GIS to reconcile irregularities between map layers or adjacent map sheets called Tiles.

Query and Analysis

GIS was used widely in decision making process for the new commission districts. We use population data to help establish an equal representation of population to area for each district. The heart of GIS is the analytical capabilities of the system.

Global Navigation Satellite System (GNSS)

- GNSS refers to the collection of the worlds global satellite-based positioning systems. It includes GPS (United States) GLONASS (Russia) GALILEO (European Union) BEODOU (China) IRNSS (India) QZSS (Japan).
- GNSS can provide centimetre level accuracy with a low-cost receiver, if an error correction technique is used. GNSS are recognized to be the systems of choice in outdoor environments and, to a great extent, one of the most accurate sources of position (and precise timing) information when it is available.
- The first satellite navigation system was **Transit**, a system deployed by the US military in 1960's. Transit's operations were based on the Doppler Effect: the satellites travelled on well-known paths and broadcast their signals on well-known radio frequency.
- The received frequency will differ slightly from the broadcast frequency because of the movement of the satellite with respect to the receiver. The satellite broadcast signals that contains orbital data (from which the position of the satellite can be calculated) and the precise time, the signals is transmitted.

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- There are multiple constellations of GNSS satellites orbiting the earth. GNSS satellites' orbit situated about 20,000 km above the earth's surface. They are moving very fast, several kilometres per second. The latest generation of GNSS satellites (Block IIF) weight over 1,400 kg.

GNSS system operated in different countries

The following are the Global Navigation satellite Systems:

GPS (United States)

GPS was the first GNSS system. GPS was launched in the late 1970's by the United States Department of Defense. It uses a constellation of 24 satellites, and provides global coverage.

GLONASS (Russia)

- The premier Soviet military navigation network was to be comprised of Uragan satellites. At the end of the Cold War, the constellation was unclassified under the name GLONASS -- a Russian abbreviation of Global Navigation Satellite System. Global Navigation Satellite System by Russian Aerospace Defense Forces is a space-based satellite navigation system.
- The life style of GNSS satellites 5-7 years and new satellites are to be launched after a specific time interval in order to fill the gap due to ageing satellites. GLONASS proves very beneficial for Russian territory by 2010. In 2011, restoration of system is improved to enable full global coverage.

GALILEO (European Union)

- Galileo is Europe's own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. Currently providing Initial Services, Galileo is interoperable with GPS and Glonass, the US and Russian global satellite navigation systems.
- By offering dual frequency as standard, Galileo is set to deliver real-time positioning accuracy down to the metre range. The Galileo constellation in space

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will comprise 30 satellites in total. There will be 24 operational satellites, plus 6 spare satellites, circulating in medium Earth orbit on three orbital planes.

BEIDOU (China)

Beidou Navigation Satellite System (BDS) is a Chinese satellite Navigation system. It consists of two separate satellite constellations. The first Beidou system is officially called the Beidou Satellite Navigation Experimental System and also known as BeiDou-1. On December 27, 2018, Beidou-3 officially began to provide global services. The Beidou-3M/G/I satellite represent the orbital segment of the third phase of the Chinese Beidou navigation system which uses satellites in Medium Earth Orbit and Geosynchronous Orbit and is also known as the Compass Navigation Satellite System.

Japan Aerospace Exploration Agency (QZSS Japan)

QZSS is a regional navigation satellite system that provides service to Japan and the Asia-Oceania region. QZSS (nickname of Michibiki - meaning to 'guide' or 'show the way') QZSS is a Japanese satellite positioning system composed mainly of satellites in quasi-zenith orbits (QZO). However, the term “Quasi-Zenith Satellite (QZS)” can refer to both satellites in QZO and geostationary orbits (GEO). For that reason, the name “QZO satellite” is used when it is necessary to specifically refer to satellites in QZO. Satellite positioning systems use satellite signals to calculate position information. The QZSS is sometimes called the “Japanese GPS.”

IRNSS (Indian Regional Navigational Satellite System)

IRNSS is an autonomous regional satellite navigation system being developed by ISRO (Indian Space Research Organization). It is designed to provide geospatial positioning information within the Indian subcontinent. It enables users to map out their location (altitude, longitude and latitude).

The objective of developing IRNSS was to cut down India's dependency on foreign navigation satellite systems.

It provides location information service to users in India and the region extending for upto 1,500 km from the Indian boundary. This is the primary service area of IRNSS

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information service to users in India and the region extending up to 1500 km from Indian boundary.

IRNSS aims to provide the following services:

1. Standard Positioning Service (SPS) for civilian, research & commercial use,
2. Restricted Service (RS) for authorized users. For example, in defense, IRNSS is used for ground, aerial and marine navigation, disaster management, mobile phone integration, mapping and visual & voice navigation for drivers, among others.

Applications of GNSS

GNSS applications are widely used to get the quick information about a particular field. Some of the commercial applications are Consumers, Transportation, GIS, Machine Control Port Automation, Precision Agriculture, Construction, Marine Mining, Unmanned Vehicles Surveying, Defense, and Aerial Photogrammetry, etc.

Consumer

GNSS technology has been adopted by the consumer market, in an ever-increasing range of products. GNSS receivers are now routinely integrated into smart phones, to support applications that display maps showing the location of and best route to stores and restaurants.

Transportation

In rail transportation, GNSS is used to track the location of locomotives and rail cars, maintenance vehicles and wayside equipment, for display at central monitoring consoles. Knowing the precise location of rail equipment reduces accidents, delays, and operating costs, enhancing safety, track capacity, and customer service. In aviation, GNSS is being used for aircraft navigation from departure, en route, to landing.

Port Automation

Using GNSS, shipping hubs can improve their operating efficiency by tracking the movement and placement of containers about their yards. Many cranes are

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equipped with GNSS based steering devices that determine the crane's position and keep it travelling in the desired path, improving accuracy and productivity as well as the safety of operators and workers on the ground.

Machine Control

GNSS technology is being integrated into equipment such as bulldozers, excavators, graders, pavers and farm machinery to enhance productivity in the real-time operation of this equipment, and to provide situational awareness information to the equipment operator.

Precision Agriculture

In precision agriculture, GNSS-based applications are used to support farm planning, field mapping, soil sampling, tractor guidance, and crop assessment. More precise application of fertilizers, pesticides and herbicides reduces cost and environmental-impact.

Surface Mining

GNSS information is being used to efficiently manage the mining of an ore body and the movement of waste material. GNSS equipment installed on shovels and haul trucks provides position information to a computer-controlled dispatch system to optimally route haul trucks to and from each shovel.

Survey

Using GNSS, it is possible for a single surveyor to accomplish in one day what might have taken a survey crew of three people a week to complete. Determining a new survey position once required measuring distances and bearings from an existing (known) survey point to the new point.

Questions

1. Enumerate the components on GIS.
2. Mention some of the GNSS system in various countries. Explain.
3. What are the functions of GIS?