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GEOLOGY
Paper: Remote Sensing and GIS
Module: Concepts of Geographic Information System (GIS); include errors in GIS

1. Introduction

The acronym GIS stands for Geographic Information System or Science where G stands for any Geographical features with reference to a particular location on the earth surface. I stand for Information about geographic features stored in tabular form and S stands for System which consists of software, hardware and geographically referenced data.

It was Roger Tomlinson who used the term Canada Geographic Information System (CGIS) first time in 1960s during his work with the Canada Land Inventory (CLI). GIS is a modern tool of ancient Cartography and its most common product is maps. Advance technology and huge Geographic data are responsible for today's colourful, advanced and interactive maps. GIS is a special tool that is integrated with data and information which help us to understand and relate to the "what," "when," "how," and "why" of the World by answering "where." The development of GIS have been four distinct phases, i) Few individuals wanted to use GIS as tool to give shape and direction of future research in early 1960s to mid 1970s. ii) National agencies saw the use of GIS technologies to focus on the development in 1970s to early 1980s. iii) In 1982 to late 1980s the development and exploitation of commercial place using GIS, final phase started late 1980s has aim to improving the usability of GIS technology by making facilities.

Effective decisions have been always dependent on information. Spatial information is quite complex to answer the question of - **Where is What** its ancient used for navigation and find the accurate position of physical features on earth. GIS was used to identify the changes on the same theme maps made on different time period. The basic concept of GIS was to determine the spatial relationship among features on an area through maps. It is a geographically oriented computer technology that is comprises of both spatial and non-spatial data, which allows the powerful analysis of big area frequently in low cost. Before digital era this has been done using manual processing and production of paper maps from analogue datasets.

Use of computers and modern technologies has led to increase the handling of spatial data in all aspects.

Peoples are used computers and computerized information system for most activities in today's life because computerization has potential to made communication, analysis and make decisions easily. Several of our decisions depend on our surroundings environment and need related information about specific places on the Earth's surface. Information related to specific places on the Earth's surface and our surroundings environment are used in several of our decisions. Such information is called geographical because it is use to distinguish places and to make decisions that are congruous for the concerned location.

GIS has ability to collect information from various sources to depict the spatial relationship among features on earth surface. GIS data can be viewed in three different ways as follows:

(i) Database view: The non-spatial data (tabular data or attribute) comes under this GIS data view and it is able to store information in the form of table associated to spatial features.

(ii) Map view: It is very essential part of GIS because it allows user to visualize the pattern and understand the relationship among data sets. Maps are very important tool that depicted the features and their relationship on the earth's surface and shows the relationship among these features on maps.

(iii) Layer view: Here, the GIS data represent in various layers. One set of data is displayed "on top of" another to show spatial pattern and relationship on map. For example, temperature at any location can show up in the first layer and pressure of same location can be show up in the second layer.

GIS is the art or science, concerned with systematic processing of data using computers to solve spatial problems. GIS is a computer aided technique encompasses software, hardware and data that is used to store, retrieve, manipulate, manage, analyse and output of geographically referenced spatial data. With the help

of GIS we can compare the positions of different objects on earth surface in order to determine their relationship to each other. For example, the utility and services map of an area including sites that produce good healthcare services like hospitals and sites where less healthcare services. The information used in GIS is based on location such as coordinates (latitude and longitude), address and PIN code etc. Attribute information are also used in GIS that describe the characteristics of features available in spatial database such as income, population and age. GIS generate data from various spatial (satellite, aerial photographs and maps) and non-spatial (Attribute and tabular) sources align and keep it together because data have different scales and projections.

A scale is defined by the ratio of map distance and corresponding distance on earth surface. Thus, projection enables the user to transfer information from 3 dimensional earth surfaces to 2 dimensional flat piece of paper. GIS used data from various sources that were prepared in different projections and keep it together so that all information can be appeared by common projection.

2. Understanding GIS: Common definitions

GIS is “a powerful set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes“ (Burrough, 1986). "A geographic information system is a special case of information systems where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines, or areas. A geographic information system manipulates data about these points, lines, and areas to retrieve data for ad hoc queries and analyses" (Dueker, 1979). Maguire (1991) defines GIS in the following manner:

- Process-/function-oriented - emphasises the information handling capabilities of GIS (e.g., storage, retrieval, manipulation, and display of geographic data);

- Application - divides information systems according to the problems they seeks to address (e.g., soil, land, and planning information system);
- Toolbox - emphasises the generic aspects of GIS as a toolbox to manipulate spatial data;
- Database - regards GIS as a database system, reflecting the influence of database theory and practice on GIS.

3. GIS Workflow

GIS Workflow depends on the following components:

3.1 User

It includes technical experts, managers and administrators who are responsible for the day-to-day operations in GIS. Peoples from various disciplines are being used GIS as a tool that allow them to perform their task more accurately. For example town planner use GIS in town planning and academician use GIS to teach and research etc.

3.2 Information

It is most important and expensive component of GIS that can be divided into following two categories.

3.2.1 Spatial data

It is the data which is available in raster or image form that comprises geographic location, shape, size, orientation and boundaries of features present on earth surface such as lake, forest, mountain, town boundary etc. It is also known as geospatial data.

3.2.2 Tabular data

It is also known as non-spatial or attribute data. It has information related to spatial features that is described in details for example India is divided into various state, natural regions, religion and population etc. are tabular data that is arranged in tabular form because these variables are independent of the India's location.

3.3 Methodology / Procedure

Methodology is the detail workflow that includes data preparation, data manipulation, data analysis and final result. Procedure is the defined way that is used to analyse the data and produce better result. It includes guidelines, standard and protocol that is very important component for project work of an organisation.

3.4 Hardware

It is play an important role in GIS environment because GIS work depend on huge datasets especially on satellite images that need more memory and fast processing for data manipulation and data analysis. Some important hardware component that used in GIS is given below.

3.4.1 Visual Display Unit (VDU) / Monitor

It is an electronic device that is used to see the information comes out from computers.

3.4.2 Keyboard

It is a device which is being used for instruction, commands and data entry. Keyboard is used to entered attribute data and manual digitizing is used for entering spatial information from maps and images in GIS.

3.4.3 Mouse

It is a wonderful pointing device used for data selection, editing, zoom in and zoom out and creating the spatial data base in GIS.

3.4.4 Central Processing Unit (CPU)

The CPU is the brain of computer and known as processor - It is an electronic circuit that execute computer program.

3.4.5 Scanner

A scanner is an electronic device that captures data from photographs, images and other sources for computer editing and display.

3.4.6 Printer / Plotter

A printer / plotter is an electronic device that accepts text and graphic output from a computer and transfers the information to paper.

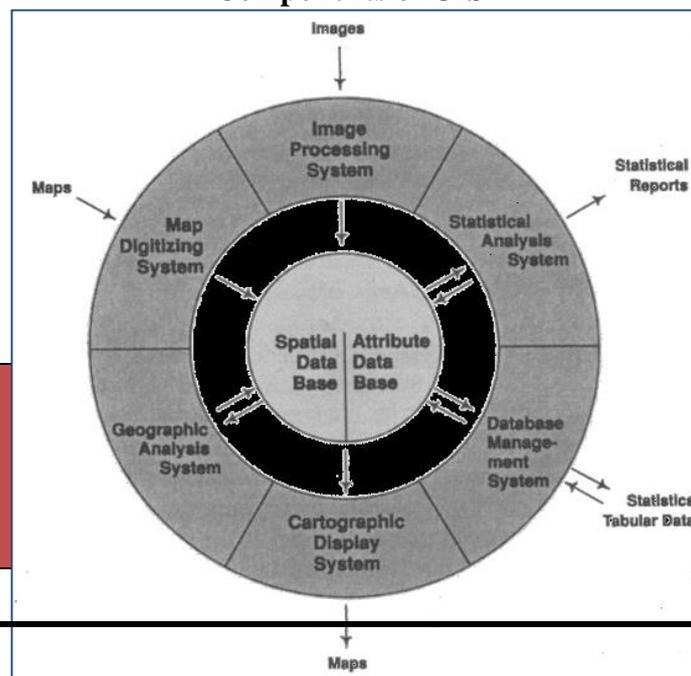
3.4.7 Internet

It is a source for information and data collection from worldwide.

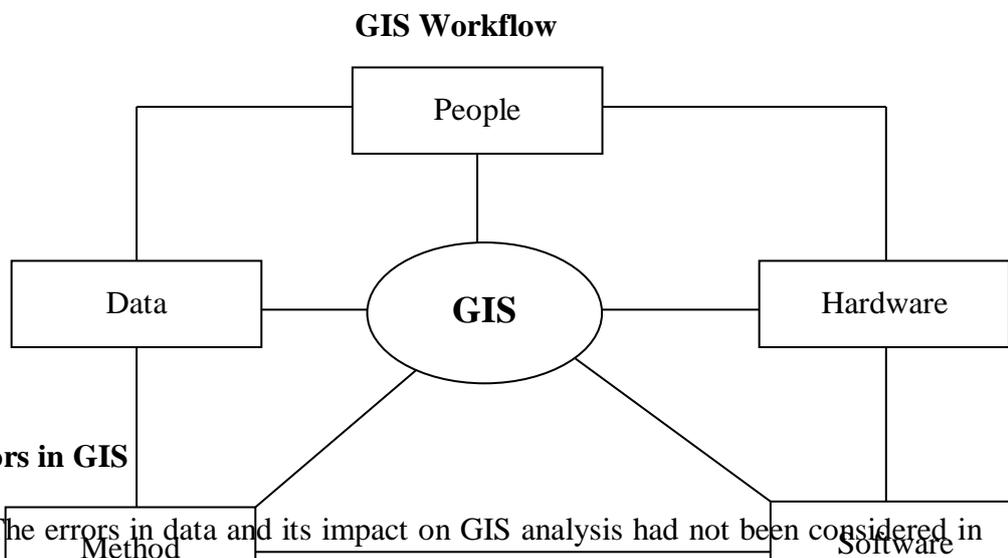
3.5 Software

GIS software is the set of functions and tools that comprises input module, editing module, analysis module and modelling capability which allow us to solve problems spatially. Some GIS software's are ArcGIS(ESRI), QGIS(Open source), MapInfo(Pitney Bowes) etc.

Components of GIS



Source: Schuurman (2004)



4. Errors in GIS

The errors in data and its impact on GIS analysis had not been considered in recent years. GIS experts started to accept errors and inaccuracy that can disturb the quality of many GIS projects in the last decades. Understanding the GIS error is important for spatial analysis to ensuring that datasets meets a minimum threshold for accuracy. The saying, “Garbage in, garbage out” applies all to well when data that is inaccurate, imprecise, or full of errors is used during analysis. Many data sets related to same geographical area are being used to perform analysis and manipulation in GIS environment. When we collected GIS data from field it contain some errors and at this stage user need to aware and understand the limitation of error in data that can be used in GIS.

Accuracy of data is dependent on the degree or closeness to which the feature on a map matches the values on the ground. In GIS accuracy cab be

associated with geographic location, geometry of feature and attribute data. Geographic data used in GIS are not error free. Accuracy of features in GIS should be attached with their associated data. Data (Spatial and non-spatial) in GIS environment contain some error. These errors are classified into following manners.

4.1 Pre-processing errors

Before start working on any GIS project, the main issue is that how to incorporate data in GIS because this is the process of most time consuming and risk of maximum error in data. Pre-processing errors are those which are generated before data processing in GIS environment are listed below;

4.1.1 Data reliability

It is decreases with data age; data are less reliable with increasing gap between data acquisition and data usage. The age of data is another source of error. The information may have changed with increasing age of data.

4.1.2 Scale

It is an error in GIS, depending on the usage of data at different scale. GIS user need to adapt the scale of work to the specified need in their project.

4.1.3 Density of data

It must be dense because sparsely distributed data is less reliable. GIS users should always be mindful when using old data and the lack of currency to that data before using it for contemporary analysis.

4.1.4 Seamless data

All data must be in same unit and projection system.

4.1.5 Inaccuracy in tabular data

It is linked to spatial features may be imprecise. Imprecise data may result from error of many kinds. Precise data associated to spatial features describes

features in detailed. For example, A precise description of climate at specific area include temperature, pressure, rainfall and many others characteristics. Attributes are attached in correct way so that contents are matched correctly.

4.2 Processing errors

It is very difficult to detect by user. It is harmful error that occur in many ways because they can occur in various data sets and being manipulated in GIS. These errors are moved through processing and increase with every manipulation. Processing errors are those which are occur at the time of data processing in GIS domain like;

4.2.1 Numerical errors

The performance of computers are vary from one to another for mathematical operations and produce valuable results for the same problem.

4.2.2 Data formatting

Changes scale, projection, export / import, convert one format to another format etc. are few examples of data formatting errors.

4.2.3 Digitization errors

It is the error which is produced by digitizing the features like i) location errors which is related to location of map features on digitized map ii) Topological errors, wrong manipulation of data and topological analysis may cause of logical errors. It includes undershoot-when two arc do not meet perfectly at a node, overshoot- when two arc overextended to each other.

4.2.4 Data manipulation errors

Some errors are occur at the time of producing maps used as GIS sources like Computations, geodetic network, data editing, enlarging/reducing and redrawing are some basic errors. Data conversion from raster to vector and vector to

raster, spatial analysis, generalization and interpolation etc. are few errors comes under this category.

Summary:

A Geographic Information System (GIS) is incorporated with hardware, software and data. The basic concept of GIS was to determine the spatial relationship among features on an area through maps. It is a geographically oriented computer technology that is comprises of both spatial and non spatial data, which allows the powerful analysis of big area frequently in low cost. Recently GIS is expanding rapidly and used by various discipline of people and organisation for wide variety of applications. Spatial analysis, database and the map views are the main views of GIS. Peoples are used computers and computerized information system for most activities in today's life because computerization has potential to made communication, analysis and make decisions easily. Several of our decisions depend on our surroundings environment and need related information about specific places on the Earth's surface.

GIS work flow depends on various components e.g. User, information, methodology/procedure, hardware and software. GIS experts started to accept errors and inaccuracy that can disturb the quality of many GIS projects in the last decades. Understanding the GIS error is important for spatial analysis to ensuring that datasets meets a minimum threshold for accuracy. Many data sets related to same geographical area are being used to perform analysis and manipulation in GIS environment. When we collected GIS data from field it contain some errors and at this stage user need to aware and understand the limitation of error in data that can be used in GIS. Accuracy of data is dependent on the degree or closeness to which the feature on a map matches the values on the ground. In GIS accuracy cab be associated with geographic location, geometry of feature and attribute data. Data in GIS environment contain some error. These errors are classified into two manners, (i) Pre-processing errors and (ii) processing errors.

Frequently Asked Questions (FAQs):

1. What is Geographical Information System (GIS) ?

GIS is a computer aided technique encompasses software, hardware and data that is used to store, retrieve, manipulate, manage, analyse and output of geographically referenced spatial data.

2. What are the components of GIS?

A GIS integrates several key components e.g. people, hardware, software, data and methods. Hardware is the computer (CPU, Memory, Keyboard, Mouse, scanner etc.) on which a GIS operates. GIS software provide the functionality to analyze and display the geographic information. GIS data is an important component of GIS and its included both spatial and non-spatial data. A successful GIS operates depends on good method and plan. People who manages the system and develop plan for applying GIS to solve the real World problems.

3. What type of data used in GIS?

In GIS broadly two types of data are being used which are mentions below

(i) Spatial data: It is the data which is available in raster or image form that comprises geographic location, shape, size, orientation and boundaries of features present on earth surface such as lake, forest, mountain, town boundary etc. It is also known as geospatial data.

(ii) Non-spatial data or Tabular data: It is also known as attribute data. It has information related to spatial features that is described in details for example India is divided into various state, natural regions, religion and population etc. are tabular data that is arranged in tabular form because these variables are independent of the India's location.

4. How many types of errors in GIS?

The errors in data and its impact on GIS analysis had not been considered in recent years. GIS experts started to accept errors and inaccuracy that can disturb the quality of many GIS projects in the last decades. Understanding the GIS error is important for spatial analysis to ensuring that datasets meets a minimum threshold for accuracy. There are two basic types of errors in GIS are mention below

(i) Pre-processing errors: Pre-processing errors are those which are generated before data processing in GIS environment are listed below;

- (a) Data reliability
- (b) Scale
- (c) Density of data
- (d) Seamless data

(ii) Processing errors: Processing errors are those which are occur at the time of data processing in GIS domain like;

- (a) Numerical errors
- (b) Data formatting
- (c) Digitization errors
- (d) Data manipulation errors

5. Why GIS is important?

There are many reasons to why GIS is important, here are few. It provides information to planners for decision making to solve complex geospatial questions. It integrates both spatial and non-spatial data in a single framework and provide spatial relationships within data that might not be obvious outside of a GIS.

Multiple Choice Questions (Quiz)

1. What does the abbreviation "GIS" stand for?

- (i) Geoscience Interpolation software

- (ii) Geological Information System
- (iii) Geographical Information System
- (iv) Geographic Interpretation System

2. A computerised system for the capture, storage, retrieval, analysis and display of spatial data is known as

- (i) Remote sensing
- (ii) a GPS
- (iii) a GIS
- (iv) None of the above

3. Which type of data is used in GIS

- (i) Spatial data
- (ii) Non-spatial data
- (iii) both (i) and (ii)
- (iv) None of above

4. Which is not a pre-processing error in GIS

- (i) Scale error
- (ii) Seamless data error
- (iii) Digitization error
- (iv) Data reliability

5. Which is not a GIS software

- (i) Erdas Imagine
- (ii) Quantum GIS
- (iii) ArcGIS
- (iv) MapInfo

Suggested Readings:

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