GEOGRAPHIC INFORMATION SYSTEM

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GIS

- Geographical Information System (GIS) is a technology that provides the means to collect and use geographic data to assist various developmental work such as urban planning, agriculture, disaster management, environmental impact assessment etc.
- A GIS is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth. (they are associated with some location having particular latitude and longitude).
- The GIS software makes it possible to synthesize large amounts of different data, combining different layers of information.

Example of Spatial data (it has got specific Lat. Long on Earth)

Example of Attribute data (Tabular data)

Location	Specialty	Population density /km2
Patna	Capital of Bihar	1823
Ranchi	Capital of Jharkhand	572
Delhi	Capital of India	11320

History

- The idea of portraying different layers of data on a series of base maps, and relating things geographically, has been around much older than computers invention.
- Possibly the earliest use of the geographic method in 1854, **John Snow** depicted a cholera outbreak in London using points to represent the locations of some individual cases. His study of the distribution of cholera led to the source of the disease, a contaminated water pump within the heart of the cholera outbreak.
- While the basic elements of topology and theme existed previously in cartography, the John Snow map was unique using

- In the year 1962, the world's first true operational GIS was developed by the federal Department of Forestry and Rural Development in Ottawa, Canada by Dr. Roger Tomlinson. It was called the "Canada Geographic Information System" (CGIS) and was used to store, analyze, and manipulate data collected for the Canada Land Inventory (CLI).
- It is an initiative to determine the land capability for rural Canada by mapping information about soils, agriculture, recreation, wildlife, forestry, and land use at a scale of 1:50,000.
- Dr. Tomlinson is known as the

- In **1964**, Howard T Fisher formed the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design, where a number of important theoretical concepts in spatial data handling were developed.
- By the early 1980s, M&S Computing (later Intergraph), Environmental Systems Research Institute (ESRI) and CARIS emerged as commercial vendors of GIS software, successfully incorporating many of the CGIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database

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During the same time, the development of a public domain GIS begun by the U.S. Army Corp of Engineering Research Laboratory (USA-CERL) in Champaign, Illinois, a branch of the U.S. Army Corps of Engineers to meet the need of the United States military for software for land management and environmental planning.

In the years 1980s and 1990s industry growth were spurred on by the growing use of GIS on Unix workstations and the personal computers. By the end of the 20th century, users were beginning to export the concept of viewing GIS data over the Internet, requiring uniform data format and transfer standards.

More recently, there is a growing number of free, open source GIS packages, which run on a range of operating systems and can be customized to perform specific tasks. As computing power increased and hardware prices slashed down, the GIS became a viable technology for state development planning. It has become a real Management Information System (MIS), and thus able to support decision

COMPONENTS OF GIS

1 Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are (a) a database management system (DBMS) (b) tools for the input and manipulation of geographic information (c) tools that support geographic query, analysis, and visualization (d) a graphical user interface (GUI) for easy access to tools. GIS software are

2 Hardware

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

3 Data

The most important component of a GIS is the data. Geographic data or Spatial data and related tabular data can be collected in-house or bought from a commercial data provider. Spatial data can be in the form of a map/ remotely-sensed data such as satellite imagery and aerial photography. These data forms must be properly georeferenced (latitude/longitude).

Tabular data can be in the form attribute data

4 Users

GIS users range from technical specialists who design and maintain the system to those who use it to help them do their everyday work. These users are largely interested in the results of the analyses and may have no interest or knowledge of the methods of analysis. A simple User Interface (UI) can consist of menus and pull-down graphic windows to perform required analysis with a few key

5 Methods

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

Currently available commercial GIS software includes Arc/Info, Intergraph, MapInfo, ERDAS Imagine, ArcGIS, ENVI, Gram++ etc. Out of these Arc/Info is the most popular software package. And, the open source software are AMS/MARS, SAGA etc.

Functions of GIS

General-purpose GIS software performs six major tasks such as

- **1. Data Input/Data Capture**
- **2. Manipulation**
- **3. Management**
- **4. Query and analysis**
- **5. Visualization**

1. DATA INPUT/DATA CAPTURE

The important input data for any GIS is **digitized maps, images, spatial data and tabular data**. Maps can be digitized using a vector format in which the actual map points, lines, and polygons are stored as coordinates. Data can also be input in a raster format in which data elements are stored as cells in a grid structure (the technology details are covered in following section). The process of converting data from paper maps into computer files is called digitizing. Modern GIS technology has the capability to automate this process fully for large projects; smaller jobs may require some manual digitizing.

2. DATA MANIPULATION/ DATA STORAGE

GIS can store, maintain, distribute and update spatial data associated text data. The spatial data must be referenced to a geographic coordinate systems (latitude/longitude). The tabular data associated with spatial data can be manipulated with help of data base management software. It is likely that data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with the system. For example, geographic information is available at different scales (scale of 1:100,000; 1:10,000; and 1:50,000). Before these can be overlaid and integrated they must be transformed to the same scale. This could be a temporary transformation for display purposes or a permanent one required for analysis. And, there are many other types of data manipulation that are routinely performed in GIS. These include projection changes, data aggregation, generalization and weeding out unnecessary data.

3. MANAGEMENT

For small GIS projects it may be sufficient to store geographic information as computer files. However, when data volumes become large and the number of users of the data becomes more than a few, it is advised to use a database management system (DBMS) to help store, organize, and manage data. A DBMS is a database management software package to manage the integrated collection of database objects such as tables, indexes, query, and other procedures in a database.

4. QUERY AND ANALYSIS

The stored information either spatial data or associated tabular data can be retrieved with the help of Structured Query Language (SQL). Depending on the type of user interface, data can be queried using the SQL or a menu driven system can be used to retrieve map data. For example, you can begin to ask questions such as:

- Where are all the soils are suitable for sunflower crop?
- What is the dominant soil type for Paddy?
- What is the groundwater available position in a village/block/district? Both simple and sophisticated queries utilizing more than one data layer can provide timely information to officers, analysts to have overall knowledge about situation and can take a more informed decision.

Analysis

- GIS systems really come into their own when they are used to analyze geographic data. The processes of geographic analysis often called spatial analysis or geo-processing uses the geographic properties of features to look for patterns and trends, and to undertake "what if" scenarios. Modern GIS have many powerful analytical tools to analyse the data. The following are some of the analysis which are generally performed on geographic data.
- ***a. Overlay Analysis***
- The integration of different data layers involves a process called overlay. At its simplest, this could be a visual operation, but analytical operations require one or more data layers to be joined physically. This overlay, or spatial join, can integrate data on soils, slope, and vegetation, or land ownership. For example, data layers for soil and land use can be combined resulting in a new map which contains both soil and land use information. This will be helpful to understand the different behavior of the situation on different parameters.

- ***b. Proximity Analysis***
- GIS software can also support buffer generation that involves the creation of new polygons from points, lines, and polygon features stored in the database. For example, to know answer to questions like; How much area covered within 1 km of water canal? What is area covered under different crops? And, for watershed projects, where is the boundary or delineation of watershed, slope, water channels

5. VISUALIZATION

GIS can provide hardcopy maps, statistical summaries, modeling solutions and graphical display of maps for both spatial and tabular data. For many types of geographic operation the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. GIS provides new and exciting tools to extend the art of visualization of output information to the users.

Data creation in GIS

Since GIS is all about data capture, data storage, data manipulation and data representation, we should know about the data creation in GIS

Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a computer-aided design program with geo-referencing capabilities. With the wide availability of rectified imagery (both from satellite and aerial sources), heads-up digitizing is becoming the main avenue through which geographic data is extracted

- The primary requirement for the source data consists of knowing the locations for the variables. Location may be annotated by x, y, and z coordinates of longitude, latitude, and elevation, or by other geocode systems like postal codes.
- Any variable that can be located spatially can be fed into a GIS. Different kinds of data in map form can be entered into a GIS.
- A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use. For example, digital satellite images generated through remote sensing can be analyzed to produce a map-like layer of digital information about vegetative covers.
- Likewise, census or hydrologic tabular data can be converted to map-like form, serving as layers of thematic information in a GIS. Heads-up digitizing involves the tracing of geographic data directly on top of the aerial imagery

DATA REPRESENTATION

GIS data represents real world objects such as roads, land use, elevation with digital data. Real world objects can be divided into two abstractions: discrete objects (a house) and continuous fields (rain fall amount or elevation).

There are two broad methods used to store data in a GIS for both abstractions:

Raster and

Vector

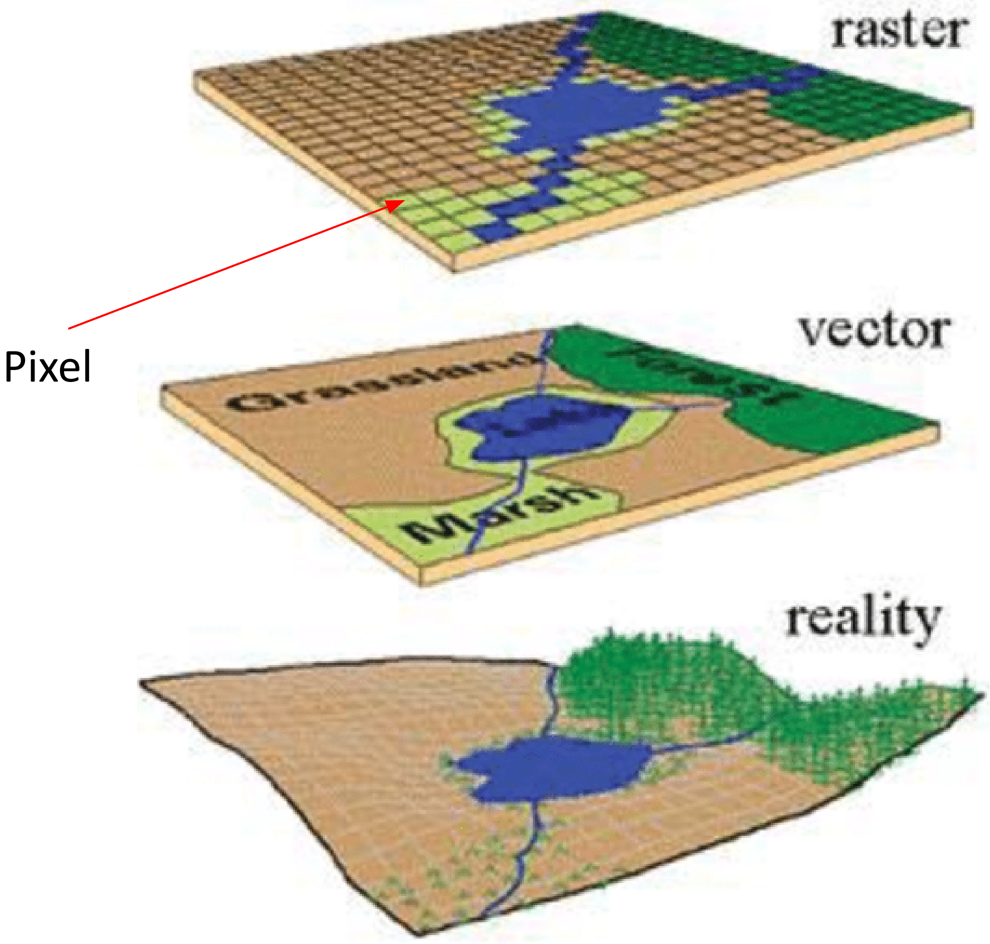
Raster

A raster data type is, in essence, any type of digital image. Anyone who is familiar with digital photography will recognize the pixel as the smallest individual unit of an image. A combination of these pixels will create an image, distinct from the commonly used scalable vector graphics, which are the basis of the vector model. Raster data is used in GIS application when we want to display information that is continuous across an area

Aerial photos are one commonly used form of raster data, with only one purpose, to display a detailed image on a map or for the purposes of digitization. Other raster data sets will contain information regarding elevation, a DEM (digital Elevation Model), or reflectance of a particular wavelength of light.

- Raster data type consists of rows and columns of cells each storing a single value.
- Raster data can be images (raster images) with each pixel containing a color value.
- Additional values recorded for each cell may be a discrete value, such as land use, a continuous value, such as temperature, or a null value if no data is available.

- Raster data is stored in various formats; from a standard file-based structure of TIF, JPEG formats to binary large object (BLOB) data stored directly in a relational database management system (RDBMS) similar to other vector-based feature classes. Database storage, when properly indexed, typically allows for quicker retrieval of the raster data but can require storage of millions of significantly sized records.



Vector

A simple vector map, using each of the vector elements: points for wells, lines for rivers, and a polygon for the lake. In a GIS, geographical features are often expressed as vectors, by considering those features as geometrical shapes. In the popular ESRI Arc series of programs, these are explicitly called shape files. Different geographical features are best expressed by different types of geometry:

Points

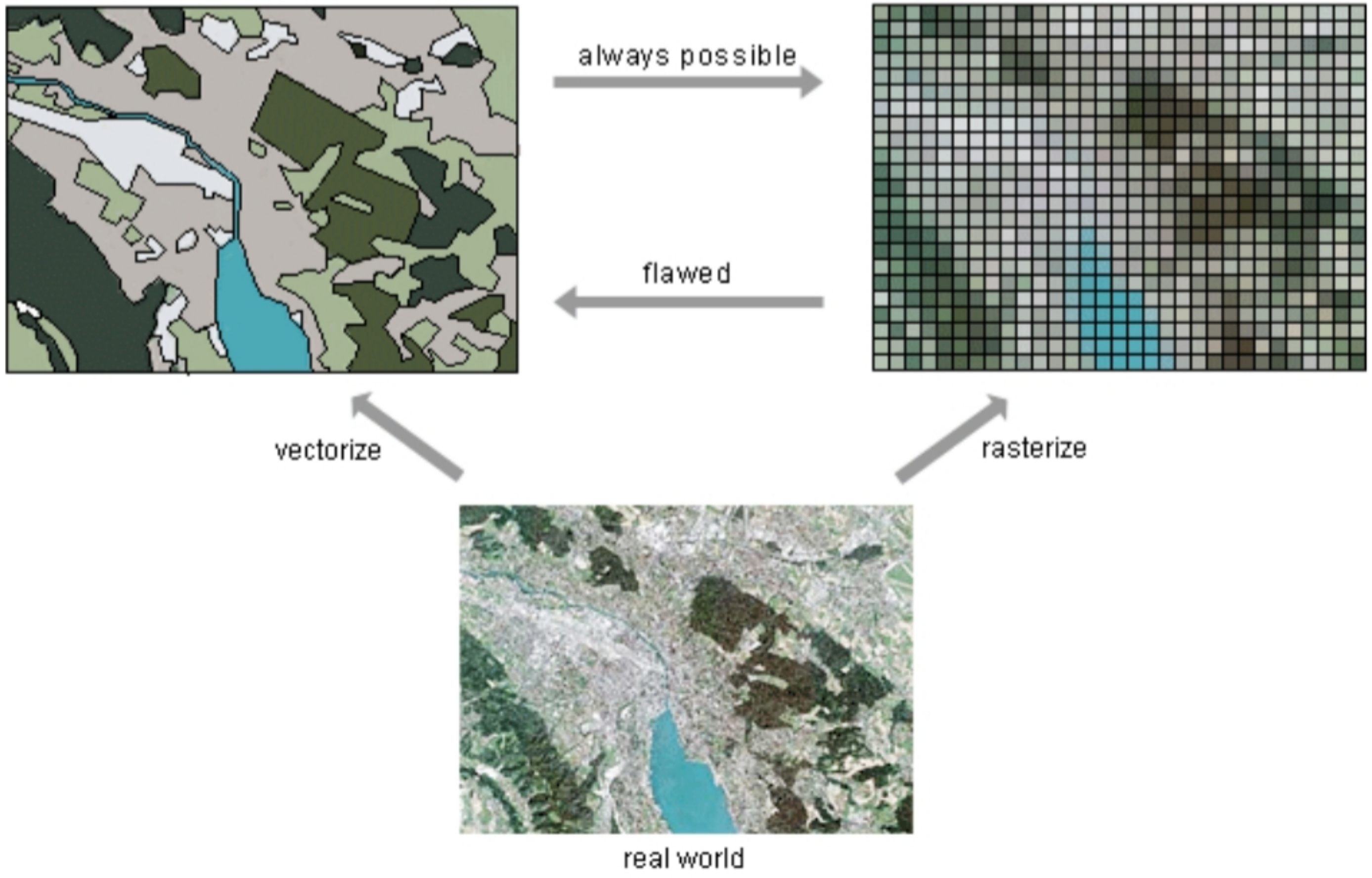
Zero-dimensional points are used for geographical features that can best be expressed by a single grid reference; in other words, simple location. For example, the locations of wells, peak elevations, features of interest or trailheads. Points convey the least amount of information of these file types.

Lines or polylines

One-dimensional lines or polylines are used for linear features such as

Polygons

Two-dimensional polygons are used for geographical features that cover a particular area of the earth's surface. Such features may include lakes, park boundaries, buildings, city boundaries, or land uses. Polygons convey the most amount of information



RASTER DATA
VERSUS
VECTOR DATA

RASTER DATA	VECTOR DATA
Type of spatial data that consists of a matrix of cells organized into rows and columns in which each cell represents specific information	Type of spatial data used for storing data that has discrete boundaries
Continuous data	Discrete data
Represents data in cells or in a grid matrix	Represents data using sequential points or vertices
Simple Data	Complex Data
Temperature, air pressure, soil PH, elevation, flow and distance are some example for raster data	Administrative borders, linear features, roads and rivers are some examples for vector data