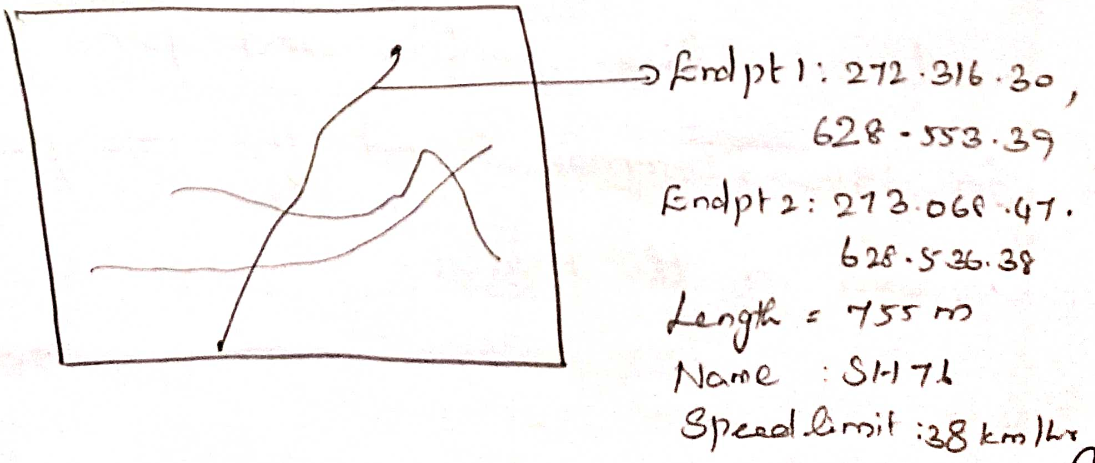
Introduction to GIS:

A geographic information system is a computer system for capturing, storing, querying, analyzing and displaying geospatial data. One of many application of GIS is disaster management. GIS plays a main role in helping responders and emergency managers to conduct rescue operations; severely damaged areas and infrastructure, prioritize medical needs and locate temporary shelters. GIS was also linked with social media as Twitter, Youtube and Flickr so that people could follow events in near real time and view overlays of streets, satellite imagery and topography.

Geospatial data describe both location and characteristics of spatial features. To describe a road, for example, we refer to its location and its characteristics as shown in the figure.



The ability of a GIS to handle and process geospatial data distinguishes GIS from other information systems and allows GIS to be used for integration of geospatial data and other data.

History of GIS:

The first operational GIS is reported to have been developed by Roger Tomlinson in the early 1960's for storing, manipulating and analyzing data collected for the Canada Inventory. In 1964, Howard Fisher founded the Harvard Laboratory for Computer Graphics, where several well known computer programs of the past such as SYMAP, SYMVU, GRID and ODESSEY were developed and distributed throughout 1970s. These earlier programs were run on mainframes and microcomputers and maps were made on line printers and pen plotters. In 1980s, commercial and free GIS packages appeared in the market.

A GIS continually evolves, two trends have emerged in recent years. One, as the core of geospatial technology, GIS has increasingly been integrated with other geospatial data such as satellite images and GPS data. Two, GIS has been linked with Web services, mobile technology, social media and cloud computing.

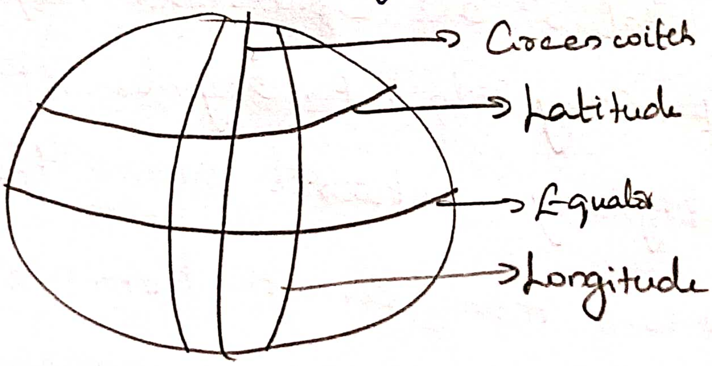
Co-Ordinate Systems:

A basic principle in geographic information system is that map layers to be used together must align spatially. Obvious mistakes can occur if they do not. For example, the two maps shown below are downloaded seperately from internet. They do not register spatially. To connect the highway networks across the shared state border, we must convert them to a common spatial reference system. The coordinate system provides spatial reference.

Geographic Coordinate System:

The geographic coordinate system is the reference system for locating spatial features on the Earth's surface. The geographic coordinate system is defined by longitude and latitude. Both longitude and angular measures: longitude measures the angle east or west from the prime meridian and latitude measures the angle north or south of the equatorial plane.

Meridians are lines of equal longitude. The prime meridian passes through Greenwich, England and has the reading of 0°.



Using the prime meridian as a reference, we can measure the longitude value of a point on the earth's surface as 0° to 180° east or west of the prime meridians.

Meridians are therefore used for measuring location in the E-W direction. Parallels are lines of equal latitude.

The angular measures of latitude and longitude are expressed in

* degrees- minutes - seconds (DMS)
* decimal degrees (DD)
* Radians (rad)

1 degree = 60 minutes

1 minute = 60 seconds

1 radian = 57.2958°

1 degree = 0.01745 rad.

Map Projections:

A map projection transforms the geographic coordinates on an ellipsoid into locations on a plane. The outcome of this transformation process is a systematic arrangement of parallels and meridians on a flat surface representing the geographic co-ordinate system.

A map projection provides couple of distinct advantages.

i) Allows to use 2D maps, either paper or digital

ii) Allows us to work with plane coordinates rather than latitude and longitude.

Map projections can be grouped by either the preserved property or the projection surface. Cartographers group map projections by the preserved property into the following four classes:

* Conformal
* Equal area / equivalent
* Equidistant
* Azimuthal / True direction.

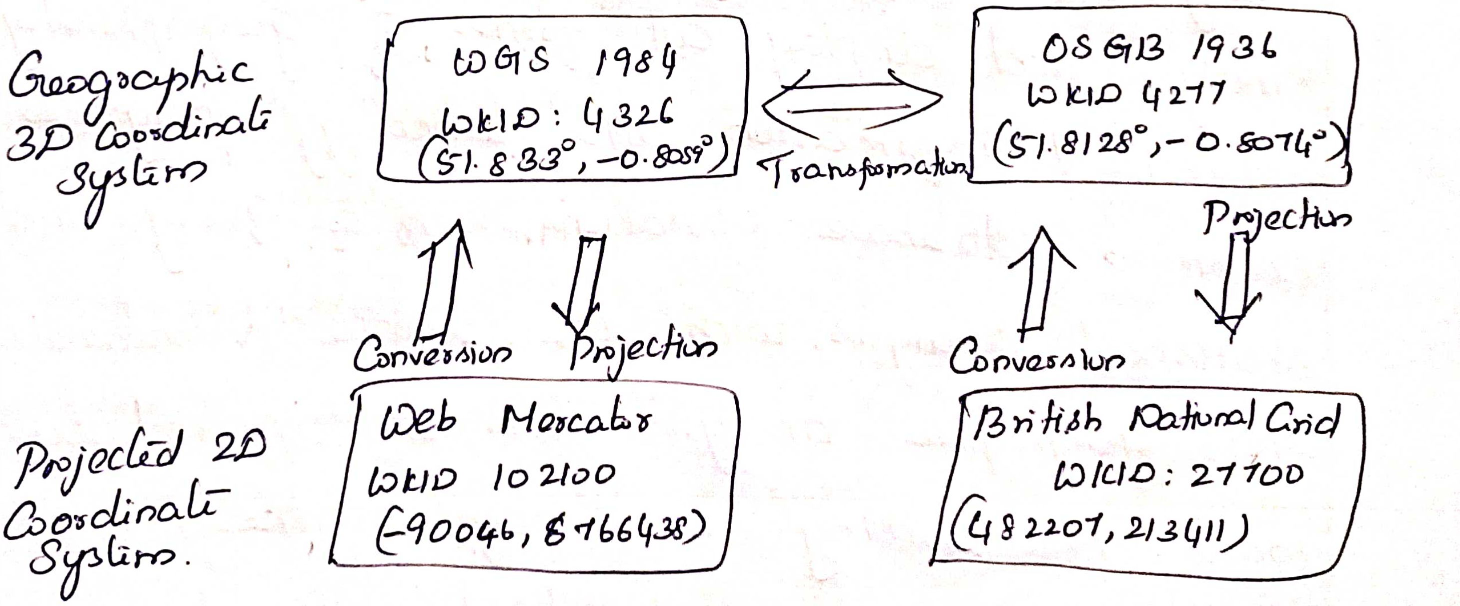
A map projection is defined by its parameters. A map projection has five or more parameters.

* Standard line
* Principal scale
* Scale factor
* False easting
* False northing.

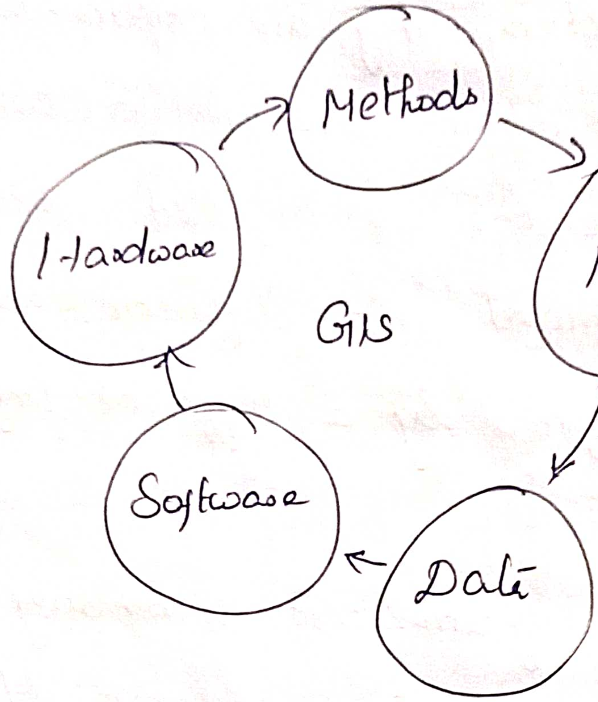
Projected Coordinate System:

A projected coordinate system is built upon a map projection. They are often used interchangably. To maintain the level of accuracy desired for measurements, a projected coordinate system is often divided into different zones, with each zone defined by a different projection center.

The coordinate systems are commonly used in the US, the Universal Transverse Mercator grid system, the Universal Polar Stereographic (UPS) grid system and State Plane Coordinate System.



Components of GIS:



A GIS is an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information. GIS technology integrates common database operations, such as query and statistical analysis, with the unique visualization and geographic analysis benifits offered by maps. A working GIS integrates the following key components, hardware, software, data, people and methods.

Hardware: GIS hardware includes computers for data processing, data storage and input/output. printers, and plotters for reports and hard-copy maps: digitizers and scanners for digitization of spatial data and GPS and mobile devices for fieldwork.

Software: GIS software, either commercial or opensource, includes programs and applications to be executed by a computer for data management, data analysis, data display and other tasks. Additional applications, written in Python, JavaScript, VB.NET, or C++ may be used in GIS for specific data analysis.

Method: A successful GIS operates according to a well defined plan and business rules, which are the models and operating practices unique to each organization. Any organization has documented their process plans for GIS operation. These documents address number question about the GIS Expert required,

required, GIS software and hardware. Process to store the data what ~~they~~ type of DBMS and more. Well designed plan will address all these questions.

People: GIS technology is of limited value without the people who manage the system and to develop plans for applying it. GIS users range from technical specialists who designed and maintain the system, to those who use it to help them do their everyday work.

Data: May be the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or bought from a commercial data provider. Most GIS employ a DBMS to create and maintain a database to help organize and manage data. The data that a GIS operates on consists of any data bearing a definable relationship to space, including any data about things and events that occurs in nature. At one time this consisted of hard copy data, like traditional cartographic maps, surveyor's logs, demographic statistics, geographic reports and descriptions from the field. Advances in spatial data collection, classification and accuracy have allowed more and more standard digital base-maps to become available at different scales.

Organization: GIS operations exist within an organizational environment; therefore, they must be integrated into the culture and decision-making process of the organization for such matters as the role and value of GIS. GIS training, data collection and dissemination and data standards.

Working of GIS:

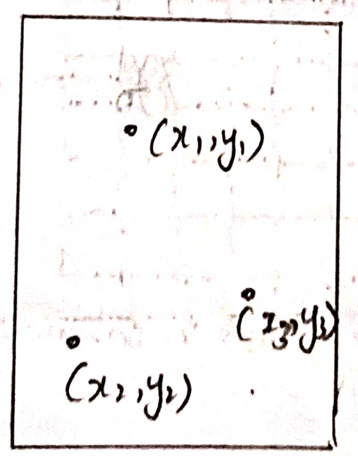
GIS consists of the following elements:

* Geo spatial data
* Data Acquisition
* Data Management

* Data display
* Data exploration
* Data Analysis.

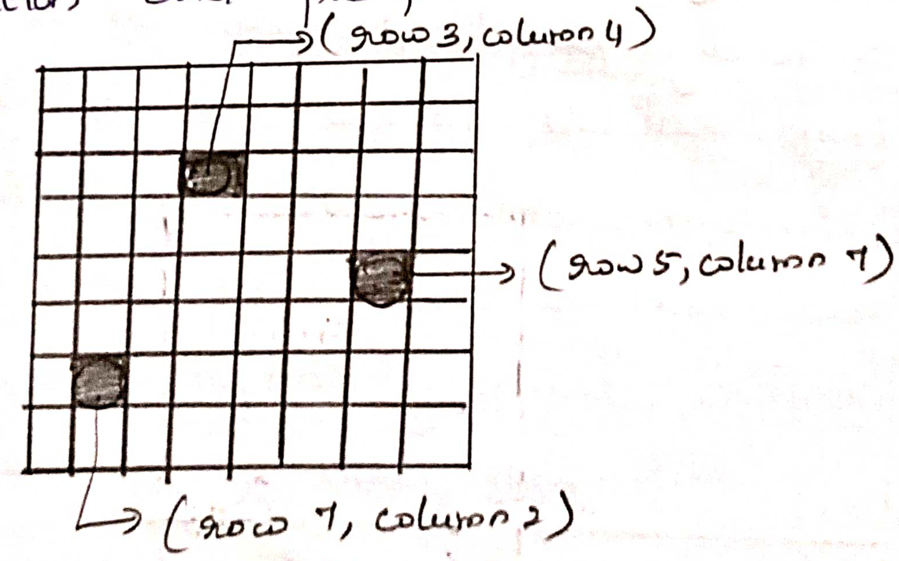
Geospatial Data:

By definition, geospatial data cover the location of spatial features. To locate spatial features on the Earth's surface, we can use either a geographic or a projected coordinate system. A geographic co-ordinate system is expressed in longitude and latitude and a projected coordinate system in x, y coordinates. Many projected coordinated systems are available for use in GIS. A GIS represents geospatial data as either vector data or raster data.



The vector data model uses points, lines and polygons to represent spatial features with a clear spatial location and boundary such as streams, land parcels and vegetation stands. Each feature is assigned an ID so that it can be associated with its attributes.

The raster data model uses a grid and grid cells to represent spatial features: point features are represented by single cells, line features by sequence of neighbouring cells and polygon features by collection of contigous cells. The cell value corresponds to the attribute of the spatial features at the cell location. Raster data are ideal for continuous features such as elevation and precipitation.



A vector data model can be georelational, or object-based, with or without topology, and simple or composite.

Data Acquisition:

Data acquisition is usually the first step in conducting a GIS project. The need for geospatial data by GIS users has been linked to the development of data clearing houses and geoportals. Since the early 1990s, government agencies at different levels in the US as well as many other countries have set up websites for sharing public data and for directing users to various data sources.

Data acquisition involves compilation of existing and new data. To be used in a GIS, a newly digitized map or a map created from satellite images requires geometric transformation. Additionally, both existing and new spatial data must be edited if they contain digitizing and/or topological errors.

Attribute Data Management:

A GIS usually employs a DBMS to handle attribute data, which can be large in size in the case of vector data. Each polygon in a soil map, for example, can be associated with dozens of attributes on the physical and chemical soil properties and soil interpretations. Attribute data are stored in a relational database as a collection of tables. These tables can be prepared, maintained and edited seperately, but they can be linked for data search and retrieval.

Data Display:

A routine GIS operation is mapmaking because maps are an interface to GIS. Mapmaking can be informal or formal in GIS. It is informal when we view geospatial data on maps, and formal when we produce maps for professional presentations and reports. A professional map combines the title, map, body, legend, scale bars and other elements together to convey geographic information to the map reader.

Data Exploration:

Data exploration refers to the activities of visualizing, manipulating and querying data using maps, tables and graphs. These activities offer a close look at the data and function as a precursor to formal data analysis.

Data exploration in GIS can be map feature-based. Map-based exploration includes data classification, data aggregation and map comparision.

Feature-based query can involve either attribute or spatial data. Attribute data query is basically the same as DB query using a DBMS. In contrast, spatial data query allows GIS users to select features based on their spatial relationships such as containment, intersect and proximity. A combination of attribute and spatial data queries provides a powerful tool for data exploration.

Data Analysis:

A GIS has a large number of tools for data analysis. Some are basic tools, meaning that they are regularly used by GIS users. Other tools tend to be discipline or application specific. Two basic tools for vector data are buffering and overlay.

Buffering creates buffer zones from selected features.

Overlay combines the geometrics and attributes of the input layers.

Four basic tools for raster data are local, neighbourhood, zonal and global operations, depending on whether the operation is performed at the level of individual cells, or group of cells, or cells within an entire raster.

GIS Software Products:

The softwares available for Geographic Information System may be of any one type.

* Commercial Software
* Free and open source Software (FOSS)

Commercial Softwares

* Environmental Science Research Institute (Esri)
* Autodesk, AutoCAD Map 3D, Autodesk Geospatial.
* Bentley Systems, Bentley Map.
* Intergraph/ Hexagon Geospatial.
* Blue Marble
* Manifold
* Pitney Bowes.
* Caliper Corporation.

* General Electric, Small World
* Clark Labs

Free and Open Source Software:

* Center for Spatial Data Science, GeoDa
* Open Source Geospatial Foundation
* gvSIG Community
* International Institute of Aerospace Survey and Earth Sciences, the Netherlands, ILWIS
* MapWindow GIS Project
* Open Jump
* Quantum GIS Project
* SAGA User Group
* Refractions Research.

ArcGIS is composed of applications and extensions at three levels. The applications include ArcMap, ArcGIS Pro, Arc Catalog, ArcScene and ArcGlobe and the extensions include 3D Analyst, Network Analyst, Geostatistical Analyst and others.

GRASS GIS, the first FOSS for GIS, was originally developed by the US Army Construction Engineering Research Lab in 1980's. Well known for its analysis tools, GRASS GIS is currently maintained and developed by a world wide network of users, academicians, government agencies (NASA, NOAA, USDA and USGS) and GIS practitioners use this open source software because its code can be inspected and tailored to their needs.

SAGA GIS is one of the classics in the world for free GIS software. It started out primarily for terrain analysis such as hill shading watershed extraction and visibility analysis.
Now SAGA GIS is a power house because it delivers a fast growing set of geoscientific methods to the geo scientific community.

GeoDa is a free GIS software program primarily used to introduce new users into spatial data analysis. Its main functionality is data exploration in statistics. One of the nicest things about how it comes with sample data for you to give a test drive. From simple box-plots all the way to regression statistics, GeoDa has complete arsenal of statistics to do nearly anything spatially.

Applications of GIS:

GIS is a useful tool because a high percentage of information we routinely encounter has a spatial component. An often cited figure among GIS users is that 80 % of data is geographic. Since its begining GIS has been important for land use planning, natural hazard assesment, wild life habitat analysis, riparian zone monitoring, timber management and urban planning. The list of fields that have benifited from the use of GIS has expanded significantly for the past three decades.

In the United States, the US ~~government~~ geological survey is a leading agency in the development and promotion of GIS. The USGS website provides case studies as well as geospatial data for applications in climate and land use change, ecosystem analysis, geologic mapping, petroleum resource assesment, watershed management, coastal zone management, natural hazard (volcano, flood, and land slide), aquifer depletion and ground water management.

In the private sector, most GIS applications are integrated with the Internet, GPS, wireless technology, and Web Services. The following shows some of these applications.

* Online mapping websites offer locators for finding real estate listings, vacation rentals, banks, restaurants, coffee shops and hotels.

* Location-based services allow mobile phone users to search for nearby banks, restaurants and taxis and to track friends, dates, children and the elderly.

* Mobile GIS allows field workers to collect and