Fundamentals of Geographic Information System

BASIC CONCEPT OF GIS

- Geographic Information Science
  - Geographic Information Science is the science concerned with the systematic and automatic processing of spatial data and information with the help of computers.
  - Geographic Information Science is the theory behind how to solve spatial problems with computers

- Geographic Information System
  - Geographic Information System is a system designed for storing, analyzing, and displaying spatial data
  - Geographic Information System is the use of hardware, software, people, procedures, and data

- Geographic Information Science
  - presents a framework for using information theory, spatial analysis and statistics, cognitive understanding, and cartography (Longley et al., 2005).

- Geographic Information System
  - focuses on the processes and methods that are used to sample, represent, manipulate and present information about the world (Goodchild, 1992).

Geographic Information System (GIS) is a computer based information system used to digitally represent and analyze the geographic features present on the Earth' surface and the events (non-spatial attributes linked to the geography under study) that taking place on it. The meaning to represent digitally is to convert analog
"Every object present on the Earth can be geo-referenced", is the fundamental key of associating any database to GIS. Here, term 'database' is a collection of information about things and their relationship to each other, and 'geo-referencing' refers to the location of a layer or coverage in space defined by the co-ordinate referencing system.

Work on GIS began in late 1950s, but first GIS software came only in late 1970s from the lab of the ESRI. Canada was the pioneer in the development of GIS as a result of innovations dating back to early 1960s. Much of the credit for the early development of GIS goes to Roger Tomilson. Evolution of GIS has transformed and revolutionized the ways in which planners, engineers, managers etc. conduct the database management and analysis.

**What is GIS**

We live in a spatial and temporal world and all our activities are related to space and time in one way or the other. The environment is a dynamic system that is sampled, monitored, modelled and simulated for planning purposes. Decision-making processes such as planning new roads or towns, managing natural resources, formulating agricultural strategies, or planning new businesses rely upon relevant spatio-temporal information. Spatial reasoning derives spatial information from facts pertaining to space and time. The spatial questions deal with the location and extent, distribution and pattern, association, spatial interaction and changes in a certain context. Geographical information systems (GIS) have emerged as tools for integrating the spatial dimension in the collection, management and analysis of information for decision-making processes.
**Definition of GIS**

GIS is a system for acquisition, processing, transformation, extraction, storage, presentation and use of spatial information. There are many definitions for GIS. However, the major characteristics are the analytical functions that provide means for deriving new information from existing data.

In Addition, A GIS is an information system designed to work with data referenced by spatial / geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. (ESRI)

A Geographic Information System is a computer based system which is used to digitally reproduce and analyse the feature present on earth surface and the events that take place on it. In the light of the fact that almost 70% of the data has geographical reference as it's denominator, it becomes imperative to underline the importance of a system which can represent the given data geographically.
various definitions given below:-

“GI Science allows us to consider the philosophical, epistemological & ontological context of geographic information & GI Systems provide the infrastructure, tools and methods for tackling real world problems within acceptable timeframes.”

Literal Definition
- Geographic relates to the surface of the earth.
- Information is a knowledge derived from study, experience, or instruction.
- System is a group of interacting, interrelated, or interdependent elements forming a complex whole.
- Science is the observation, identification, description, experimental investigation, and theoretical explanation of phenomena.

Functional Definition
- GIS is a system for inputting, storing, manipulating, analyzing, and reporting data.

Component Definition
- GIS is an organized collection of computer hardware, software, geographic data, procedures, and personnel designed to handle all phases of geographic data capture, storage, analysis, query, display, and output

However geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on Earth.
Burrough in 1986 defined GIS as, "Set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes"

Arnoff in 1989 defines GIS as, "a computer based system that provides four sets of capabilities to handle geo-referenced data:

- data input
- data management (data storage and retrieval)
- manipulation
- analysis data output."

DoE (1987), A system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially reference to the earth.

Carter (1989), An institutional entity, reflecting and organizational structure that integrates technology with a database, expertise and continuing financial support over time.

Parker (1988) An information technology which stores, analysis and displays both spatial and non-spatial data.

Dueker (1979) A special case of information systems where the database consists of observation on spatially distributed features, activities or events, which are definable in space as points, lines or areas. A GIS manipulates data about these points, lines and areas to retrieve data for queries and analysis.
Smith et al. 1987, A database system in which most of the data are spatially indexed and upon which a set of procedures operated in order to answer queries about spatial entities in the database.

Ozemoy, Smith and Sicherman (1981) an automated set of functions that provides professionals’ with advanced capabilities for the storage, retrieval, manipulation and display of geographically located data.

Cowen 1988, A decision support system involving the integration of spatially referenced data in a problem-solving environment.

Koshkariov, Tikunov and Trofimov (1989) A system with advanced geo-modeling capabilities.

Devine and Field, 1986, A form of MIS (Management Information System) that allows map display of the general information.

**Why GIS**

Many professionals, such as foresters, urban planners, and geologists, have recognized the importance of spatial dimensions in organizing and analyzing information. Whether a discipline is concerned with the practical aspects of business or with purely academic research, GIS can introduce a perspective that can provide valuable insights. GIS is simply an extension of one’s own analytical thinking. The system has no inherent answers; these depend upon the analyst. It is a tool just as statistics is a tool. It is a tool for thought. In many ways, learning GIS involves learning to think—learning to think about patterns, space and processes that act in space. GIS is a means to an end, not an end in itself. The value of GIS
lies not just in the immediate efficiency with which the technology is implemented. Rather, it lies in how the technology helps us to think differently about the way we organize, understand and use spatial information. New appreciation of the importance of spatial location or geography in real-world analysis has emerged from the application of GIS. Basic factors affecting the diffusion of GIS have been influenced by the reasons described below.

**Firstly**, the rapidly declining cost of computer hardware and, at the same time, the exponential growth of computing power.

**Secondly**, the user-friendliness and increasing functions of GIS software.

**Thirdly**, the visualization impact of GIS that corroborates the proverb ‘a picture is worth a thousand words’.

**Fourthly**, and most importantly, geography and data describing it are part of our everyday life; almost every decision we make is somehow dictated or influenced by some fact of geography.

**History of GIS**

**1960's**
- Canada Geographic Information System (CGIS) - developed by Roger Tomlinson,
- In USA a similar system developed for processing natural resources data

**1970's**
- Main developments took place in universities in the US, Canada and UK.
- Commercial agencies like ESRI and Intergraph starting to develop and offer.
- Growing awareness of the need for sound and stable structures to store and analyze map data becoming a dominant trend.

**1980's**
- Marked with the widespread availability of PCs, tremendous progress on research on spatial data structures, indexing methods, and spatial databases.
- In 1988 with the formation of NCGIA major contributions towards the progress in GIS research.

**1990's**
- Breakthrough of object orientation in system and database design,
- Geo-informatics in professional recognition, spatial information theory-theoretical basis for GIS
- GIS enters medium and small businesses and new domains such as geo-marketing
- Evolution of Desktop GIS