IS311
Geographical Information Systems

Dr. Waleed M.Ead

Textbooks

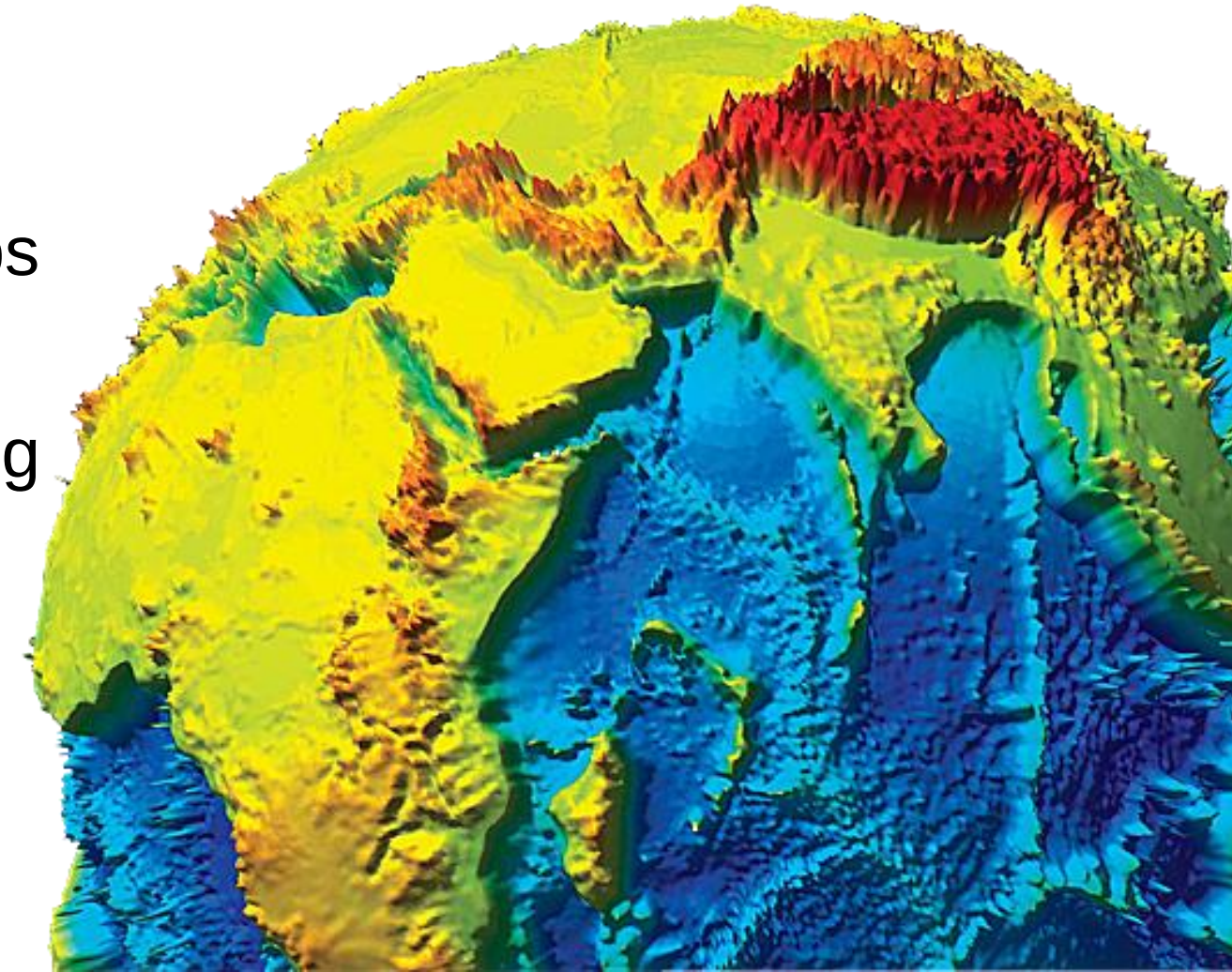
- Chang, Kang-Tsung. Introduction to geographic information systems. McGraw-Hill Science/Engineering/Math, 2015.
- Panigrahi, Narayan. Computing in geographic information systems. CRC Press, 2014.
- Practical part
  - **Qgis**

Geography is the Science of Our World

Increasingly Being Seen as a Framework for

- Understanding
  - Patterns
  - Relationships
  - Processes
- Conceptualizing
- Modeling
- Visualizing

. . . Integrating What We Know



Data - Data - Data
We've all "got data"

- Location Data

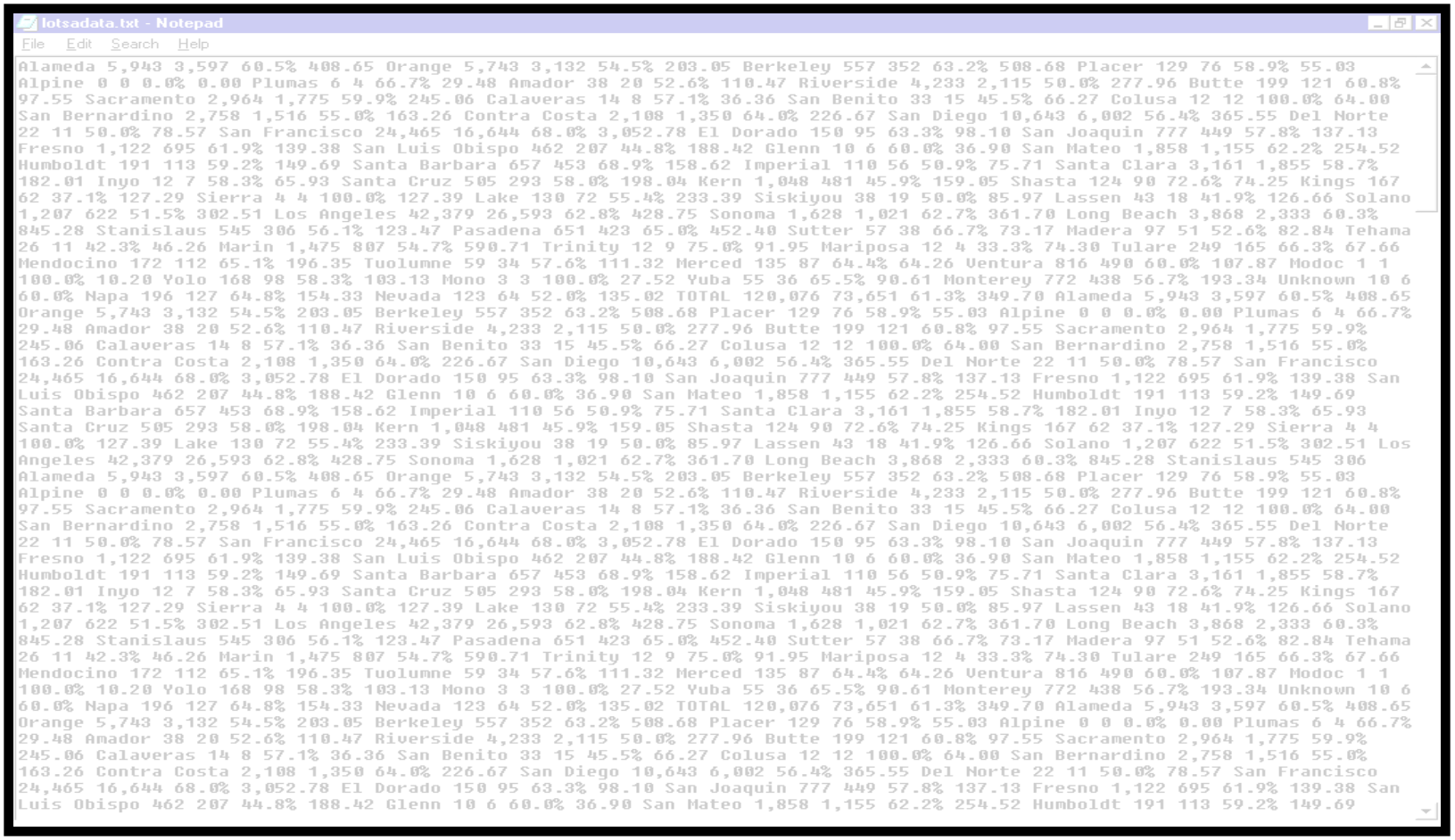
  -- How Many -- What Kind -- Where
- Scale of Data

  -- Local to Global
- Data Presentation

  -- Words, Charts, Graphs, Tables, or Maps

Exploring data using GIS turns <u>data</u> into <u>information</u> into <u>knowledge</u>

How is information normally ‘seen’? … non-spatially?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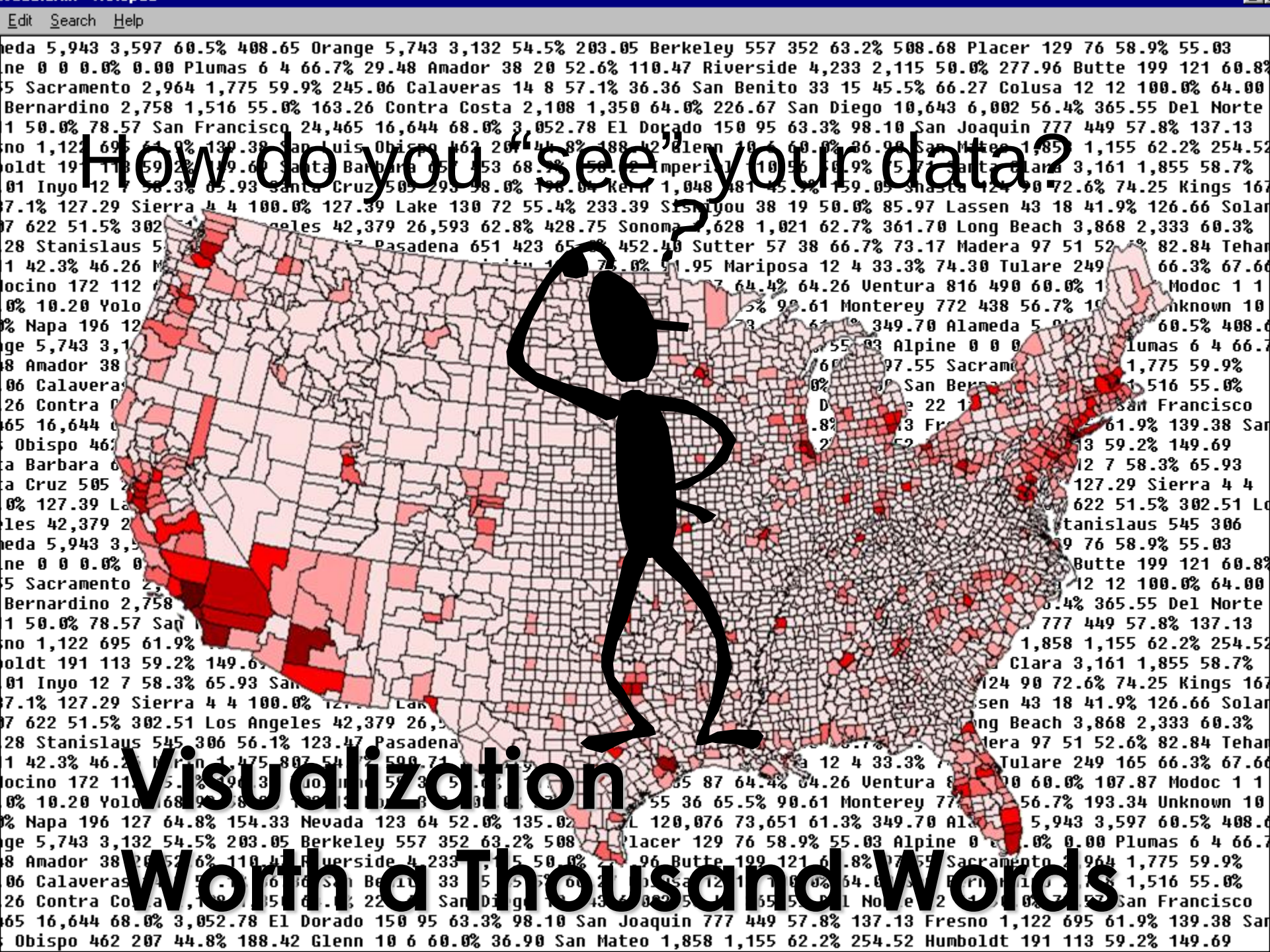
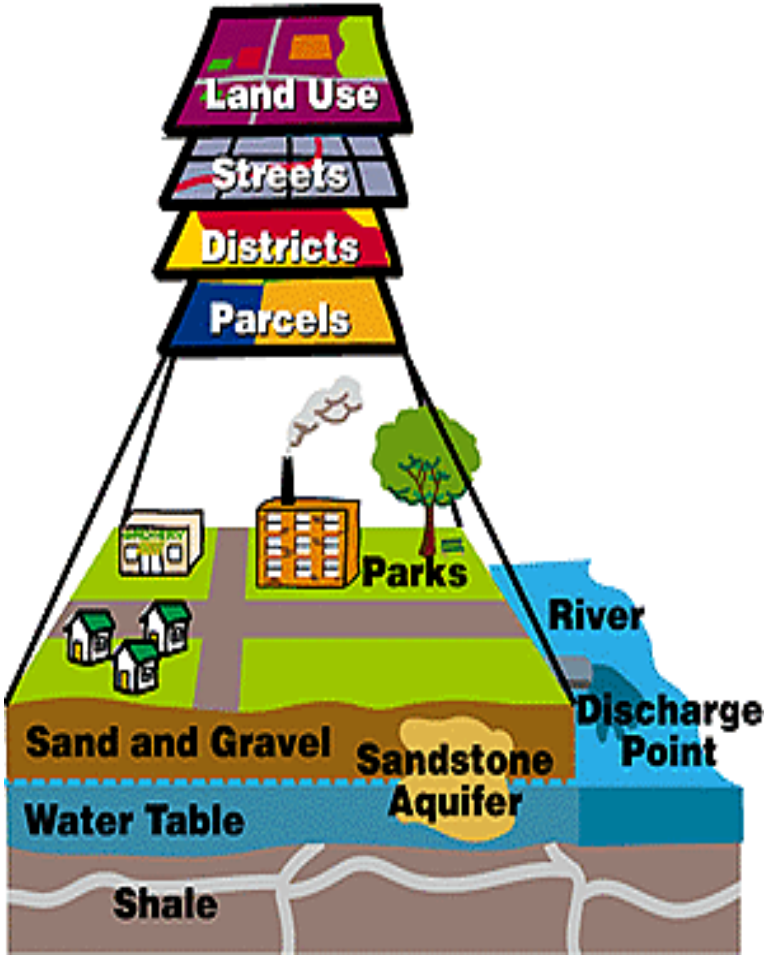

How do you "see" your data?
Visualization
Worth a Thousand Words

What is GIS?



- *A method to visualize, manipulate, analyze, and display spatial data*
- *"Smart Maps" linking a database to a map*

GIS: a formal definition

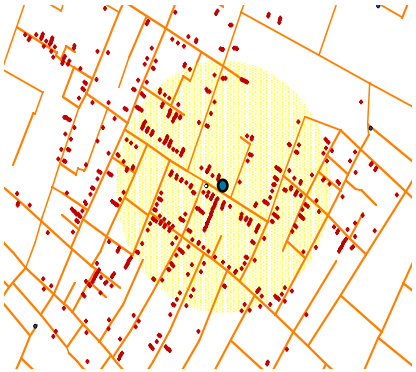
"A system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatially referenced computer database and appropriate applications software"
Chorley Report, 1987

Why is GIS unique?

- What distinguishes GIS from other information systems?
- GIS handles SPATIAL information
  - Information referenced by its location in space
- GIS integrates spatial* and other kinds of information within one system: it offers a consistent framework for analysing space
- GIS makes connections between activities based on spatial proximity
- GIS provides the mechanisms for undertaking the manipulation and display of geographic knowledge

Historical Background

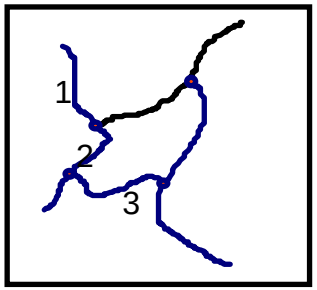
- GIS Concept is not new?
  - John Snow
- Canadian Efforts
  - Roger Tomlinson
- American Efforts
  - Harvard Laboratory for Computer Graphics and Spatial Analysis
  - Howard Fisher(1963)
  - USA Census
  - ESRI
- Sciences
  - Digital cartography and CAD
  - Data Base Management Systems



Soho

Cholera death

Water pump



CAD System

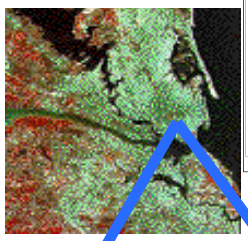
ID	X,Y
1	
2	
3	

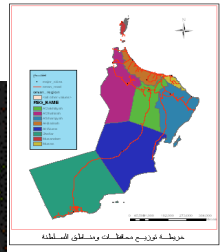
ID	ATTRIB
1	
2	
3	

Data Base Management System

GIS components

Spatial data





GIS

?

Computer hardware / software tools

Specific applications / decision making objectives

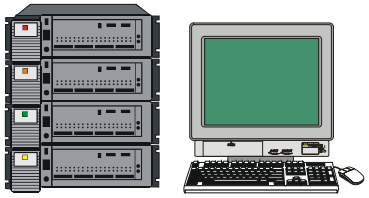
Why it is important?

- Helps us to distinguish one place from another & to make decisions for one place appropriate for that location
- Apply general principles to specific conditions of each location
- Allows us to track what's happening at any place
- Helps us to understand how one place differs from another

GIS Method

Traditional Method

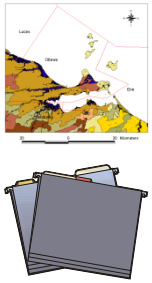
Data Acquisition



Analysis & Modeling

$F( )_{xyz}=f(p1)_{xyz}+f(p2)_{xyz}+\ldots+f(pN)_{xyz}$

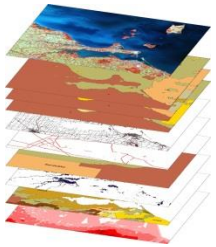
Map Composition



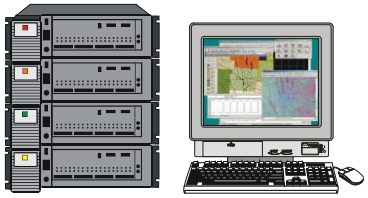
Result Report

GIS Method

Data Acquisition

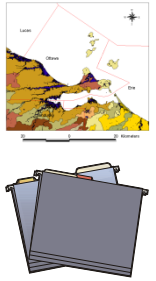


Data Organization



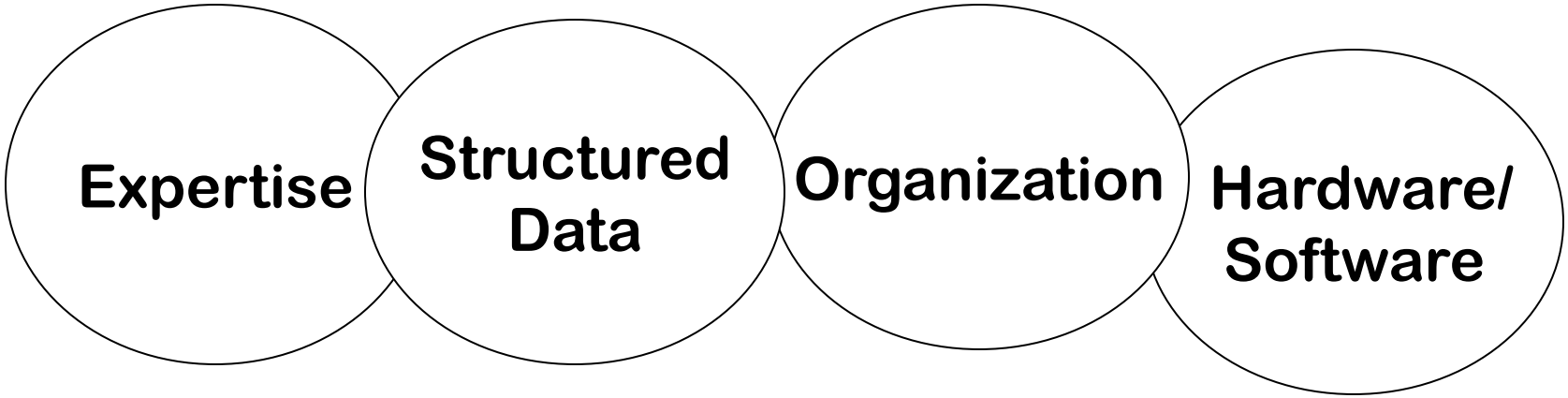
Analysis & Modeling

F( ) =Layer1+Layer2+ … + LayerN



Result Report

GIS Chain

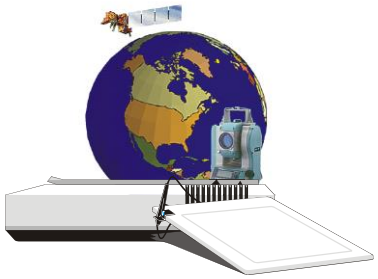


Hardware/software functions:

Acquisition & verification
Compilation
Storage
Updating & changing
Management & exchange
Manipulation
Retrieval & presentation
Analysis & combination

Components

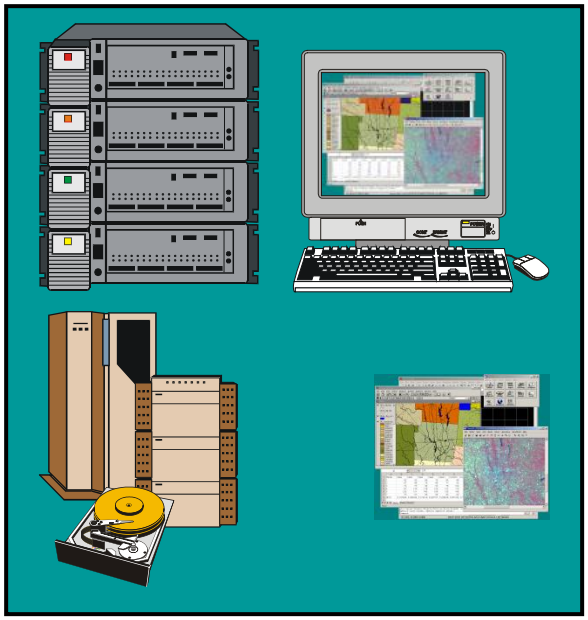
Input



Data Acquisition
- Geodetic Positioning
- Remote Sensing
- Field Sampling

Analog Data Conversion
- Scan
- Digitize

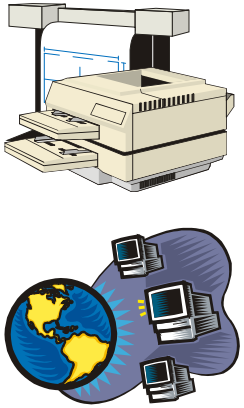
Management & Analytical Modules



Management
- Data Storage
- Data Retrieval, Expand Edit, and Update
- Query

Analytical Modules
- Data Conversion
- Data Manipulation
- Modeling

Output

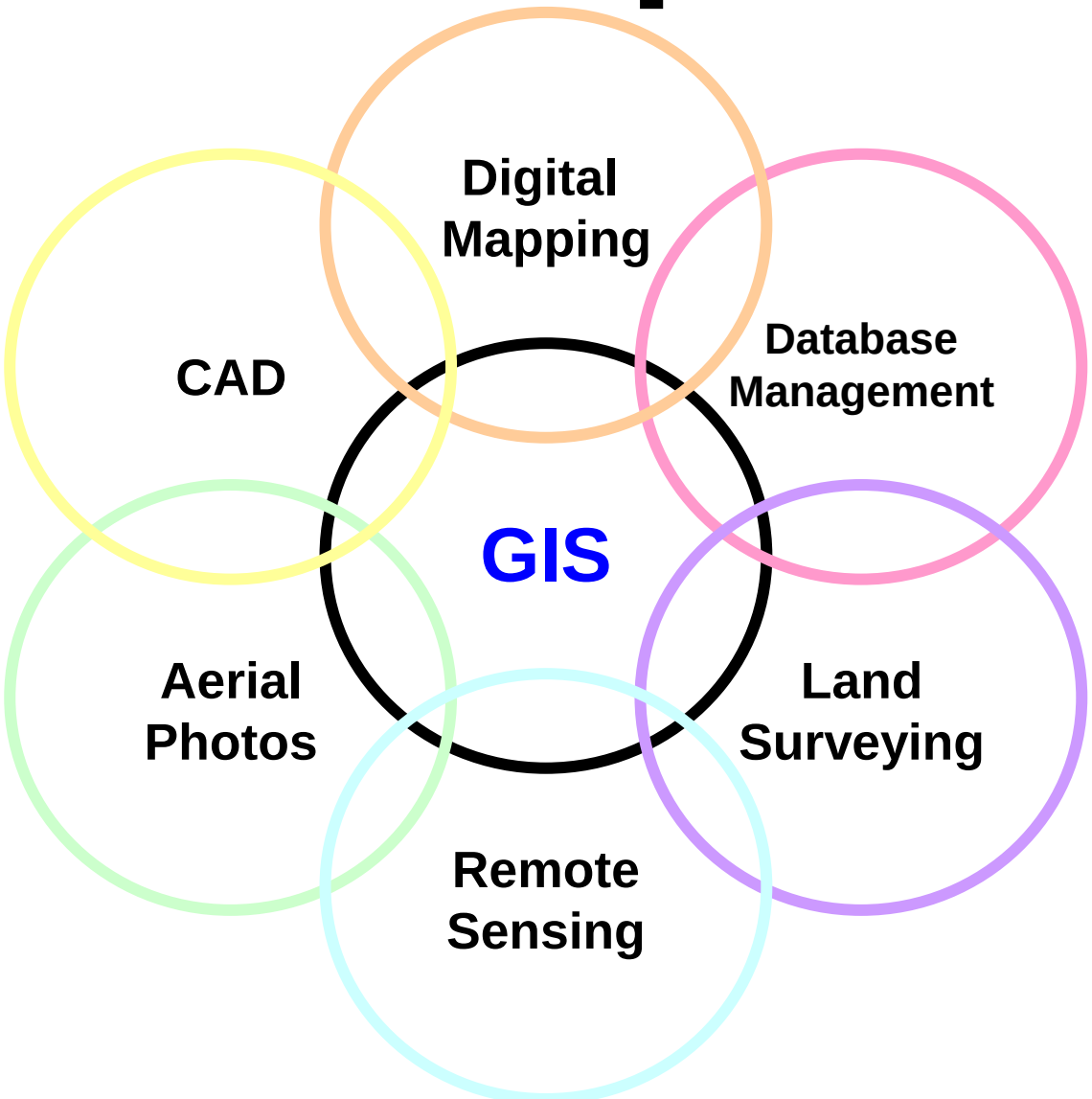


Data Output
- Visual Presentation
- Analog Map Output
- Reports

The Field of GIS Involves Many:

- Disciplines
- Applications
- Data
- Users

GIS Overlap


Digital Mapping
CAD
Database Management
GIS
Aerial Photos
Land Surveying
Remote Sensing

GIS Overlap

- **Image processing**
  - **Wide range of operations on images captured by video cameras, still cameras, & satellites**
  - **Extraction of information from images**
  - **GIS is analysis of that information**
- **CAD (computer-assisted drafting)**
  - **Emphasizes design over analysis**
  - **Produce graphic images, not normally tied to external descriptive data files**
  - **Often lacks analytical capabilities of a GIS**

GIS Overlap

- CAC (computer-assisted cartography)
  - Computer system designed to create maps from graphical objects combined with descriptive attributes
  - Purely mapping purposes – developed specifically for input, design & output of mappable data
  - Excellent display, but lacks analytical capabilities of a GIS

Many Views of GIS

- Planning system to aid the design of road systems, excavations, or forest harvest operation
- Electronic navigation system for land or sea transport – uses GPS (global positioning system)
- Market analysis – determine amount of market within reasonable reach of business (allocation) or analyze existing facilities to determine where best to place a competing or complementary facility (location)

GIS Designated by Applications

- LIS – Land Information System
  - Manage land records
- UIS – Urban Information System
- NRIS – Natural Resources Information System
- AM/FM – Automatic Mapping/Facility Management

Socioeconomic Challenges

- Our complex society
- Operation & maintenance
- Environmental & resource management
- Planning & development
- Management & public services
- Safety at sea
- Land transportation
- Military use and Privacy Protection

Why GIS Is *Hot* Application Area for Digital Technology

- About a 20% growth each year in the software industry
- $500 M – total annual sales of GIS software

GIS Applications

- Facilities management
- Marketing and retailing
- Environmental
- Transport/vehicle routing
- Health
- Insurance
- and many more . . .

http://grindgis.com/blog/gis-applications-uses#prettyPhoto

Applications

Urban Planning, Management & Policy

- Zoning, subdivision planning
- Land acquisition
- Economic development
- Code enforcement
- Housing renovation programs
- Emergency response
- Crime analysis
- Tax assessment

Applications

Environmental Science

- Monitoring environmental risk
- Modeling storm water runoff
- Management of watersheds, floodplains, wetlands, forests, aquifers
- Environmental Impact Analysis
- Hazardous or toxic facility siting
- Groundwater modeling and contamination tracking

Applications

Political Science

- Redistricting
- Analysis of election results
- Predictive modeling

Applications

Civil Engineering/Utility

- Locating underground facilities
- Designing alignment for freeways, transit
- Coordination of infrastructure maintenance

Applications

Business

- Demographic Analysis
- Market Penetration/ Share Analysis
- Site Selection

Applications

Real Estate

- Neighborhood land prices
- Traffic Impact Analysis
- Determination of Highest and Best Use

Applications

Health Care

- Epidemiology
- Needs Analysis
- Service Inventory

Applications

Agriculture

- Farm management
- Pest/Disease tracking
- Crop monitoring
- Yield prediction
- Soil analysis (please Visit: http://solim.geography.wisc.edu/

Applications

Natural Recourses Management

- Forestry
- Ecology
- Mining
- Petroleum
- Water Resources

Applications

Planning and Economic Development

- Land Use/Zoning
- Emergency Preparedness
- Population Forecast
- Market Analysis
- Property Tax Assessment
- Transportation

Week3,Lec3

GIS Tasks

- **Input**
- **Manipulation**
- **Management**
- **Query and Analysis**
- **Visualization**

GIS Tasks

Input

- Before geographic data can be used in a GIS, the data must be converted into a suitable digital format.

- The process of converting data from paper maps into computer files is called ***digitizing***.

GIS Tasks

Input

- Modern GIS technology can automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing (using a digitizing table).
- Today many types of geographic data already exist in GIS-compatible formats.
- These data can be obtained from data suppliers and loaded directly into a GIS.

GIS Tasks

Manipulation

- 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 your system.

- For example, geographic information is available at different scales (detailed street centerline files; less detailed census boundaries; and postal codes at a regional level).

GIS Tasks

Manipulation

- Before this information can be integrated, it must be transformed to the same scale (degree of detail or accuracy).
- This could be a temporary transformation for display purposes or a permanent one required for analysis.
- GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

GIS Tasks

Management

- For small GIS projects it may be sufficient to store geographic information as simple files.
- However, when data volumes become large and the number of data users becomes more than a few, it is often best to use a database management system (DBMS) to help store, organize, and manage data.
- A DBMS is nothing more than computer software for managing a database.

GIS Tasks

Query and Analysis

- Once you have a functioning GIS containing your geographic information, you can begin to ask simple questions such as:
  - Who owns the land parcel on the corner?
  - How far is it between two places?
  - Where is land zoned for industrial use?

GIS Tasks

Query and Analysis

- Analytical questions such as:
  - Where are all the sites suitable for building new houses?
  - What is the dominant soil type for oak forest?
  - If I build a new highway here, how will traffic be affected?

GIS Tasks

Visualization

- 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 Tasks

Visualization

- While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography.

- Map displays can be integrated with reports, three-dimensional views, photographic images, and other output such as multimedia.

Data for GIS

What Map Data Do I Need?

- If you are unfamiliar with map data, think first about how you want to use map data.
- Many project needs are met with the following common map data types.

Data for GIS

Base Map

- Include streets and highways; boundaries for census, postal, and political areas; rivers and lakes; parks and landmarks; place names; and raster maps.

Data for GIS

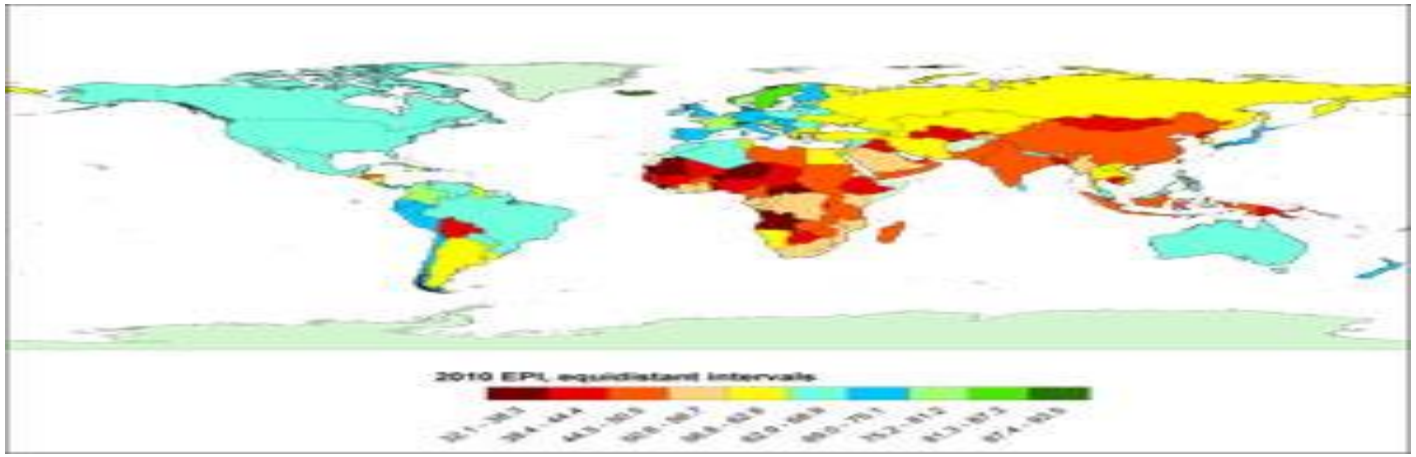
Business Map and Data

- Include data related to census/demography, consumer products, financial services, health care, real estate, telecommunications, emergency preparedness, crime, advertising, business establishments, and transportation.

Data for GIS

Environmental Map and Data

- Include data related to the environment, weather, environmental risk, satellite imagery, topography, and natural resources.

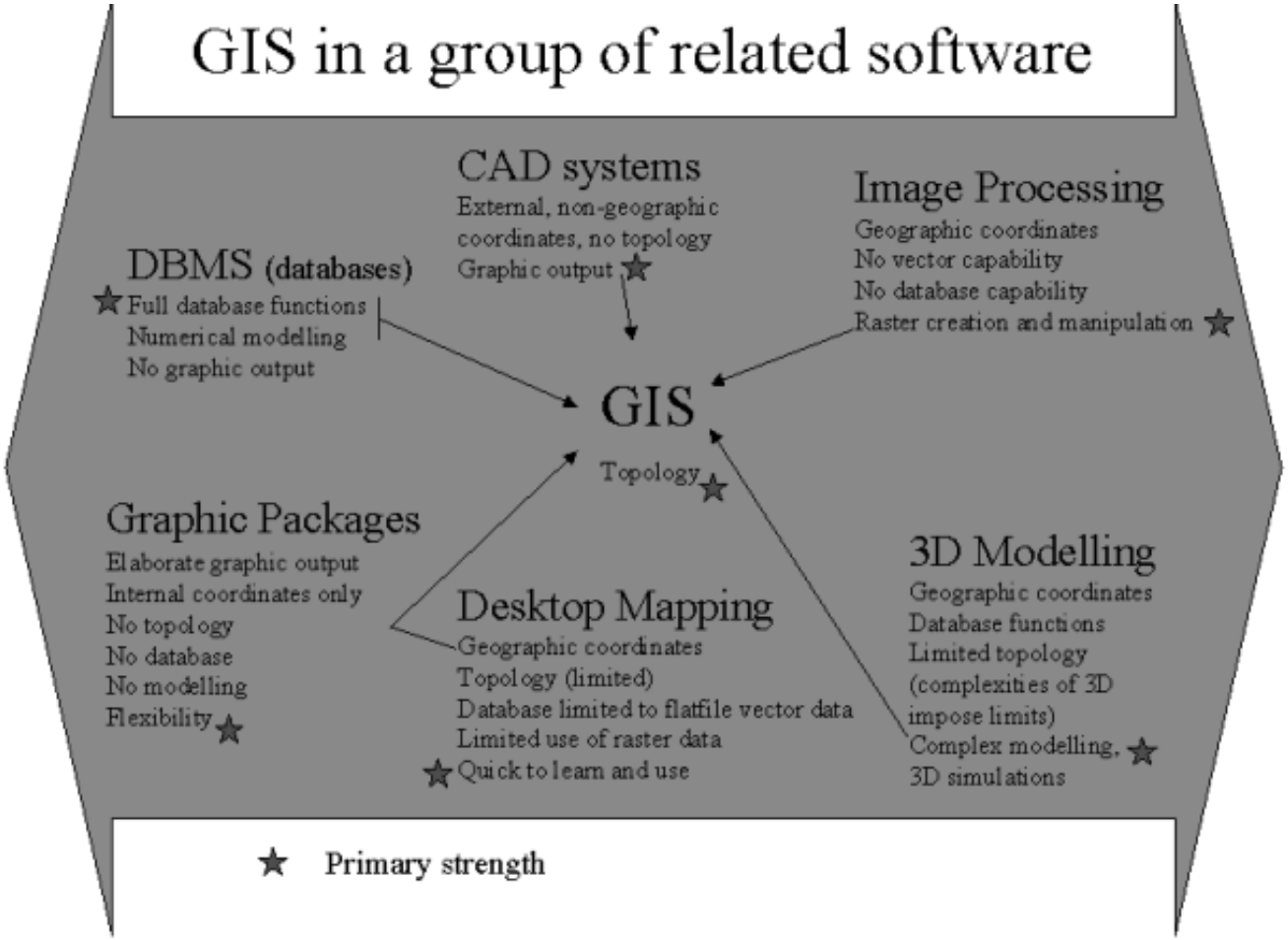


Data for GIS

General Reference Maps

- World and country maps and data that can be a foundation for your database.

Related Technology



Related Technology

Desktop Mapping

- A desktop mapping system uses the map metaphor to organize data and user interaction.
- The focus of such systems is the creation of maps: the map is the database.
- Most desktop mapping systems have more limited data management, spatial analysis, and customization capabilities.
- Desktop mapping systems operate on desktop computers such as PCs and Macintoshes.

Related Technology

CAD

- CAD systems evolved to create designs and plans of buildings and infrastructure.
- These systems require few rules to specify how components can be assembled and very limited analytical capabilities.
- CAD systems have been extended to support maps but typically have limited utility for managing and analyzing large geographic databases.

Related Technology

Remote Sensing and GPS

- Remote sensing is the art and science of making measurements of the earth using sensors such as cameras carried on airplanes, GPS receivers, or other devices.
- These sensors collect data in the form of images and provide specialized capabilities for manipulating, analyzing, and visualizing those images.
- Lacking strong geographic data management and analytical operations, they cannot be called true GISs.

Related Technology

DBMS

- Database management systems specialize in the storage and management of all types of data including geographic data.
- DBMSs are optimized to store and retrieve data and many GISs rely on them for this purpose.
- They do not have the analytic and visualization tools common to GIS.

Questions