UNIT-I

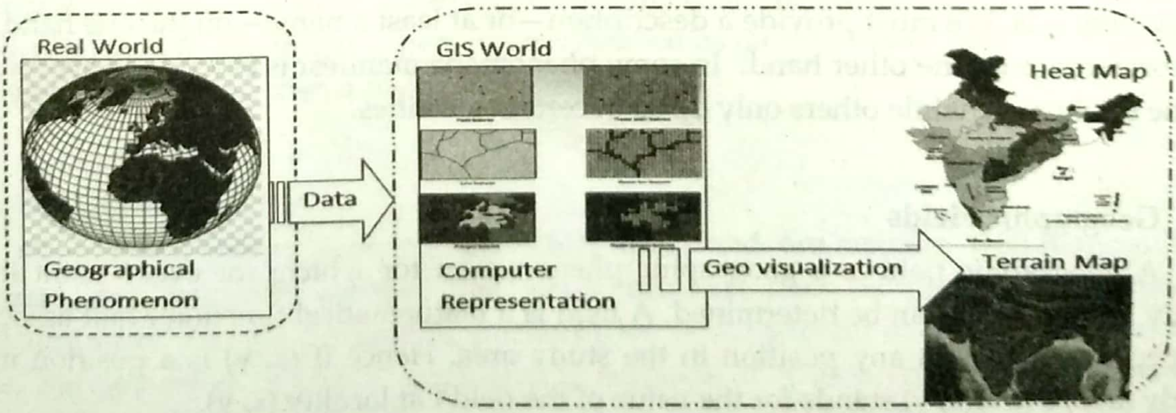
(Part – 2)

GEOGRAPHIC INFORMATION AND SPATIAL DATABASE

2.1 MODELS AND REPRESENTATIONS OF THE REAL WORLD

GIS helps to analyze and understand more about the real world processes and phenomena. Modeling is the process of producing an abstraction of the 'real world' to observe and study it easily. It is the process of representing key aspects of the real world using computer system. These representations are made up of spatial data, stored in run time memory, on media such as the hard drive of a computer. This digital representation can then be subjected to various analytical functions and computations in GIS, and the output can be visualized in different ways. Depending on the application domain of the model, it may be necessary to manipulate the data with specific techniques. Eg. to study the geology of an area, geological classification is required.

Modeling begins with the process of translating the relevant aspects of the real world into a computer representation of it is a domain of expertise. It can be done using direct observations using sensors, and digitizing (converting) the sensor output for computer usage or by indirect means: like, by making use of the output of a previous project, such as a paper map, and re-digitizing it.



Geo-visualization gives a better understanding to both, the representation of the phenomena, and the eventual output from any analysis and can use to create it from the computer representation, either on-screen, printed on paper, or both.

Given the complexity of real world phenomena, a model can by definition never be perfect. There are limitations on the amount of data that we can store, limits on the amount of detail we can capture (called as granularity of fact), and limits on the time available for a project. It is therefore possible that some facts or relationships that exist in the real world may not be discovered through our 'models'. Therefore models are defined within the limited scope of entity under consideration.

Any geographic phenomenon can usually be represented in various ways; the choice of which representation is best depends mostly on two issues. Firstly, what original, raw data (from sensors or otherwise) is available, and secondly, what sort of data manipulation is required or will be undertaken.

2.2 GEOGRAPHIC PHENOMENA

- **Defining Geographic Phenomena**

A geographic phenomenon is something of interest that :

- can be named or described,
- can be georeferenced, and
- can be assigned a time (interval) at which it is/was present.

Eg. In water management, the objects of study can be river basins, agro-ecologic units, measurements of actual evaporation, meteorological data, ground water levels, irrigation levels, water budgets and measurements of total water use. In multipurpose cadastral administration, the objects of study are different: houses, land parcels, streets of various types, land use forms, sewage canals and other forms of urban infrastructure. All of these can be named/described, geo-referenced and provided with a time interval at which each exists.

A spatial phenomenon occurs in a two or three dimension. Euclidean space can be informally defined as a model of space in which locations are represented by coordinates—(x, y) in 2D; (x, y, z) in 3D; and distance and direction can defined with geometric formulas. In the 2D case, this is known as the Euclidean plane.

- **Types of Geographic Phenomena**

In order to be able to represent a phenomenon in a GIS, it requires to state what it is, and where it is. We must provide a description—or at least a name—on the one hand, and a georeference on the other hand. In some phenomena manifest is essentially everywhere in the study area, while others only do so in certain localities.

- **Geographic Fields**

A geographic field is a geographic phenomenon for which, for every point in the study area, a value can be determined. A field is a mathematical function f that associates a specific value with any position in the study area. Hence if (x, y) is a position in the study area, then f(x, y) stands for the value of the field f at locality (x, y).

Fields can be continuous or discrete.

In a continuous field, the underlying function is assumed to be 'mathematically smooth'.

Discrete fields divide the study space in mutually exclusive, bounded parts, with all locations in one part having the same field value.

Example :

Continuous field : Air temperature, barometric pressure and elevation.

Discrete Field : population, traffic condition, land use and soil classifications

A field-based model consists of a finite collection of geographic fields : these two types of fields differ in the type of cell values. A discrete field stores cell values of the type 'integer', also called an integer raster. A continuous raster field stores cell value of type 'float', also called a 'floating point' raster.

Different kinds of data values can be use to represent a geographic 'phenomena'.

1. **Nominal data values** are values that provide a name or identifier to distinguish or classify between different values. This kind of data value is called categorical data when the values assigned are sorted according to some set of non-overlapping categories. Eg. Coding schemes for land use, soil types, ZIP Codes etc.
2. **Ordinal data values** are data values that can be put in some natural sequence but that do not allow any other type of computation. For example, temperature can be classified as "hot", "warm", "lukewarm", "chilly" or "cold".
3. **Interval data values** are quantitative, in that they allow simple forms of computation like addition and subtraction. However, interval data has no arithmetic zero value, and does not support multiplication or division. For instance, a temperature of 20º C is not twice as warm as 10º C, and thus centigrade temperatures are interval data values, not ratio data values. Time of day, calendar years, the Fahrenheit temperature scale, and pH values are all examples of interval measurements. These are values on a linear calibrated scale, but they are not relative to a true zero point in time or space.
4. **Ratio data values** allow most, if not all, forms of arithmetic computation. Rational data have a natural zero value, and multiplication and division of values are possible operators (distances measured in meters are an example). Continuous fields can be expected to have ratio data values, and hence we can interpolate them.

Nominal and categorical data values as 'qualitative' data. Interval and ratio data is known as 'quantitative' data. However, ordinal data does not seem to fit either of these data types. Often, ordinal data refers to a ranking scheme or some kind of hierarchical phenomena. Road networks, for example, are made up of motorways, main roads, and residential streets. We might expect roads classified as motorways to have more lanes and carry more traffic and than a residential street.

- **Geographic Objects**

Geographic objects populate the study area, and are usually well-distinguished, discrete, and bounded entities. The space between them is potentially 'empty' or undetermined. When a geographic phenomenon is not present everywhere in the study area, but somehow 'sparsely' populates it, we look at it as a collection of geographic objects. Such objects are usually easily distinguished and named, and their position in space is determined by a combination of one or more of the following parameters:

- Location (where is it?),
- Shape (what form is it?),

- Size (how big is it?), and
- Orientation (in which direction is it facing?).

How the GIS application uses the information about a geographic object determines which of the above four parameters is required to represent it. For example, in an automotive navigation system, all that matters about geographic objects like petrol stations is where they are. Thus, location alone is enough to describe them in this particular context, and shape, size and orientation are not necessarily relevant. In the same system, however, roads are important objects, and for these some notion of location (where does it begin and end), shape (how many lanes does it have), size (how far can one travel on it) and orientation (in which direction can one travel on it) seem to be relevant information components.

Collections of geographic objects can be interesting phenomena at a higher aggregation level: forest plots form forests, groups of parcels form suburbs, streams, brooks and rivers form a river drainage system, roads form a road network, and SST buoys form an SST sensor network. It is sometimes useful to view geo graphic phenomena at this more aggregated level and look at characteristics like coverage, connectivity, and capacity.

For example : Question like; which part of the road network is within 5 km of a fuel station? Refers coverage attribute. And; what is the shortest route between two locations via the road network? Refers connectivity attribute.

- **Boundaries**

Where shape and/or size of contiguous areas matter, the notion of boundary is used. Boundary used for geographic objects and for discrete geographic field. Location, shape and size are fully determined if we know an area's boundary, so the boundary is a good candidate for representing it. Naturally crisp boundaries are one that can be determined with almost arbitrary precision, dependent only on the data acquisition technique applied. Fuzzy boundaries contrast with crisp boundaries in that the boundary is not a precise line, but rather itself an area of transition. Crisp boundaries are more common in man-made phenomena, whereas fuzzy boundaries are more common with natural phenomena.

2.3 COMPUTER REPRESENTATIONS OF GEOGRAPHIC INFORMATION

Geographic phenomena have the characteristics of continuous functions over space. Elevation, can be measured at many locations and each location may give a different value. In order to represent such a phenomenon in computer memory, either:

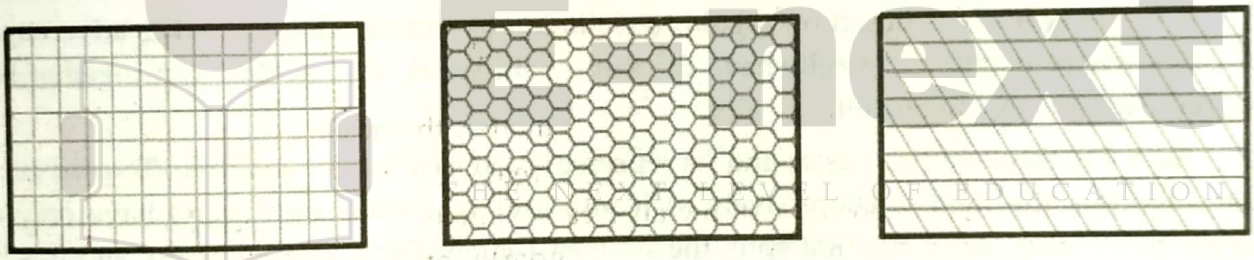
- Try to store as many (location, elevation) observation pairs as possible, or
- Try to find a symbolic representation of the elevation field function, as a formula in x and y—like ($7.8678x^2 + 29.78x - 2.48y$) or so—which can be evaluated to give us the elevation at any given (x, y) location.

The first suffers approach has a drawback that it will never be able to store all elevation values for all locations; as, there are infinitely many locations. The second approach has a drawback that we do not know just what this function should look like, and that it would be extremely difficult to derive such a function for larger areas. GIS applications typically use combination of both. A finite, but intelligently chosen set called sample locations with their elevation. This gives the elevation for those stored locations, but not for others. An interpolation function that allows to infer a reasonable elevation value for locations that are not stored. A simple and commonly used interpolation function takes the elevation value of the nearest location that is stored. A smarter interpolation functions (involving more than a single stored value), can be used as well Interpolation is made possible by a principle called spatial autocorrelation. This is a fundamental principle which refers to the fact that locations that are closer together are more likely to have similar values than locations that are far apart commonly referred to as 'Tobler's first law of Geography'.

Geographical phenomena with intrinsic continuous and/or infinite characteristics have to be represented with finite means computer memory representation for computer manipulation, and any finite representation scheme is open to errors of interpretation. To this end, fields are usually implemented with a tessellation approach, and objects with a topological vector approach.

- **Regular Tessellations**

A tessellation (or tiling) is a partitioning of space into mutually exclusive cells that together make up the complete study space. With each cell, some (thematic) value is associated to characterize that part of space. Three regular tessellation types are illustrated in Figure



Square cells hexagonal cells triangular cells.

In regular tessellations, the cells are of the same shape and size, and the field attribute value assigned to a cell is associated with the entire area occupied by the cell. The square cell tessellation is by far the most commonly used, mainly because georeferencing a cell become straightforward. Different GIS packages name these tessellations under various names, but most frequently as raster.

A raster is a set of regularly spaced (and contiguous) cells with associate (field) values. The associated values represent cell values, not point values. This means that the value for a cell is assumed to be valid for all locations within the cell.

Size of the area that a single raster cell represents is called the raster's resolution or raster grid.

The field value of a cell can be interpreted as one for the complete tessellation cell, which is discrete and/or different. Also, convenation is needed to state which value represents a cell boundary.

To improve the continuity of cell, do the following two things :

- Make the cell size smaller, so as to make the 'continuity gaps' between the cells smaller, and/or
- Assume that a cell value only represents elevation for one specific location in the

cell, and to provide a good interpolation function for all other locations that has the continuity characteristic.

The location associated with a raster cell is fixed by convention, and may be the cell centroid (mid-point) or grids left lower corner. Values for other positions than these must be computed through some form of interpolation function, which will use one or more nearby field values to compute the value at the requested position. This allows us to represent continuous, even differentiable, functions.

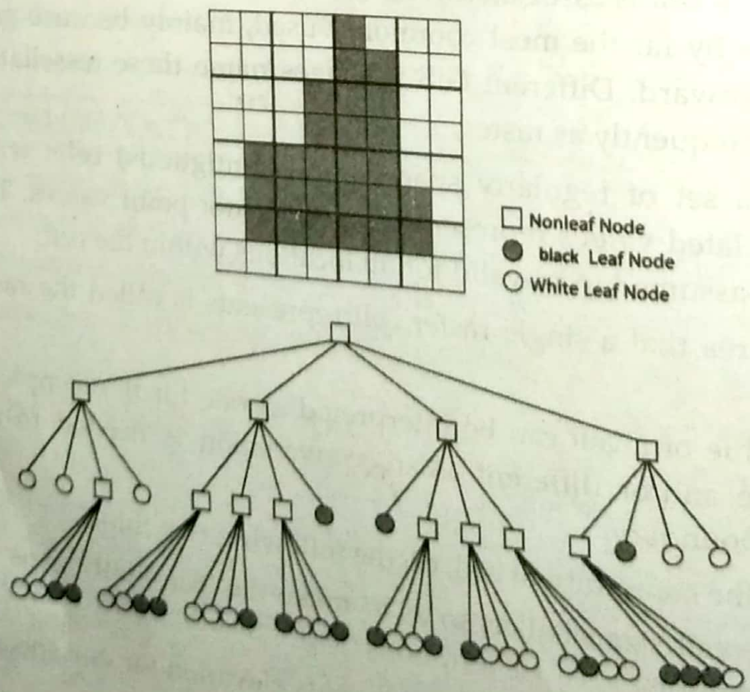
An important advantage of regular tessellations is that, using known partition space, computations specific to the partition can be applied. This results in fast calculation of algorithm. A disadvantage is that they are not adaptive to the spatial phenomenon that we want to represent i.e. the cell boundaries are both artificial and fixed: they may or may not coincide with the boundaries of the phenomena of interest.

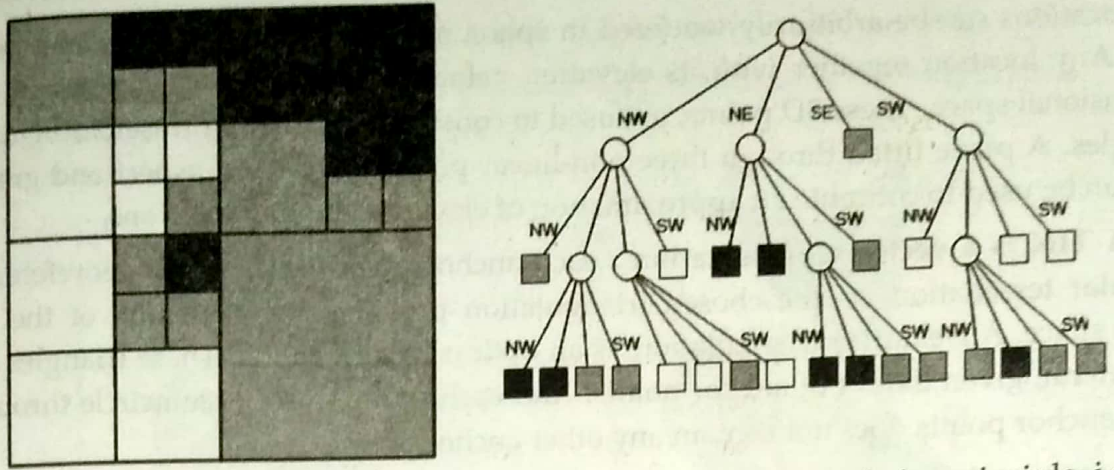
- **Irregular Tessellations**

Regular tessellations provide simple structures with simple and straightforward algorithms, but are not adaptive to the phenomena they represent. I*rregular tessellations* are partitions of space into mutually disjoint and adaptive cells of dynamic size and shape, allowing them to adapt to the spatial phenomena that they represent. Irregular tessellations are more complex than the regular ones, but they are also more adaptive, which typically leads to a reduction in the amount of memory used to store the data.

A region quadtree is based on regular tessellation of square cells, and takes advantage of cases where neighboring cells have the same field value, so that they can together be represented as one bigger cell.

An 8 × 8, three-valued raster and its representation as a region quadtree. To construct the quadtree, the field is successively split into four quadrants until parts have only a single field value. After the first split, the southeast quadrant is entirely green, and this is indicated by a green square at level two of the tree. Other quadrants had to be split further.

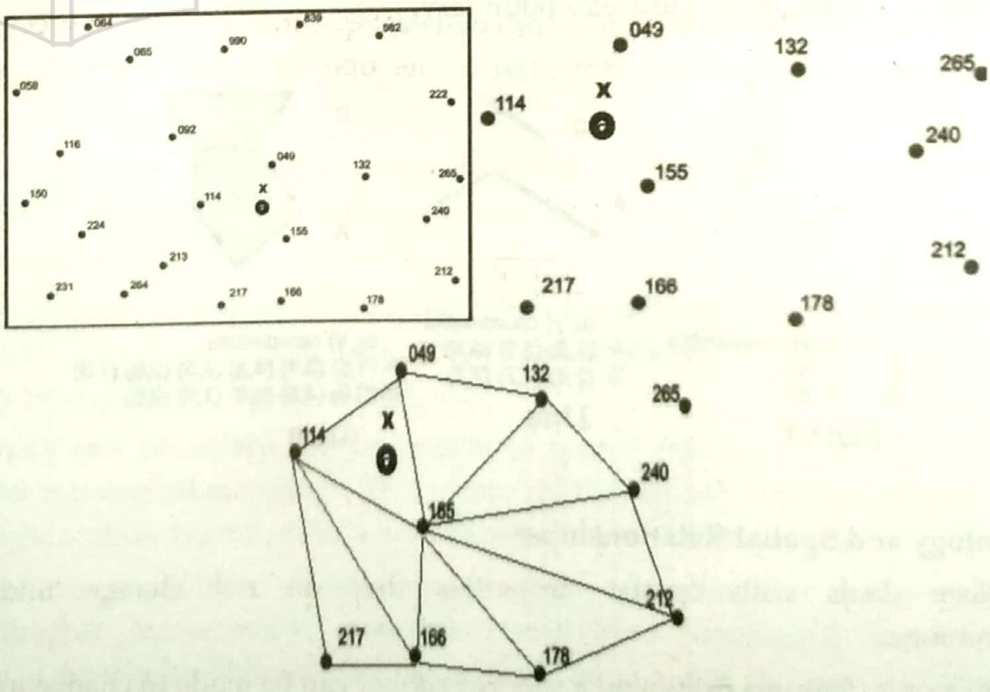




Quadtrees are adaptive because they apply the *spatial autocorrelation* principle, i.e. that locations that are near in space are likely to have similar field values. When a conglomerate of cells has the same value, they are represented together in the quad tree. The square nodes at the same level represent equal area sizes, allowing quick computation of the area associated with some field value. The top node of the tree represents the complete raster.

- **Vector Representations**

Tessellations do not explicitly store geo-references of the phenomena they represent; only provide a geo reference of the lower left corner of the raster. *Vector representations*, associate geo references with the geographic phenomena. A georeference is a coordinate pair from some geographic space, and is also known as a vector. TIN is a representation for geographic fields that can be considered a hybrid between tessellations and vector representation and is commonly used data structure in GIS software.



TIN is one of the standard implementation techniques for digital terrain models, but it can be used to represent any continuous field. It is built from a set of locations for which there is a measurement unit, like an elevation from mean sea level (MSL) or any reference.

The locations can be arbitrarily scattered in space, and are usually not on a nice regular grid. Any location together with its elevation value can be viewed as a point in three-dimensional space. These 3D points, are used to construct an irregular tessellation made of triangles. A plane fitted through three non-linear points has a fixed aspect and gradient, and can be used to compute an approximation of elevation of other locations.

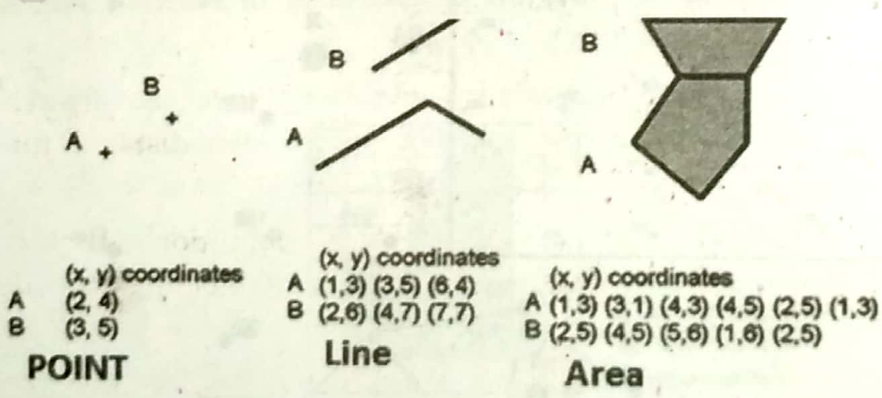
A TIN is a vector representation : each anchor point has a stored georeference or irregular tessellation, as the chosen triangulation provides a partitioning of the entire study space. A Delaunay triangulation, is an optimal triangulation. These triangles are as equilateral, given the set of anchor points. And each triangle, the circumcircle through its three anchor points does not contain any other anchor point.

Point representations

Points are defined as single coordinate pairs (x, y) in 2D, or co-ordinate triplets (x, y, z) in 3D. Points are used to represent objects that are best described as shape-less and size-less, one-dimensional features. Besides the georeference, usually attribute data is stored for each point object also called attribute or thematic data, anything that is considered relevant about the object. Eg. Tourist location may associate its relevant information about its historical data.

Line representations : Line data are used to represent one-dimensional objects such as roads, railroads, canals, rivers and power lines. For example mapping tourist information, bus, subway and streetcar routes. The two end nodes and zero or more internal nodes or vertices define a line. Other terms for 'line' that are commonly used in some GIS are polyline, arc or edge. A node or vertex is like a point. The straight parts of a line between two consecutive vertices or end nodes are called line segments. Collections of connected lines represent networks.

Area representations : Area feature is represented by collection of arc/node structure that determines a polygon as the area's boundary.



- **Topology and Spatial Relationships**

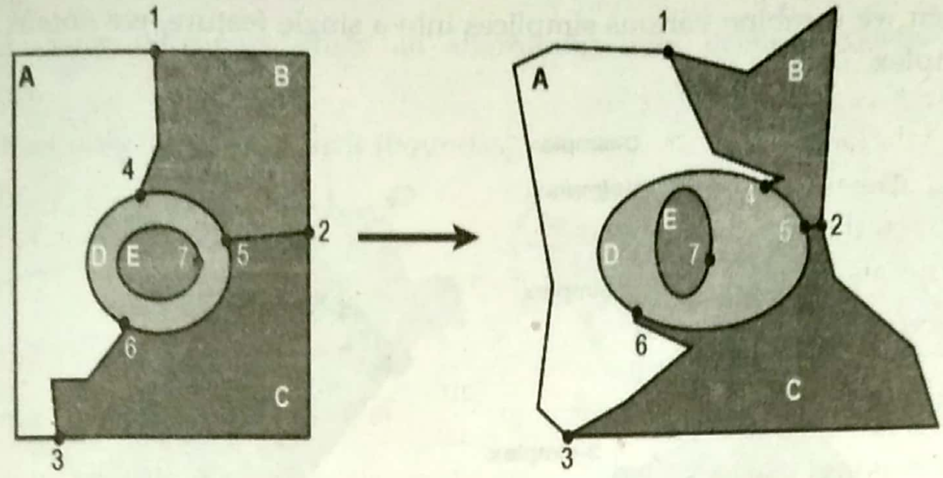
Topology deals with spatial properties that do not change under certain transformations.

For example, features drawn on a sheet of rubber can be made to change in shape and size by stretching and pulling the sheet. However, some properties of these features do not change :

- Area *E* is still inside area *D*,
- The neighbourhood relationships between *A*, *B*, *C*, *D*, and *E* stay intact, and their

boundaries have the same start and end nodes, and

- The areas are still bounded by the same boundaries, only the shapes and lengths of their perimeters have changed.



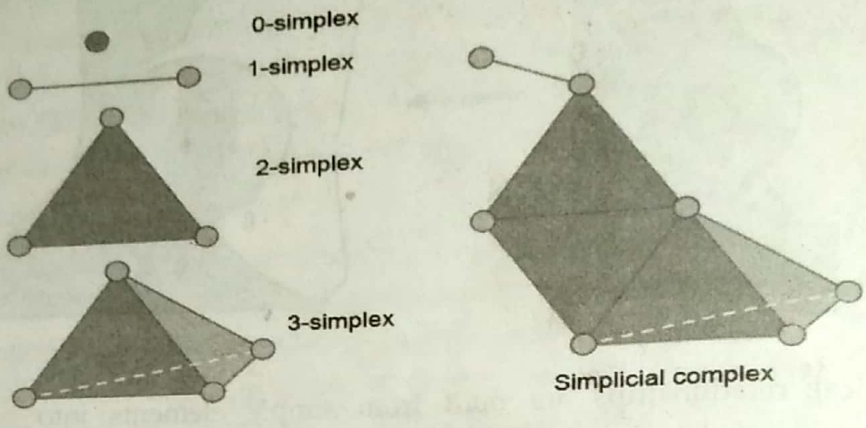
Topological relationships are built from simple elements into more complex elements: nodes define line segments, and line segments connect to define lines, which in turn define polygons. The fundamental issues relating to order, connectivity and adjacency of geographical elements form the basis of more sophisticated GIS analyses. These relationships called topological properties are invariant under a continuous transformation, referred to as a topological mapping.

The mathematical properties of the geometric space used for spatial data can be described as follows :

- The space is a three-dimensional Euclidean space where for every point we can determine its three-dimensional coordinates as a triple (x, y, z) of real numbers. In this space, we can define features like points, lines, polygons, and volumes as geometric primitives of the respective dimension. A point is zero-dimensional, a line one-dimensional, a polygon two-dimensional, and a volume is a three-dimensional primitive.
- The space is a metric space, which means that we can always compute the distance between two points according to a given distance function. Such a function is also known as a metric.
- The space is a topological space, of which the definition is a bit complicated. In essence, for every point in the space we can find a neighbourhood around it that fully belongs to that space as well.
- Interior and boundary are properties of spatial features that remain invariant under topological mappings. This means that under any topological mapping, the interior and the boundary of a feature remains unbroken and intact.
- There are a number of advantages when our computer representations of geographic phenomena have built-in sensitivity of topological issues. Questions related to the 'neighbourhood' of an area are a point in case. To obtain some 'topological sensitivity' simple building blocks have been proposed with which more complicated representations can be constructed:
- We can define within the topological space, features that are easy to handle and that can be used as representations of geographic objects. These features are called

simplices as they are the simplest geometric shapes of some dimension: point (0-simplex), line segment (1-simplex), triangle (2-simplex), and tetrahedron (3-simplex).

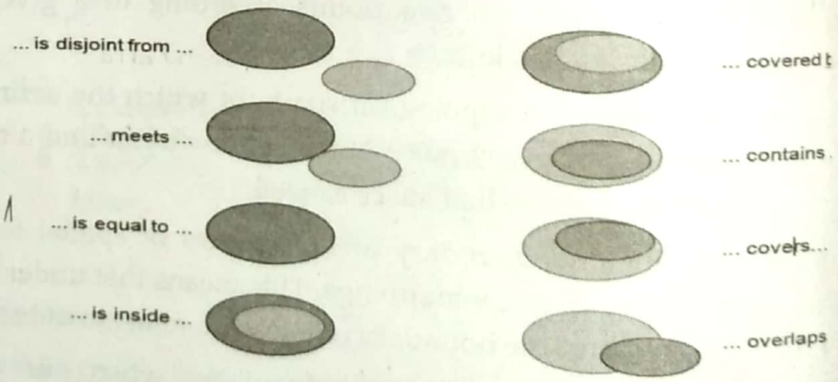
❖ When we combine various simplices into a single feature, we obtain a simplicial complex.



The topological properties of interior and boundary define relationships between spatial features. Because the properties of interior and boundary do not change under topological mappings, it is possible to study relations between spatial features. Let's define the *interior* of a region *R* as the largest set of points of *R* for which can construct a disk-like environment around it that also falls completely inside *R*. The boundary of *R* is the set of those points belonging to *R* but that do not belong to the interior of *R*, i.e. one cannot construct a disk-like environment around such points that still belongs to *R* completely.

Consider a spatial region *A*, having a boundary and an interior, both seen as (infinite) sets of points, and which are denoted by *boundary*(*A*) and *interior*(*A*), consider all possible combinations of intersections (∩) between the boundary and the interior of *A* with those of another region *B*, and test whether they are the empty set or not. From these intersection patterns, eight (mutually exclusive) spatial relationships between two regions can be derived.

$$A \text{ meets } B \stackrel{\text{def}}{=} \begin{array}{l} \mathit{interior}(A) \cap \mathit{interior}(B) = \Box \wedge \\ \mathit{boundary}(A) \cap \mathit{boundary}(B) = \Box \wedge \\ \mathit{interior}(A) \cap \mathit{boundary}(B) = \Box \wedge \\ \mathit{boundary}(A) \cap \mathit{interior}(B) = \Box \end{array}$$

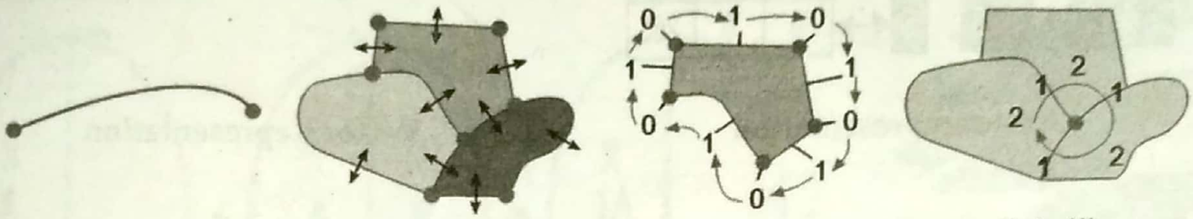


The rules of how simplices and simplicial complexes can be emdedded in space are quite different for two-dimensional space than they are for three-dimensional space. Such a set of rules defines the topological consistency of that space.

1. Every 1-simplex ('arc') must be bounded by two 0-simplices ('nodes', namely its begin and end node)
2. Every 1-simplex borders two 2-simplices ('polygons', namely its 'left' and 'right'

polygons)

3. Every 2-simplex has a closed boundary consisting of an alternating (and cyclic) sequence of 0- and 1-simplices.
4. Around every 0-simplex exists an alternating (and cyclic) sequence of and 2-simplices.
5. 1-simplices only intersect at their (bounding) nodes.



rule (1) rules (2, 5) rule (3) Rule (4)

- **Scale and Resolution**

Map scale can be defined as the ratio between the distance on a paper map and the distance of the same stretch in the terrain. A 1:50,000 scale map means that 1 cm on the map represents 50,000 cm, i.e. 500 m, in the terrain. 'Large-scale' means that the ratio is large, so typically it means there is much detail, as in a 1:1,000 paper map. 'Small-scale' in contrast means a small ratio, hence less detail, as in a 1:2,500,000 paper map. When applied to spatial data, the term resolution is commonly associated with the cell width of the tessellation applied.

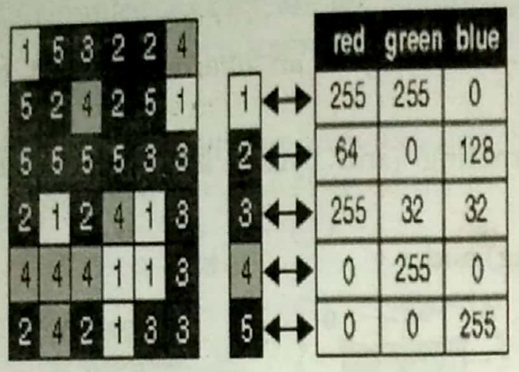
When digital spatial data sets have been collected with a specific map-making purpose in mind, and these maps were designed to be of a single map scale, like 1:25,000, we might suppose that the data carries the characteristics of "a 1:25,000 digital data set."

- **Representation of Geographic Fields**

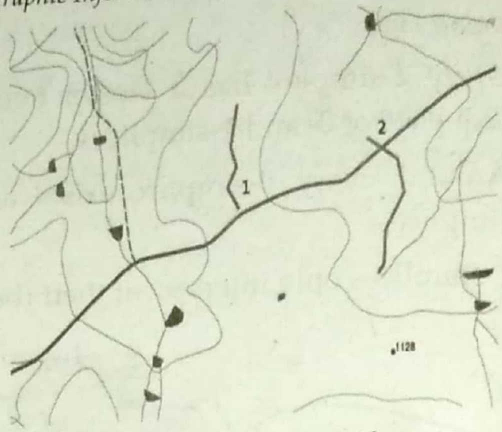
A geographic field can be represented through a tessellation, through a TIN or through a vector representation. The choice between them is determined by the requirements of the application under consideration.

Raster representation of a field: A raster 2D array of field values: i.e. collection of m × n values. May also contain additional attributes to represent some extra information, like a single georeference as the origin of the whole raster, a cell size indicator, the integer values for m and n, and a data type indicator for interpreting cell values.

Vector representation of a field: This technique uses isolines of the field. An isoline is a linear feature that connects the points with equal field value. When the field is elevation, we also speak of contour lines.



Raster representation



Vector Representation

- **Representation of Geographic Objects**

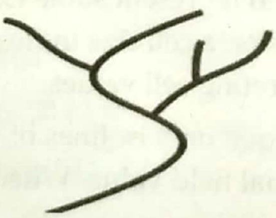
The representation of geographic objects is most naturally supported with vectors. Because objects are identified by the parameters of location, shape, size and orientation and these parameters can be expressed easily in terms of vectors. However, tessellations are still commonly used for representing geographic objects.

Tessellations to represent geographic objects

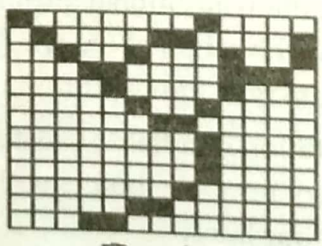
Remotely sensed images are an important data source for GIS applications. Unprocessed digital images contain many pixels, with each pixel carrying a reflectance value. Various techniques exist to process digital images into classified images that can be stored in a GIS as a raster. Image classification attempts to characterize each pixel into one of a finite list of classes, thereby obtaining an interpretation of the contents of the image. The classes recognized can be crop types or urban land use classes etc. Area objects are conveniently represented in raster, with area boundaries may appear as jagged edges. This is a typical by-product of raster resolution versus area size, and artificial cell boundaries. Line and point objects are more awkward to represent using rasters. Lines can be represented as strings of neighbouring raster cells with equal value. Supported operations are connectivity operations and distance computations. There is again an issue of precision of such computations.

Vector representations for geographic objects

The more natural way to represent geographic objects is by vector representation.



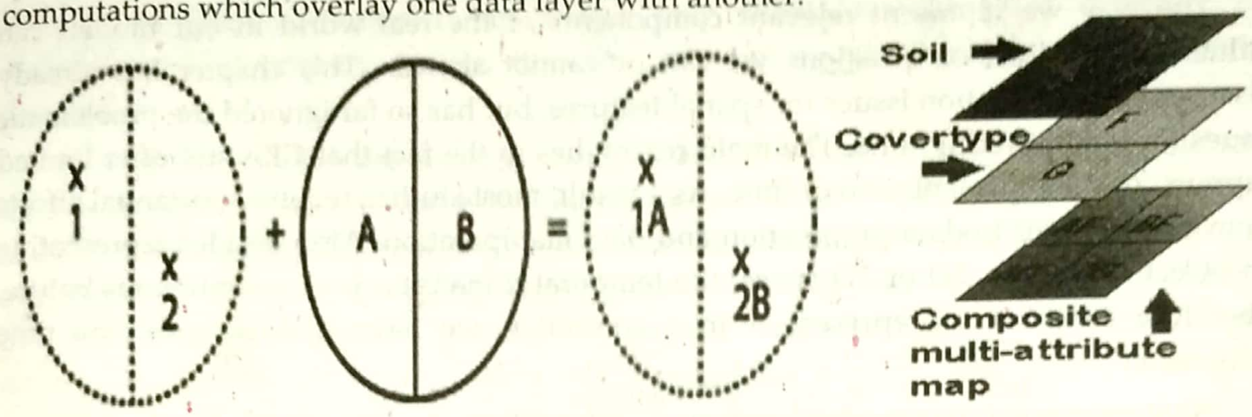
Vector

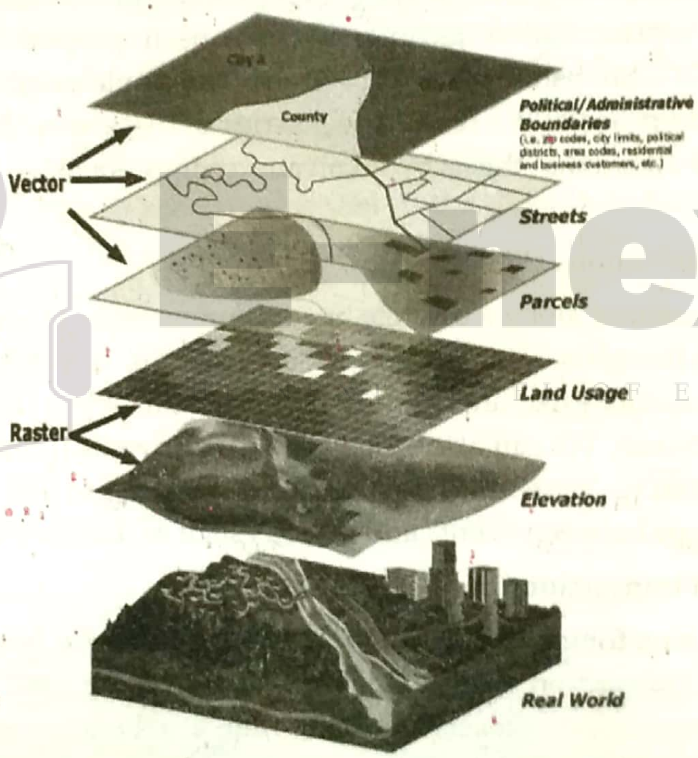


Raster

2.4 ORGANIZING AND MANAGING SPATIAL DATA

The main principle of data organization applied in GIS systems is that of a spatial data layer. A spatial data layer is either a representation of a continuous or discrete field, or a collection of objects of the same kind. Usually, the data is organized so that similar elements are in a single data layer. For example, all telephone booth point objects would be in one layer, and all road line objects in another. A data layer contains spatial data—of any of the types discussed above—as well as attribute (or: thematic) data, which further describes the field or objects in the layer. Attribute data is quite often arranged in tabular form, maintained in some kind of geodatabase. Data layers can be overlaid with each other, inside the GIS package, so as to study combinations of geographic phenomena. A GIS can be used to study the spatial relationships between different phenomena, requiring computations which overlay one data layer with another.





In a more complex analysis several layers can be used in spatial analysis.

2.5 THE TEMPORAL DIMENSION

Besides having geometric, thematic and topological properties, geographic phenomena are also dynamic; they change over time. For an increasing number of applications, these changes themselves are the key aspect of the phenomenon to study. Examples include identifying the owners of a land parcel in 1972, or how land cover in a certain area changed from native forest to pastures over a specific time period. We can note that some features or phenomena change slowly, such as geological features, or as in the example of land cover given above. Other phenomena change very rapidly, such as the movement of people or atmospheric conditions. For different applications, different scales of measurement will apply.

Examples of the kinds of questions involving time include:

- ❖ Where and when did something happen?
- ❖ How fast did this change occur?
- ❖ In which order did the changes happen?

The way we represent relevant components of the real world in our models can influence the kinds of questions we can or cannot answer. This chapter has already discussed representation issues for spatial features, but has so far ignored the problematic issues for incorporating time. The main reason lies in the fact that GISs still offer limited support for the representation of time. As a result, most studies require substantial efforts from the GIS user in data preparation and data manipulation. Also, besides representing an object or field in 2D or 3D space, the temporal dimension is of a continuous nature. Therefore in order to represent it in a computer, we have to 'discretize' the time dimension.

Spatiotemporal data models are ways of organizing representations of space and time in a GIS. Several representation techniques have been proposed. Perhaps the most commmon of these is a 'snapshot' state that represents a single point in time of an ongoing natural or man-made process. We may store a series of these snapshot states to represent change, but must be aware that this is by no means a comprehensive representation of that process.

1. Discrete and continuous time

Time can be measured along a discrete or continuous scale. Discrete time is composed of discrete elements (seconds, minutes, hours, days, months, or years). In continuous time, no such discrete elements exist, and for any two different points in time, there is always another point in between. We can also structure time by events (points in time) or periods (time intervals). When we represent time periods by a start and end event, we can derive temporal relationships between events and periods such as 'before', 'overlap', and 'after'.

2. Valid time and transaction time

Valid time (or world time) is the time when an event really happened, or a string of events took place. Transaction time (or database time) is the time when the event was stored in the database or GIS. Observe that the time at which we store something in the database/GIS typically is (much) later than when the related event took place.

3. Linear, branching and cyclic time

Time can be considered to be linear, ex- tending from the past to the present ('now'), and into the future. This view gives a single time line. For some types of temporal analysis, branching time—in which different time lines from a certain point in time onwards are possible—and cyclic time—in which repeating cycles such as seasons or days of a week are recognized, make more sense and can be useful.

4. Time granularity

When measuring time, we speak of granularity as the precision of a time value in a GIS or database (e.g. year, month, day, second, etc.). Different applications may obviously require different granularity. In cadastral applications, time granularity might well be a day, as the law requires deeds to be date-marked; in geological mapping applications, time granularity is more likely in the order of thousands or millions of years.

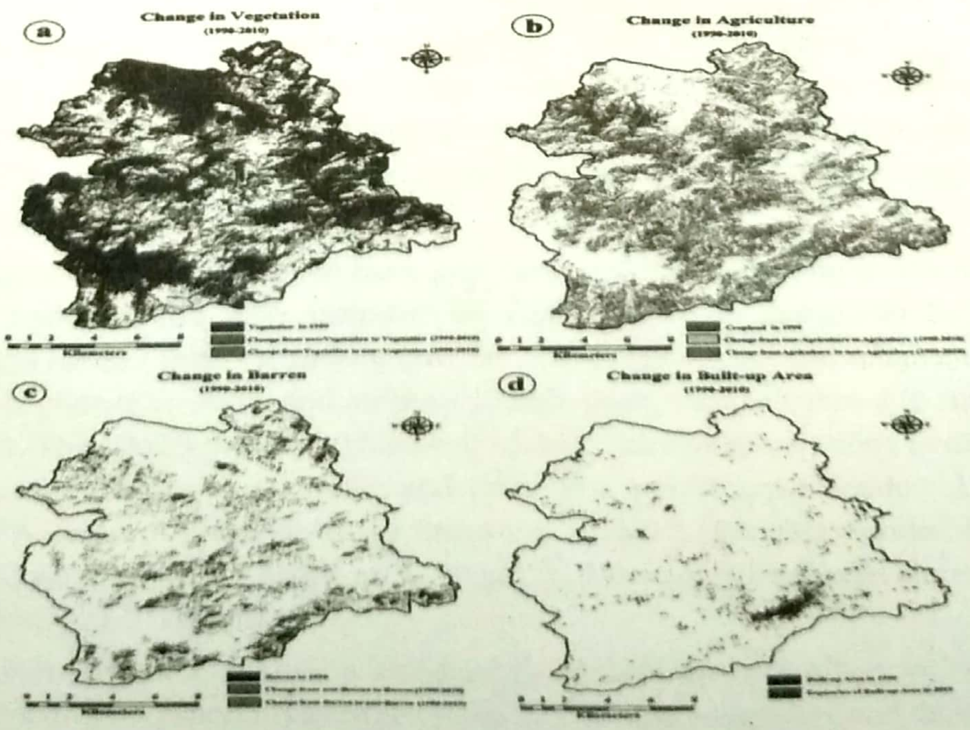
5. Absolute and relative time

Time can be represented as absolute or relative. Absolute time marks a point on the time line where events happen (e.g. '6 July 1999 at 11:15 p.m.'). Relative time is indicated relative to other points in time (e.g. 'yesterday', 'last year', 'tomorrow', which are all relative to 'now', or 'two weeks later', which is relative to some other arbitrary point in time.).

Eg. To assess whether radar images are reliable resources for detecting the disappearance of primary forests, this area of work is commonly known as change detection.

Studies of this type are usually based on some 'model of change', which includes knowledge and hypotheses of how change occurs for the specific phenomena being studied. In spatiotemporal analyses we consider changes of spatial and thematic attributes over time. We can keep the spatial domain fixed and look only at the attribute changes over time for a given location in space. We might be interested how land cover changed for a given location or how the land use changed for a given land parcel over time, provided its boundary did not change. On the other hand, we can keep the attribute domain fixed and consider the spatial changes over time for a given thematic attribute. In this case, we might want to identify locations that were covered by forest over a given period of time. Finally, we can assume both the spatial and attribute domain variable and consider how fields or objects changed over time. This may lead to notions of object motion, a subject receiving increasing attention in the literature. Applications of moving object research include traffic control, mobile telephony, wildlife tracking, vector-borne disease control, and weather forecasting.

In these types of applications, the problem of object identity becomes apparent. When does a change or movement cause an object to disappear and become a new one? With wildlife this is quite obvious; with weather systems less so. But this should no longer surprise the reader : we have already seen that some geographic phenomena can be nicely described as objects, while others are better represented as fields.



QUESTIONS

1. Define GIS. Briefly explain nature of GIS.
2. Define GIS. Explain its four set of capabilities.
3. What is geo-spatial data and geo-information?
4. Define Model. Explain the use of modeling in GIS.
5. Explain the following terms :
   a) Model
   b) Database
   c) Map
   d) Geographic Phenomenon
6. Define Geographic Phenomenon. What are geographic field and geographic object? Explain
7. How real world objects are represented using Model in GIS? Explain.
8. Write a short note on Regular and Irregular tessellations.
9. Explain vector representation of geographic objects.
10. Explain about topology and spatial representation of geographic objects.
11. Explain the temporal dimension using suitable example.
12. Write a note on organizing and managing spatial data.
13. How geographic fields are represented in GIS? Explain using suitable diagram.
14. How geographic object are represented in GIS? Explain using suitable diagram.