Principles of Geographic Information Systems Practical
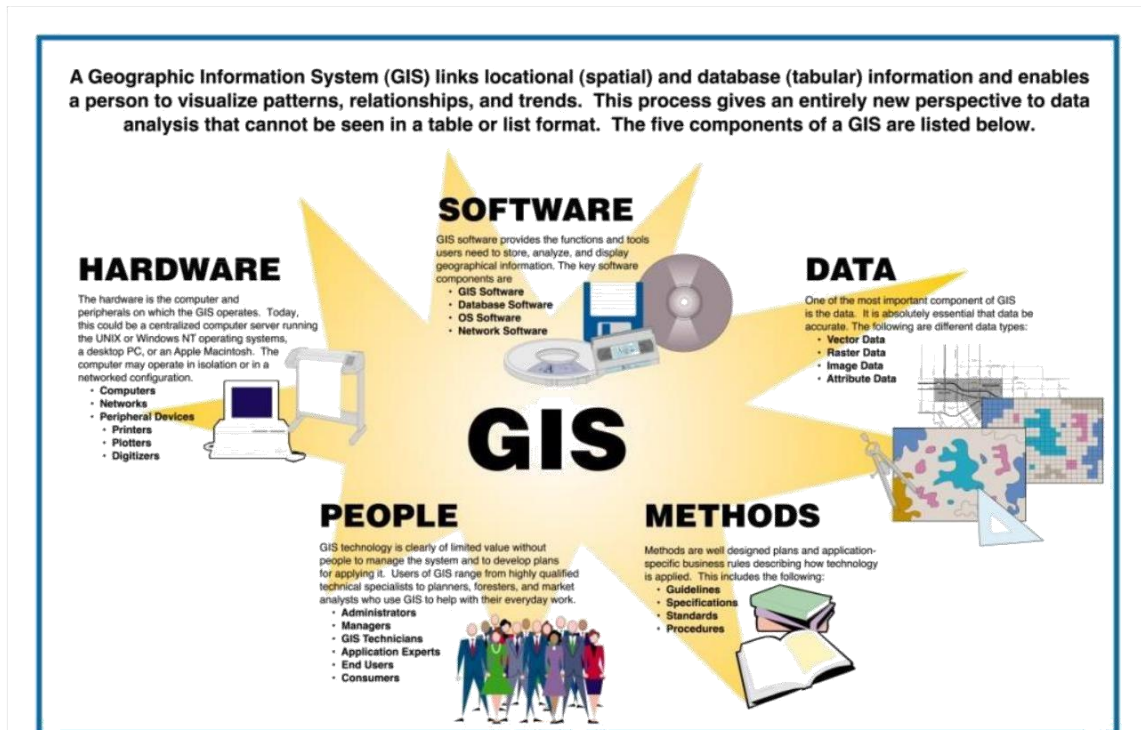
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Prerequisites to GIS Practical

What is a Geographic Information System (GIS)?

A Geographical Information System (GIS) is an organized collection of computer **hardware**, **software** and **data** used to link, analyze and display geographically referenced information.

The foundation of GIS is the ability to locate objects and events (streams, villages, disease cases) and link them with appropriate information in order to identify patterns and provide a basis for map making and analysis. Key types of geographical data, represented as separate map layers in a GIS, are outlined in the table below.

Sr. No	Data Type	Example	Layer on Map	
1	POINT	Building, Hospital, City, Well.		
2	LINE	River, Road		
	POLYGON	Administrative Boundaries, Census tacts.		
4	RASTER	Pixel or grid data		

Vector data: A representation of the world using points, lines, and polygons. Vector models are useful for storing data that has discrete boundaries, such as country borders, land parcels, and streets.

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Point features: A map feature that has neither length nor area at a given scale, such as a city on a world map or a building on a city map.

*Line features***:** A map feature that has length but not area at a given scale, such as a river on a world map or a street on a city map.

*Polygon features***:** A map feature that bounds an area at a given scale, such as a country on a world map or a district on a city map.

Raster data. A representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.

With a GIS application you can open digital maps on your computer, create new spatial information to add to a map, create printed maps customised to your needs and perform spatial analysis.

Understanding QGIS

What is Quantum GIS?

Quantum GIS (QGIS) is a user friendly Open Source GIS application licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

Like all GIS applications, QGIS provides a graphical user interface allowing display of map layers and manipulation of data for analyses and map-making.

A Geographical Information System (GIS) is a collection of software that allows you to create, visualize, query and analyze geospatial data. Geospatial data refers to information about the geographic location of an entity. This often involves the use of a geographic coordinate, like a latitude or longitude value. Spatial data is another commonly used term, as are: geographic data, GIS data, map data, location data, coordinate data and spatial geometry data. Applications using geospatial data perform a variety of functions. Map production is the most easily understood function of geospatial applications. Mapping programs take geospatial data and render it in a form that is viewable, usually on a computer screen or printed page. Applications can present static maps(a simple image) or dynamic maps that are customized by the person viewing the map through a desktop program or a web page.

Many people mistakenly assume that geospatial applications just produce maps, but geospatial data analysis is another primary function of geospatial applications. Some typical types of analysis include computing:

- Distances between geographic locations
- The amount of area (e.g., square meters) within a certain geographic region What geographic features overlap other features?
- The amount of overlap between features
- The number of locations within a certain distance of another and so on...

These may seem simplistic, but can be applied in all sorts of ways across many disciplines. The results of analysis may be shown on a map, but are often tabulated into a report to support management decisions. The recent phenomena of location-based services promises to introduce all sorts of other features, but many will be based on a combination of maps and analysis. For example, you have a cell phone that tracks your geographic location. If you have the right software, your phone can tell you what kinds of restaurants are within walking distance. While this is a novel application of geospatial technology, it is essentially doing geospatial data analysis and listing the results for you.

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1. Raster Mosaicing and Clipping

A mosaic is a combination or merge of two or more images. In ArcGIS, you can create a single raster dataset from multiple raster datasets by mosaicking them together. Alternatively, you can create a mosaic dataset and create a virtual mosaic from a collection of raster datasets.

The illustration below shows how six adjacent raster datasets are mosaicked together into one raster dataset.

This tool allows you to extract a portion of a raster dataset based on a template extent. The clip output includes any pixels that intersect the template extent. If you want to extract a portion of a feature dataset, use the Clip tool in the Analysis toolbox.

2. Searching and Downloading OpenStreetMap Data

Getting high quality data is essential for any GIS task. One great resource for free and openly licensed data is OpenStreetMap(OSM) . The OSM database consists of all types of mapping data - streets, local data, building polygons, administrative boundaries etc. Getting access to OSM data in a GIS format in QGIS is possible via the *QuickOSM** plugin. This practical explains the process for searching, downloading and using this plugin.

Overview of the task

We will use a scanned map of southern India from 1870 and geo-reference it using QGIS.

3. Working with Terrain Data

Terrain or elevation data is useful for many GIS Analysis and it is often used in maps. QGIS has good terrain processing capabilities built-in. It enables to generate various products from elevation data such as contours, hillshade etc.

Overview of the task

The task is to create contours and hillshade map for area around Mt. Everest.

4. Working with Projections

Map projections - or Coordinate Reference System (CRS) - often cause a lot of frustration when working with GIS data. But proper understanding of the concepts and access to the right tools will make it much easier to deal with projections. In this tutorial, we will explore how projections work in QGIS and learn about tools available for vector and rasters - particularly re-projecting vector and raster data, enabling on-the-fly re-projection and assigning projection to data without projection.

Overview of the task

The task is to re-project and overlay data layers of difference projections together in QGIS.

5. Working with WMS Data

Often you need reference data layers for your basemap or to display your results in the context of other datasets. Many organizations publish datasets online that can be readily used in GIS. A popular standard for publishing maps online is called **WMS (Web Map Service)**. This is a better choice for using reference layers as you get access to rich datasets in your GIS without the hassle of downloading or styling the data.

6. Georeferencing Topo Sheets and Scanned Maps

Most GIS projects require georeferencing some raster data. *Georeferencing* is the process of assigning real-world coordinates to each pixel of the raster. Many times these coordinates are obtained by doing field surveys - collecting coordinates with a GPS device for few easily identifiable features in the image or map. In some cases, where you are looking to digitize scanned maps, you can obtain the coordinates from the markings on the map image itself. Using these sample coordinates or GCPs (Ground Control Points), the image is warped and made to fit within the chosen coordinate system. In this tutorial I will discuss the concepts, strategies and tools within QGIS to achieve a high accuracy georeferencing.

7. Georeferencing Aerial Imagery

That method involved reading the coordinates from your scanned map and entering them manually as control points. Many times though you may not have the coordinates printed on your map, or you are trying to georeference an image. In that case, you can use another georeferenced data-source as your input. In this tutorial, you will learn how to use existing open data sources in your georeferencing process.

8. **Digitizing Map Data**

   Digitizing is one of the most common tasks that a GIS Specialist has to do. Often a large amount of *GIS time* is spent in digitizing raster data to create vector layers that you use in your analysis. QGIS has powerful on-screen digitizing and editing capabilities. **We will use a raster topographic map and create several vector layers representing features around a park.**

   Other skills you will learn

- Building pyramids for large raster datasets to speed up zoom and pan operations.
- Working with a Spatialite database.

9. **Performing Table Joins**

   Not every dataset you want to use comes in spatial format. Often the data would come as a table or a spreadsheet and you would need to link it with your existing spatial data for use in your analysis. This operation is known as a **Table Join** and is done using the Join attributes by field value Processing algorithm

10. **Performing Spatial Joins**

    Spatial Join is a classic GIS problem - transferring attributes from one layer to another based on their spatial relationship. In QGIS, this functionality is available through the Join attributes by location Processing algorithm.

11. **Performing Spatial Queries**

    Spatial queries are core to many types of GIS analysis. Spatial queries allows you to select features in a layer by their spatial relationships (intersect, contain, touch etc.) with features from another layer. In QGIS, this functionality is available via the **Select by Location** and **Extract by Location** Processing tools.

    Other skills you will learn

- Choosing an appropriate projection and re-projecting vector data.
- Creating buffers.
- Working with the geopackage (.gpkg) data format.

12. **Nearest Neighbor Analysis**

    GIS is very useful in analyzing spatial relationship between features. One such analysis is finding out which features are closest to a given feature. There are multiple ways to do this analysis in

QGIS. We will explore the **Distance to nearest hub** and **Distance matrix** tools to carry out the nearest neighbor analysis.

13. Sampling Raster Data using Points or Polygons

Many scientific and environmental datasets come as gridded rasters. Elevation data (DEM) is also distributed as raster files. In these raster files, the parameter that is being represented is encoded as the pixel values of the raster. Often, one needs to extract the pixel values at certain locations or aggregate them over some area. This functionality is available in QGIS via processing algorithms. Sample raster values for point layers and Zonal Statistics for polygon layers.

14. Interpolating Point Data

Interpolation is a commonly used GIS technique to create continuous surface from discrete points. A lot of real world phenomena are continuous - elevations, soils, temperatures etc. If we wanted to model these surfaces for analysis, it is impossible to take measurements throughout the surface. Hence, the field measurements are taken at various points along the surface and the intermediate values are inferred by a process called 'interpolation'. In QGIS, interpolation is achieved using the built-in Interpolation plugin.

Other skills you will learn

- Creating contours from point data.
- Masking no-data values from a raster layer.
- Adding labels to a vector layer.