Prof:Siddhesh Zele's

WE IT TUTORIALS

GIS
UNIT
1,2,3,4,5,6

TYBSC(IT) SEM 6

COMPILED BY : SIDDHESH ZELE

302 PARANJPE UDYOG BHAVAN, NEAR KHANDELWAL SWEETS, NEAR THANE STATION , THANE (WEST)

PHONE NO: 8097071144 / 8097071155 / 8655081002

Syllabus

UNIT 1

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

Spatial Data Concepts

Q.1 What is GIS?

(A) A geographic Information system (GIS) is a computer system for capturing, storing, querying, analyzing, and displaying geospatial data. Also called geographically referenced data, geospatial data are data that describe both the locations and the characteristics of spatial features such as roads, land parcels, and vegetation stands on the Earth's surface. The ability of a GIS to handle and process geospatial data distinguishes GIS from other information systems. It also establishes GIS as a technology important to such occupations as market research analysts, environmental engineers, and urban and regional planners, which are also listed at the U.S. Department of Labor's website.

Q.2 Explain applications of GIS.

(A) From its beginnings, GIS has been important in natural resource management, including land-use planning, natural hazard assessment, wildlife habitat analysis, riparian zone monitoring, and timber management. Here are some examples on the Internet:

- The U.S. Geological Survey has the National Map program that provides nationwide geospatial data for applications in natural hazards, risk assessment, homeland security, and many other areas (http://nationalmap.usgs.gov).
- The U.S. Census Bureau maintains an On-Line Mapping Resources website, where Internet users can map public geographic data of anywhere in the United States (http://www.census.gov/geo/www/maps/).
- The U.S. Department of Housing and Urban Development has a mapping program that combines housing development information with environmental data (http://www.hud.gov/offices/cio/emaps/index.cfm).
- The U.S. Department of Health and Human Services warehouse provides access to information about health resources, including community health centers (http:// datawarehouse.hrsa.gov/).

  In more recent years GIS has been used for crime analysis, emergency planning, land records management, market analysis, and transportation applications. Here are some examples on the Internet:
- The Department of Homeland Security's National Incident Management System (NIMS) identifies GIS as a supporting technology for managing domestic incidents (http:/I www.dhs.gov/).
- The National Institute of Justice uses GIS to map crime records and to analyze their spatial patterns by location and time (http://www.ojp.usdoj.gov/nij/maps/).
- The Federal Emergency Management Agency links a flood insurance rate map database to physical features in a GIS database (http://www.fema.gov/plan/ prevent/fhm/mm_main.shtml).

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

- Larimer County, Colorado allows public access to the county's land records in a GIS database (http://www.larimer.org/).

Integration of GIS with the global positioning system (GPS), wireless technology, and the Internet has also introduced new and exciting applications (e.g.. Tsou 2004). Here are some examples:

- Location-based services (LBS) technology allows mobile phone users to be located and to receive location information, such as nearby ATMs and restaurants.
- Interactive-mapping websites let users select map layers for display and make their own maps.
- In-car navigation systems find the shortest route between an origin and destination and provide tum-by-tum directions to drivers.
- Mobile mapping allows field workers to collect and access geospatial data in the field.
- Precision farming promotes site-specific farming activities such as herbicide or fertilizer application.

Q.3 Explain components of GIS.

(A) Like any other information technology, GIS requires the following four components to work with geospatial data:

- **Computer System :** The computer system includes the computer and the operating system to run GIS. Typically the choices are PCs that use the Windows operating system (e.g., Windows 2000, Windows XP) or workstations that use the UNIX or Linux operating system. Additional equipment may include monitors for display, digitizers and scanners for spatial data input. GPS receivers and mobile devices for fieldwork, and printers and plotters for hard-copy data display.

- **GIS Software :** The GIS software includes the program and the user interface for driving the hardware. Common user interfaces in GIS are menus, graphical icons, command lines, and scripts.

- **People :** People refers to GIS professionals and users who define the purpose and objectives, and provide the reason and justification for using GIS.

- **Data :** Data consist of various kinds of inputs that the system takes to produce information.

- **Infrastructure (METHOD) :** The infrastructure refers to the necessary physical, organizational, administrative, and cultural environments that support GIS operations. The infrastructure includes requisite skills, data standards, data clearinghouses, and general organizational patterns.

Q.4 Explain the following terms - (a) Spatial Data, (b) Attribute Data

(A) (a) Spatial Data

Spatial data describe the locations of spatial features, which may be discrete or continuous. Discrete features are individually distinguishable features that do not exist between observations. Discrete features include points (e.g. wells), lines (e.g., roads), and areas (e.g., land use types). Continuous features are features that exist spatially between observations. Examples of continuous features are elevation and precipitation. A GIS represents these spatial features on the Earth's surface as map features on a plane surface. This transformation involves two main issues: the spatial reference system and the data model.

The locations of spatial features on the Earth's surface are based on a geographic coordinate system with longitude and latitude values, whereas the locations of map features are based on a plane coordinate system with x-y-coordinates. Projection is the process that can transform the Earth's spherical surface to a plane surface and bridge the two spatial reference systems. But because the transformation always involves some distortion, hundreds of plane coordinate systems that have been developed to preserve certain spatial properties are in use. To align with one another spatially for GIS operations, map layers must be based on the same coordinate system. A basic understanding of projection and coordinate systems is therefore crucial to users of spatial data.

(b) Attribute Data

Attribute data describe the characteristics of spatial features. For raster data, each cell has a value that corresponds to the attribute of the spatial feature at that location. A cell is tightly bound to its cell value. For vector data, the amount of attribute data to be associated with a spatial feature can vary significantly. A road segment may only have the attributes of length and speed limit, whereas a soil polygon may have dozens of properties, interpretations, and performance data. How to join spatial and attribute data is therefore important in the case of vector data.

Q.5 Explain GIS Operations.

(A) GIS OPERATIONS:

Although GIS activities no longer follow a set sequence, to explain what we do in GIS. we can group GIS activities into spatial data input, attribute data management, data display, data exploration, data analysis, and GIS modeling (Following Table 1). This section provides an overview of GIS operations.

Spatial Data Input

The most expensive part of a GIS project is data acquisition. We can acquire data by using existing data or by creating new data. Digital data clearinghouses have become commonplace on the Internet in recent years. It is therefore wise to look at what exists in the public domain before deciding to either buy data from private companies or create new data.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

Table 1 : A classification of GIS operations.

Spatial data Input	1. Data entry: use existing data, create new data 2. Data editing 3. Geometric transformation 4. Projection and reprojection
Attribute data management	1. Data entry and verification 2. Database management 3. Attribute data manipulation
Data display	1. Cartographic symbolization 2. Map design
Data exploration	1. Attribute data query 2. Spatial data query 3. Geographic visualization
Data analysis	1. Vector data analysis: buttering, overlay, distance measurement, spatial statistics, map manipulation 2. Raster data analysis: local, neighborhood, zonal, global, raster data manipulation 3. Terrain mapping and analysis 4. View shed and watershed 5. Spatial interpolation 6. Geocoding and dynamic segmentation 7. Path analysis and network applications
GIS modeling	1. Binary models 2. Index models 3. Regression models 4. Process models

Attribute Data Management

To complete a GIS database, we must enter and verify attribute data through digitizing and editing. Attribute data reside as tables in a relational database. An attribute table is organized by row and column. Each row represents a spatial feature, and each column or field describes a characteristic. Attribute tables in a database must be designed to facilitate data input, search, retrieval, manipulation, and output. Two basic elements in the design of a relational database are the key and the type of data relationship: the key establishes a connection between corresponding records in two tables, and the type of data relationship dictates how the tables are actually joined or linked. In practice, attribute data management also includes such tasks as adding or deleting fields and creating new fields from existing fields.

Data Display

Because maps are most effective in communicating spatial information, mapmaking is a routine GIS operation. A map is derived from data query and analysis, and prepared maps for data visualization and presentation. A map for presentation usually has a number of elements: title, subtitle, body, legend, north arrow, scale bar. acknowledgment, neat line and border. These elements work together to bring spatial information to the map reader. The first step in map making is to assemble map elements. Windows based GIS packages have simplified this process by providing choice for map element.

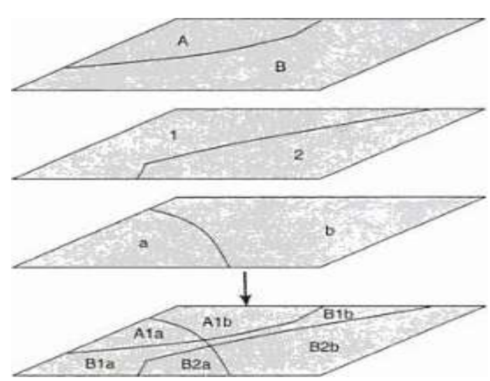
Data Exploration

Usually a precursor to data analysis, **data exploration** involves the activities of exploring the general trends in the data, taking a close look at data subsets, and focusing on possible relation-ships between data sets. Effective data exploration requires interactive and dynamically linked visual tools. A Windows-based GIS package is ideal for data exploration. We can display maps, graphs, and tables in multiple but dynamically linked windows so that, when we select a data subset from a table, it automatically highlights the corresponding features in a graph and a map. This kind of interactivity increases capacity for information processing and synthesis. Because geospatial data consist of spatial and attribute data, data exploration can be approached from spatial data, or attribute data, or both. Additionally, data exploration in GIS can employ map based tools such as data classification, data aggregation, and map comparison.

Data Analysis

Table 1 classifies data analysis into seven groups. The first two groups include basic analytical tools. For vector data, these tools include buffering, overlay, distance measurement, spatial statistics, and map manipulation. Buffering creates buffer zones by measuring straight-line distances from selected features. Overlay, recognized by many as the most important GIS tool, combines geometries and attributes from different layers to create the output (Figure 1). Distance measurement calculates distances between spatial features. Spatial statistics detect spatial dependence and patterns of concentration among features. And map manipulation tools manage and alter layers in a database. Common to GIS for analyzing raster data on grouped into local neighborhood zonal and global operation.

Fig. 1



ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

GIS Models and Modeling

A model is a simplified representation of a phenomenon or a system, and **GIS modeling** refers to the use of a GIS and its functionalities in building a model with geospatial data (i.e.. a spatially explicit model). GIS models can be grouped into four general types: binary, index, regression, and process models.

Q.6 Explain Geographic Coordinate System

(A) Geographic Coordinate System

The geographic coordinate system is the location reference system for spatial features on the Earth's surface (Figure 2). The geographic coordinate system is defined by longitude and latitude.

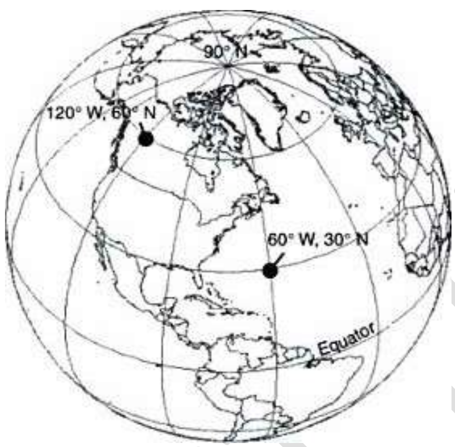


Fig. 2 : The geographic coordinate system.

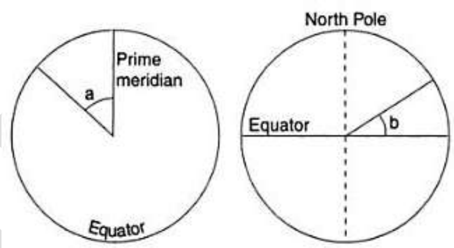


Fig. 3 : A longitude reading is represented by *a* on the left, and a latitude reading is represented by *b* on the right. Both longitude and latitude

Both longitude and latitude are 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 (Figure 3).

Q.7 Explain the term 'Datum'.

(A) Datum

A datum is a mathematical model of the Earth, which serves as the reference or base for calculating the geographic coordinates of a location (Burkard 1984; Moffitt and Bossler 1998). The definition of a datum consists of an origin, the parameters of the spheroid selected for the computations, and the separation of the spheroid and the Earth at the origin. Many countries have developed their own datums for local surveys. Among these local datums are the European

Datum, the Australian Geodetic Datum, the Tokyo Datum, and the Indian Datum (for India and several adjacent countries).

Until the late 1980s. Clarke 1866, a ground-measured spheroid, was the standard spheroid for mapping in the United States. Clarke 1866's semi-major axis (equatorial radius) and semi-minor axis (polar radius) measure 6.378.206.4 meters (3962.96 miles) and 6,356,583.8 meters (3949.21 miles), respectively, with the flattening of 1/294.979. NAD27 (North American Datum of 1927) is a local datum based on the Clarke 1866 spheroid, with its origin at Meades Ranch in Kansas.

In 1986 the National Geodetic Survey (NGS) introduced NAD83 (North American Datum of 1983), an Earth-centered (also called geocentered) datum based on the GRS80 (Geodetic Reference System 1980) spheroid. GRS80's semi-major axis and semi-minor axis measure 6,378,137.0 meters (3962.94 miles) and 6,356,752.3 meters (3949.65 miles), respectively, with the flattening of 1/298.257. In the case of

Q.8 What are map projections? What are their types?

(A) The process of projection transforms the spherical Earth's surface to a plane (Robinson et al. 1995; Dent 1999; Slocum et al. 2005). The outcome of this transformation process is a map projection: a systematic arrangement of parallels and meridians on a plane surface representing the geographic coordinate system.

Types of Map Projections

Map projections can he 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 or equivalent, equidistant, and azimuthal or true direction. A conformal projection preserves local angles and shapes. An equivalent projection represents areas in correct relative size. An equidistant projection maintains consistency of scale along certain lines. And an azimuthal projection retains certain accurate directions. The preserved property of a map projection is often included in its name such as the Lambert conformal conic projection or the Albers equal-area conic projection.

The conformal and equivalent properties are mutually exclusive. Otherwise a map projection can have more than one preserved property, such as conformal and azimuthal. The conformal and equivalent properties are global properties, meaning that they apply to the entire map projection. The equidistant and azimuthal properties are local properties and may be true only from or to the center of the map projection.

The preserved property is important for selecting an appropriate map projection for thematic mapping. For example, a population map of the world should be based on an equivalent projection. By representing areas in correct size, the population map can create a correct impression of population densities. In contrast, an equidistant projection would be better for mapping the distance ranges from a missile site.

Cartographers often use a geometric object and a globe (i.e., a sphere) to illustrate how to construct a map projection. For example, by placing a cylinder tangent to a lighted globe, one can draw a projection by tracing the lines of longitude and latitude onto the cylinder. The cylinder in this example is the projection surface, also called the developable surface, and the globe is called the reference globe. Other common projection surfaces include a cone and a plane. Therefore, map projections can be grouped by their projection surfaces into cylindrical, conic, and azimuthal. A map projection is called a cylindrical projection if it can be constructed using a cylinder, a conic projection if using a cone, and an azimuthal projection if using a plane.

The use of a geometric object helps explain two other projection concepts: case and aspect. For a conic projection, the cone can be placed so that it is tangent to the globe or intersects the globe (Figure 4). The first is the simple case, which results in one line of tangency, and the second is the secant case, which results in two lines of tangency. A cylindrical projection behaves the same way as a conic projection in terms of case. An azimuthal projection, on the other hand, has a point of tangency in the simple case and a line of tangency in the secant case. Aspect describes the placement of a geometric object relative to a globe. A plane, for example, may be tangent at any point on a globe. A polar aspect refers to tangency at the pole, an equatorial aspect at the equator, and an oblique aspect anywhere between the equator and the pole (Figure 5).

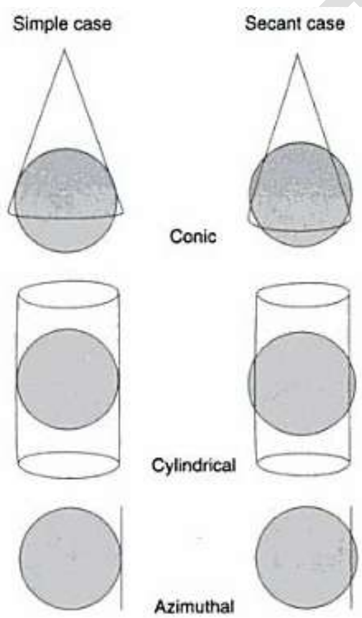


Fig. 4 : Case and projection.

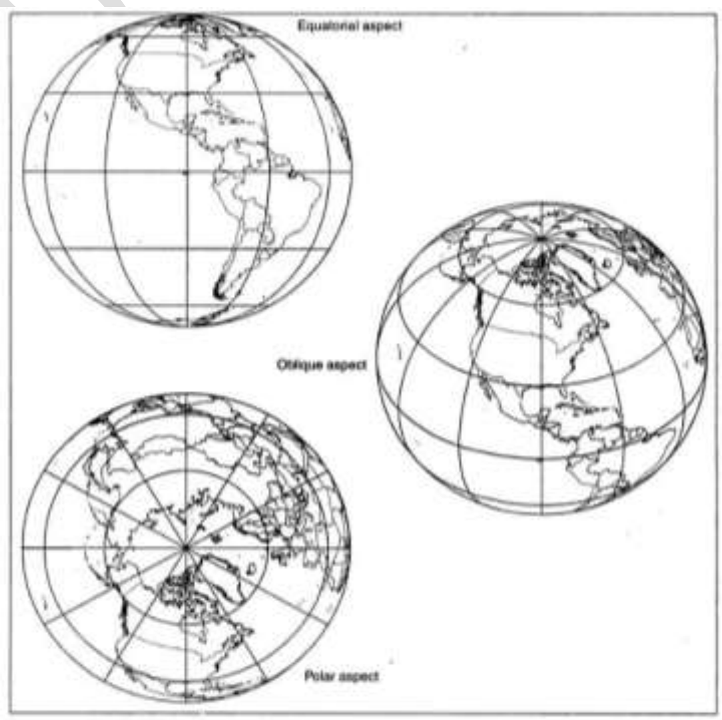


Fig. 5 : Aspect and

Q.9 Explain Projected Coordinate System

(A) A projected coordinate system, also called a plane coordinate system, is built on a map projection. Projected coordinate systems and map projections are often used interchangeably. For example, the Lambert conformal conic is a map projection but it can also refer to a coordinate system. In practice, however, projected coordinate systems are designed for detailed calculations and positioning, and are typically used in large-scale mapping such as at a scale of 1:24,000 or larger . Accuracy in a feature's location and its position relative to other features is therefore a key consideration in the design of a projected coordinate system.

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. Moreover, a projected coordinate system is defined not only by the parameters of the map projection it is based on but also the parameters (e.g., datum) of the geographic coordinate system that the map projection is derived from. All mapping systems are based on a spheroid rather than a sphere. The difference between a spheroid and a sphere may not be a concern for general mapping at small map scales but can be a matter of importance in the detailed mapping of land parcels, soil polygons, or vegetation stands.

Three coordinate systems are commonly used in the United States: the Universal Transverse Mercator (UTM) grid system, the Universal Polar Stereographic (UPS) grid system, and the State Plane Coordinate (SPC) system. As a group, coordinates of these common systems are sometimes called real-world coordinates. This section also includes the Public Land Survey System (PLSS). Although the PLSS is a land partitioning system and not a coordinate system, it is the basis for land parcel mapping. Additional readings on these systems can be found in Robinson et al. (1995). Muehrcke et al. (2001). and Slocum et al. (2005).

Q.10 Explain the state plane coordinate system.

(A) The SPC system was developed in the 1930s to permanently record original land survey monument locations in the United States. To maintain the required accuracy of one part in 10,000 or less, a state may have two or more SPC zones. As examples. Oregon has the North and South SPC zones and Idaho has the West, Central and East SPC zones (Figure 6). Each SPC zone is mapped onto a map projection. Zones that are elongated in the north-south direction (e.g., Idaho's SPC zones) use the transverse Mercator and zones that are elongated in the east-west direction (e.g., Oregon's SPC zones) use the Lambert conformal conic. (The only exception is zone 1 of Alaska, which uses the oblique Mercator to cover the panhandle of Alaska,) Point locations within each SPC zone are measured from a false origin located to the southwest of the zone.

Because of the switch from NAD27 to NAD83, there are SPC27 and SPC83. Besides the change of the datum, SPC83 has a few other changes. SPC83 coordinates are published in meters instead of feet. The states of Montana, Nebraska, and South Carolina have each replaced multiple zones with a single SPC zone. California has reduced SPC zones from seven to six. And Michigan has changed from transverse Mercator to Lambert conformal conic projections.

Some states in the United States have developed their own statewide coordinate system. Montana, Nebraska, and South Carolina all have a single SPG zone, which can serve as the statewide coordinate system. Idaho is another example. Idaho is divided into two UTM zones (11 and 12) and three SPC zones (West, Central, and East). These zones work well as long as the study area is within a single zone. When a study area covers two or more zones, the data sets must be converted to a single zone for spatial registration. But the conversion to a single zone also means that the data sets can no longer maintain the accuracy level designed for the UTM or the SPC coordinate system. The Idaho statewide coordinate system, adopted in 1994 and modified in 2003, is still based on a transverse Mercator projection but its central meridian passes through the center of the stale (114° W). (A complete list of parameters of the Idaho statewide coordinate system is included in Task 1 of the applications section.) Changing the location of the central meridian means one zone for the entire state.

Fig. 6 : SPC83 zones in the conterminous United States. The thinner lines are county boundaries, and the bold lines are state boundaries. This map corresponds to the SPC83 table on the inside of this book's

Q.11 Describe the Public Land Survey System

(A) The PLSS is a land partitioning system (Figure 7). Using the intersecting township and range lines, the system divides the lands mainly in the central and western states into 6X6 mile squares or townships. Each township is further partitioned into 36 square-mile parcels of 640 acres, called sections. (In reality, many sections are not exactly 1 mile by 1 mile in size.)

Land parcel layers are typically based on the PLSS. The Bureau of Land Management (BLM) is developing a Geographic Coordinate Data Base (GCDB) of the PLSS for the western United

States (http://www.blm.gov/gcdb/). Generated from BLM survey records, the GCDB contains coordinates and other descriptive information for section comers and monuments recorded in the PLSS. Legal descriptions of a parcel layer can then be entered using, for example, bearing and distance readings originating from section corners.

Q.12 Explain what is meant by 'Vector Data Model'.

(A) Vector Data Model

The vector data model uses the geometric objects of point, line, and area to represent simple spatial features (Figure 8). Dimensionality and property distinguish the three types of geometric objects as well as the features they represent.

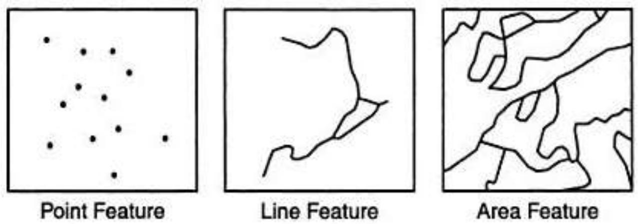


Fig. 8 : Point, line, and area features.

A point has 0 dimension and has only the property of location. A point may also be called a node, vertex, or 0-cell. A point feature is made of a point or a set of separate points. Wells, benchmarks, and gravel pits are examples of point features.

A line is one-dimensional and has the property of length. A line has two end points and points in between to mark the shape of the line. The shape of a line may be a smooth curve or a connection of straight-line segments. Smooth curves are typically fitted by mathematical equations such as splines. Straight-line segments may represent human-made features such as canals and streets, or they may simply be approximations of curves. A line is also called an edge, link, chain, or 1-cell. A line feature is made of lines. Roads, streams, and contour lines are examples of line features.

An area is two-dimensional and has the properties of area (size) and perimeter. Made of connected lines, an area may be alone or share boundaries with other areas. An area may contain holes, such as a national forest containing private land parcels (holes). The existence of holes means that the area has both external and internal boundaries. An area is also called a polygon, face, zone, or 2-cell. An area feature is made of polygons. Examples of area features include timber stands, land parcels, and water bodies.

The representation of simple features using points, lines, and areas is not always straightforward because it can depend on map scale. For example, a city on a 1:1,000,000 scale map may appear as a point, but the same city may appear as an area on a 1:24,000 scale map. Occasionally, the representation of vector data can also depend on the criteria established by government mapping agencies (Robinson et al. 1995). A stream may appear as a single line near its headwaters but as an area along its lower reaches. In this case, the width of the stream determines how it should be represented on a map. The U.S. Geological Survey (USGS) uses single lines to represent streams less than 40 feet wide on 1:24,000 scale topographic maps and double lines for larger streams. Therefore, a stream may appear as a line or an area depending on its width and the criterion used by the government agency.

Q.13 Explain 'TIGER' database.

(A) An early application of topology in preparing geospatial data is the TIGER (Topologically Integrated Geographic Encoding and Referencing) database from the U.S. Census Bureau (Broome and Meixler 1990). The TIGER database contains legal and statistical area boundaries such as counties, census tracts, and block groups, which can be linked to the census data, as well as roads, railroads, streams, water bodies, power lines, and pipelines. The database also includes the address range on each side of a street segment.

In the TIGER database, points are called 0-cells, lines I-cells, and areas 2-cells (Figure 9). Each 1-cell in a TIGER file is a directed line, meaning that the line is directed from a starting point toward an end point with an explicit left and right side. Each 2-cell and 0-cell has knowledge of the 1-cells associated with it. In other words, the TIGER database includes the spatial relationships between points, lines, and areas. Using the built-in spatial relationships, we can associate a block group with the streets or roads that make up its boundary. Likewise, we can identify an address on either the right side or the left side of a street (Figure 10).

The TIGER database, with its Census 2000 version, is available for download at the Census Bureau's website (http://www.census.gov/). Topology used in the TIGER database is also included in the USGS digital line graph (DLG) products. DLGs are digital representations of point, line, and area features from the USGS quadrangle maps, including roads, streams, boundaries, and contours.

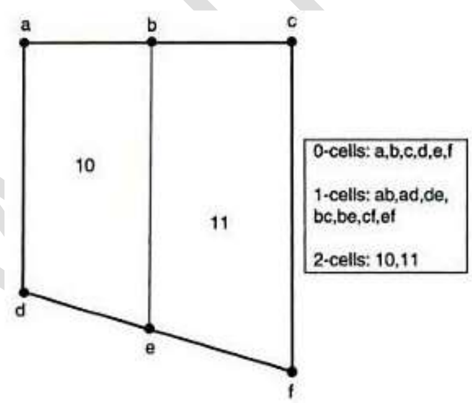


Fig. 9 : Topology in the TIGER database involves 0-cells or points.

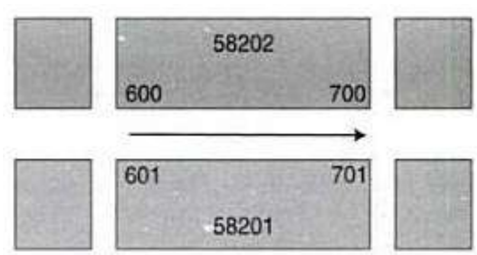


Fig. 10 : Address ranges and ZIP codes in the TIGER database have the right- or left-side designation based on the

(A) Besides work by federal agencies, commercial GIS vendors such as ESRI, Inc. have also used topology to develop proprietary vector data formats. ESRI, Inc. introduced the coverage model in the 1980s to separate GIS from CAD (computer-aided design) at the time. AutoCAD by Autodesk was, and still is, the leading CAD package. A data format used by AutoCAD for the transfer of data files is called DXF (drawing exchange formal). DXF maintains data in separate layers and allows the user to draw each layer using different line symbols, colors, and text. But DXF files do not support topology.

Coverage is a topology-based vector data format. A coverage can be a point coverage, line coverage, or polygon coverage. The coverage model supports three basic topological relationships (Environmental Systems Research Institute, Inc. 1998):

Connectivity: Arcs connect to each other at nodes.

- Area definition: An area is defined by a series of connected arcs.
- Contiguity: Arcs have directions and left and right polygons.

Other than the use of terms, these three topological relationships are similar to the topological relationships in the TIGER database.
For example, a road network for traffic volume analysis is typically a topology-based line coverage. The connectivity relationship ensures that roads (arcs) meet perfectly at road junctions (nodes). And the contiguity relationship makes it possible to distinguish northbound from southbound roads and to associate traffic analysis zones on each side of the road.

Q.15 Explain 'Raster Data Model'.

(A) A raster data model is variously called a grid, a raster map a surface cover, or an image in GIS. A raster represents a continuous surface, but for data storage and analysis, a raster is divided into rows, columns, and cells. Cells are also called pixels with images. The origin of rows and columns is typically at the upper-left corner of the raster. Rows function as y-coordinates and columns as x-coordinates. Each cell in the raster is explicitly defined by its row and column position.

Raster data represent points with single cells, lines with sequences of neighboring cells, and areas with collections of contiguous cells (Figure 11). Although the raster data model lacks the vector model's precision in representing the location of spatial features, it has the distinct advantage of having fixed cell locations (Tomlin 1990). In computing algorithms, a raster can be treated as a matrix with rows and columns, and its cell values can be stored in a two-dimensional array. All commonly used programming languages can easily handle arrayed variables. Raster data are therefore much easier to manipulate, aggregate, and analyze than vector data.

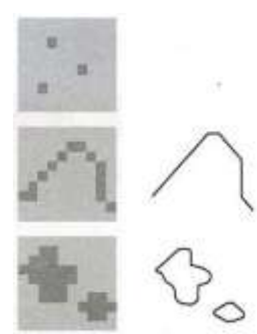


Fig. 11 : Representation of point, line, and area features: roster formal on the left and vector format on the right.

Q.16 Explain the terms : (a) Cell Value (b) Cell Size (c) Raster Bands (d) Spatial Reference

(A) (a) Cell Value

Each cell in a raster carries a value, which represents the characteristic of a spatial phenomenon at the location denoted by its row and column. Depending on the coding of its cell values, a raster can be either an integer or a floating-point raster. An integer value has no decimal digits, whereas a floating-point value does. Integer cell values usually represent categorical data, which may or may not be ordered. A land cover raster may use 1 for urban land use, 2 for forested land, 3 for water body, and so on. A wildlife habitat raster, on the other hand, may use the same integer numbers to represent ordered categorical data of optimal, marginal, and unsuitable habitats. Floating-point cell values represent continuous, numeric data. For example, a precipitation raster may have precipitation values of 20.15, 12.23, and so forth.

A floating-point raster requires more computer memory than an integer raster. This difference can become an important factor for a GIS project that covers a large area. There are a couple of other differences. We can access the cell values of an integer raster through a value attribute table. But a floating-point raster usually does not have a value attribute table because of its potentially large number of records. We can use individual cell values to query and display an integer raster. But die same operation on a floating-point raster should be based on value ranges, such as 12.0 to 19.9, because the chance of finding a specific value is small.

Where does the cell value apply within the cell? The answer depends on raster data operation. Typically the cell value applies to the center of the cell in operations that involve distance measurements. Examples include resampling pixel values and calculating physical distances. Many other raster data operations are cell-based, instead of point-based, and assume that die cell value applies to the entire cell.

(b) Cell Size

The cell size determines the resolution of the raster data model. A cell size of 10 meters means that each cell measures 100 square meters (10 x 10 meters). A cell size of 30 meters, on the other hand, means that each cell measures 900 square meters (30 x 30 meters). Therefore a 10-meter raster has a finer (higher) resolution than a 30-mctcr raster.

A large cell size cannot represent the precise location of spatial features, thus increasing the chance of having mixed features such as forest, pasture, and water in a cell (Box 5.1). These problems lessen when a raster uses a smaller cell size. But a small cell size increases the data volume and the data processing lime.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

(c) Raster Bands

A raster may have a single band or multiple bands. Each cell in a multiband raster is associated with more than one cell value. An example of a multi-band raster is a satellite image, which may have five, seven, or more bands at each cell location. Each cell in a single-band raster has only one cell value. An example of a single-band raster is an elevation raster, which has one elevation value at each cell location.

(d) Spatial Reference

Raster data must have the spatial reference information so that they can align spatially with other data sets in a GIS. For example, to superimpose an elevation raster on a vector-based soil layer, we must first make sure that both data sets are based on the same coordinate system. A raster that has been processed to match a projected coordinate system is often called a georeferenced raster.

Two adjustments are necessary in associating a projected coordinate system with a raster. First, the origin of a projected coordinate system is at the lower-left comer whereas the origin of a raster is typically at the upper-left corner. Second, projected coordinates must correspond to the rows and columns of the raster. The following example illustrates what these two adjustments mean.

Suppose an elevation raster has the following information on the number of rows, number of columns, cell size, and area extent expressed in UTM (Universal Transverse Mercator) coordinates:

- Rows: 463. columns: 318, cell size: 30 meters
- x-, y-coordinates at the lower-left comer 499995.5177175
- x-, y-coordinates at the upper-right comer: 509535.5191065

We can verify that the numbers of rows and columns are correct by using the bounding UTM coordinates and the cell size:

- Number of rows = (5191065 – 5177175) / 30 = 463
- Number of columns = (509535 – 499995) / 30 = 318

We can also derive the UTM coordinates that define each cell. For example, the cell of row 1, column 1 has the following UTM coordinates (Figure 12)

- 499995.5191035 or (5191065 – 30) at the lower left corner
- 500025 or (499995 + 30), 5191065 at the upper-right corner
- 500010 or (499995 + 15), 5191050 or (5191065 - 15) at the cell center

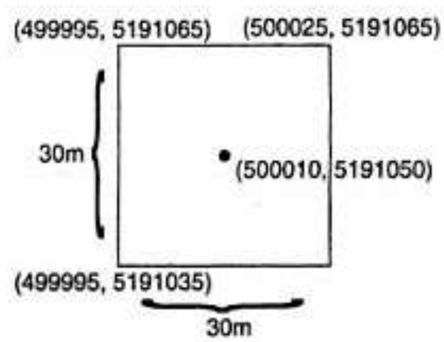


Fig. 12 : UTM coordinates for the extent and the center of a 30-meter cell.

Q.17 Describe types of Raster Data

(A) A large variety of data that we use in GIS are encoded in raster format. These data all share the same basic elements of the raster data model.

Satellite Imagery

Remotely sensed satellite data are familiar to GIS users. The spatial resolution of a satellite image relates to the ground pixel size. For example, a spatial resolution of 30 meters means that each pixel in the satellite image corresponds to a ground pixel of 900 square meters. The pixel value, also called the brightness value, represents light energy reflected or emitted from the Earth's surface (Jensen 1996: Lillesand et al. 2004). The measurement of light energy is based on spectral bands from a coninuum of wavelengths known as the electromagnetic spectrum. Panchromatic images are comprised of a single spectral band, whereas multispectral Images are comprised of multiple bands.

USGS Digital Elevation Models (DEMs)

A digital elevation model (DEM) consists of an array of uniformly spaced elevation data. A DEM is point-based, but it can easily be converted to raster data by placing each elevation point at the center of a cell. Most GIS users in the United States use DEMs from the USGS. USGS DEMs include the 7.5-minute DEM, 30-minute DEM, 1-degree DEM, and Alaska DEM.

Non-USGS DEMs

A basic method for producing DEMs is to use a stereoplotter and aerial photographs with overlapped areas. The stereoplotter creates a 3-D model, which allows the operator to compile elevation data. Although this method can produce highly accurate DEM data at a finer resolution than USGS DEMs, it is expensive for coverage of large areas.

Global DEMs

DEMs at different resolutions are now available on the global scale. SRTM DEMs are available for land areas outside the United States but at a coarser spatial resolution of 3 are-seconds (about 90 meters at the equator) (http://edcsns17.cr.usgs.gov/srtmdted2). These global-scale DEMs are called SRTM DTED (digital terrain elevation data) Level 1 as opposed to DTED Level 2 for the United States and territorial islands. Because SRTM DTED Level 1 elevation values are derived from SRTM DTED Level 2 values, they have the same vertical accuracy of better than 16 meters at coincident points.

Digital Orthophotos

A digital orthophoto quad (DOQ) is a digitized image prepared from on aerial photograph or other remotely sensed data, in which the displacement caused by camera tilt and terrain relief has been removed. The USGS began producing DOQs in 1991 from 1:40,000 scale aerial photographs of the National Aerial Photography Program. These USGS DOQs are georeferenced (NAD83 UTM coordinates) and can be registered with topographic and other maps.

Bi-Level Scanned Files

A bi-level scanned file is a scanned image containing values of 1 or 0 (Figure 13). In GIS, bi-level scanned files are usually made for the purpose of digitizing. They are scanned from paper or Mylar maps that contain boundaries of soils, parcels, and other features. A GIS package has tools for converting bi-level scanned files into vector-based features. Maps to be digitized are typically scanned al 300 or 400 dots per inch (dpi).

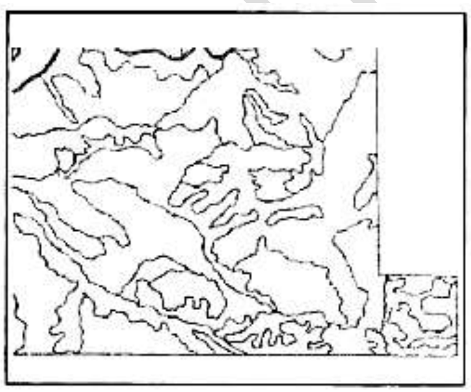


Fig. 13 : A bi–level scanned file

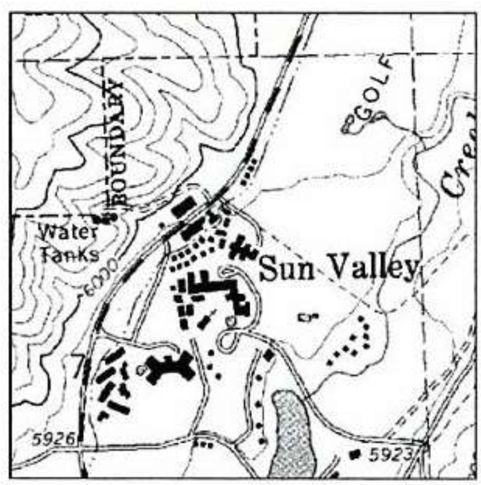


Fig. 14 : USGS DRG for Sun Valley. Idaho. This DRG is outdated compared to the DOQ.

Digital Raster Graphics (DRGs)

A digital raster graphic (DRG) is a scanned image of a USGS topographic map (Figure 14). The USGS scans the 7.5-minute topographic map at 250 dpi, thus producing a DRG with a ground resolution of 2.4 meters. The USGS uses up to 13 colors on each 7.5-minute DRG. Because these 13 colors are based on an 8-bit (256) color palette, they may not look exactly the same as on the paper maps. USGS DRGs are georeferenced to the UTM coordinate system, most likely based on NAD27.

Graphic Files

Maps, photographs, and images can be stored as digital graphic files. Many popular graphic files are in raster format, such as TIFF (tagged image file format), GIF (graphics interchange format), and JPEG (Joint Photographic Experts Group). The USGS distributes DOQs in TIFF or GeoTIFF. GeoTIFF is a georeferenced version of TIFF. By having the spatial reference information of the image, DOQs can be readily used with other GIS data.

GIS Software-Specific Raster Data

GIS packages use raster data that are imported from DEMs, satellite images, scanned images, graphic files, and ASCII files or are converted from vector data. These raster data are named differently. For example, ESRI, Inc. calls raster data grids.

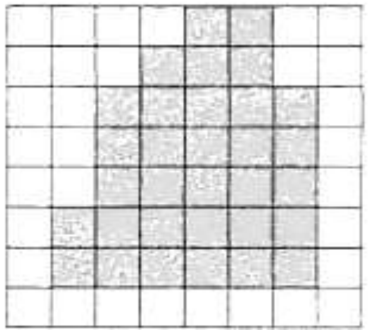
Q.18 Explain the terms (a) Cell by Cell Encoding (b) Run-length Encoding (c) Quad tree

(A) (a) Cell by Cell Encoding

The cell-by-cell encoding method provides the simplest raster data structure. A raster is stored as a matrix, and its cell values are written into a file by row and column (Figure 15). Functioning at the cell level, this method is an ideal choice if the cell values of a raster change continuously.

DEMs use the cell-by-cell data structure because the neighboring elevation values are rarely the same. Satellite images also use the cell-by-cell encoding method for data storage. With multiple spectral bands, however, each pixel in a satellite image has more than one value. Multiband imagery is typically stored in the following three formats. The band sequential (.bsq) method stores the values of an image band as one file. Therefore, if an image has seven bands, the data set has seven consecutive files, one file per band. The band interleaved by line (.bil) method stores, row by row, the values of all the bands in one file. Therefore the file consists of row 1, band 1; row 1, band 2 ... row 2. band 1; row 2, band 2 ... and so on. The band interleaved by pixel (.bip) method stores the values of all the bands by pixel in one file. The file is therefore comprised of pixel (1,1), band 1; pixel (1,1), band 2 ... pixel (2, 1), band 1; pixel (2, 1), band 2 ... and so on.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55



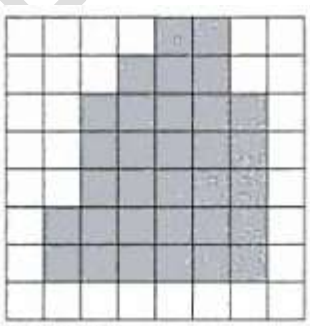
Row 1: 0 0 0 0 1 1 0 0
Row 2: 0 0 0 1 1 1 0 0
Row 3: 0 0 1 1 1 1 1 0
Row 4: 0 0 1 1 1 1 1 0
Row 5: 0 0 1 1 1 1 1 0
Row 6: 0 1 1 1 1 1 1 0
Row 7: 0 1 1 1 1 1 1 0
Row 8: 0 0 0 0 0 0 0 0

Fig. 15 : The cell–by–cell data structure records each cell value by row and column. The gray cells have the cell value of 1.

(b) Run-length Encoding

The cell-by-cell encoding method becomes inefficient if a raster contains many redundant cell values. For example, a bi-level scanned file from a soil map has many 0s representing non-inked areas and only occasional 1s representing the inked soil lines. Raster models with many repetitive cell values can be more efficiently stored using the run-length encoding (RLE) method, which records the cell values by row and by group. A group refers to adjacent cells with the same cell value. Figure 16 shows the run-length encoding of the polygon in gray. For each row, the starting cell and the end cell denote the length of the group ("run") that falls within the polygon.

A bi-level scanned file of a 7.5-minute soil quadrangle map, scanned at 300 dpi, can be over 8 megabytes (MB) if it is stored on a cell-by-cell basis. But using the RLE method, the file is reduced to about 0.8 MB at a 10:1 compression ratio. RLE is therefore a method for encoding as well as compressing raster data. Many GIS packages use RLE in addition to the cell-by-cell encoding method for storing raster data. They include GRASS, IDRISI, and ArcGIS.



Row 1: 5 6
Row 2: 4 6
Row 3: 3 7
Row 4: 3 7
Row 5: 3 7
Row 6: 2 7
Row 7: 2 7

Fig. 16 : The run-length encoding method records the gray cells by row. Row 1 has two adjacent gray cells in columns 5 and 6. Row 1 is therefore encoded with one run, beginning in column 5 and ending in

c) Quad tree

Instead of working along one row at a time, quad tree uses recursive decomposition to divide a raster into a hierarchy of quadrants (Samet 1990). Recursive decomposition refers to a process of continuous subdivision until every quadrant in a quad tree contains only one cell value.

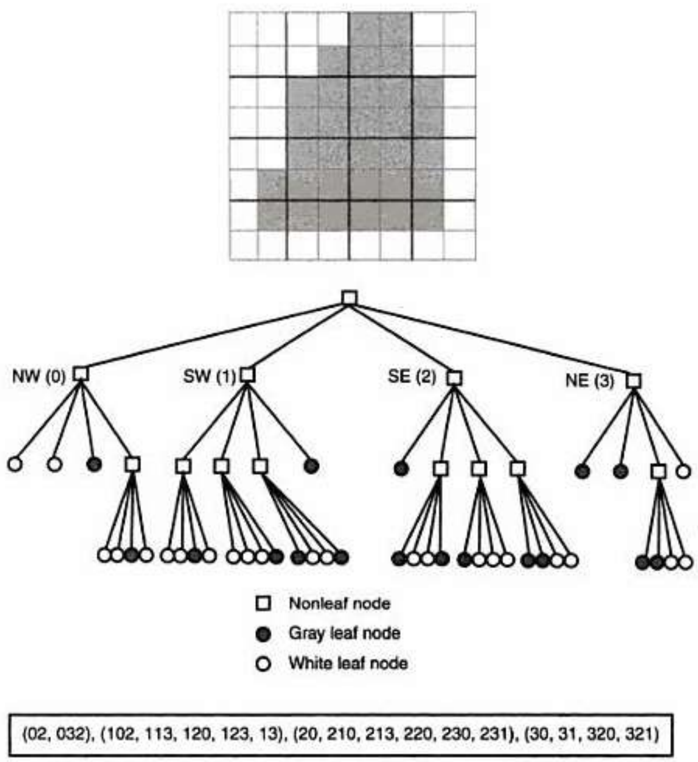


Fig. 17 : The regional quad tree method divides a raster into a hierarchy of quadrants. The division stops when a quadrant is made of cells of the same value (gray or white). A quadrant that cannot be subdivided is called a leaf node. In the diagram, the quadrants are indexed spatially: 0 for NW, 1 for SW. 2 for SE. and 3 for NE. Using the spatial indexing method and the hierarchical quad tree structure, the gray cells can be coded as 02,032, and so on.

Figure 17 shows a raster with a polygon in gray, and a quad tree that stores the feature. The quad tree contains nodes and branches (subdivisions). A node represents a quadrant. Depending on the cell value(s) in the quadrant, a node can be a nonleaf node or a leaf node. A nonleaf node represents a quadrant that has different cell values. A nonleaf node is therefore a branch point, meaning that the quadrant is subject to subdivision. A leaf node, on the other hand, represents a quadrant that has the same cell value. A leaf node is therefore an end point, which can be coded with the value of the homogeneous quadrant (gray or white). The depth of a quad tree, or the number of levels in the hierarchy, can vary depending on the complexity of the two-dimensional feature.

After the subdivision is complete, the next step is to code the two-dimensional feature using the quad tree and a spatial indexing method. For example, the level-1 NW quadrant (with the spatial index of 0) in Figure 17 has two gray leaf nodes. The first, 02, refers to the level-2 SE quadrant, and die second, 032, refers to the level-3 SE quadrant of the level-2 NE quadrant.

The string of (02, 032) and others for the other three Ievel-1 quadrants completes the coding of the two-dimensional feature.

Regional quad tree is an efficient method for storing area data, especially if the data contain few categories. This method is also efficient for data processing (Samet 1990). Quad tree has other uses in GIS as well. Researchers have proposed using a hierarchical quad tree structure for storing, indexing, and displaying global data (Tobler and Chen 1986; Dutton 1999; Ottoson and Hauska 2002; Platings and Day 2004). Quad tree is also useful as a spatial index method. Spatial indexing helps locate spatial data, both raster and vector, easily and quickly. Oracle, for example, uses quad tree as a method in indexing spatial data in Oracle Spatial.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

UNIT 2

Q.1 Explain how to use existing GIS data and where to obtain it.

(A) To find existing GIS data for a project is often a matter of knowledge, experience, and luck. Since the early 1990s, government agencies at different levels in the United States as well as other countries have set up websites for sharing public data and for directing users to the source of the desired information (Onsrud and Rushton 1995; Masser 1999; Jacoby et al. 2002). The Internet is also a medium for finding existing data from nonprofit organizations and private companies. But searching for GIS data, especially data of different kinds for a GIS project, can be difficult (Falke 2002). A keyword search will probably result in thousands of matches, but most hits are irrelevant to the user Internet addresses may be changed or discontinued. Data on the Internet may be in a format that is incompatible with the GIS package used for a project, or to be usable for a project, the data may need extensive processing such as clipping the study area from a large data set or merging several data sets.

Common types of GIS data on the Internet are data that many organizations regularly use for GIS activities. These are called framework data, which typically include seven basic layers: geodetic control (accurate positional framework for surveying and mapping), orthoimagery (rectified imagery such as orthophotos), elevation, transportation, hydrography, governmental units, and cadastral information (http://www.fgdc. gov/framework/). In recent years some thematic data such as environmental data have also become available online.

Public data are downloadable from the Internet. Most data are free or available for fees that cover their cost of processing. All levels of government let GIS users access their public data through clearinghouses in the United States. The following sections describe public data that are available at the federal, state, regional, metropolitan, and county levels as well as data from private companies.

Federal Geographic Data Committee :

The Federal Geographic Data Committee (FGDC) is a 19-member interagency committee (http://www.fgdc.gov/). FGDC leads the development of policies, metadata standards, and training to support the National Spatial Data Infrastructure (NSDI) and coordination efforts. The NSDI is aimed at the sharing of geospatial data throughout all levels of government, the private and nonprofit sectors, and the academic community. The FGDC website provides a link to the Geospatial Data Clearinghouse, a collection of 250 spatial data nodes in the United States and overseas.

Geospatial One-Stop :

The Geospatial One-Stop (GOS) is a geospatial data portal established by the Federal Office of Management and Budget in 2003 as an e-government initiative (http://www.geo-one-stop. gov/). The main objective of GOS is to expand collaborative partnerships at all levels of government to help leverage investments in geospatial data and to reduce the duplication of data. The initial GOS acted as a data clearinghouse for government agencies to post metadata describing their data

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

resources. In the second phase of development launched in July 2005, GOS changed its function to that of an interactive portal, allowing users to access geospatial data from federal, state, local, and private sources and to use the data in their own environments.

U.S. Geological Survey :

Through its National Map program, the U.S. Geological Survey (USGS) is the major provider of GIS data in the United States. Its website (http;// geography.usgs.gov/) offers pathways to USGS national mapping and remotely sensed data and to thematic data clearinghouses on biological, geologic, and water resources data. Public data available from the USGS include both vector and raster data.

Digital Line Graphs (DLGs) are digital representations of point, line, and area features from the USGS quadrangle maps at the scales of 1:24,000, 1:100,000, and 1:2,000,000. DLGs include such data categories as hypsography (i.e., contour lines and spot elevations), hydrography, boundaries, transportation, and the U.S. Public Land Survey System. DLGs contain attribute data and are topo-logically structured. It should be noted that the term DLG also refers to a data format.

National Land Cover Data (NLCD) 1992 includes 21 thematic classes for the conterminous United States. NLCD 1992 were compiled from the Thematic Mapper (TM) imagery of the early 1990s and other geospatial ancillary data sets. The 21 classes resemble the Anderson level II land use/land cover scheme used by the USGS in the 1970s and early 1980s (Anderson et al. 1976). A new project called National Land Cover Characterization 2001 (NLCD 2001) uses the Landsat 7 ETM + imagery to compile land cover data for all 50 states and Puerto Rico. Information on both NLCD 1992 and 2001 is available at http://landcover.usgs.gov/.

USGS digital elevation models (DEMs) can be downloaded at three designated websites (http://data.geocomm.com/, http://www.mapmart.com/, http://www.atdi-us.com/). They include 7.5-minute. 15-minute and 30-minute DEMs. The 7.5-minute DEMs have either a 30-meter or 10-meter resolution. The National Elevation Dataset (NED) is a recent effort made by the USGS to provide 1:24,000 scale DEMs nationwide (1:63,360 scale DEMs for Alaska) (http://ned.usgs.gov/). The NED uses a seamless data distribution system so that DEMs to be downloaded are based on user-defined areas. The NED also updates its data sets bimonthly to incorporate the "best available" DEM data.

Other GIS-related data available from the USGS include Landsat 7 ETM+ data. TM data, digital orthophoto quads (DOQs), digital raster graphics (DRGs), and aerial photographs from the National Aerial Photography Program. In 2000, the USGS initiated America View, a program de-signed to make satellite data from the U.S. government more accessible to the public through a network of state consortia (http://americaview. usgs.gov/). The pilot consortium, Ohio View, of-fered Landsat 7 and ASTER data for the State of Ohio and elsewhere (http://www.ohloview.org/). The USGS expects to expand the program to all 50 states.

U.S. Census Bureau :

The U.S. Census Bureau offers the TIGER/Line files, which are extracts of geographic/ cartographic information from its TIGER (Topologically Integrated Geographic Encoding and Referencing) database. The TIGER/Line files contain legal and statistical area boundaries such as counties, census tracts, and block groups, which can he linked to the census data, as well as roads, railroads, streams, water bodies, power lines, and pipelines (Sperling 1995). TIGER/Line attributes include the address range on each side of a street segment that can be used for address matching.

Several versions of the TIGER/Line files, including the Census 2000 version, are available for download at the Census Bureau's website (http:// www.census.gov/).

Natural Resources Conservation Service :

The Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture distributes soils data nationwide through its website (http://solls.usda.gov/). There are two soil databases: STATSGO and SSURGO. Compiled at 1:250,000 scales, the STATSGO (Stale Soil Geographic) database is suitable for broad planning and management uses. Compiled from field mapping at scales ranging from 1:12,000 lo 1:63,360, the SSURGO (Soil Survey Geographic) database is designed for uses al the farm, township, and county levels.

Statewide Public Data: An Example

The Geospatial One-Stop website provides a link to every state in the United States for statewide GIS data. An example is the Montana State Library (http://www.nris_state.mt.us/). This clearinghouse offers both statewide and regional data. Statewide data include such categories as administrative and political boundary, biological and ecologic, environmental, inland water resources, and transportation networks. These data are available in ArcInfo export files and shape files for downloading.

Regional Public Data: An Example

The Greater Yellowstone Area Data Clearinghouse (GYADC) (http://www.sdvc.uwyo. edu/gya/) is a FGDC data node sponsored by a group of federal agencies, state agencies, universities, and non-profit organizations. This data clearinghouse focuses on basic framework data for Yellowstone and Grand Teton National Parks.

Metropolitan Public Data: An Example

Sponsored by 18 local governments in the San Diego region, the San Diego Association of Governments (SANDAG) (http://www.sandag.cog.ca.us/) is an example of a metropolitan data clearinghouse. Data that can be downloaded from SANDAG's website include administrative boundaries, base map features, district boundaries, land cover and activity centers, transportation, and sensitive lands/natural resources.

County-Level Public Data: An Example

Many counties in the United States offer GIS data for sale. Clackamas County in Oregon, for example, distributes data in Arclnfo export files, shape files, and DXF tiles through its GIS division (http://www.co.clackamas.or.us/gis/). Examples of data sets include zoning boundaries, flood zones, tax lots, school districts, voting precincts, park districts, and fire districts.

GIS Data from Private Companies

Many GIS companies are engaged in software development, technical service, consulting, and data production. Some also provide free sample data or can direct GIS users to suitable sources. ESRI, Inc., for example, offers the Geography Network (http://www.geographynetwork.com/), a clearinghouse with data provided by organizations worldwide. (The Geography Network can be accessed directly from ArcMap.)

Some companies provide specialized GIS data for their customers. For example. Tele Atlas (http://www.teleatlas.com/) offers road and address databases for urban centers and rural areas. In contrast, online GIS data stores tend to carry a variety of geospatial data. Examples of GIS data stores include GIS Data Depot (http://data.geocomm.com/), Map-Mart (http://www.mapmart.com/), and LAND INFO International (http://www.land info.com/).

Q.2. What is metadata? What constitutes metadata?

(A) Metadata provide information about geospatial data (Guptill 1999). They are therefore an integral part of GIS data and are usually prepared and entered during the data production process. Metadata are important to anyone who plans to use public data for a GIS project (Comber et al. 2005). First, metadata let us know if the data meet our specific needs for area coverage, data quality, and data currency. Second, metadata show us how to transfer, process, and interpret geospatial data. Third, metadata include the contact for additional information.

The FGDC has developed the content standards for metadata and provides detailed information about the standards at its website (http://www.fgdc.gov/). These standards have been adopted by federal agencies in developing their public data. FGDC metadata standards describe a data set based on the following categories:

- Identification information – basic information about the data set, including title, geographic data covered, and currency.
- Data quality information – information about the quality of the data set, including positional and attribute accuracy, completeness, consistency, sources of information, and methods used to produce the data.
- Spatial data organization information – information about the data representation in the data set, such as method for data representation (e.g., raster or vector) and number of spatial objects.

- Spatial reference information – description of the reference frame for and means of encoding coordinates in the data set, such as the parameters for map projections or coordinate systems, horizontal and vertical datums, and the coordinate system resolution.
- Entity and attribute information – information about the content of the data set, such as the entity types and their attributes and the domains from which attribute values may be assigned.
- Distribution information – information about obtaining the data set.
- Metadata reference information – information on the currency of the metadata information and the responsible party.

Q.3. Explain how existing data is converted in GIS.

(A) Conversion of Existing Data

Public data are delivered in a variety of formats. Unless the data format is compatible with the GIS package in use. we must first convert the data. Data conversion is defined here as a mechanism for converting GIS data from one format to another Data conversion can he easy or difficult: it depends upon the specificity of the data format. Proprietary data formats require special translators for data conversion, whereas neutral or public formats require a GIS package that has translators to work with the formats.

Direct Translation

Direct translation uses a translator in a GIS package to directly convert geospatial data from one formal to another (Figure1). Direct translation used to be the only method for data conversion before the development of data standards and open GIS. Many users Mill prefer direct translation because it is easier to use than other methods. ArcToolbox in ArcGIS, for example, can translate ArcInfo's interchange files, MGE and Microstation's DGN files. AutoCAD's DXF and DWG files, and MapInfo files into shapefiles or geodatabases. Likewise, GeoMedia can access and integrate data from ArcGIS. AutoCAD, MapInfo, MGE, and Microstation.

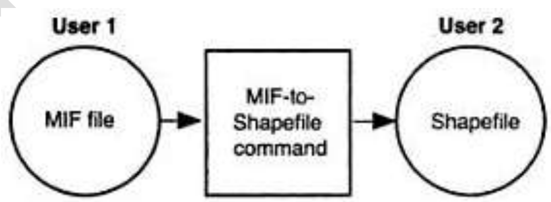


Fig. 1 : The MIF to Shapefile tool in ArcGIS converts a MapInfo file to a shapefile.

Neutral Format :

A neutral format is a public or de facto format for data exchange. For example, DLG is a neutral format originally developed by the USGS for DLG files.

The Spatial Data Transfer Standard (SDTS) is a neutral format approved by the Federal Information Processing Standards (FIPS) Program in 1992 (http://mcmcweb.er.usgs .gov/sdts/). Several federal agencies have converted some of their data to SDTS format. They include the USGS, U.S. Army, U.S. Army Corps of Engineers, Census Bureau, and U.S. National Oceanic and Atmospheric Administration. The USGS, for example, has converted many DLG files into SDTS format. These files are sometimes called SDTS/DLG files, GIS vendors such as ESRI. Inc., Intergraph, and MapInfo provide translators in their software packages for importing SDTS data (Figure 2).

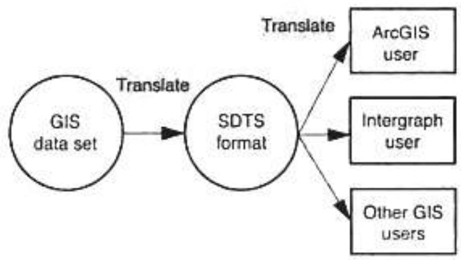


Fig. 2 : To accommodate users of different GIS packages, a government agency can translate public data into a neutral format such as SDTS format. Using the translator in the GIS package, the user can convert the

In practice, SDTS uses "profiles" to transfer spatial data. Each profile is targeted at a particular type of spatial data. Currently there are five SDTS profiles:

- The Topological Vector Profile (TVP) covers DLG, TIGER, and other topology-based vector data.
- The Raster Profile and Extensions (RPE) accommodate DOQ, DEM, and other raster data.
- The Transportation Network Profile (TNP) covers vector data with network topology.
- The Point Profile supports geodetic control point data.
- The Computer Aided Design and Drafting Profile (CADD) supports vector-based CADD data, with or without topology.

USGS 7.5-minute DEMs that can be downloaded online are typically in SDTS format. So are USGS DLG files. Creating an elevation raster from an SDTS raster profile transfer is relatively straightforward. But creating a topology-based vector data set from an SDTS topological vector profile transfer can be challenging because a topological vector profile transfer may contain composite features such as routes and regions in addition to topology.

The **vector product format (VPF)** is a standard format, structure, and organization for large geographic databases that are based on the georelational data model. The National Geospatial-Intelligence Agency (NGA) uses VPF for digital vector products developed at a variety of scales (http://www.nga.mil/). NGA's vector products for drainage systems, transportation, political boundaries, and populated places are also part of the global database that is being developed by the International Steering Committee for Global Mapping (ISCGM) (http://www.iscgm.org/cgibin/fswiki/wiki.cgi). Similar to an SDTS topological vector profile, a VPF file may contain composite features of regions and routes.

Although a neutral format is typically used for public data from government agencies, it can also be found with "industry standards" in the private sector. A good example is the DXF (drawing interchange file) format of AutoCAD. Another example is the ASCII format. Many GIS packages can import ASCII files, which have point data with x–, y-coordinates, into digital data sets.

Q.4. Explain various methods of creating new GIS Data.

(A) Creating New Data

Address geocoding, also called address matching, can create point features from street addresses. Street addresses are therefore an important data source for creating new data.

Remotely Sensed Data :

Satellite images can be digitally processed to produce a wide variety of thematic data for a GIS project. Land use/land cover data such as USGS National Land Cover Data are typically derived from satellite images. Other types of data include vegetation types, crop health, eroded soils, geologic features, the composition and depth of water bodies, and even snowpack. Satellite images provide timely data and, if collected at regular intervals, they can also provide temporal data that are valuable for recording and monitoring changes in the terrestrial and aquatic environments.

Some GIS users fell in the past that satellite images did not have sufficient resolution, or were not accurate enough, for their projects. This is no longer the case with high-resolution satellite images. Ikonos and QuickBird images can now be used to extract detailed features such as roads, trails, buildings, trees, riparian zones, and impervious surfaces.

Field Data :

Two important types of field data are survey data and global positioning system (GPS) data. Survey data consist primarily of distances, directions, and elevations. Distances can be measured in feet or meters using a tape or an electronic distance measurement instrument. The direction of a line can be measured in azimuth or bearing using a transit, theodolite, or total station. An azimuth is an angle measured clockwise from the north end of a meridian to the line. Azimuths range in magnitude from 0° to 360°. A bearing is an acute angle between the line and a meridian. The bearing angle always has the accompanied letters that locate the quadrant (i.e., NE, SE, SW, or NW) in which the line falls. In the United States, most legal plans use bearing directions. An elevation difference between two points can be measured in feel or meters using levels and rods.

In GIS, field survey typically provides data for determining parcel boundaries. An angle and a distance can define a parcel boundary between two stations (points). For example, the description of N45°30′W 500 feet means that the course (line) connecting the two stations has a bearing angle of 45 degrees 30 minutes in the NW quadrant and a distance of 500 feet. A parcel represents a close traverse, that is. a series of established stations lied together by angle and distance (Kavanagh 2003). A close traverse also begins and ends at the same point. Coordinate geometry (COGO), a study of geometry and algebra, provides the methods for creating geospatial data of points, lines, and polygons from survey data.

Text Files with x-,y-Coordinates :

Geospatial data can be generated from a text file that contains x-, y-coordinates. The x-, y-coordinates can be geographic (in decimal degrees) or projected. Each pair of x-, y-coordinates creates a point. Therefore, we can create spatial data from a file that records the locations of weather stations, epicenters, or a hurricane track.

Digitizing Using a Digitizing Table :

Digitizing is the process of converting data from analog to digital format. Manual digitizing uses a digitizing table (Figure 3). A digitizing table has a built-in electronic mesh, which can sense the position of the cursor. To transmit the x-, y-coordinates of a point to the connected computer, the operator simply clicks on a button on the cursor after lining up the cursor's cross hair with the point. Large-size digitizing tables typically have an absolute accuracy of 0.001 inch (0.003 centimeter).

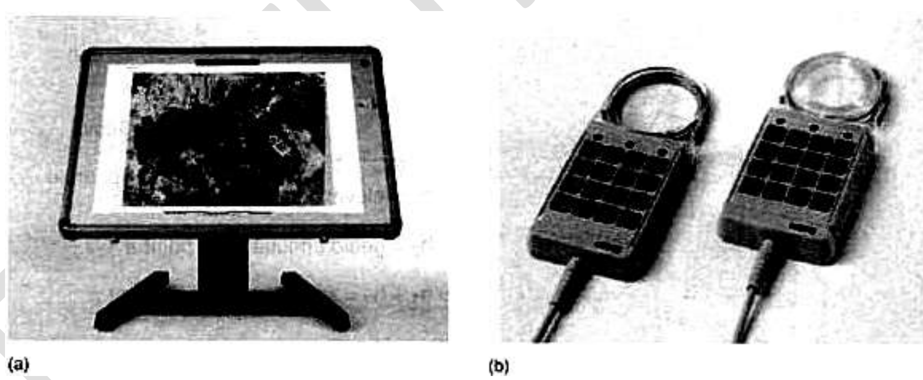


Fig. 3 : A large digitizing table (a) and a cursor with a 16-button keypad (b) (Courtesy of GTCO Calcomp, Inc.)

Scanning

Scanning is a digitizing method that converts an analog map into a scanned file, which is then converted back to vector format through tracing (Verbyla and Chang 1997). A scanner converts an analog map into a scanned image file in raster format. The simplest type of map to be scanned is a black-and-white map: black lines represent map features, and white areas represent the background. The map may be a paper or Mylar map and it may be inked or penciled.

Scanning converts the map into a binary scanned file in raster format; each pixel has a value of either 1 (map feature) or 0 (background). Map features are shown as raster lines, a series of connected pixels on the scanned file (Figure 4). The pixel size depends on the scanning resolution, which is often set at 300 dots per inch (dpi) or 400 dpi for digitizing. A raster line representing a thin inked line on the source map may have a width of 5 to 7 pixels (Figure 5).

Fig. 4 : A binary scanned file: The lines are soil lines, and the black areas are the background.

Fig. 5 : A raster line in a scanned file has a width of several pixels.

On-Screen Digitizing :

On-screen digitizing, also called heads-up digitizing, is manual digitizing on the computer monitor using a data source such as a DOQ as the background. DOQs combine the image characteristics of a photograph with the geometric qualities of a map. Easily integrated in a GIS. DOQs are the ideal background for digitizing. On-screen digitizing is an efficient method for editing or updating an existing layer such as adding new trails or roads that are not on an existing layer but are on a new DOQ. Likewise, we can use the method to update new clear-cuts or burned areas in a vegetation layer.

Importance of Source Maps :

Despite the increased availability of high-resolution remotely sensed data and GPS data, maps are still a dominant source for creating new GIS data. Digitizing, either manual digitizing or scanning, converts an analog map to its digital format. The accuracy of the digital map is therefore directly related to the accuracy of the source map. The digital map can be only as good or as accurate as its source map.

A variety of factors can affect the accuracy of the source map. Maps such as USGS quadrangle maps are secondary data sources because these maps have gone through the cartographic processes of compilation, generalization, and symbolization. Each of these processes can affect the accuracy of the mapped data. For example, if the compilation of the source map contains errors, these errors will be passed on to the digital map.

Q.5. What is geometric transformation?

(A) Geometric Transformation

Geometric transformation is the process of using a set of control points and transformation equations to register a digitized map, a satellite image, or an aerial photograph onto a projected coordinate system. As its definition suggests, geometric transformation is a common operation in GIS, remote sensing, and photogrammetry. But the mathematical aspects of geometric transformation are from coordinate geometry (Moffitt and Mikhail 1980).

Q.6. Explain Map-to-Map and Image-to-Map transformations.

(A) Map-to-Map and Image-to-Map Transformation

A newly digitized map, either manually digitized or traced from a scanned file, is based on digitizer units. Digitizer units can be in inches or dots per inch. Geometric transformation converts the newly digitized map into projected coordinates in a process often called map-to-map transformation.

Image-to-map transformation applies to remotely sensed data (Jensen 1996; Richards and Jia 1999). The term suggests that the transformation changes the rows and columns (i.e., the image coordinates) of a satellite image into projected coordinates. Another term describing this kind of transformation is georeferencing (Verbyla and Chang 1997; Lillesand et al. 2004). A georeferenced image can register spatially with other feature or raster layers in a GIS database, as long as the coordinate system is the same.

Whether map-to-map or image-to-map, a geometric transformation uses a set of control points to establish a mathematical model that relates the map coordinates of one system to another or image coordinates to map coordinates. The use of control points makes the process somewhat uncertain. This is particularly true with image-to-map transformation because control points are selected directly from the original image. Misplacement of the control points can make the transformation result unacceptable.

Q.7. List the various transformation methods. Explain Affine method.

(A) Transformation Methods

Different methods have been proposed for transformation from one coordinate system to another (Taylor 1977; Moffitt and Mikhail 1980). Each method is distinguished by the geometric properties it can preserve and by the changes it allows. The effect of transformation varies from changes of position and direction, to a uniform change of scale, to changes in shape and size (Figure 6). The following summarizes these transformation methods and their effect on a rectangular object.

- Equiarea transformation allows rotation of the rectangle and preserves its shape and size.

- Similarity transformation allows rotation of the rectangle and preserves its shape but not size.
- Affine transformation allows angular distortion of the rectangle but preserves the parallelism of lines (i.e., parallel lines remain as parallel lines).
- Projective transformation allows both angular and length distortions, thus allowing the rectangle to be transformed into an irregular quadrilateral.

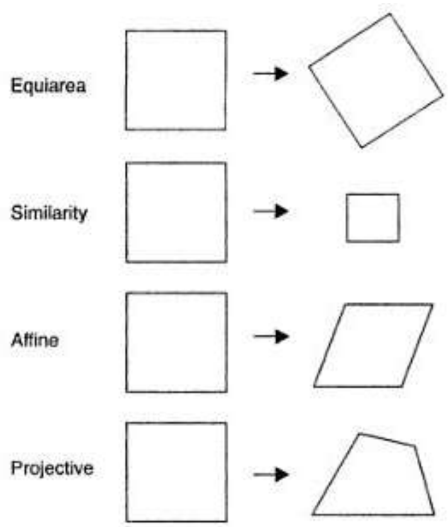


Fig. 6 : Different types of geometric transformations.

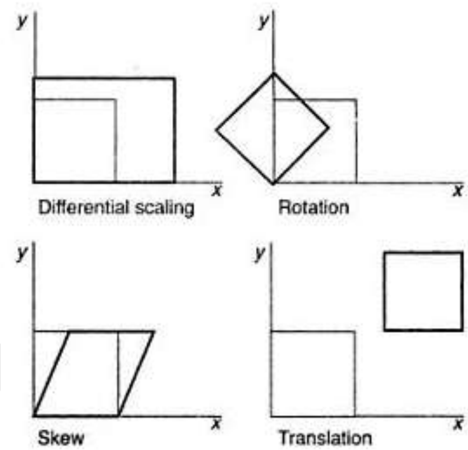


Fig. 7 : Differential scaling, rotation, skew and translation in the affine transformation.

These transformation methods are available in GIS packages such as ArcGIS and MGE. The general rules suggest the use of the affine transformation for map-to-map or image-to-map transformations and the projective transformation for aerial photographs with relief displacement. Also available in GIS packages are general polynomial transformations that use surfaces generated from second- or higher-order polynomial equations to transform satellite images with high degrees of distortion and topographic relief displacement. The process of general polynomial transformations is commonly called warping (Jensen 1996).

Affine Transformation

The affine transformation allows rotation, translation, skew, and differential scaling on a rectangular object, while preserving line parallelism (Pet-tofrezzo 1978; Loudon et al. 1980; Chen et al. 2003). Rotation rotates the object's x- and y-axes from the origin. Translation shifts its origin to a new location. Skew allows a non-perpendicularity (or affinity) between the axes, thus changing its shape to a parallelogram with a slanted direction. And differential scaling changes the scale by expanding or reducing in the x and/or y direction. Figure 7 shows these four transformations graphically.

Mathematically, the affine transformation is expressed as a pair of first-order polynomial equations:

$$X = Ax + By + C \quad \ldots (1)$$

$$Y = Dx + Ey + F \quad \ldots (2)$$

where x and y are the input coordinates that are given, X and Y are the output coordinates to be determined, and A, B, C. D, E, and F are the transformation coefficients. The affine transformation is also called the six-parameter transformation because it involves six estimated coefficients.

The same equations apply to both digitized maps and satellite images. But there are two differences. First, x and y represent point coordinates in a digitized map, but they represent columns and rows in a satellite image. Second, the coefficient E is negative in the case of a satellite image. This is because the origin of a satellite image is located at the upper-left corner, whereas the origin of a projected coordinate system is at the lower-left corner.

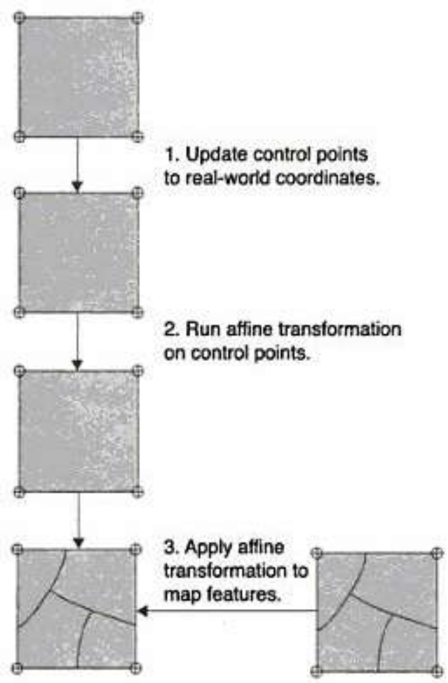


Fig. 8 : A geometric transformation typically involves three steps. Step 1 updates the control points to real-world coordinates. Step 2 uses the control points to run an affine transformation. Step 3 creates the output by applying the transformation equations to the input features.

Operationally, an affine transformation of a digitized map or image involves three steps (Figure 8). First, update the x- and y-coordinates of selected control points to real-world coordinates. If real-world coordinates are not available, we can derive them by projecting the longitude and latitude values of the control points. Second, run an affine transformation on the control points and examine the RMS error. If the RMS error is higher than the expected value, select a different set of control points and rerun the affine transformation. If the RMS error is acceptable, then the six coefficients of the affine transformation estimated from the control points are used in the next step. Third, use the estimated coefficients and the transformation equations to compute the new x- and y-coordinates of map features in the digitized map or pixels in the image. The outcome from the third step is a new map or image that is based on a user-defined projected coordinate system.

Q.8. What is RMS (Root Mean Square) Error? What are its acceptable value ranges?

(A) Root Mean Square (RMS) Error

The affine transformation uses the coefficients derived from a set of control points to transform a digitized map or a satellite image. The location of a control point on a digitized map or an image is an estimated location and can deviate from its actual location. A common measure of the goodness of the control points is the RMS error, which measures the deviation between the actual (true) and estimated (digitized) locations of the control points.

How is an RMS error derived from a digitized map? After the six coefficients have been estimated, we can use the digitized coordinates of the first control point as the inputs (i.e., the x and y values) to Eq. (1) and Eq. (2) and compute the X and Y values, respectively. If the digitized control point were perfectly located, the computed X and Y values would be the same as the control point's real-world coordinates. But this is rarely the case. The deviations between the computed (estimated) X and Y values and the actual coordinates then become errors associated with the first control point on the output. Likewise, to derive errors associated with a control point on the input, we can use the point's real-world coordinates as the inputs and measure the deviations between the computed x and y values and the digitized coordinates.

The procedure for deriving RMS errors also applies to GCPs used in an image-to-map transformation. Again, the difference is that columns and rows of a satellite image replace digitized coordinates.

Mathematically, the input or output error for a control point is computed by:

$$\sqrt{(x_{act} - x_{est})^2 + (y_{act} - y_{est})^2} \qquad \ldots (3)$$

where x_{act}, and y_{act} are the x and y values of the actual location, and x_{est}, and y_{est} are the x and y values of the estimated location.

The average RMS error can be computed by averaging errors from all control points:

$$\sqrt{\left[\sum_{i=1}^{n}(x_{act,i} - x_{est,i})^2 + \sum_{i=1}^{n}(y_{act,i} - y_{est,i})^2\right] / n} \qquad \ldots (4)$$

where n is the number of control points, $x_{act,\ i}$ and $y_{act,\ i}$ are the x and y values of the actual location of control point i, and $x_{est,\ i}$ and $y_{est,\ i}$ are the x and y values of the estimated location of control point i.

Q.**9.** Explain the concept of 'Resampling of Pixel Values', the methods and the advantages of Resampling.

(A) Resampling of Pixel Values

The result of geometric transformation of a satellite image is a new image based on a projected coordinate system. But the new image has no pixel values. The pixel values must be filled through resampling. Resampling in this case means filling each pixel of the new image with a value or a derived value from the original image.

Resampling Methods

Three common resampling methods are nearest neighbor, bilinear interpolation, and cubic convolution. The nearest neighbor resampling method fills each pixel of the new image with the nearest pixel value from the original image. For example, Figure 9 shows that pixel A in the new image will take the value of pixel a in the original image because it is the closest neighbor. The nearest neighbor method is computationally efficient. The method has the additional property of preserving the original pixel values, which is important for categorical data such as land cover types and desirable for some image processing such as edge detection.

Both bilinear interpolation and cubic convolution fill the new image with distance-weighted averages of die pixel values from the original image.

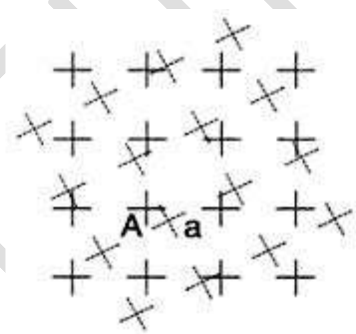


Fig. 9 : Because a in the original image is closest to pixel A in the new image, the pixel value at a is assigned lo be the pixel value at A using the nearest neighbor technique.

The bilinear interpolation method uses the average of the four nearest pixel values from three linear interpolations, whereas the cubic convolution method uses the average of the 16 nearest pixel values from five cubic polynomial interpolations (Richards and Jia 1999). Cubic convolution tends to produce a smoother output man bilinear interpolation but requires a longer processing time.

Other Uses of Resampling

Geometric transformation of satellite images is not the only operation that requires resampling. Resampling is needed whenever there is a change of cell location or cell size between the input raster and the output raster. For example, projecting a raster from one coordinate system to another requires resampling to fill in the cell values of the output raster. Resampling is also involved when a raster changes from one cell size to another (e.g., from 10 to 15 meters). Pyramiding is a common technique for displaying large raster data sets. Resampling is used with pyramiding to build different pyramid levels. Regardless of its application, resampling typically uses one of the three methods covered to produce the output raster.

Pyramiding: GIS packages have adopted pyramiding for displaying large raster data sets. Pyramiding build difference pyramid levels to represent reduced or lower resolutions of larger raster. Because a lower resolution raster required lern memory space, it can display

UNIT 3

Q.**1.** Explain Attribute Data in GIS.

(A) Attribute data in GIS

Attribute data are stored in tables. An attribute table is organized by row and column. Each row represents a spatial feature, each column describes a characteristics, and the intersection of a column and a row shows the value of particular characteristic for a particular feature (Figure 1). A row is also called a record or a tuple, and a column is also called a field or an item.

Type of Attribute Table

There are two types of attribute tables. The first type is called the **feature attribute table**, which has access to the spatial data. Every vector data set must have a feature attribute table. In the case of the georelational data model, the feature attribute table uses the feature **ID** to link to the feature's geometry. In the case of the object-based data model, the feature attribute table has a field that stores the feature's geometry. Feature attribute tables also have default fields t hat summarize the feature geometries such as length for line features and area and perimeter for area features.

Label0ID	pH	Depth	Fertility	
1	6.8	12	High	→ Row
2	4.5	4.8	Low	
			↓ Column	

Fig. 1 : A feature attribute table consists of rows and columns. Each row represents a spatial feature, and each column represents a property or characteristic of the spatial

Database Management

The presence of feature attribute and nonspatial data tables means that a GIS requires a database management system (DBMS) to manage these tables. A DBMS is a software package that enables us to build and manipulate a database (Oz 2004). A DBMS provides tools for data input, search, retrieval, manipulation, and output. Most commercial GIS packages include database management tools for local databases. For example, as of version 9.1, ArcGIS Desktop uses Microsoft Access for local database management.

Type of Attribute Data

One method for classifying attribute data is by data type. The data type determines how an attribute is stored in a GIS. Depending on the GIS package, the available data types can vary. Common data types are number, text (or character), date, and binary large object (BLOB). Data types for numbers include integer (for numbers without decimal digits) and floats (for numbers with decimal digits). Moreover, depending on the designated computer memory, an integer can be short or long and a float can be single precision or double precision. BLOB stores images, multimedia, and the geometry of spatial features as long sequences of binary numbers.

Q.2. Write a short note on Relation Model.

(A) A database is a collection of interrelated tables in digital format. There are at least four types of database designs that have been proposed in the literature: flat file, hierarchical, network, and relational.

A **flat file** contains all data in a large table. A feature attribute table is like a flat file. Another example is a spreadsheet with data only. A **hierarchical database** organizes its data at different levels and uses only the one-to-many association between levels. The simple example in (Figure 2) shows the hierarchical levels of zoning, parcel, and owner. Based on the one-to-many association, each level is divided into different branches. A **network database** builds connections across tables, as shown by the linkages between the tables in (Figure 2). A common problem with both the hierarchical and the network database designs is that the linkages (i.e., access paths) between tables must be known in advance and built into the database at design time. This requirement tends to make a complicated and inflexible database and limit the database applications.

GIS vendors typically use the relational model for database management. A **relational database** is a collection of tables, also called relations, which can be connected to each other by keys. A **primary key** represents one or more attributes whose values can uniquely identify a record in a table. Its counterpart in another table for the purpose of linkage is called a **foreign key**. Thus a key common to two tables can establish connections between corresponding records in the tables. In, (Figure 2) the key connecting zoning and parcel is the zone code and the key connecting parcel and owner is the PIN (parcel ID number). When used together, the keys can relate zoning and owner.

Q.3. Write a note on SSURGO with example.

(A) The Natural Resources Conservation Service (NRCS) produces the **Soil Survey Geographic** (SSURGO) database nationwide (**http://soils. usda.gov/**). The NRCS collects SSURGO data from field mapping, archives the data in 7.5-minute quadrangle units, and organizes the database by soil survey area. A soil survey area may consist of a county, multiple counties, or parts of multiple counties. The SSURGO database represents the most detailed level of soil mapping by the NRCS in the United States.

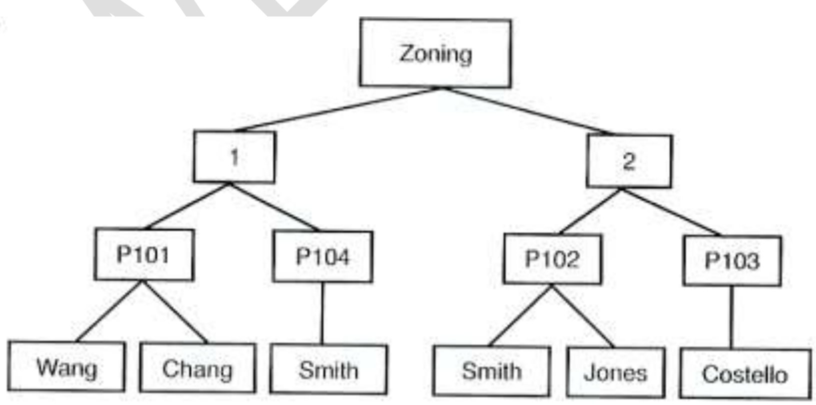
The SSURGO database consists of spatial data and tabular data. For each soil survey area, the spatial data contain a detailed soil map. The soil map is made of soil map units, each of which may be composed of one or more noncontiguous polygons. As the smallest area unit for soil mapping, a soil map unit represents a set of geographic areas for which a common land-use management strategy is suitable. Interpretations and properties of soil map units are provided by links between soil maps and data that exist in more than 50 tables in the SSURGO database. For example, the Component table shows if a soil map unit comprises a single dominant soil or two or more soil components. The NRCS provides metadata that describe each table and the keys that link tables.

The sheer size of the SSURGO database can be overwhelming at first. But the database is not difficult to use if we have a proper understanding of the relational model.

(a) Flat file

PIN	Owner	Zoning
P101	Wang	Residential (1)
P101	Chang	Residential (1)
P102	Smith	Commercial (2)
P102	Jones	Commercial (2)
P103	Costello	Commercial (2)
P104	Smith	Residential (1)

(b) Hierarchical



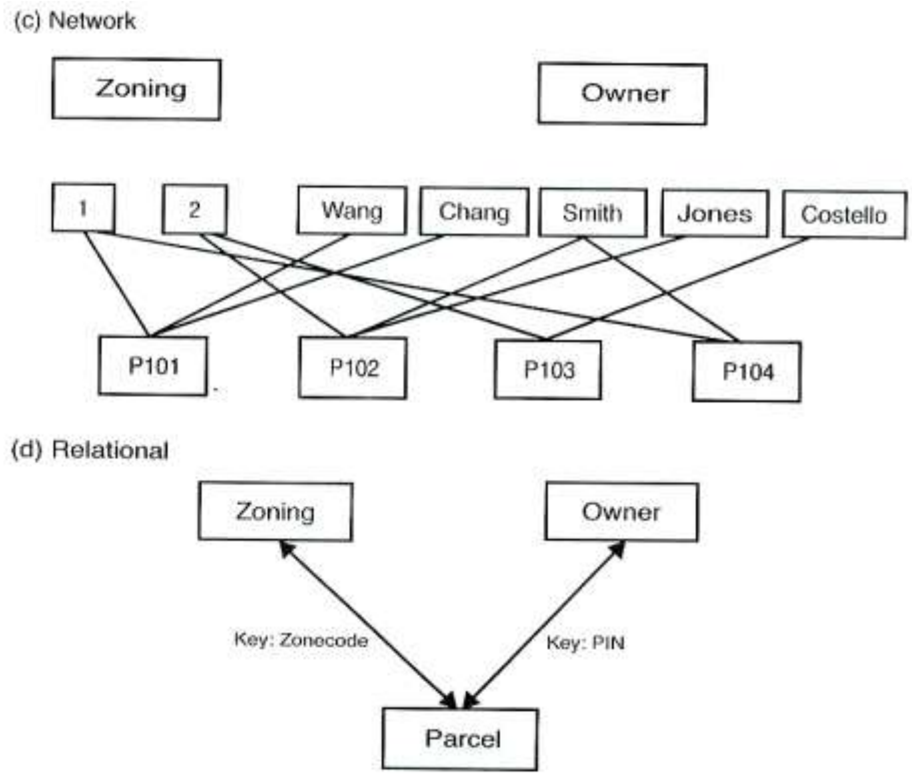


Fig. 2 : Four types of database (a) flat file, (b) hierarchical, (c) network, and (d) relational.

Q.4. Explain with example what is meant by Normalization.

(A) Preparing a relational database such as SSURGO involves following certain rules. An important rule is called normalization. **Normalization** is a process of decomposition, taking a table with all the attribute data and breaking it down into small tables while maintaining the necessary linkages between them (Vetter 1987). Normalization is designed to achieve the following objectives:

- To avoid redundant data in tables that waste space in the database and may cause data integrity problems.
- To ensure that attribute data in separate tables can be maintained and updated separately and can be linked whenever necessary.
- To facilitate a distributed database.

An example of normalization is offered here, Table 1 shows attribute data for a parcel map. The table contains redundant data: owner addresses are repeated for Smith and residential and commercial zoning are entered twice. The table also contains uneven records: depending on the parcel, the fields of owner and owner address can have either one or two values. An unnormalized table such as Table 1 cannot be easily managed or edited. To begin with, it is difficult to define the fields of owner and owner address and to store their values. A change of the ownership requires that all attribute data be updated in the table. The same difficulty applies to such operations as adding or deleting values.

Table 2 represents the first step in normalization. Often called the first normal form. Table 2 no longer has multiple values in its cells, but the problem of data redundancy has increased. P101 and P102 are duplicated except for changes of the owner and the owner address. Smith's address is included twice. And the zoning descriptions of residential and commercial are listed three times each. Also, identifying the owner address is not possible with PIN alone but requires a compound key of PIN owner.

Table 1 : An Unnormalized Table

PIN	Owner	Owner address	Sale date	Aeres	Zone code	Zoning
P101	Wang	101 Oak St	1–10–98	1.0	1	Residential
	Chang	200 Maple St				
P102	Smith	300 Spruce Rd	10–6–68	3.0	2	Commercial
	Jones	105 Ash St				
P103	Costello	206 Elm St	3–7–97	2.5	2	Commercial
P104	Smith	300 Spruce Rd	7–30–78	1.0	1	Residential

Table 2 : First Step in Normalization

PIN	Owner	Owner address	Sale date	Aeres	Zone code	Zoning
P101	Wang	101 Oak St	1–10–98	1.0	1	Residential
P101	Chang	200 Maple St	1–10–98	1.0	1	Residential
P102	Smith	300 Spruce Rd	10–6–68	3.0	2	Commercial
P102	Jones	105 Ash St	10–6–68	3.0	2	Commercial
P103	Costello	206 Elm St	3–7–97	2.5	2	Commercial
P104	Smith	300 Spruce Rd	7–30–78	1.0	1	Residential

Q.5. Explain types of relationships among database tables.

(A)

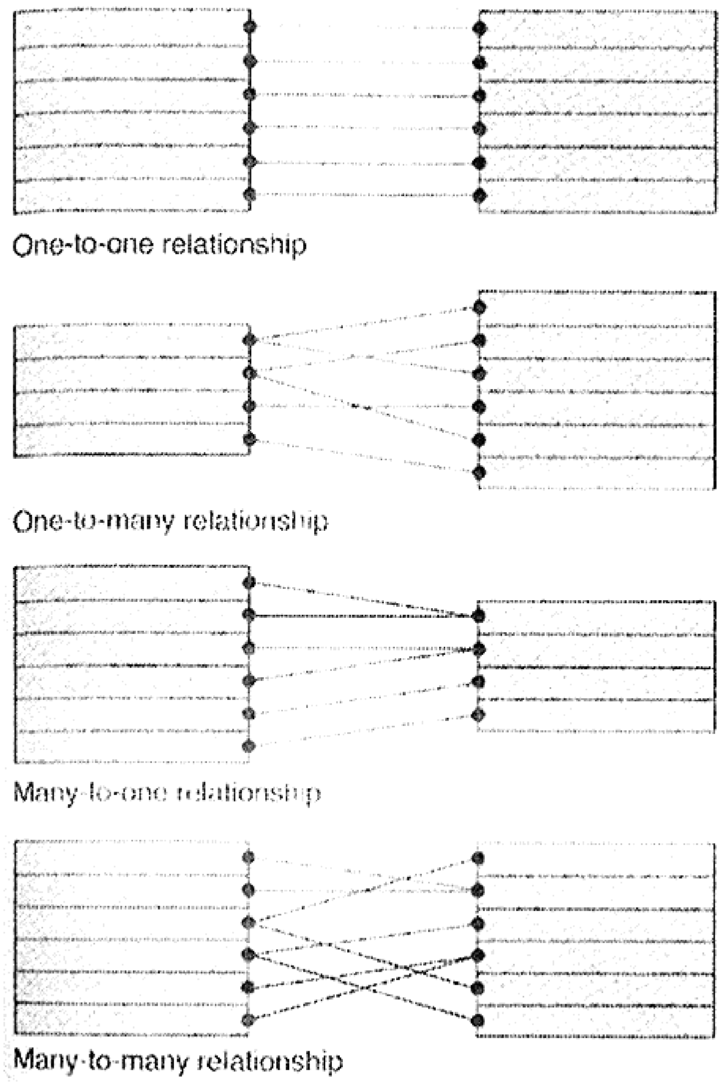


Fig. 3 : Four types of data relationships between tables; one–to–one, one–to–many, many–to–one, and many–to–many.

A relational database may contain four types of relationships (also called cardinalities) between tables, or more precisely, between records in tables : one–to –one, one–to–many, many–to–one, and many–to–many (Figure 3). The **one–to–one relationship** means that one and only one record in a table is related to one and only record in another table. The **one–to–many relationship** means that one record in a table may be related to many records in another table. For example, the street address of an apartment complex may include several households. The **many–to–one relationship** means that many records in a table may be related to one record in another table. For example, several households may share the same street address. The **many–to-many relationship** means that many records in a table may be related to many records in another table. For example, a timber stand can grow more than one species and a species can grow in more than one stand.

Q.6. Explain the various steps in Attribute Data Entry.

(A) Field Definition

The first step in attribute data entry is to define each held in the table. A field definition usually includes the filed name, data width, data type, and number of decimal digits. The width refers to the number of spaces to lie reserved for a field. The width should be large enough for the largest number, including the sign, or the longest string in the data. The data type must follow data types allowed in the GIS package. The number of decimal digits is part of the definition for the float data type. In ArcGIS, the precision defines the number of digits, and the scale defines the number of decimal digits, for the float data type.

The field definition can be confusing at times. For example, the map unit key in the SSURGO database is defined as text, although it is coded as numbers such as 79522, 79523 and so on. Of course, we cannot perform computations with these map unit key numbers.

Methods of Data Entry

Suppose a map has 4000 polygons, each with 50 fields of attribute data. This could require entering 200,000 values. How to reduce time and effort in attribute data entry is of interest to any GIS user.

Just as we look for existing spatial data, we should determine if an agency has already entered attribute data in digital format. If yes, we can simply import the digital data file into a GIS. The data format is important for importing. Most GIS packages can import delimited text files and dBASE files as well as data from other database management systems. If attribute data files do not exist, then typing is the only option. But the amount of typing can vary depending on which method or command is used. For example, an editing command in a GIS package works with one record at a time. One way to save time is to follow the relational database design and to take advantage of keys and lookup tables.

Attribute Date Verification

Attribute data verification has two stops. The first is to make sure that attribute data are properly linked to spatial data: the label or feature ID should be unique and should not contain null (empty) values. The second step is to verify the accuracy of attribute data. Data verification is difficult because inaccuracies can be attributed to a large number of factors including observation errors, outdated data, and data entry errors.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

There are at least two traditional methods for checking for data entry errors. First, attribute data can be printed for manual verification, This is like using check plots to check the accuracy of spatial data. Second, computer programs can be written to verify data accuracy. For example, a computer program can be written to catch logical errors in soil attribute data such as data type and numeric range. The same program may also test attribute data against a master set of valid attributes to catch logical errors such as having incompatible components in the same soil map unit.

Q.7. Explain how to Manipulate fields of Attribute Data in GIS.

(A) Manipulation of Fields and Attribute Data

Database management tasks involve tables as well as fields and field values in tables. Field management includes adding or deleting fields and creating new attributes through classification and computation of existing attribute data.

Adding and Deleting Fields

We regularly download data from the Internet for GIS projects. Often the downloaded data set contains far more attributes than we need. It is a good idea to delete those fields that are not needed. This not only reduces confusion in using the data set but also saves computer time for data processing. Deleting a field is straightforward. The process requires specifying an attribute table and the field in the table to be deleted. Obviously the table involved in the process cannot be used by another program or application.

Classification of Attribute Data

New attribute data can be created from existing data through data classification. Based on an attribute or attributes, data classification reduces a data set to a small number of classes. For example, elevations may be grouped into < 500, 500 to 1000, and so on. Another example is to classify by elevation and slope: class 1 has < 500 in elevation and 0 to 10% slope, class 2 has > 500 in elevation and 10 to 20% slope, and so on.

Computation of Attribute Data

New attribute data can also be created from existing data through computation. Operationally, it involves two steps: defining a new field, and computing the new field values from the values of an existing attribute or attributes. The computation is through a formula, which can ho coded manually or by using a dialog with controls for various mathematical functions.

Q.8. Explain the term 'Cartographic Symbolization' with its various aspects.

(A) Spatial Features and Map Symbols

Spatial features are characterized by their locations and attributes. To display a Spatial feature on a map, we use a map symbol to indicate the feature's location and a visual variable, or visual

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

variables, with the symbol to show the feature's attribute data. For example, a thick line in red may represent an interstate highway and a thin line in black may represent a state highway. The line symbol shows the location of the highway in both cases, but the line width and color two visual variables with the line symbol–separate the interstate from the state highway. Choosing the appropriate map symbol and visual variables is therefore the main concern for data display and mapmaking (Robinson et al. 1995; Dent 1999; Slocum et al. 2005).

The choice of map symbol is simple for raster data: the map symbol applies to cells whether the spatial feature to be depicted is a point, line, or area. The choice of map symbol for vector data depends on the feature type. The general rule is to use point symbols for point features, line symbols for line features, and area symbols for area features. But this general rule does not apply to volumetric data or aggregate data. There are no volumetric symbols for data such as elevation, temperature, and precipitation. Instead, .3–D surfaces and isolines are often used to map volumetric data. Aggregate data such as county populations are data

reported at an aggregate level. A common approach is to assign aggregate data to the center of each county and display the data using point symbols.

Use of Color

Because color adds a special appeal to a map, map makers will choose color maps over black and white maps whenever possible. But color is probably the, most misused visual variable, according to published critiques of computer-generated maps (Monmonier 1006). The use of color in mapmaking must begin with an understanding of the visual dimensions of hue value, and chroma.

Hue is the quality that distinguishes one color from another, such as red from blue. Hue can also be defined as the dominant wavelength of light making up a color. We tend to relate different hues with different kinds of data. **Value** is the lightness or darkness of a color, with black at the lower end and white at the higher end. We generally perceive darker symbols on a map as being, more impor-darker, or greater in terms of magnitude (Robinson el al. 1995). Also called saturation or intensity, **chroma** refers to the richness, or brilliance, of a color. A fully saturated color is pure, whereas a low saturation approaches gray. We generally associate higher intensity symbols with greater visual importance.

Data Classification

Data classification involves the use of a classification method and a number of classes for aggregating data and map features. A GIS package typically offers different data classification methods. The following summarizes five commonly used methods :

- *Equal interval* : This classification method divides the range of data values into equal intervals. (e.g. 01–10, 11–20, 21–30, etc.)

- *Equal frequency* : Also called quantile, this classification method divides the total number of data values by the number of classes and ensures that each class contains the same number of data values.
- *Mean and standard deviation* : This classification method sets the class breaks at units of the standard deviation (0.5, 1.0, etc.) above or below the mean.
- *Natural breaks* : Also called the Jenks optimization method, this classification method optimizes the grouping of data values (Slocum et al. 2005). The method uses a computing algorithm to minimize differences between data values in the same class and to maximize differences between classes.
- *User defined* : This method lets the user choose the appropriate or meaningful class breaks. Par example, in mapping rates of population change by state, the user may choose zero or the national average as a class break.

With changes in the classification method, the number of classes, or both, the same data can produce different-looking maps and different spatial patterns. This is why mapmakers usually experiment with data classification before deciding on a classification scheme for the final map. Although the decision is ultimately subjective, it should be guided by map purpose and map communication principles.

Q.9. Explain the various types of maps in GIS Packages.

(A) TYPES OF MAPS

Cartographers classify maps by function and by symbolization. By function, maps can be general reference or thematic. The **general reference map** is used for general purposes, For example, a U.S. Geological Survey (USGS) quadrangle map shows a variety of spatial features, including boundaries, hydrology, transportation, contour lines, settlements, and land covers. The **thematic map** is also called the special purpose map, because its main objective is to show the distribution pattern of a theme, such as the distribution of population densities by county in a state.

By map symbol, maps can be qualitative or quantitative. A qualitative map uses visual variables that are appropriate for portraying qualitative data, whereas a quantitative map uses visual variables that are appropriate for communicating quantitative data. The following describes several common types of quantitative maps (Figure 4) (Robinson et al. 1995; Dent 1999; Slocum et al. 2005).

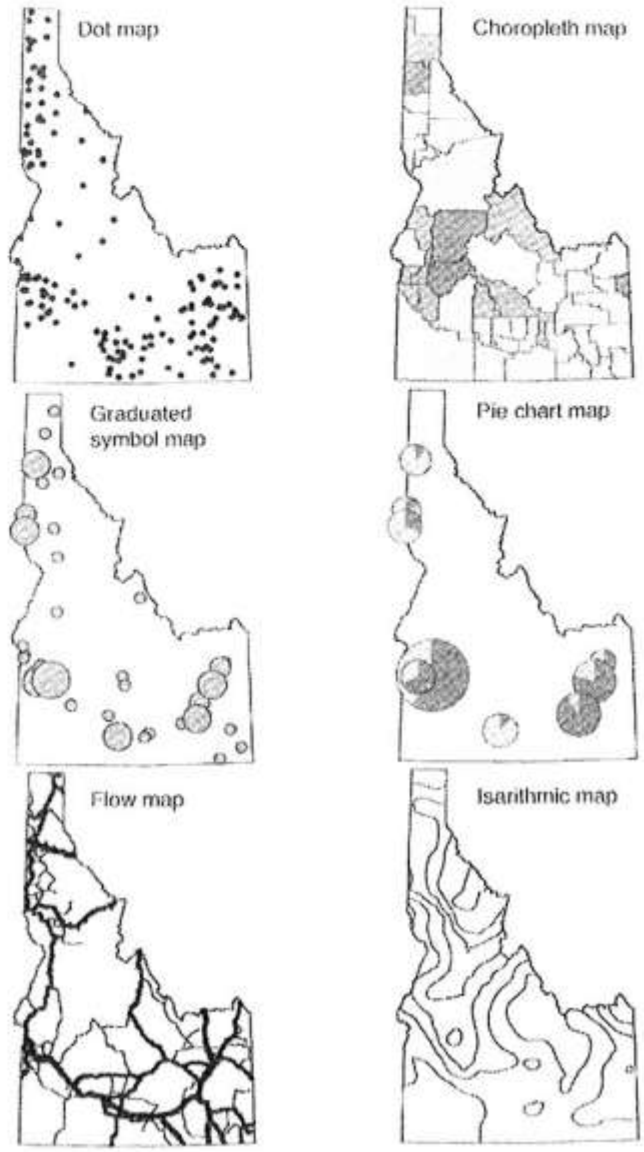


Fig 4 : Six common types of quantitative maps

The dot map uses uniform point symbols to show spatial data, with each symbol representing a unit value. One-to-one dot mapping uses the unit value of one, such as one dot representing one crime location. But in most cases, it is one-to-many dot mapping and the unit value is greater than one. The placement of dots becomes a major consideration in one-to-many dot mapping.

The choropleth map symbolizes, with shading, derived data based on administrative units. An example is a map showing average household income by county. The derived data are usually classified prior to mapping and are symbolized using a color scheme for quantitative data.

Therefore, the appearance of the choropleth map can be greatly affected by data classification. Cartographers often make several versions of the choropleth map from the same data and choose one–typically one with a good spatial organization of classes–for final map production.

The **dasymetric map** is a variation of the simple choropleth map. By using statistics and additional information, the dasytmetric map delineates areas of homogeneous values rather than following administrative boundaries (Robinson et al. 1995) (Figure 5). Dasymetric mapping used to be a time-consuming task, but the analytical functions of a GIS have simplified the mapping procedure (Holloway et al. 1999; Eicher and Brewer 2001; Holt et al. 2004).

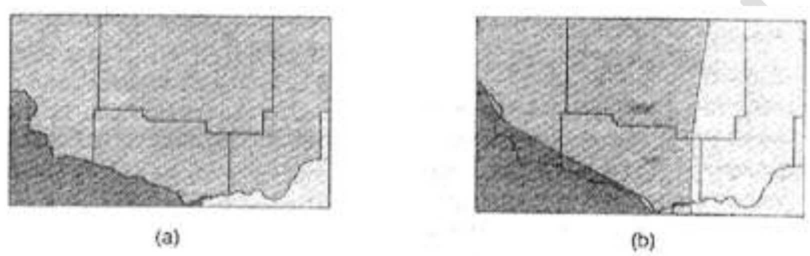


Fig.5 : map symbols follow the boundaries in the choropleth map (a) but not in the dasymetric map (b).

A GIS package such as ArcGIS uses the term **graduated color map** to cover the choropleth and dasymetric maps because both map types use a graduated color scheme to show the variation in spatial data.

The **graduated symbol map** uses differentsized symbols such as circles, squares, of triangles to represent different ranges of values. For example, we can use graduated symbols to represent cities of different population ranges. Two important issues to this map type are the range of sizes and the discernible difference between sizes. Both issues are obviously related to the number of graduated symbols on a map.

A **proportional symbol map** is a map that uses a specific symbol size for each numeric value rather than a range of values. Therefore, one circle size may represent a population of 10,000, another 15,000, and so on.

The **chart map** uses either pie charts or bar charts. A variation of the graduated circle, the pie chart can display two sets of quantitative data: the circle size can be made proportional to a value such as a county population, and the subdivisions can show the makeup of the value, such as the racial composition of the county population. Bar charts use vertical bars and their height to represent quantitative data. Bar charts are particularly useful for comparing data side by side.

The **flow map** displays different quantities of flow data such as traffic volume and stream flow by varying the line symbol width. Similar to the graduated symbols, the flow symbols usually represent ranges of values.

The **isarithmic map** uses a system of isolines to represent a surface. Each isoline connects points of equal value.

Q.10. Explain the role of Typography in GIS.

(A) Type Variations

Type can vary in typeface and form. **Typeface** refers to the design character of the type. Two main groups of typefaces are **serif** (with serif) and **sans serif** (without serif). Serifs are small, finishing touches at the ends of line strokes, which tend to make running text in newspapers and books easier to read. Compared to serif types, sans serif types appear simpler and bolder. Although rarely used in books or other text-intensive materials, a sans serif type stands up well on maps with complex map symbols and remains legible even in small sizes. Sans serif types have an additional advantage in mapmaking because many of them come in a wide range of type variations.

Type form variations include **type weight** (bold, regular, or light), **type width** (condensed or extended), upright versus slanted (or roman versus italic), and uppercase versus lowercase (Figure 6). A font is a complete set of all variants of a given typeface. Fonts on a computer are those loaded from the printer manufacturer and software packages. They are usually enough for mapping purposes. If necessary, additional fonts can be imported into a GIS package.

Helvetica Normal

Helvetica Italic

Helvetica Bold

Helvetica Bold–Italic

Times Roman Normal

Times Roman Italic

Times Roman Bold

Times Roman Bold–Italic

Fig 6 : Type variations in weight and roman versus italic.

Selection of Type Variations

Type variations for text symbols can function in the same way as visual variables for map symbols. How does one choose type variations for a map? A practical guideline is to group text symbols into qualitative and quantitative classes. Text symbols representing qualitative classes such as names of streams, mountains, parks, and so on can vary in typeface, color, and upright versus italic. In contrast, text symbols representing quantitative classes such as names of different-sized cities can vary in type size, weight, and uppercase versus lowercase. Grouping text symbols into classes simplifies the process of selecting type variations.

Besides classification, cartographers also recommend legibility, harmony, and conventions for type selection (Dent 1999). Legibility is difficult to control on a map because it can be influenced not only by type variations but also by the placement of text and the contrast between text and the background symbol. As GIS users, we have the additional problem of having to design a map on a computer monitor and to print it on a larger plot. Experimentation may be the only way to ensure type legibility in all parts of the map.

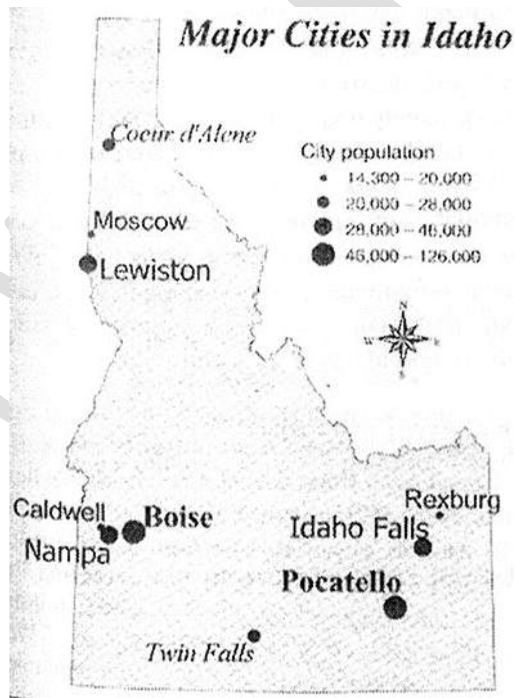


Fig 7 : The look of the map is not harmonious because of too many typefaces.

Placement of Text in the Map Body

Text elements in the map body, also called labels, are directly associated with the spatial features. In most cases, these labels are names of the spatial features. But they can also be some attribute values such as contour readings or precipitation amounts. Other text elements on a map such as the title and the legend are not tied to any specific locations. Instead, the placement of these text elements (i.e., graphic elements) is related to the layout of the map.

As a general rule, a label should be placed to show the location or the area extent of the named spatial feature. Cartographers recommend placing the name of a point feature to the upper right of its symbol, the name of a line feature in a block and parallel to the course of the feature, and the name of an area feature in a manner that indicates its area extent. Other general rules suggest aligning labels with either the map border or lines of latitude, and placing labels entirely on land or on water.

Q.11. Explain Map Design with reference to : (a) Layout (b) Visual Hierarchy.

(A)

(a) Layout

Layout, or planar organization, deals with the arrangement and composition of various map elements, Major concerns with layout are focus, order, and balance. A thematic map should have a clear focus, which is usually the map body or a part of the map body. To draw the map reader's attention, the focal element should be placed near the optical center, just above the map's geometric center. The focal element should be differentiated from other map element by contrast in line width, texture, value detail, and color.

After viewing the focal element, the reader should be directed to the rest of the map in an ordered fashion. For example, the legend and the title are probably the next elements that the viewer needs to look at after the map body. To smooth the transition, the mapmaker should clearly place the legend and the title on the map, with perhaps a box around the legend and a larger type size for the title to draw attention to them.

A finished map should look balanced. It should not give the map reader an impression that the map "looks" heavier on the top, bottom, or side. But balance does not suggest the breaking down of the map elements and placing them, almost mechanically, in every part of the map. Although in that case the elements would be in balance, the map would be disorganized and confusing. Mapmakers therefore should deal with balance within the context of organization and map communication.

Cartographers used to thumbnail sketches to experiment with balance on a map. Now they use computers to manipulate map elements on a layout page. ArcGIS, for example, offers two basic methods for layout design. The first method is to use a layout template. These templates are grouped as general, industry, USA, and would. Each group has a list of choices. For example, the layout templates for the United States include USA, conterminous USA, and five different regions of the country. The idea of using a layout template is to use a built-in design option to quickly compose a map.

(b) Visual Hierarchy

Visual hierarchy is the process of developing a visual plan to introduce the 3–D effect or depth to maps (Fig. 8). Mapmakers create the visual hierarchy by placing map elements at different visual levels according to their importance to the map's purpose. The most important element should be at the top of the hierarchy and should appear closest to the map reader. The least important element should be at the bottom. A thematic map may consist of three or more levels in a visual hierarchy.

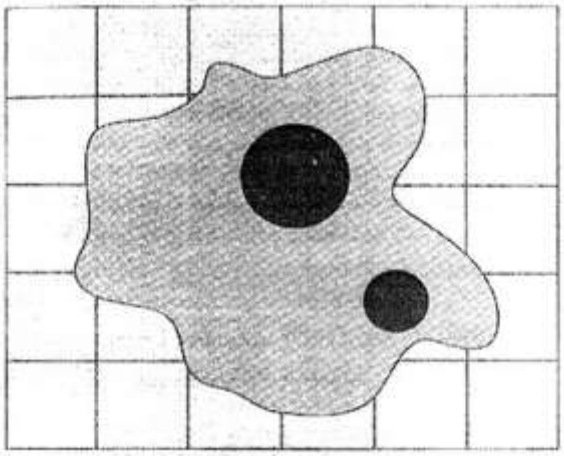


Fig. 8: A visual hierarehy example. The two black circles are on top (closest to the map reader), followed by the gray polygon. The grid, the least important, is on the bottom.

The concept of visual hierarchy is an extension of the **figure-ground relationship** in visual perception (Arnheim 1965). The figure is more important visually, appears closer to the viewer, has form and shape, has more impressive color, and has meaning. The ground is the background. Cartographers have adopted the depth cues for developing the figure-ground relationship in map design.

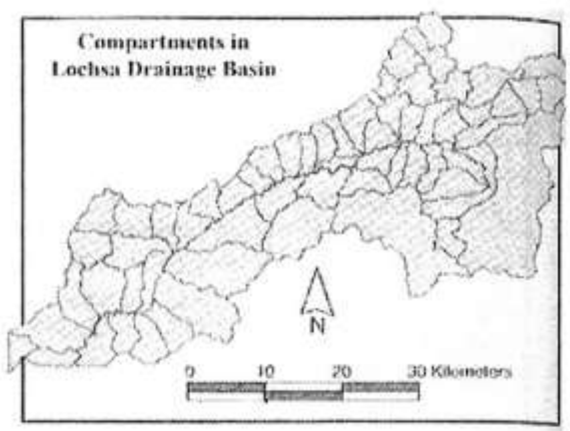


Fig. 9 : The interposition effect in map design

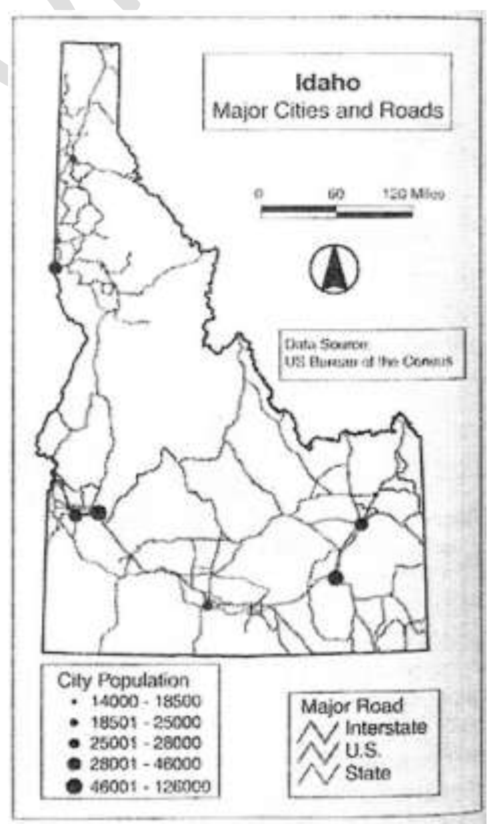


Fig.10 : A map looks confusing if it uses too many boxes to highlight individual elements

Probably the simplest and yet most effective principle in creating a visual hierarchy is interposition or superimposition (Dent 1999). **Interposition** uses the incomplete outline of an object to make it appear as though it is behind another. Examples of interposition abound in maps, especially in newspapers and magazines. Continents on a map look more important or occupy a higher level in visual hierarchy if the lines of longitude and latitude stop at the coast. A map title, a legend, or an inset map looks more prominent if it lies within a box, with or without the drop shadow. When the map body is deliberately placed on top of the neat line around a map, the map body will stand out more (Figure 9). Because interposition is so easy to use, it can be over used or misused. A map looks confusing if several of its elements compete for the map leader's attention (Figure 10).

Q.12. Explain the process of Map Production.

(A) GIS users design and make maps on the computer screen. These soft-copy maps can be used in a variety of ways. They can be printed, exported for use on the Internet, used in overhead computer projection systems, exported to other software packages, or further processed for publishing.

Map production is a complex topic. We are often surprised that color symbols from the color printers do not exactly match those on the computer screen. This discrepancy results from the use of different media and color models.

Data display on the computer screen uses either C**RT (cathode ray tube) or LCD (liquid crystal display).** It used to be that desktop computers used CRTs and laptop or portable computers used LCDs. But now more desktop computers are also using LCDs to take advantage of the thin, flat screen. A CRT screen has a built in line mesh of pixels, and each pixel has colored dots called phosphors. When struck by electron from an electron gun, a dot lights up and slowly grows dim. An LCD screen uses two sheets of polarizing materials with a liquid crystal solution between them. Each pixel on an LCD screen can be turned on or off independently. Besides being thinner and lighter. LCD screens have two oilier advantages over CRT screens: they consume less power, and they produce sharper, flicker-free images.

With either a CRT or an LCD, a color symbol we see on a screen is made of pixels, and the color of each pixel is a mixture of **RGB** (red, green, and blue). The intensity of each primary color in a mixture determines its color. The number of intensity levels each primary color can have depends on the number of bit-planes assigned to the electron gun in a CRT screen or the variation of the voltage applied in an LCD screen. Typically, the intensity of each primary color can range over 256 shades. Combining the three primary colors produces a possible palette of 16.8 million colors (256 x 256 X 256).

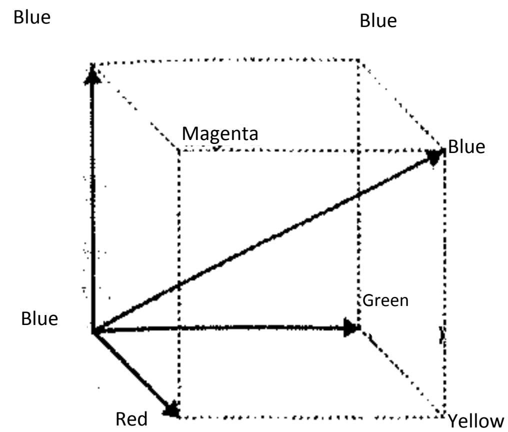


Fig. 11: The RGB (red, green and blue) color model

UNIT 4

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

Q.1. Explain the term 'Data Exploration' with its various aspects.

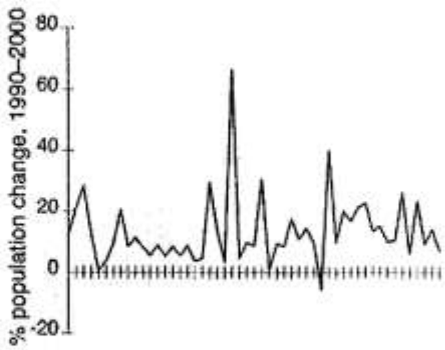
(A) Similar to statistics, data exploration in GIS lets the user view the general patterns in the data set, query data subsets, and hypothesize about possible relationships between data sets (Anselin 1999; Andrienko et al. 2001; Haining 2003). But there are two important differences. First, data exploration in a GIS involves both spatial and attribute data. Second, the media for data exploration in GIS include maps and map features. For example, in studying soil conditions, we want to know not only how much of the study area is rated poor but also where those poor soils are distributed on a map. Therefore, besides descriptive statistics and graphics, data exploration in GIS must also cover attribute data query, spatial data query, and map manipulation.

Descriptive Statistics : Descriptive statistics summarize the values of a data set. They include the following :

- Range: the difference between the minimum and maximum values.
- Median: the midpoint value, or the 50^{th} percentile.
- First quartile: the 25^{th} percentile.
- Third quartile: the 75^{th} percentile.
- Mean: the average of data values. The mean can be calculated by $\sum_{i=1}^{n} x_i \big/ n$, where x_i is the i^{th} value and n is the number of values.
- Variance: the average of the squared deviations of each data value about the mean. The variance can be calculated by $\sum_{i=1}^{n} (x_i - \text{mean})^2 \big/ n$
- Standard deviation: the square root of the variance.
- Z score: a standardized score that can be computed by (x – mean)/s, where s is the standard deviation.

Graphs

Different types of graphs are used for data exploration. A line graph displays data as a line. The line graph example in figure 1 shows the rate of population change in the United States along the y-axis and the state along the x-axis. Notice a couple of “peaks” in the line graph.



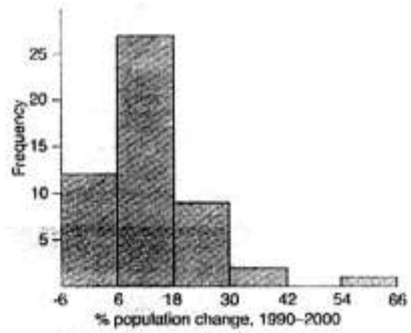


Fig. 2 : A histogram (bar chart)

Fig. 1 : A line graph

A bar chart, also called a histogram, groups data into equal intervals and uses bars to show the number of frequency of values falling within each class. A bar chart may have vertical bars or horizontal bars. Figure 2 uses a vertical bar chart to group rates of population change in the United States into six classes. Notice one bar at the high end of the histogram.

A cumulative distribution graph is one type of line graph that plots the ordered data values against the cumulative distribution values. The cumulative distribution value of the ith ordered value is typically calculated as $(i - 0.5)/n$, where n is the number of values. This computational formula converts the values of a data set to within the range of 0.0 to 1.0. Figure 3 show a cumulative distribution graph.

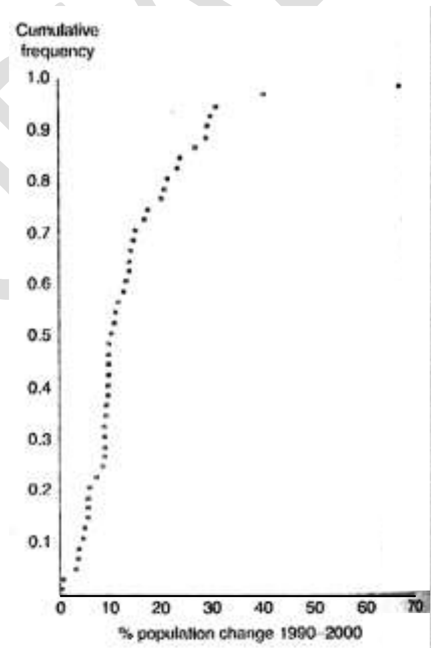


Fig. 3 : A cumulative distribution graph

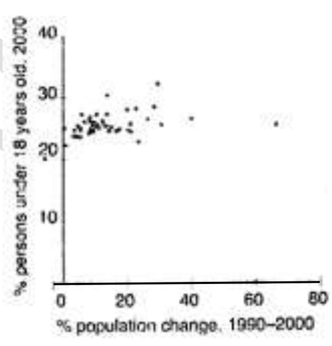


Fig. 4 : A scatterplot plotting percent persons 18 years old in 2000 against percent population change, 1990-2000. A weak-positive relationship is present

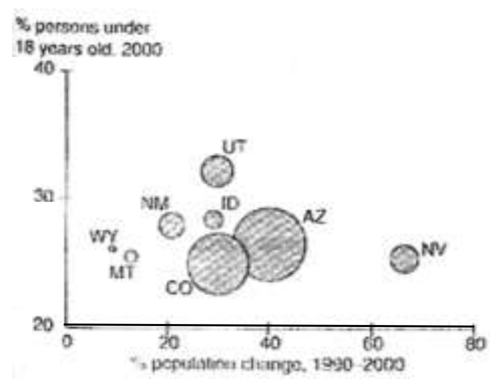


Fig. 5 : A bubble plot showing percent population change 1990-2000, percent persons under 18 years old in 2000, and state population

scatterplot uses markings to plot the values of two variables along the x– and y–axes. Figure 4 plots percent population change1990–2000 against percent persons under 18 years old in 2000 by state in the United States. The scatterplot suggests a weak positive relationship between the two variables.

Bubble plots are a variation of scatterplots. Instead of using constant symbols as in a scatterplot, a bubble plot has varying sized bubbles that are made proportional to the value of a third variable. Figure 5 is a variation of Figure 4, the additional variable shows by the bubble size is the state population ins 2000. As an illustration, Figure 5 only shown states in the Mountain region, one of the nine regions defined by the U.S. Census Bureau.

Boxplots, also called the “box and whisker” plots, summarized the distribution of five statistics from a data set the minimum, first quartile, median, third quartile, and maximum. By examining the position of the statistics in a boxplot, we can tell if the distribution of data values is symmetric or skewed and if there are unusually data points (i.e. outliers). Figure 6 shows a boxplot based on the rate of population change in the United States. This data set is clearly skewed toward the higher end. Figure 7 summarizes three basic types of data sets in terms of distribution of data values. Boxplots are therefore useful for comparisons between different data sets.

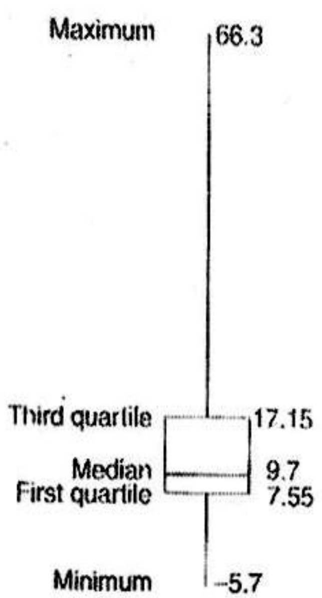


Fig. 6 : A boxplot based on the percent population change 1990-2000 data set.

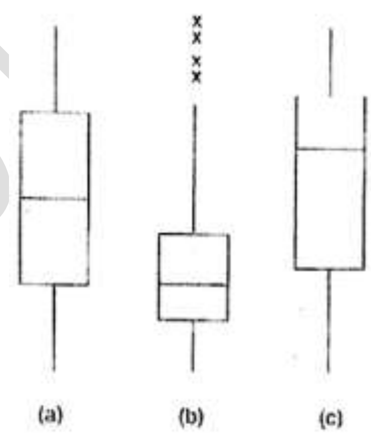


Fig. 7 : Boxplot (a) suggests that the data values follow a normal distribution. Boxplot (b) shows a positively skewed distribution with a higher concentration of data values near the high end. The x’s in (b) may represent outliers, which are more than 1.5 box lengths from the end of the box. Boxplot (c) shows a

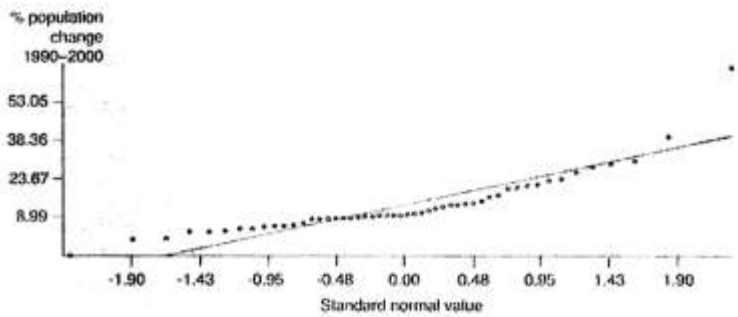


Fig. 8 : A QQ plot plotting percent population change, 1990-2000 against the standardized value from a normal distribution.

Some graphs are more specialized. Quantile-quantile plots, also called QQ plots, compare the cumulative distribution of a data set with that of some theoretical distribution such as the normal distribution, a bell-shaped frequency distribution.

The points in a QQ plot fall along a straight line if the data set follows the theorectical distribution. Figure 8 plots the rate of population change against the standardized value from a normal distribution. It shows that the data set is not normally distributed. The main departure occurs at the two highest values, which are also highlighted in previous graphs.

Some graphs are designed for spatial data. Figure 9, for example, shows a plot of spatial data values by raising a bar at each point location so that the height of the bar is proportionate to its value. This kind of plot allows the user to see the general trends among the data values in both the x-dimension (east-west) and y-dimension (north-south).

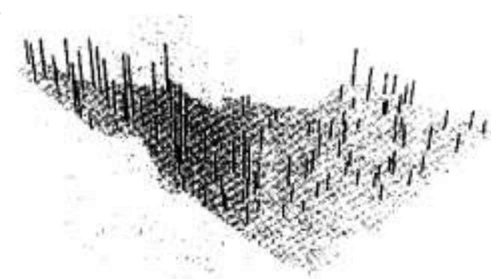


Fig.9 : A 3–D plot showing annual precipitation at 105 weather stations in Idaho. A north-to-south decreasing trend is apparent in the plot.

Dynamic Graphics

When graphs are displayed in multiple and dynamically linked windows, they become dynamic graphs. We can directly manipulate data points in dynamic graphs. For example, we can pose a query in one windows and get the response in other windows, all in the same visual field. By viewing selected data points highlighted in multiple windows, we can hypothesize any patterns or relationships that may exist in the data. This is why multiple linked views have been described as the optimal framework for posing queries about data (Buja et al. 1996).

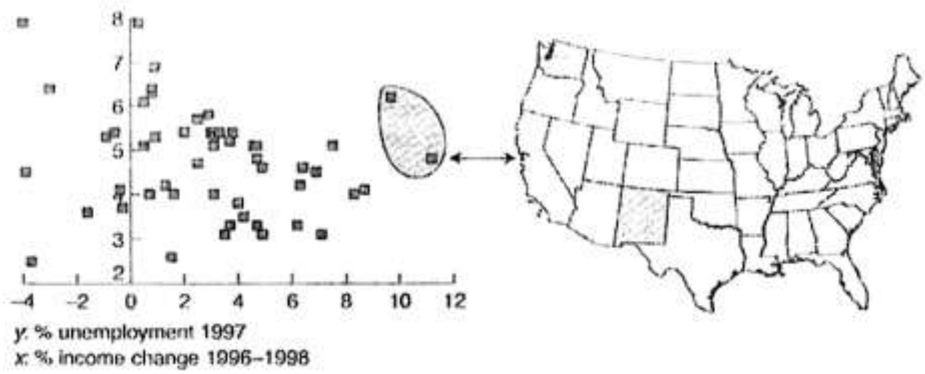


Fig. 10 : The scatterplot on the left is dynamically linked to the map on the right. The "brushing" of two data points in the scatterplot highlights the corresponding states (Washington and New Mexico) on the map.

A common method for manipulating dynamic graphs is brushing, which allows the user to graphically select a subset of points from a scatter plot and views related data points in other graphics (Backer and Cleveland, 1987). Brushing can be extended to maps (Monmonier 1989). Figure 10 illustrates a brushing example that links a scatter plot and a map. May GIS packages including ArcGIS have implemented brushing in the graphical user interface?

Q.2. Explain the term 'Attribute Data Query' with its various aspects.

(A) Attribute Data Query

Attribute data query retrieves a data subset by working with attribute data. The selected data subset can be simultaneously examined in the table, displayed in charts, and linked to the highlighted features in the map. The selected data subset can also be saved for further processing.

Attribute data query requires the use of expressions, which must be interpretable by a GIS of a database management system. The structure of these expressions varies from one system to another, although the general concept is the same. ArcGIS, for example, uses SQL (Structured Query Language) for query expressions

SQL (Structured Query Language)

SQL is a data query language designed for relational databases. IBM developed SQL in the 1970s, and many commercial database management systems such as Oracle. Informix, DB2, Access, and Microsoft SQL Server have since adopted the query language. A new development is to extend SQL to object-oriented database management systems and to spatial data (Shekhar and Chawla 2003).

To use SQL to access a database, we must follow the structure (i.e., syntax) of the query language. The basic syntax of SQL, with the keywords in italic, is

select < attribute list >
from < relation >
where < condition >

The select keyword selects field(s) from the database the from keyword selects table(s) from the database, and the Where keyword specifies the condition or criterion for data query. The following shows three examples of using SQL to query the tables in Figure 11. The Parcel table has the fields PIN (string type), Sale_date (date type), Acres (double type). Zone_code (integer type), and Zoning (string type), with the data type in parentheses. The Owner table has the fields PIN (string type) and Owner_name (string type).

PIN	Owner_name
P101	Wang
P101	Chang
P102	Smith
P102	Jones
P103	Costello
P104	Smith

Relation 1: Owner

PIN	Sale_date	Acres	Zone_code	Zoning
P101	1-10-98	1.0	1	Residential
P102	10-6-68	3.0	2	Commercial
P103	3-7-97	2.5	2	Commercial
P104	7-30-78	1.0	1	Residential

Relation 2: Parcel

Fig. 11: PIN (parcel ID number) relates the Owner and Parcel tables and allows the use of SQL with both tables.

Query Expressions

Query expressions, or the where conditions, consist of Boolean expressions and connectors. A simpie **Boolean expression** contains two operands and a logical operator. For example, Parcel. PIN = 'P101' is an expression in which PIN and P101 are operands and = is a logical operator. In this example, PIN is the name of a field, P101 is the field value used in the query, and the expression selects the record that has the PIN value of P101. Operands may be a field, a number, or a string. Logical operators may be equal to (=), greater than (>), less than (<), greater than or equal to (> =), less than or equal to (< =), or not equal to (< >).

Boolean expressions may contain calculations that involve operands and the arithmetic operators +, –, X, and /. Suppose length is a field measured in feet. We can use the expression, "length" X 0.3048 > 100, to find those records that have the length value of greater than 100 meters. Longer calculations, such as "length" X 0.3048 – 50 > 100, evaluate the X and /

operators first from left to right and then the + and – operators. We can use parentheses to change the order of evaluation. For example, to subtract 50 from length before multiplication by 0.3048, we can use the following expression : (“length” – 50) x 0.3048 > 100.

Type of Operation

Attribute data query begins with a complete data set. A basic query operation is to select a subset and divide the data set into two groups: one containing selected records and the other unselected records. Given a selected data subset, three types of operations can act on it: add more records to the subset, remove records from the subset, and select a smaller subset (Figure 12). Operations can also be performed between the selected and unselected subsets. We can switch between the selected and the unselected subsets, or we can clear the selection by bringing back all records.

These different types of operations allow greater flexibility in data query. For example, instead of using an expression of Parcel. Acres > 2 AND Parcel.Zone_code = 2, we can first use Parcel.Acres > 2 to select a subset and then use Parcel.Zone_code = 2 to select a subset from the previously selected subset. Although this example may be trivial, the combination of query expressions and operations can be quite useful for examining various data subsets in data exploration.

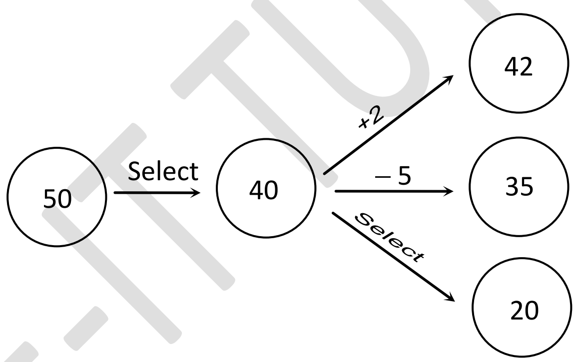


Fig. 12 : Three types of operation may be performed on the selected of 40 records; add more records to the subset (+2), remove records from the subset (–5), or select a smaller subset (20).

Q.3. Explain how an attribute query is executed on a relational GIS database.

(A) Relational Database Query

Relational database query works with a relational database, which may consist of many separate but interrelated tables. A query of a table in a relational database not only selects a data subset in the table but also selects records related to the subset in other tables. This feature is desirable in data exploration because it allows the user to examine related data characteristics from multiple linked tables.

To use a relational database, we must be familiar with the overall structure of the database, the designation of keys in relating tables, and a data dictionary listing and describing the fields in each table. For data query involving two or more tables, we can choose to either join or relate the tables. A join operation combines attribute data from two or more tables into a single table. A relate operation dynamically links the tables but keeps the tables separate. When a record in one table is selected, the link will automatically select and highlight the corresponding record or records in the related tables. An important consideration in choosing a join or relate operation is the type of data relationship between tables. A join operation is appropriate for the one–to–one or many–to–one relationship but inappropriate for the one–to–many or many–to–many relationship. A relate operation, on the other hand, can be used with all four types of relationships.

Table : A Data Set for Query Operation Examples

Cost	Soiltype	Area	Cost	Soiltype	Area
1	Ns1	500	6	Tn4	300
2	Ns1	500	7	Tn4	200
3	Ns1	400	8	N3	200
4	Tn4	400	9	N3	100
5	Tn4	300	10	N3	100

Q.4. Explain the term 'Spatial Data Query' with all its aspects.

(A) Spatial Data Query

Spatial data query refers to the process of retrieving a data subset from a layer by working directly with features. We may select features using a cursor, a graphic, or the spatial relationship between features. As the geographic interface to the database, spatial data query complements attribute data query in data exploration.

Similar to attribute data query, the results spatial data query can be simultaneously inspected in the map, linked to the highlighted records in the table, and displayed in charts. They can also be saved as a new data set for further processing.

Feature Selection by Cursor

The simplest spatial data query is to select a feature by pointing at it or to select features by dragging a box around them.

Feature Selection by Graphic

This query method uses a graphic such as a circle, a box, a line, or a polygon to select features that fall inside or are intersected by the graphic object (Figure 13). We can draw the graphic for selection by using the mouse pointer. Examples of query by graphic include selecting restaurants within a 1-mile radius of a hotel, selecting land parcels that intersect a proposed highway, and finding owners of land parcels within a proposed nature reserve.

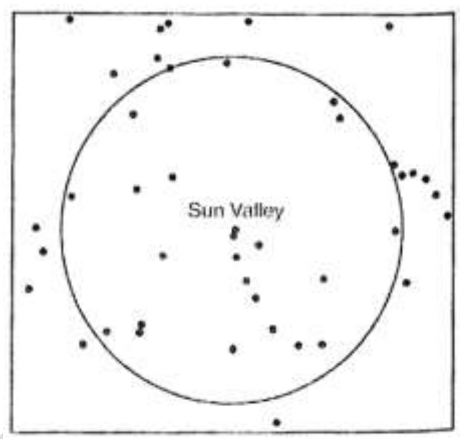


Fig. 13: Select features by a circle centered at Sun Valley

Feature Selection by Spatial Relationship

This query method selects features based on their spatial relationships to other features. Features to be selected may be in the same layer as features for selection. Or, more commonly, they are in different layers. An example of the first type of query is to find roadside rest areas within a radius of 50 miles of a selected rest area, in this case, features to be selected and for selection are in the same layer. An example of the second type of query is to find rest areas within each county. Two layers are required for this query one layer showing county boundaries and the other roadside rest areas.

Spatial relationships used for query include the following :

- **Containment** – selects features that fall completely within features for selection. Examples include finding schools within a selected county, and finding state parks within a selected state.

- **Intersect** – selects features that intersect features for selection. Examples include selecting land parcels that intersect a proposed road, and finding urban areas that intersect an active fault line.

- **Proximity**—selects features that are within a specified distance of features for selection. Examples include finding state parks within 10 miles of an interstate highway, and finding pet shops within 1 mile of selected streets. If features to be selected and features for selection share common boundaries and if the specified distance is 0, then proximity becomes adjacency. Examples of spatial adjacency include selecting land parcels that are adjacent to a flood zone, and finding vacant lots that are adjacent to a new theme park.

Combining Attribute and Spatial Data Queries :

So far we have approached data exploration through attribute data query or spatial data query. In many cases data exploration requires both types of queries. For example, both are needed to find gas stations that are within 1 mile of a freeway exit in southern. California and have an annual revenue exceeding $2 million each. Assuming that the layers of gas stations and freeway exits are available, there are at least two ways to answer the question.

1. Locate all freeway exits in the study area, and draw a circle around each exit with a 1 mile radius. Select gas stations within the circles through spatial data query. Then use attribute data query to find gas stations that have annual revenues exceeding $2 million.

2. Locate all gas stations in the study area, and select those stations with annual revenues exceeding $2 million through attribute data query. Next, use spatial data query to narrow the selection of gas stations to those within 1 mile of a freeway exit.

The first option queries spatial data and then attribute data. The process is reversed with the second option. Assuming that there are many more gas stations than freeway exits, the first option may be a better option, especially if the gas station map must be linked to other attribute tables for getting the revenue data.

The Combination Of spatial and attribute data queries opens wide the possibilities of data exploration. Some GIS users might even consider this kind of data exploration to be data analysis because that is what they need to do to solve most of their routine tasks.

Q.5. Explain the term 'Raster Data Query' with all its aspects.

(A) Raster Data Query

Although the concept and even some methods for data query are basically the same for both raster data and vector data, there are enough practical differences to warrant a separate section on raster data query.

Query by Cell Value

The cell value in a raster typically represents a specific attribute value (e.g.. land-use type, elevation value, etc.) at the cell location. Therefore, the operand in raster data query

is the raster itself rather than a field as in the case of vector data query. This is illustrated in the following examples.

A raster data query uses a Boolean statement to separate cells that satisfy the query statement from cells that do not. The expression, [road] = 1, queries a road raster that has the cell value of 1. The Operand [road] refers to the raster and the operand 1 refers to a cell value, which may represent the interstate category. This next expression, [elevation] > 1243.26, queries a floating-point elevation raster that has the cell value greater than 1243.26. Again the operand [elevation] refers to the raster itself. Because a floating-point elevation raster contains continuous values, querying a specific value is not likely to find any cell in the raster.

Raster data query can also use the Boolean Connectors of AND, OR, and NOT to string together separate expressions. A compound statement with separate expressions usually applies to multiple rasters, which may be integer, or floating point, or a mix of both types. For example, the statement, ([slope] = 2) AND ([aspect] = 1), selects cells that have the value of 2 (e.g., 10-20% slope) in the slope raster, and 1 (e.g., north aspect) in the aspect

raster (Figure 14). Those cells that satisfy the statement have cell value of 1 on the output, while other cells value of 0.

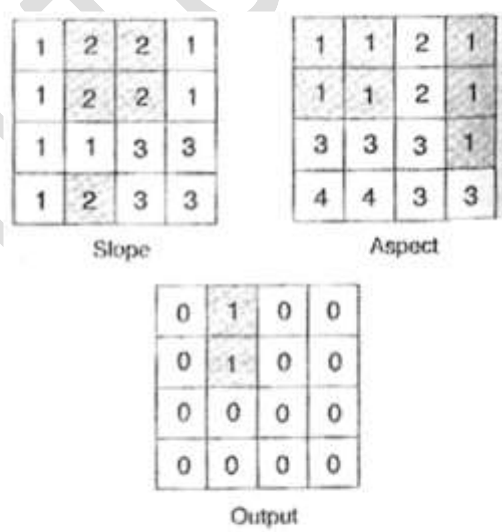


Fig. 14: Raster data query involving two rasters: slope = 2 and aspect = 1.
Selected cells are coded 1 and others 0 in the output raster.

Querying multiple rasters directly is unique to raster data. For vector data, all attributes to be used in a compound expression must be from a table or a joint attribute table. Another difference is that a GIS package such as ArcGIS has dialogs specifically designed for vector data query but does not have them for raster data query. The user interface for raster data query is often mixed with raster data analysis.

Query by Select Features

We can query a raster by using features such as points, circles, boxes, or polygons. The query returns an output raster with values tor cells that correspond to the point locations or fall within the features for selection. Other cells on the output carry no data. Again, this type of raster data query shares the same user interface as data analysis.

Q.6. Explain Geographic Visualization and its various techniques.

(A)

(a) Data Classification :

Data classification can be a tool for data exploration, especially if the classification is based on descriptive statistics. Suppose we want to explore rates of unemployment by state in the United States. To get a preliminary look at the data, we may place rates of unemployment into classes of above and below the national average (Figure 15(a)). Although generalized, the map divides the country into contiguous regions, which may suggest some regional factors for explaining unemployment.

To isolate those states dial arr way above or below the national average, we can classify rates of unemployment by using the mean and standard deviation method (Figure 15(b)), We can now focus our attention on states that are, for example, more than one standard deviation above the mean.

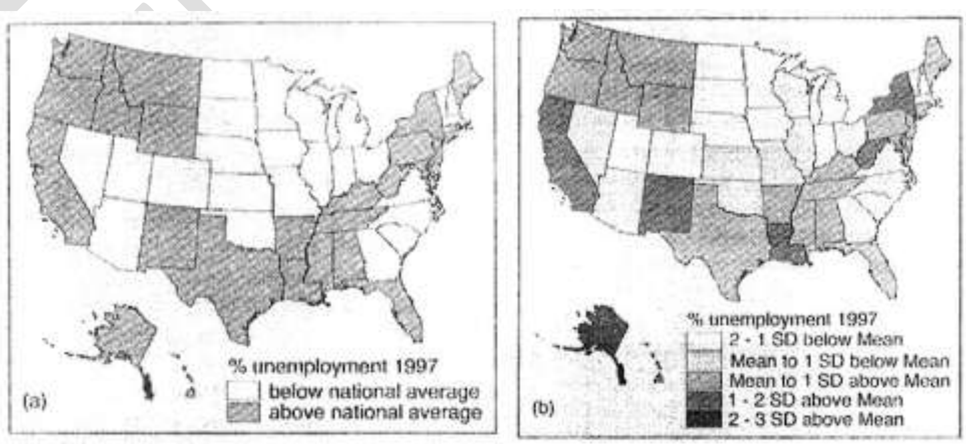


Fig. 15 : Two classification schemes : above or below the national average (a), and mean and standard deviation (SD) (b).

Classified maps can he linked with tables, graphs, and Statistics for more data exploration activities (Egbert and Slocum 1992). Pot example, we can link the maps in Figure 15 with a table showing percent change in median household income and find out whether states that have lower unemployment rates tend to have higher rates of income growth, and versa.

(b) Spatial Aggregation

Spatial aggregation is functionally similar to data classification except that it groups data spatially. Figure 16, shows percent population change in the United States by state and by region. Used by the U.S. Census Bureau for data collection, regions are spatial aggregates of states. As shown in 16(b), a map by region gives more general view of population growth in the country than a map by state does. Other geographic levels used by the U.S. Census Bureau are county, census tract, block group, and block. Because these levels of geographic units form a hierarchical order, we can explore the effect of spatial scaling by examining data at different spatial scales.

If distance is the primary factor in a study, we can aggregate spatial data by distance measures from points, lines, or areas. An urban area, for example, may be aggregated into distance zones away from the city center or from its streets (Batty and Xie 1994). Unlike the geography of census, these distance zones require additional data processing such as buffering and areal interpolation.

Spatial aggregation for raster data means aggregating cells of the input raster to produce a coarser-resolution raster. For example, we can aggregate cells of a raster by a factor of 3. Each cell in the output raster corresponds to a 3-by-3 matrix in the input raster, and the cell value is a computed statistic such as mean, median, minimum, maximum, or sum from the nine input cell values.

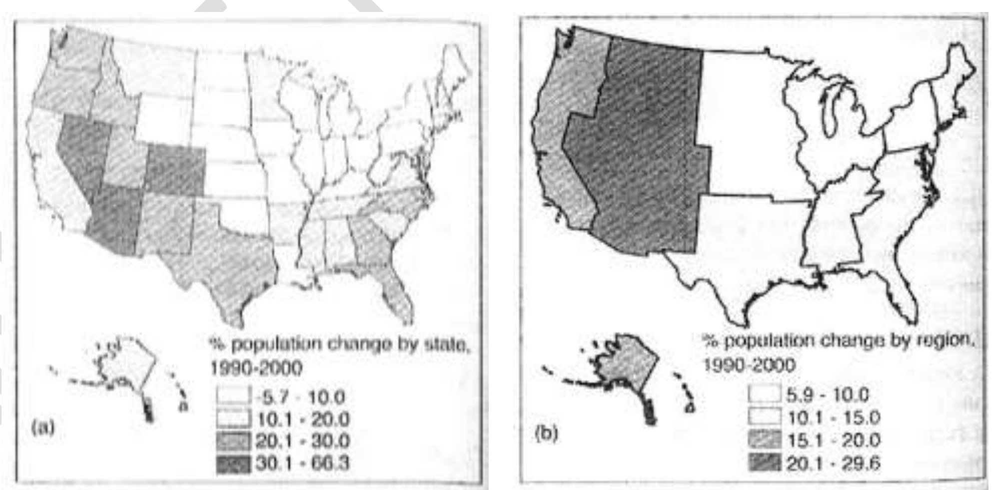


Fig.16 : Two levels of spatial aggregation : by state (a), and by region (b)

(c) Map Comparison

Map comparison can help a GIS user sort out the relationship between different maps. For example, the display of wildlife locations on a vegetation layer may reveal the association between the wildlife species and the distribution of vegetation covers.

If the maps to be compared consist of only point or line features, they can be coded in different colors and superimposed on one another in a single view. But this process becomes difficult if they include polygon features or raster data. One option is to use transparency as a visual variable. A semitransparent layer allows another layer to show through. For example, to compare two raster layers, we can display one layer in a color scheme and the other in semitransparent shades of gray. The gray shades simply darken the color symbols and do not produce confusing color mixtures. Another example is to use transparency for displaying temporal changes such as land cover change between 1990 and 2000. Because one layer is semitransparent, we can follow the areal extent of a land cover type from both years. But it is difficult to apply transparency to more than two layers.

There are three other options for comparing polygon or raster layers. The first option is to place all polygon and raster layers, along with other point and line layers, onto the screen but to turn on and off polygon and raster layers so that only one of them is viewed at a time. Used by many websites for interactive mapping, this option is designed for casual users.

UNIT 5

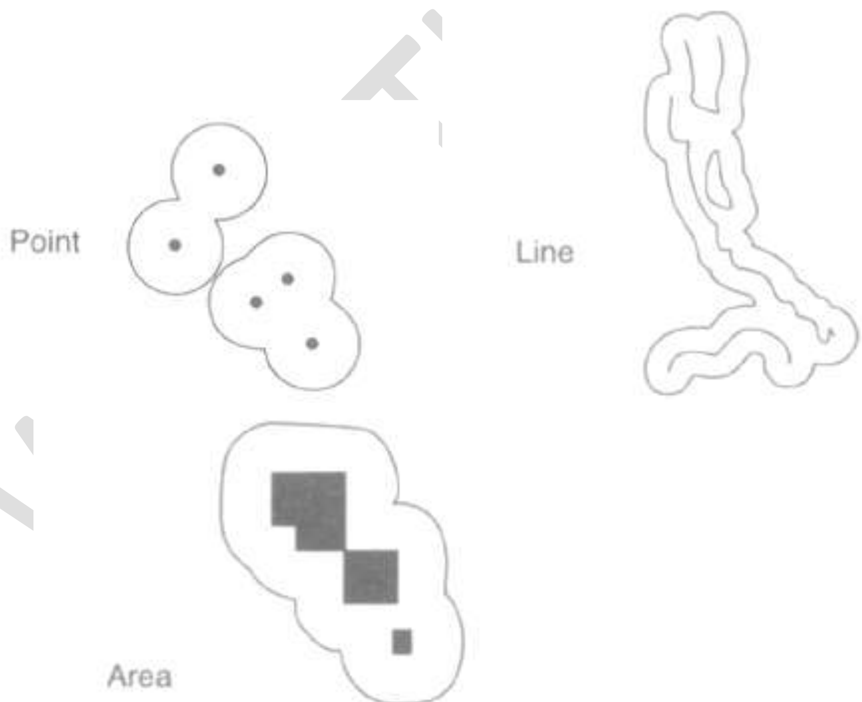
Q.1 Explain Vector Data Analysis

(A) The vector data model uses points and their x-, y-coordinates to construct spatial features of points, lines, and polygons. Therefore vector data analysis uses the geometric objects of point, line, and polygon. And the accuracy of analysis results depends on the accuracy of these objects in terms of location and shape. Because vector data may be topology-based or non topological, topology can also be a factor for some vector data analyses such as buffering and overlay.

A number of analytical tools such as Union and Intersect also appear as editing tools. Although the terms are the same, they perform different functions. As overlay tools, Union and Intersect work with both spatial and attribute data. But as editing tools, they only work with spatial data.

Q.2 Explain Buffering

(A) Based on the concept of proximity, buffering creates two areas: one area that is within a specified distance of select features and the other area that is beyond. The area that is within the specified distance is called the buffer zone. Features for buffering may be points, lines, or areas Buffering around points creates circular buffer zones. Buffering around lines creates a series of elongated buffer zones. And buffering around polygons creates buffer zones that extend outward from the polygon boundaries.



Variations in Buffering

The buffer distance or buffer size does not have to be constant; it can vary according to the values of a given field (Figure 2). For example, the width of the riparian buffer can vary depending on its expected function and the intensity of adjacent land use.

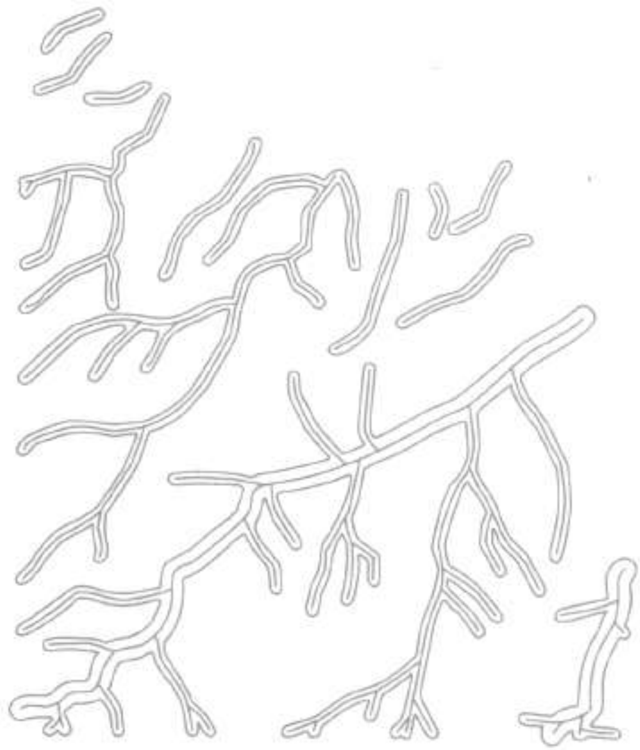


Figure 2
Buffering with different buffer distances

A feature may have more than one buffer zone. As an example, a nuclear power plant may be buffered with distances of 5, 10, 15, and 20 miles, thus forming multiple rings around the plant (Figure 3). These buffer zones, although spaced equally from the plant, are not equal in area. The second ring from the plant in fact covers an area about three times larger than the first ring. One must consider this area difference if the buffer zones are part of an evacuation plan.

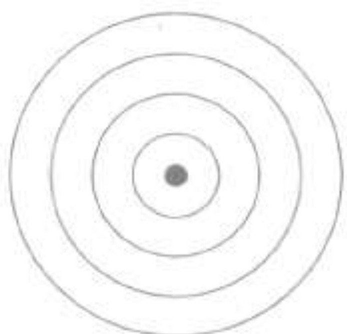


Figure 3 Buffering with four rings.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

Q.3 Applications of Buffering

(A) Buffering creates a buffer zone data set, which sets the buffering operation apart from the use of proximity measures for spatial data query Spatial data query using the proximity relationship can select spatial features that are located within a certain distance of other features but cannot create a buffer zone data set.

A buffer zone is often treated as a protection zone and is used for planning or regulatory purposes:

- A city ordinance may stipulate that no liquor stores or pornographic shops shall be within 1000 feet of a school or a church.
- Government regulations may set 2-mile buffer zones along streams to minimize sedimentation from logging operations.
- A national forest may restrict oil and gas well drilling within 500 feet of roads or highways.

Q.4 Explain what is Overlay and its types

(A) An overlay operation combines the geometries and attributes of two feature layers to create the output. The geometry of the output represents the geometric intersection of features from the input layers.

Figure 4 illustrates an overlay operation with two polygon layers. Each feature on the output contains a combination of attributes from the input layers, and this combination differs from its neighbors.

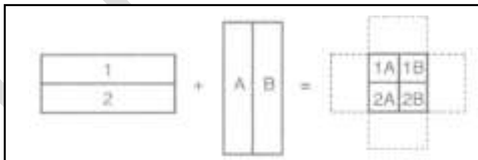


Figure 4

Overlay combines the geometries and attributes from two layers into a single layer. The dashed lines are for illustration only and are not included in the output.

There are two groups of overlay operations. The first group uses two polygon layers as inputs. The second group uses one polygon layer and another layer, which may contain points or lines.

Overlay operations can therefore be classified by feature type into point-in-polygon, line-in-polygon, and polygon-on-polygon.

To distinguish the layers in the following discussion, the layer that may be a point, line, or polygon layer is called the input layer, and the layer that is a polygon layer is called the overlay layer.

In a **point-in-polygon overlay** operation, the same point features in the input layer are included in the output but each point is assigned with attributes of the polygon within which it falls (Figure 5). For example, a point-in-polygon overlay can find the association between wildlife locations and vegetation types.

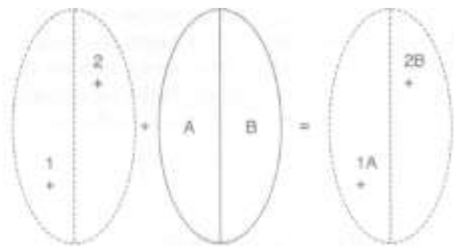


Figure 5

Point-in-polygon overlay. The input is a point layer. The output is also a point layer but has attribute data from the polygon layer.

In a **line-in-polygon overlay** operation, the output contains the same line features as in the input layer but each line feature is dissected by the polygon boundaries on the overlay layer (Figure 6). Thus the output has more line segments than does the input layer. Each line segment on the output combines attributes from the input layer and the underlying polygon. For example, a line-in-polygon overlay can find soil data for a proposed road. The input layer includes the proposed road. The overlay layer contains soil polygons. And the output shows a dissected proposed road, each road segment having a different set of soil data from its adjacent segments.

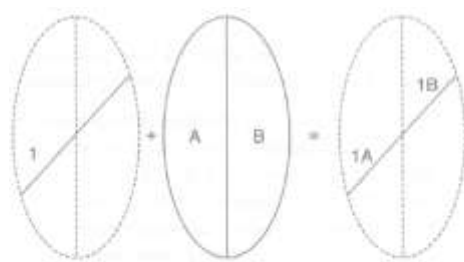


Figure 6

Line-in-polygon overlay. The input is a line layer. The output is also a line layer. But the output differs from the input in two aspects: the line is broken into two segments, and the line segments have attribute data from the polygon layer.

The most common overlay operation is polygon-on-polygon, involving two polygon layers. The output combines the polygon boundaries from the input and overlay layers to create a new set of polygons (Figure 7). Each new polygon carries attributes from both layers, and these attributes differ from those of adjacent polygons. For example, a polygon-on-polygon overlay can analyze the association between elevation zones and vegetation types.

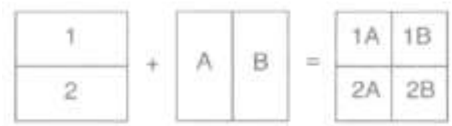


Figure 7

Polygon-on-polygon overlay. In the illustration, the two layers for overlay have the same area extent. The output combines the geometries and attributes from the two layers into a single polygon layer.

Q.5 Explain Overlay methods?

(A) all overlay methods are based on the Boolean connectors AND, OR, and XOR. An overlay operation is called Intersect if it uses the AND connector.

- An overlay operation is called Union if it uses the OR connector.
- An overlay operation that uses the XOR connector is called Symmetrical Difference or Difference.
- And an overlay operation is called Identity or Minus if it uses the following expression: [(input layer) AND (identity layer)] OR (input layer).

Union preserves all features from the inputs (Figure 8). The area extent of the output combines the area extents of both input layers. Union requires that both input layers be polygon layers.

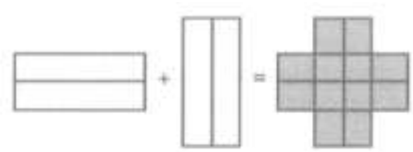


Figure 8
The Union method keeps all areas of the two input layers in the output.

Intersect preserves only those features that fall within the area extent common to the inputs (Figure 9). The input layers may contain different feature types, although in most cases, one of them (the input layer) is a point, line, or polygon layer and the other (the overlay layer) is a polygon layer. Intersect is often a preferred method of overlay because any feature on its output has attribute data from both of its inputs.

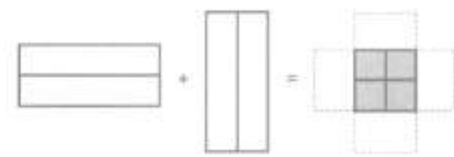


Figure 9
The Intersect method preserves only the area common to the two input layers in the output.

Symmetrical Difference preserves features that fall within the area extent that is common to only one of the inputs (Figure 12.11). In other words, Symmetrical Difference is opposite to Intersect in terms of the output's area extent. Symmetrical Difference requires that both input layers be polygon layers.

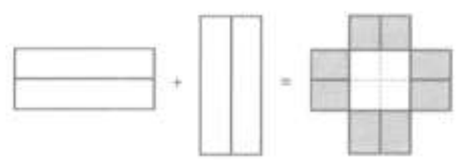


Figure 10
The Symmetrical Difference method preserves areas common to only one of the input layers in the output.

Identity preserves only features that fall within the area extent of the layer defined as the input layer (Figure 12.12). The other layer is called the identity layer. The input layer may contain points, lines, or polygons, and the identity layer is a polygon layer.

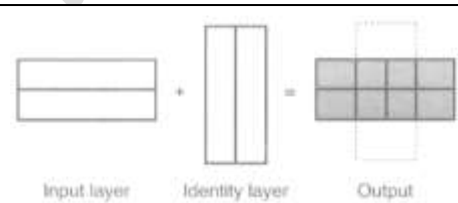


Figure 11
The Identity method produces an output that has the same extent as the input layer. But the output includes the geometry and attribute data from the identity layer.

Q.6. What is Overlay of Shapefiles and what is its common error(silvers)

(A) Unlike the coverage model, both shapefile and geodatabase allow polygons to have multiple components, which may also overlap with one another. This means that overlay operations can actually be applied to a single feature layer: Union creates a new feature by combining different polygons, and Intersect creates a new feature from the area where polygons overlap. But when used with a single layer, Union and Intersect are basically editing tools for creating new features.

Many shapefile users are aware of a problem with the overlay output: the area and perimeter values are not automatically updated.

Silvers

A common error from overlaying polygon layers is slivers, very small polygons along correlated or shared boundary lines (e.g., the study area boundary) of the input layers (Figure 12). The existence of slivers often results from digitizing errors. Because of the high precision of manual digitizing or scanning, the shared boundaries on the input layers are rarely on top of one another. When the layers are overlaid, the digitized boundaries intersect to form slivers. Other causes of slivers include errors in the source map or errors in interpretation. Polygon boundaries on soil and vegetation maps are usually interpreted from field survey data, aerial photographs, and satellite images.

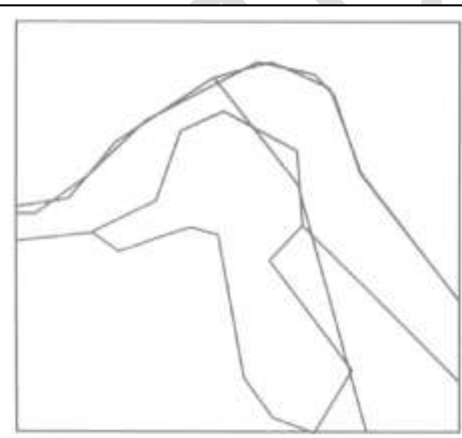


Figure 12
The top boundary has a series of slivers. These slivers are formed between the coastlines from the input layers in overlay.

Most GIS packages incorporate some kind of tolerance in overlay operations to remove slivers. ArcGIS, for example, uses the cluster tolerance, which forces points and lines to be snapped together if they fall within the specified distance (Figure 13). The cluster tolerance is either defined by the user or based on a default value.

Slivers that remain on the output of an overlay operation are those beyond the cluster tolerance. Therefore, one option to reduce the sliver problem is to increase the cluster tolerance.

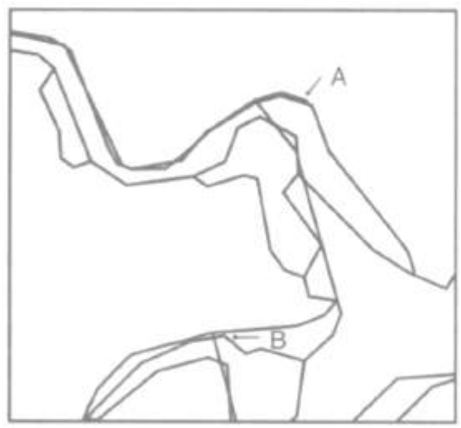


Figure 13
A cluster tolerance can remove many slivers along the top boundary (A) but can also snap lines that are not slivers (B).

Q.7 Distance Measurement

(A) Distance measurement refers to measuring straightline (euclidean) distances between features. Measurements can be made from points in a layer to points in another layer, or from each point in a layer to its nearest point or line in another layer.

In both cases, distance measures are stored in a field. A GIS package such as ArcGIS may include distance measurement as an analysis tool or as a join operation between two tables.

Distance measures can be used directly for data analysis. Chang et al. (1995), for example, use distance measures to test whether deer relocation points are closer to old-growth/clear-cut edges than random points located within the deer's relocation area. Fortney et al. (2000) use distance measures between home locations and medical providers to evaluate geographic access to health services. Distance measures can also be used as inputs to data analysis. The Gravity Model, a spatial interaction model commonly used in migration studies and business applications, uses distance measures between points as the input.

Q.8. Map Manipulation

Tools are available in a GIS package for manipulating and managing maps in a database. Like buffering and overlay, these tools are considered basic GIS tools often needed for data preprocessing and data analysis. Map manipulation is easy to follow graphically, even though terms describing the various tools may differ between GIS packages.

Dissolve aggregates features that have the same attribute value or values (Figure 14). For example, we can aggregate roads by highway number or counties by state. An important application of Dissolve is to simplify a classified polygon layer. Classification groups values of a selected attribute into classes and makes obsolete boundaries of adjacent polygons, which have different values initially but are now grouped into the same class. Dissolve can remove these unnecessary boundaries and creates a new, simpler layer with the classification results as its attribute values. Another application is to aggregate both spatial and attribute data of the input layer. For instance, to dissolve a county layer, we can choose state name as the attribute to dissolve and county population to aggregate. The output is a state layer with an attribute showing the state population (i.e., the sum of county populations).

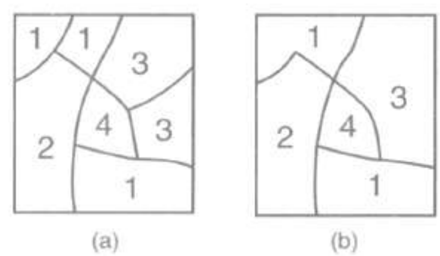


Figure 14

Dissolve removes boundaries of polygons that have the same attribute value in (a) and creates a simplified layer *(b).*

Clip creates a new layer that includes only those features of the input layer that fall within the area extent of the clip layer (Figure 15). Clip is a useful tool, for example, for cutting a map acquired elsewhere to fit a study area. The input may be a point, line, or polygon layer, but the clip layer must be a polygon layer.

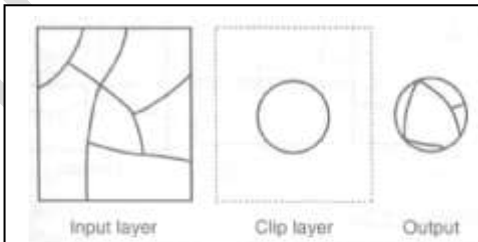


Figure 15
Clip creates an output that contains only those features of the input layer that fall within the area extent of the clip layer.

Append creates a new layer by piecing together two or more layers (Figure 12.23). For example, Append can put together a layer from four input layers, each corresponding to the area extent of a USGS 7.5-minute quadrangle. The output can then be used as a single layer for data query or display. But the boundaries separating the inputs still remain on the output and divide a feature into separate features if the feature crosses the boundary.

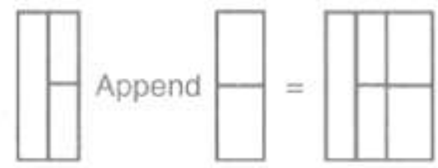


Figure 16

Append pieces together two adjacent layers into a single layer but does not remove the shared boundary between the layers.

Select creates a new layer that contains features selected from a user-defined query expression (Figure 17). For example, we can create a layer showing high-canopy closure by selecting stands that have 60 to 80 percent closure from a stand layer.

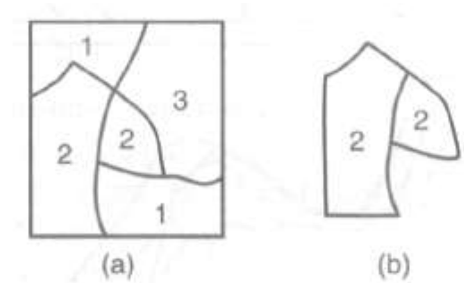


Figure 17

Select creates a new layer *(b)* with selected features from the input layer *(a).*

Eliminate creates a new layer by removing features that meet a user-defined query expression (Figure 18). For example, Eliminate can implement the minimum mapping unit concept by removing polygons that are smaller than the defined unit in a layer.

Update uses a “cut and paste” operation to replace the input layer with the update layer and its features (Figure 19). As the name suggests, Update is useful for updating an existing layer with new features in limited areas. It is a better option than redigitizing the entire map.

Erase removes from the input layer those features that fall within the area extent of the erase layer (Figure 20). Suppose a suitability analysis stipulates that potential sites cannot be within 300 meters of any stream. A stream buffer layer can be used in this case as the erase layer to remove itself from further consideration.

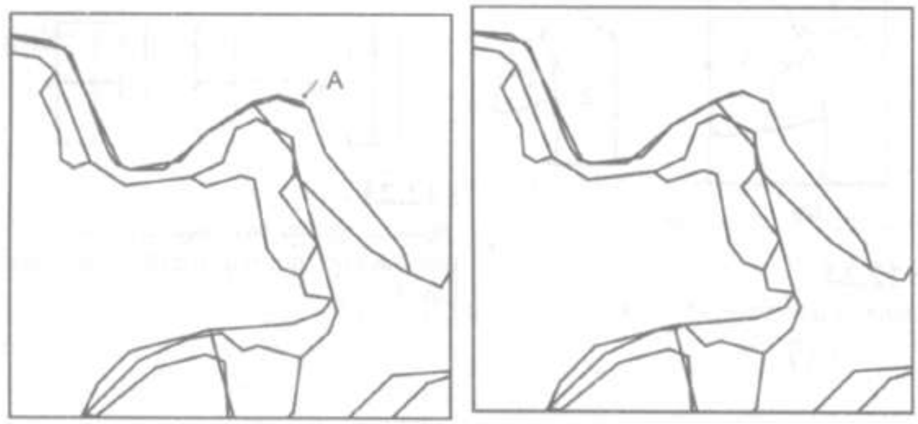


Figure 18

Eliminate removes some small slivers along the top boundary (A).

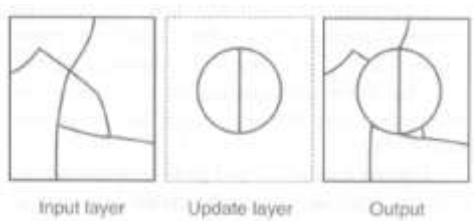


Figure 19

Update replaces the input layer with the update layer and its features.

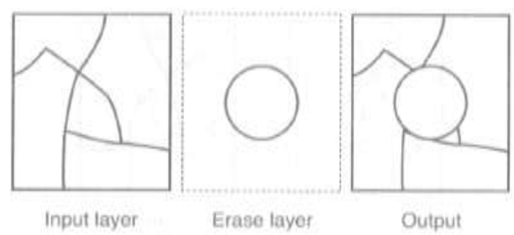


Figure 20

Erase removes features from the input layer that fall within the area extent of the erase layer.

Split divides the input layer into two or more layers (Figure 21). A split layer, which shows area subunits, is used as the template for dividing the input layer. For example, a national forest can' split a stand layer by district so that each district office can have its own layer. In ArcGIS, Clip and Split are also editing tools. These editing tools work with features rather than layers. For example, the editing tool of Split splits a line at a specified location or a polygon along a line sketch. The tool does not work with layers. It is therefore important that we understand the function of a tool before using it.

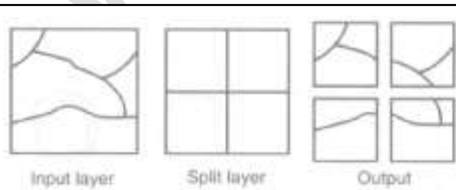


Figure 21

Split uses the geometry of the split layer to divide the input layer into four separate layers.

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

Q.9 Explain Raster data analysis and data analysis environment

(A) The raster data model uses a regular grid to cover the space and the value in each grid cell to represent the characteristic of a spatial phenomenon at the cell location. This simple data structure of a raster with fixed cell locations not only is computationally efficient, but also facilitates a large variety of data analysis operations.

raster data analysis is based on cells and rasters. Raster data analysis can be performed at the level of individual cells, or groups of cells, or cells within an entire raster. Some raster data operations use a single raster; others use two or more rasters.

Data Analysis Environment

The analysis environment refers to the area for analysis and the output cell size. The area extent for analysis may correspond to a specific raster, or an area defined by its minimum and maximum x-,y-coordinates, or a combination of rasters.

The union option uses an area extent that encompasses all input rasters, whereas the intersect option uses an area extent that is common to all input rasters.

An analysis mask can also determine the area extent for analysis. An analysis mask limits analysis to cells that do not carry the cell value of “no data.” No data differs from zero. Zero is a valid cell value, whereas no data means the absence of data.

Q.10 explain Local Operations in raster data analysis.

(A) Constituting the core of raster data analysis, local operations are cell-by-cell operations. A local operation can create a new raster from either a single input raster or multiple input rasters. The cell values of the new raster are computed by a function relating the input to the output or are assigned by a classification table.

Local Operations with a Single Raster

Given a single raster as the input, a local operation computes each cell value in the output raster as a mathematical function of the cell value in the input raster.

a large number of mathematical functions are available in a GIS package.(Figure 22)

Converting a floating-point raster to an integer raster, for example, is a simple local operation that uses the integer function to truncate the cell value at the decimal point on a cell-by-cell basis. Converting a slope raster measured in percent to one measured in degrees is also a local operation but requires a more complex mathematical expression.

In Figure 23, the expression [slope_d] = 57.296 X arctan ([slope_p]/100) can convert *slope_p* measured in percent to *slope_d* measured in degrees. Because computer packages typically use radian instead of degree in trigonometric functions, the constant 57.296 (360/2π, π = 3.1416) changes the angular measure to degrees.

Arithmetic	+, -, /, *, absolute,integer,floating-point
Logarithmic	exponentials, logarithms
Trigonometric	sin, cos, tan, arcsin, arccos, arctan
Power	square, square root, power

Figure 22

Arithmetic, logarithmic, trigonometric, and power functions for local operations.

(a)

15.2	16.0	18.5
17.8	18.3	19.6
18.0	19.1	20.2

(b)

8.64	9.09	10.48
10.09	10.37	11.09
10.20	10.81	11.42

Figure 23

A local operation can convert a slope raster from percent *(a)* to degrees (*b*).

Reclassification

A local operation, reclassification creates a new raster by classification. Reclassification is also referred to as recoding, or transforming, through lookup tables (Tomlin 1990). Two reclassification methods may be used.

- The first method is a one-to-one change, meaning that a cell value in the input raster is assigned a new value in the output raster.
- The second method assigns a new value to a range of cell values in the input raster.

Local Operations with Multiple Rasters

Local operations with multiple rasters are also referred to as compositing, overlaying, or superimposing maps (Tomlin 1990). Another common term for local operations with multiple input rasters is map algebra, a term that refers to algebraic operations with raster map layers

(Tomlin 1990; Pullar 2001). Because local operations can work with multiple rasters, they are the equivalent of vector-based overlay operations.

A greater variety of local operations have multiple input rasters than have a single input raster. Besides mathematical functions that can be used on individual rasters, other measures that are based on the cell values or their frequencies in the input rasters can also be derived and stored on the output raster. Some of these measures are, however, limited to rasters with numeric data.

Summary statistics, including maximum, minimum, range, sum, mean, median, and standard deviation, are measures that apply to rasters with numeric data. Figure 24, for example, shows a local operation that calculates the mean from three input rasters. If a cell contains no data in one of the input rasters, the cell also carries no data in the output raster by default.

Other measures that are suitable for rasters with numeric or categorical data are statistics such as majority, minority, and number of unique values. For each cell, a majority output raster tabulates the most frequent cell value among the input rasters, a minority raster tabulates the least frequent cell value, and a variety raster tabulates the number of different cell values. Figure 25, for example, shows the output with the majority statistics from three input rasters.

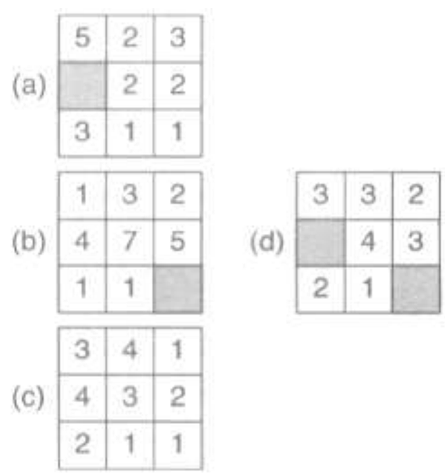


Figure 24
The cell value in (*d*) is the mean calculated from three input rasters *(a. b,* and c) in a local operation. The shaded cells have no data.

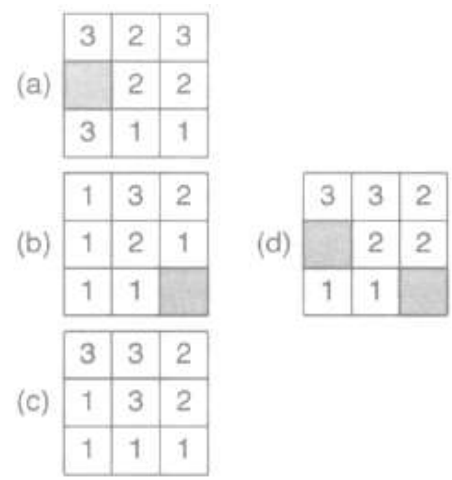


Figure 25

The cell value in *(d)* is the majority statistic derived from three input rasters *(a, b,* and c) in a local operation. The shaded cells have no data.

Q.11 explain neighborhood operation and its applications?

(A) A neighborhood operation involves a focal cell and a set of its surrounding cells. The surrounding cells are chosen for their distance and/or directional relationship to the focal cell. Common neighborhoods include rectangles, circles, annuluses, and wedges (Figure 26). A rectangle is defined by its width and height in cells, such as a 3-by-3 area centered at the focal cell. A circle extends from the focal cell with a specified radius. An annulus or doughnut-shaped neighborhood consists of the ring area between a smaller circle and a larger circle centered at the focal cell. And a wedge consists of a piece of a circle centered at the

focal cell. As shown in Figure 26, some cells are only partially covered in the defined neighborhood. The general rule is to include a cell if the center of the cell falls within the neighborhood.

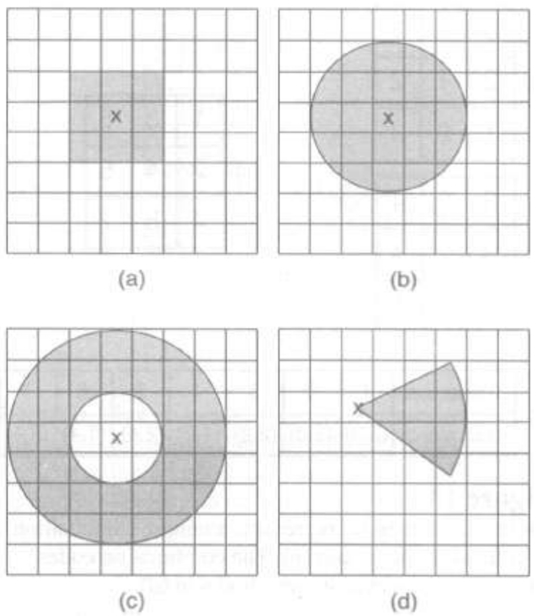


Figure 26

Four common neighborhood types: rectangle (*a*), circle(,*b*), annulus (c), and wedge *(d).* The cell marked with an x is the focal cell.

An important application of neighborhood operations is data simplification

The moving **average method**, for instance, reduces the level of cell value fluctuation in the input raster (Figure 27).

Edge enhancement, for example, can use a range filter, essentially a neighborhood operation using the **range statistic** (Figure 28). The range measures the difference between the maximum and minimum cell values within the defined neighborhood.

The opposite of edge enhancement is a smoothing operation that is based on the (Figure 29). The majority operation assigns the most frequent cell value within the neighborhood to the focal cell, thus creating a smoother raster than the original raster.

(a)

1	2	2	2	2
1	2	2	2	3
1	2	1	3	3
2	2	2	3	3
2	2	2	2	3

(b)

1.56	2.00	2.22
1.67	2.11	2.44
1.67	2.11	2.44

Figure 27

The cell values in *(b)* are the neighborhood means of the shaded cells in *(a)* using a 3-by-3 neighborhood. For example, 1.56 in the output raster is calculated from (1 + 2 + 2 + 1 + 2 + 2 + 1 + 2 + 1)/9.

(a)

200	200	110	210	210
200	200	110	210	210
150	150	100	170	170
140	140	130	160	160
140	140	130	160	160

(b)

100	110	110
100	110	110
50	70	70

Figure 28

The cell values in (*b*) are the neighborhood range statistics of the shaded cells in *(a)* using a 3-by-3 neighborhood. For example, the upper-left cell in the output raster has a cell value of 100, which is calculated from (200 — 100).

(a)

1	2	2	2	2
1	2	2	2	3
1	2	1	3	3
2	2	2	3	3
2	2	2	2	3

(b)

2	2	2
2	2	3
2	2	3

Figure 29

The cell values in (*b*) are the neighborhood majority statistics of the shaded cells in *(a)* using a 3-by-3 neighborhood. For example, the upper-left cell in the output raster has a cell value of 2 because there are five 2s and four 1s in its neighborhood.

Q.12 explain zonal operations and zonal statistics?

(A) A zonal operation works with groups of cells of same values or like features. These groups are called zones. Zones may be contiguous or noncontiguous. A contiguous zone includes cells that are spatially connected, whereas a noncontiguous zone includes separate regions of cells.

Zonal Statistics

A zonal operation may work with a single raster or two rasters. Given a single input raster, zonal operations measure the geometry of each zone in the raster, such as area, perimeter, thickness, and centroid (Figure 30). The area is the sum of the cells that fall within the zone times the cell size. The perimeter of a contiguous zone is the length of its boundary, and the perimeter of a noncontiguous zone is the sum of the length of each region. The thickness calculates the radius (in cells) of the largest circle that can be drawn within each zone. And the centroid is the geometric center of a zone located at the intersection of the major axis and the minor axis of an ellipse that best approximates the zone.

Zone	Area	Perimeter	Thickness
1	36,224	1708	77.6
2	48,268	1464	77.4

Figure 30

Thickness and centroid for two large watersheds (zones). Area is measured in square kilometers, and perimeter and thickness are measured in kilometers. The centroid of each zone is marked with an x.

Q.13 Explain physical distance measures operations

The physical distance measures the straight-line or euclidean distance, whereas the cost distance measures the cost for traversing the physical distance.

Physical distance measure operations calculate straight-line distances away from cells designated as the source cells.

For example, to get the distance between cells (1 ,1) and (3, 3) in Figure 31, we can use the following formula:

$$\text{cell size} \times \sqrt{(3-1)^2 + (3-1)^2}$$

or cell size X 2.828. If the cell size were 30 meters, the distance would be 84.84 meters.

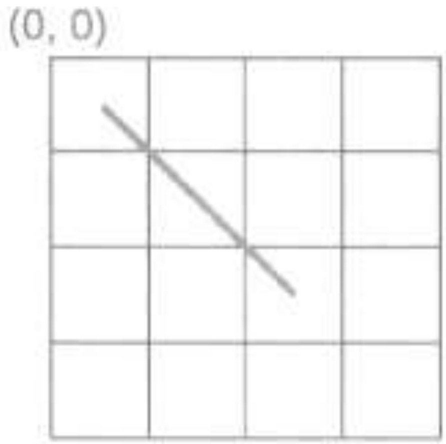


Figure 31

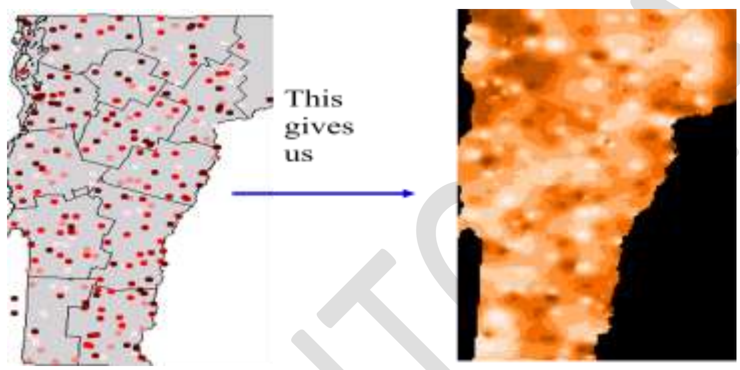
A straight-line distance is measured from a cell center to another cell center. This illustration shows the straight-line distance between cell (1,1) and cell (3,3).

UNIT 6

Q.1 What is interpolation

(A)

- Process of creating a surface based on values at isolated sample points.
- Sample points are locations where we collect data on some phenomenon and record the spatial coordinates
- We use mathematical estimation to “guess at” what the values are “in between” those points
- We can create either a raster or vector interpolated surface
- Interpolation is used because field data are expensive to collect, and can’t be collected everywhere



Q.2 Elements of Spatial Interpolation

(A) **Control Points.**

- Control Points are points with known values.
- Also called known points , sample points , or observations, control points provide the data necessary for the development of interpolator (e.g.. Mathematical equation) for spatial interpolation.
- The number and distribution of control points can greatly influence the accuracy of spatial interpolation.

Type of Spatial Interpolation.

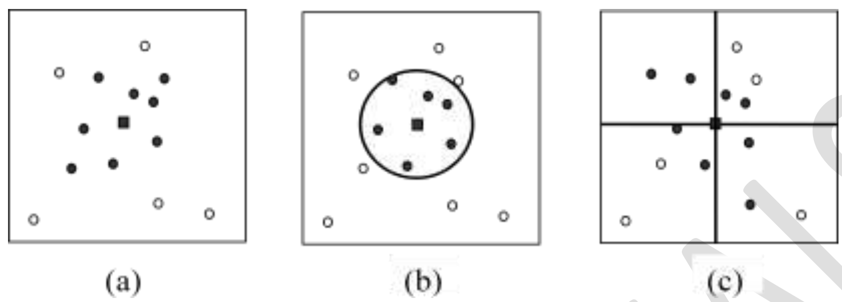
Spatial Interpolation can be grouped into :-

1. Global Interpolation:- It uses every known point available to estimate an unknown value.
2. Local Interpolation:- It uses a sample of known points to estimate an unknown value.

Similarly Spatial Interpolation can be grouped into Exact and Inexact interpolation, Stochastic and Deterministic interpolation

ADD:302 PARANJPE UDYOG BHAVAN, OPP MAHESH TUTORIALS, THANE STATION, THANE(W)
PH:8097071144/55

- **Global vs. Local**
  - A **global interpolation** method uses every known point available to estimate an unknown value.
  - A **local interpolation** method, on the other hand, uses a sample of known points to estimate an unknown value.



Three search methods for sample points: (a) find the closest points to the point to be estimated, (b) find points within a radius, and (c) find points within each of the four quadrants.

- **Exact vs. Inexact**
  - Exact interpolation predicts a value at the point location that is the same as its known value. In other words, exact interpolation generates a surface that passes through the control points. In contrast,
  - inexact interpolation or approximate interpolation predicts a value at the point location that differs from its known value.

- **Deterministic vs. Stochastic**
  - A deterministic interpolation method provides no assessment of errors with predicted values.
  - A stochastic interpolation method, on the other hand, offers assessment of prediction errors with estimated variances.

Q.3 Explain Global methods, local methods, Kriging?

(A)

A classification of spatial interpolation methods

Global		Local	
Deterministic	**Stochastic**	**Deterministic**	**Stochastic**
Trend surface (inexact)*	Regression (inexact)	Thiessen (exact) Density estimation (inexact) Inverse distance weighted (exact) Splines (exact)	Kriging (exact)

Global Methods

- **Trend Surface Models** :- An inexact method , trend surface analysis approximates points with known values with a polynomial equation. The equation or the interpolator can then be used to estimate values at other points.

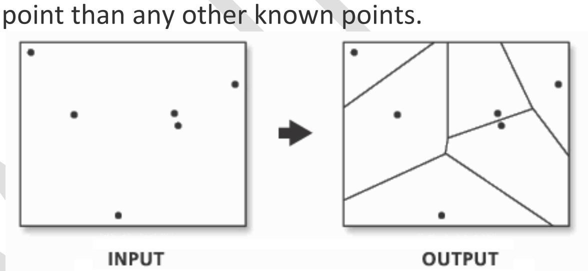
  $$Z_{x,y} = b_o + b_1 x + b_2 y$$

  where the attribute value z is a function of x and y coordinates. The b coefficients are estimated from the known points.

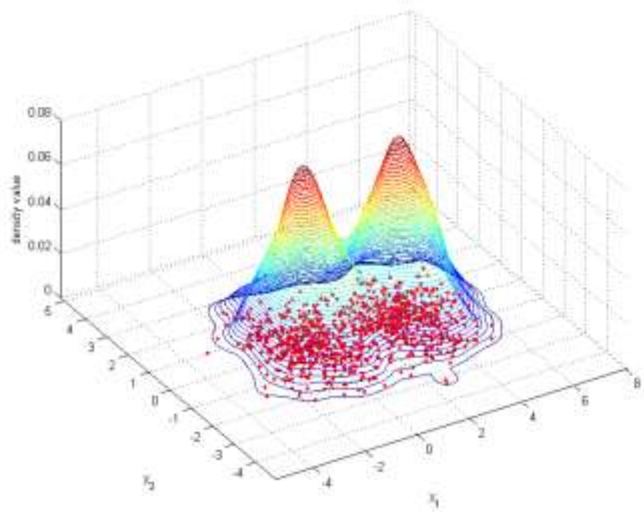
- **Regression Models** :- A regression model relates a dependent variables in a linear equation (an interpolator), which can then be used for predictions or estimation.

Local Methods

- **Thiessen Polygons**:-It assumes that any point within a polygon is closer to the polygon's known point than any other known points.

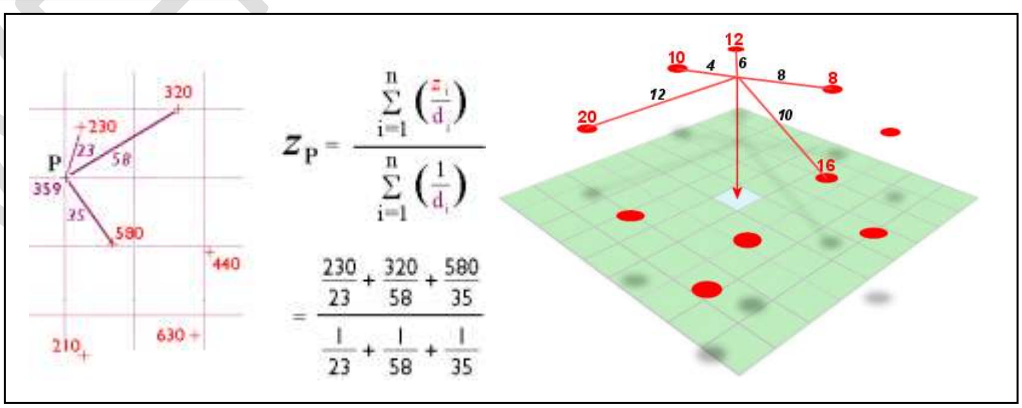


- **Density Estimation**:-Density estimation measures cell densities in a raster by using a sample of known points. There are simple and kernel density estimation methods.

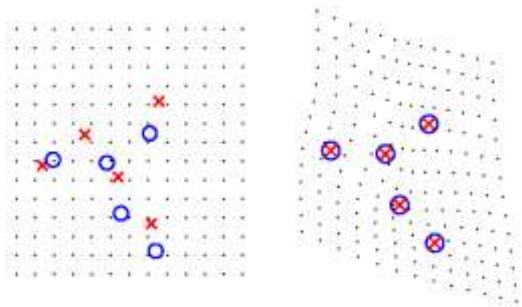


- **Inverse Distance Weighted Interpolation** :- Inverse distance weighted (IDW) interpolation is an exact method that enforces the condition that the estimated value of a point is influenced more by nearby known points than by those farther away. The general equation for the IDW method is Inverse distance weighted (IDW) interpolation is an exact method that enforces the condition that the estimated value of a point is influenced more by nearby known points than by those farther away. The general equation for the IDW method is points used in estimation, and *k* is the specified power.

$$z_0 = \frac{\sum_{i=1}^{s} z_i \frac{1}{d_i^k}}{\sum_{i=1}^{s} \frac{1}{d_i^k}}$$



- **Thin-Plate Splines** : Splines for spatial interpolation are conceptually similar to splines for line smoothing except that in spatial interpolation they apply to surfaces rather than lines. Thin-plate splines create a surface that passes through the control points and has the least possible change in slope at all points (Franke 1982). In other words, thin-plate splines fit the control points with a minimum curvature surface.



$$Q(x,y) = \sum A_i d_i^2 \log d_i + a + bx + cy$$

Where x and y are the coordinates of the point to be interpolated , $d_i^2 = (x - x_i)^2 + (y - y_i)^2$ and xi and yi are the coordinates of control point.

ThinPlateSplines:-Thin Plate Splines create a surface that passes through the control points and has the least possible changes in slope at all the points.

- **Kringing**:Kringing is a geostatistical method for spatial interpolation. Kringing differs from the interpolation methods discussed so far because kringing can assess the quality of prediction with estimated prediction errors.