Spatial data

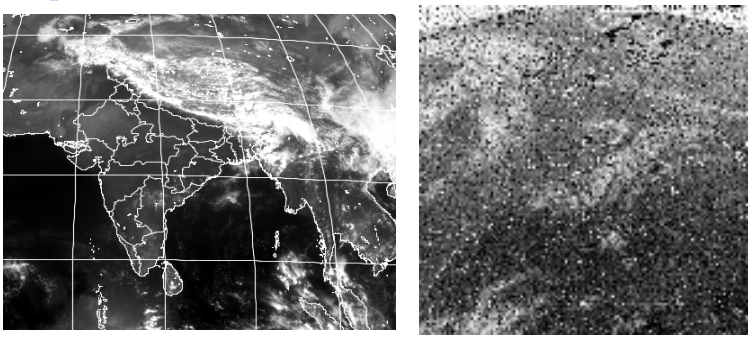
Spatial data is about instances located in a physical space.

Spatial data

- Spatial data has location features.
  - Address, latitude/longitude (explicit)
  - Location-based partitions in databases (implicit)

Spatial data

- Spatial data can be categorized into two types:
  - Raster data (Such data consist of bit maps or pixel maps in two or more dimensions)



Example of raster image: satellite image of cloud cover, where each pixel store the cloud visibility in a particular area.

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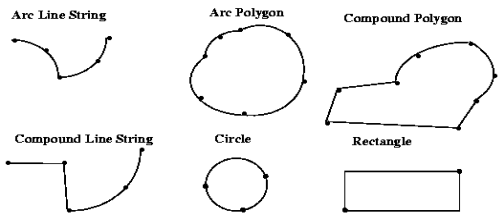
Spatial data

- **Vector data (vector data are constructed from basic geometric objects. such as points, line segments, triangles, polygons in two dimension. cylinders, spheres, cuboids in three dimension.)**



- **Example of vector data : (such as map data. Rivers & roads represented as line segments, states & countries may be represented as polygons)**

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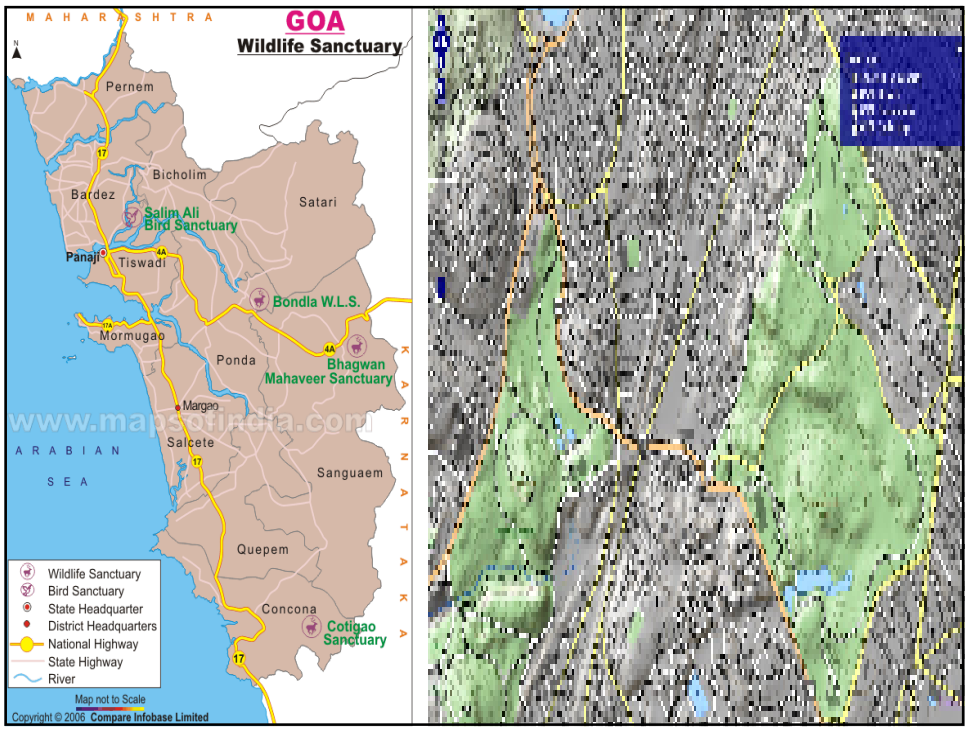
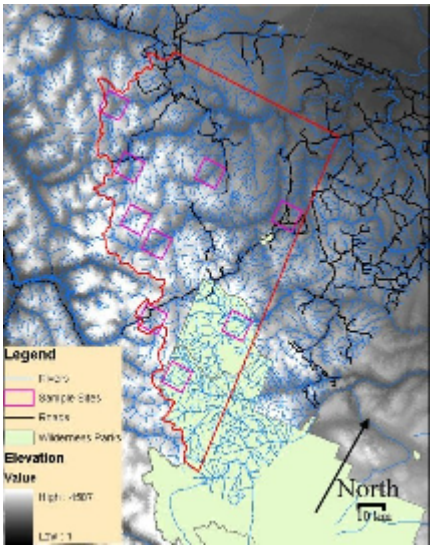


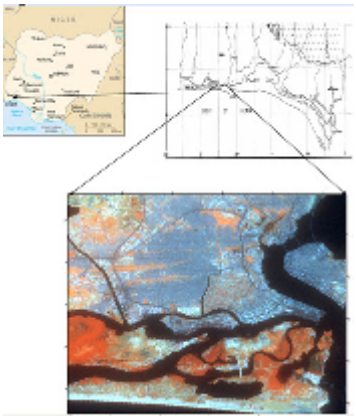
SPATIAL DATABASE

- A spatial database stores a large amount of space-related data.
  - Such as maps data, preprocessed remote sensing or medical imaging data, VLSI chip layout data.



SPATIAL DATABASE

- Example of Spatial database:
  - Cartographic databases (that store maps)
  - Meteorological databases (for weather information)



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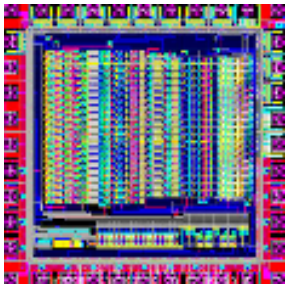
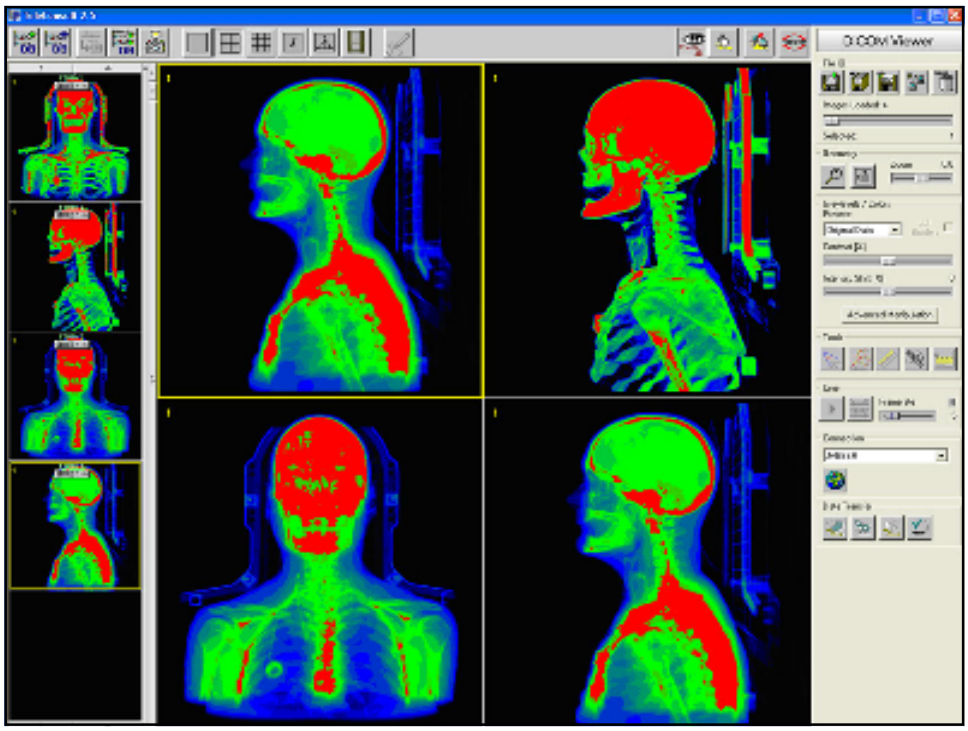
Spatial Database

- **A spatial database is a database that is optimized to store and query data that is related to objects in space, including points, lines and polygons**
- **A spatial database stores a large amount of space-related data.**
- **Such as maps data, preprocessed remote sensing or medical imaging data, VLSI chip layout data.**





Example of Spatial database:

- **Cartographic databases** (that store maps)
- A database containing x-y coordinates defining a geographical area. When combined with other data (such as any of a wide variety of variables, such as income distribution, age, etc.), a cartographic database can be used to map the distribution of that variable within a geographical region.

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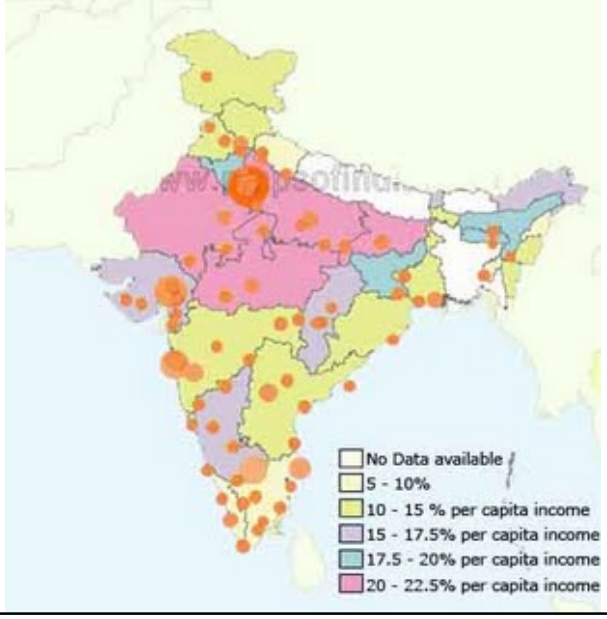
Per capita income means how much each individual receives, in monetary terms, of the yearly income



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Meteorological databases (for weather information)

MeteoDB

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Spatial Database

Special features of spatial databases:

- **That can interpret spatial characteristics.**
- **Special indexing & storage structures to improve performance.**
- **They carry topological & distance information.**
- **Require spatial reasoning, geometric computation, & spatial knowledge representation techniques.**

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SPATIAL DATABASE

A description of the spatial positions of many types of objects would be needed:

- Some of these objects have **static spatial** characteristics, such as streets, highways, police stations, water pumps, fire stations & hospitals.

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Spatial Database

Other objects have dynamic spatial characteristics that change over time, such as police vehicles, ambulances, or fire trucks.

Spatial database query

- Accessing spatial data can be more complicated than accessing non-spatial data. There are specialized operations and data structures used to access spatial data.
- Accessing non-spatial data uses the standard comparison operations: **< , > , ≤ , ≥ , ≠ , = .**
- Accessing Spatial data uses the spatial comparators:
  - near, north, south, east, west, contained in, overlap, intersect.

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Spatial database query

Types of Spatial queries:

- **Range query: (find the objects of a particular type that are within a given spatial area or within a particular distance from a given location.)**

  Example: Find all hospitals within the Bhopal city area.
- **Nearest neighbor query: (find an object of particular type that is closest to a given location)**

  Example: find the police car that is closest to a particular location(Bhopal Lake).
- **Spatial joins or overlays: (joins the objects of two types based on some spatial condition, such as the objects intersecting or overlapping spatially)**

  Example: find all homes that fall on a major highway, find all homes that are two miles of a lake.

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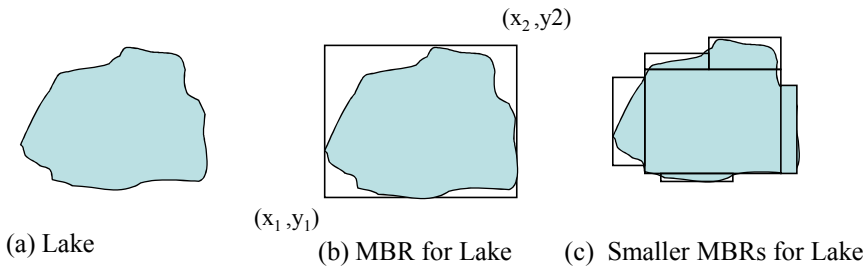
Spatial data structure

- **Many data structures that have been designed specifically to store or index spatial data.**
  - **Quad tree, R- tree, k-D tree**
- **MBR (Minimum Bounding Rectangle):**
  - **A common technique used to represent a spatial object is by the small rectangle that completely contains that object.**



(a) Lake (b) MBR for Lake (c) Smaller MBRs for Lake

MBR Example

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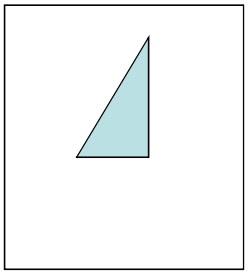
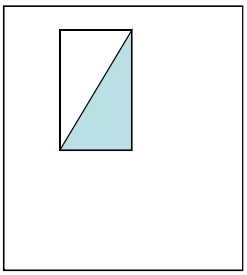
Spatial data structure

- **Quad tree:**
  - **A quad tree represents a spatial object by a hierarchical decomposition of the space into quadrants.**



(a) Triangle



(b) MBR for Triangle

Spatial object example

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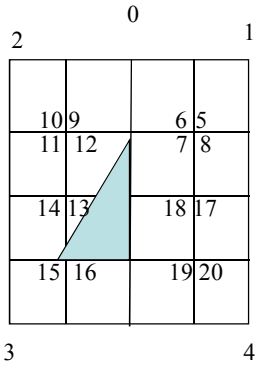
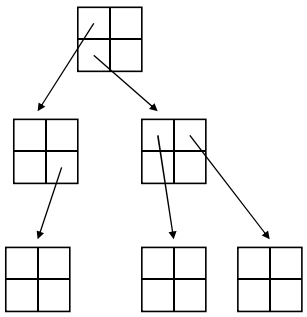
Quad tree

- **Quad-trees generally divide each space or subspace into equally sized areas , and proceed with the subdivisions of each subspace to identify the positions of various objects.**



(a) Representing triangle with quadrants



(b) Quad tree

Quad tree Example

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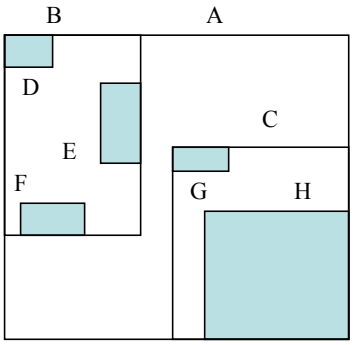
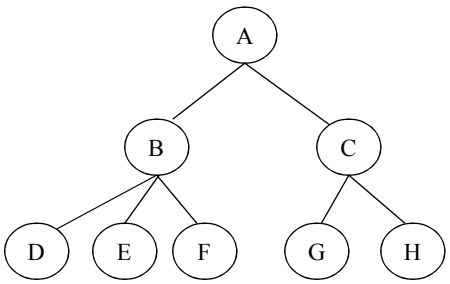
R-trees

- **R tree:**
  - **One approach to indexing spatial data represented as MBRs.**



(a) Partitioning with MBRs



(b) R-Tree

R-Tree Example

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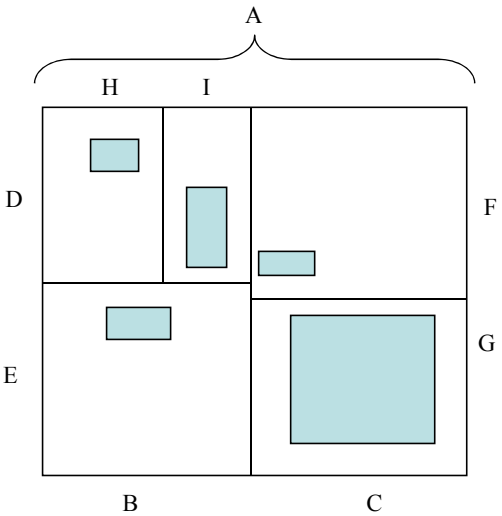
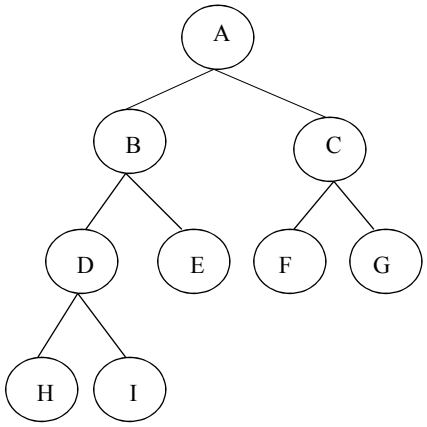
k-D tree

- **A k-D tree was designed to index multi-attribute data**



(a) Divide & Conquer partitioning



(b) k-D tree

K-D tree example

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R Tree & K-D Tree

•Nodes in *k*d-trees represent separating planes, whereas nodes in R-trees represent bounding boxes.
•*k*d-trees partition the whole of space into regions whereas R-trees only partition the subset of space containing the points of interest.
• *k*d-trees represent a disjoint partition (points belong to only one region) whereas the regions in an R-tree may overlap.

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Pattern

- What is a Pattern?
  - A frequent arrangement, configuration, composition, regularity
  - A rule, law, method, design, description
  - A major direction, trend, prediction
- What is not a pattern?
  - Random, haphazard, chance, accidental, unexpected
  - Without definite direction, trend, rule, method, design, aim, purpose
  - Accidental - without design,
  - Casual - absence of pre-arrangement, relatively unimportant
  - Fortuitous - What occurs without known cause

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Spatial Data Mining

Defining Spatial Data Mining

- Search for spatial patterns
- **Non-trivial search** - as "automated" as possible—reduce human effort
- **Interesting, useful** and **unexpected** spatial pattern

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Spatial Data mining

- **Spatial data mining refers to the extraction of knowledge, spatial relationships, or other interesting patterns not explicitly stored in spatial databases.**
- **Such mining demands an integration of data mining with spatial database technologies.**
- **Used for understanding spatial data, discovering spatial relationships and relationships between spatial & Non-spatial data, Constructing spatial knowledge bases and optimizing spatial queries.**

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What is NOT Spatial Data Mining?

- Simple Querying of Spatial Data
  - Find neighbors of India given names and boundaries of all countries
  - Find shortest path from Bhopal to Indore
  - Search space is not large (not exponential)
- Testing a hypothesis via a primary data analysis
  - Ex. Female chimpanzee territories are smaller than male territories
  - Search space is not large !
- Uninteresting or obvious patterns in spatial data
  - Heavy rainfall in Minneapolis is correlated with heavy rainfall in St. Paul, Given that the two cities are 10 miles apart.
  - Common knowledge: Nearby places have similar rainfall
- Mining of non-spatial data
  - Laptop sales and Digital Camera sales are correlated in evenings
  - GPS product buyers are of 3 kinds:
    - outdoors enthusiasts, farmers, technology enthusiasts

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Spatial Data Mining: Actors

- Domain Expert -
  - Identifies SDM goals, spatial dataset,
  - Describe domain knowledge, e.g. well-known patterns, e.g. correlates
  - Validation of new patterns
- Data Mining Analyst
  - Helps identify pattern families, SDM techniques to be used
  - Explain the SDM outputs to Domain Expert
- Joint effort
  - Feature selection
  - Selection of patterns for further exploration

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Spatial data-mining primitives

- Equals:
  - A equal B if all points in the two objects are in common.
- Covered by or inside or contained in:
  - A is contained in B if all points in A are in B. there may be points in B that are not in A..
- Covers or Contains:
  - A contains B if and only if B is contained in A.

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Spatial rules

- Spatial rules can be generated that describe the relationship between Spatial object and structure of spatial objects.
- Three types of rules:
  - Spatial characteristic rules describe the data.

    Example: In Bhopal the average family income is Rs. 50,000.
  - Spatial discriminant rules describe the differences between different classes of the data. They describe the features that differentiate the different classes.

    Example: In Bhopal the average family income is Rs. 50,000, while In Indore the average family income is Rs. 75,000.
  - Spatial association rules are implications of one set of data by another.

    Example: In Bhopal the average family income for families living near great lake is Rs. 90,000.

    is_a(X, “school”) ^ close_to(X, “sports_center”) ➔ close_to(X, “park”) [0.5% , 80%]

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Spatial Data mining

Spatial data mining used in following Applications:

- **Medical imaging, Cancer clusters to investigate environment health hazards**
- **Crime hotspots for planning police patrol routes**
- **Navigation, Traffic control, Environmental studies,**
- **Remote Sensing**

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Reference

Data Mining
Introduction and Advance Topics
Margaret H.Dunham

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