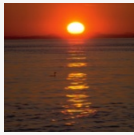
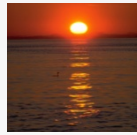
Spatial and Geographic Databases



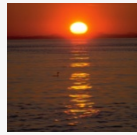
Spatial and Geographic Databases

- Spatial databases store information related to spatial locations, and support efficient storage, indexing and querying of spatial data.
- Special purpose index structures are important for accessing spatial data, and for processing spatial join queries.
- **Computer Aided Design (CAD)** databases store design information about how objects are constructed E.g.: designs of buildings, aircraft, layouts of integrated-circuits
- Geographic databases store geographic information (e.g., maps): often called geographic information systems or GIS.

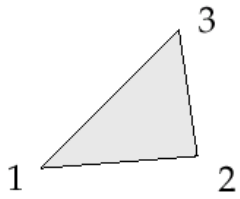
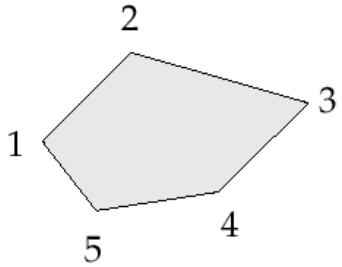
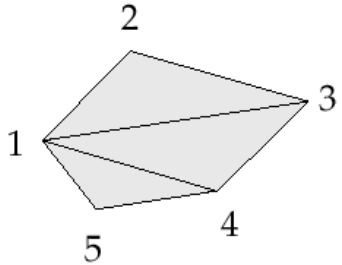


Represented of Geometric Information

- Various geometric constructs can be represented in a database in a normalized fashion.
- Represent a line segment by the coordinates of its endpoints.
- Approximate a curve by partitioning it into a sequence of segments
  - Create a list of vertices in order, or
  - Represent each segment as a separate tuple that also carries with it the identifier of the curve (2D features such as roads).
- Closed polygons
  - List of vertices in order, starting vertex is the same as the ending vertex, or
  - Represent boundary edges as separate tuples, with each containing identifier of the polygon, or
  - Use **triangulation** — divide polygon into triangles
    - Note the polygon identifier with each of its triangles.

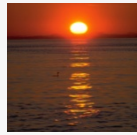


Representation of Geometric Constructs

object	representation
line segment 	{(x1,y1), (x2,y2)}
triangle 	{(x1,y1), (x2,y2), (x3,y3)}
polygon 	{(x1,y1), (x2,y2), (x3,y3), (x4,y4), (x5,y5)}
polygon 	{(x1,y1), (x2,y2), (x3,y3), ID1} {(x1,y1), (x3,y3), (x4,y4), ID1} {(x1,y1), (x4,y4), (x5,y5), ID1}

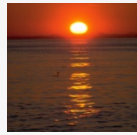
Representation of Geometric Information (Cont.)

- Representation of points and line segment in 3-D similar to 2-D, except that points have an extra z component
- Represent arbitrary polyhedra by dividing them into tetrahedrons, like triangulating polygons.
- Alternative: List their faces, each of which is a polygon, along with an indication of which side of the face is inside the polyhedron.

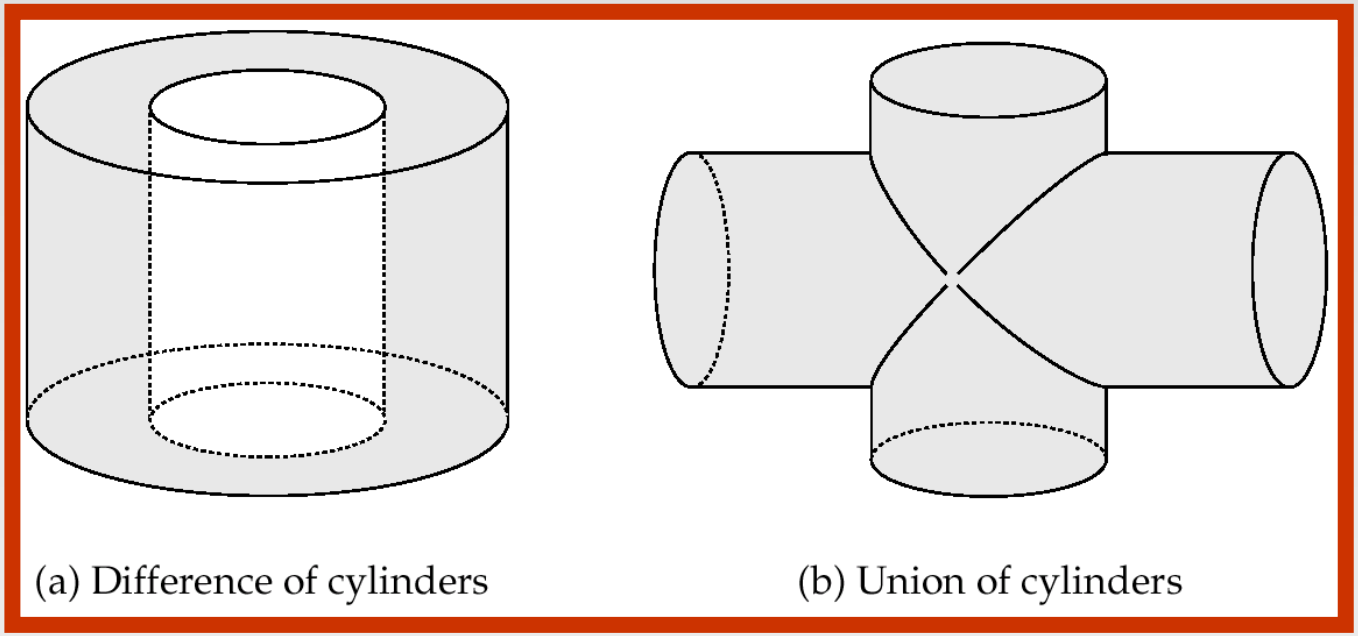


Design Databases

- Represent design components as objects (generally geometric objects); the connections between the objects indicate how the design is structured.
- Simple two-dimensional objects: points, lines, triangles, rectangles, polygons.
- Complex two-dimensional objects: formed from simple objects via union, intersection, and difference operations.
- Complex three-dimensional objects: formed from simpler objects such as spheres, cylinders, and cuboids, by union, intersection, and difference operations.
- Wireframe models represent three-dimensional surfaces as a set of simpler objects.



Representation of Geometric Constructs

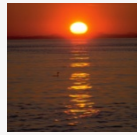


(a) Difference of cylinders (b) Union of cylinders

- Design databases also store non-spatial information about objects (e.g., construction material, color, etc.)
- Spatial integrity constraints are important.
  - E.g., pipes should not intersect, wires should not be too close to each other, etc.

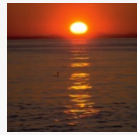
Geographic Data

- **Raster data** consist of bit maps or pixel maps, in two or more dimensions.
  - Example 2-D raster image: satellite image of cloud cover, where each pixel stores the cloud visibility in a particular area.
  - Additional dimensions might include the temperature at different altitudes at different regions, or measurements taken at different points in time.
- Design databases generally do not store raster data.



Geographic Data (Cont.)

- **Vector data** are constructed from basic geometric objects: points, line segments, triangles, and other polygons in two dimensions, and cylinders, speheres, cuboids, and other polyhedrons in three dimensions.
- Vector format often used to represent map data.
  - Roads can be considered as two-dimensional and represented by lines and curves.
  - Some features, such as rivers, may be represented either as complex curves or as complex polygons, depending on whether their width is relevant.
  - Features such as regions and lakes can be depicted as polygons.



Applications of Geographic Data

- Examples of geographic data
  - map data for vehicle navigation
  - distribution network information for power, telephones, water supply, and sewage
- Vehicle navigation systems store information about roads and services for the use of drivers:
  - **Spatial data**: e.g, road/restaurant/gas-station coordinates
  - **Non-spatial data**: e.g., one-way streets, speed limits, traffic congestion
- **Global Positioning System (GPS)** unit - utilizes information broadcast from GPS satellites to find the current location of user with an accuracy of tens of meters.
  - increasingly used in vehicle navigation systems as well as utility maintenance applications.