BSc.(Information Technology)

(Semester VI)

2018-19

Principles of Geographic Information System

(USIT 501 Core)

University Paper Solution

By

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Question 1

Q1a. Define GIS.Breifly explain any two capabilities of GIS

Ans: Defining GIS:

A GIS is a computer-based system that provides the following four sets of capabilities to handle georeferenced data:

1. Data capture and preparation

2. Data management, including storage and maintenance

3. Data manipulation and analysis

4. Data presentation

1. Data capture and preparation
data capture refers to the collection of sea water temperatures and wind speed measurements. This is achieved by placing buoys with measuring equipment at various places in the ocean. Each buoy measures a number of things: wind speed and direction; air temperature and humidity; and sea water temperature at the surface and at various depths down to 500 metres. For the sake of our example we will focus on sea surface temperature (SST) and wind speed (WS).

2. Data management, including storage and maintenance
Data management refers to the storage and maintenance of the data transmitted by the buoys via satellite communication. This phase requires a decision to be made on how best to represent our data, both in terms of their spatial properties and the various attribute values which we need to store.

3. Data manipulation and analysis
Once the data has been collected and organized in a computer system, we can start analysing it.

4. Data presentation
After the data manipulations , our data is prepared for producing output. In this case, The data presentation phase deals with putting it all together into a format that communicates the result of data analysis in the best possible way.

Q1b. What is GI System, GI Science and GIS Application? Explain.

Ans: GI Science:
The discipline that deals with all aspects of the handling of spatial data and geoinformation is called geographic information science (often abbreviated to geo-information science or just GIScience).

Geo-Information Science is the scientific field that attempts to integrate different disciplines studying the methods and techniques of handling spatial information.

GI System:
a geographic information system— in the 'narrow' sense—in terms of its functions as is a computerized system that facilitates the phases of data entry, data management, data analysis and data presentation specifically for dealing with georeferenced data.
In the 'wider' sense, a functioning GIS requires both hardware and software, and also people such asGI Systems the database creators or administrators, analysts who work with the software, and the users of the end product.

GIS Application of GIS are as follow:

1. An urban planner might want to assess the extent of urban fringe growth in her/his city and quantify the population growth that some suburbs are witnessing. S/he might also like to understand why these suburbs are growing and others are not;

2. A biologist might be interested in the impact of slash-and-burn practices on the populations of amphibian species in the forests of a mountain range to obtain a better understanding of long-term threats to those populations;

3. A natural hazard analyst might like to identify the high-risk areas of annual monsoon-related flooding by investigating rainfall patterns and terrain characteristics;

Q 1c. How modeling helps in representing real world? Explain

Ans: Modelling is a term used in many ways and which has many different meanings. A representation of some part of the real world can be considered a model because the representation will have certain characteristics in common with the real world. Specifically, those which we have identified in our model design. This then allows us to study and operate on the model itself instead of the real world in order to test what happens under various conditions and help us answer 'what if' questions. We can change the data or alter the parameters of the model and investigate the effects of the changes.

In the GIS environment, the most familiar model is that of a map. A map is a miniature representation of some part of the real world. Paper maps are the most common, but digital maps also exist

Databases are another important class of models. A database can store a considerable amount of data, and provides various functions to
operate on the stored data. The collection of stored data represents some real-world phenomena, so it too is a model.

A 'real world model' is a representation of several phenomena that we can observe in reality, usually to enable some type of study, administration, computation and/or simulation. The phrase 'data modelling' is the common name for the design effort of structuring a database. This process involves the identification of the kinds of data that the database will store.

***Q1d. Define* Geographic field. Explain its different datatype and values.**

Ans: A field is a geographic phenomenon that has a value 'everywhere' in the study
area. We can therefore think of a field as 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 at locality (x,y).Fields can be discrete or continuous. In a continuous field, the underlying function is assumed to be 'mathematically smooth', meaning

that the field values along any path through the study area do not change abruptly, but only gradually.

A continuous field can even be differentiable, meaning we can determine a measure of change in the field value per unit of distance anywhere and in any direction. For example, if the field is elevation, this measure would be slope, i.e. the change of elevation per metre distance; if the field is soil salinity, it would be salinity gradient, i.e. the change of salinity per metre distance.

Discrete fields divide the study space in mutually exclusive, bounded parts, with all locations in one part having the same field value. Typical examples are land classifications, for instance, using either geological classes, soil type, land use type, crop type or natural vegetation type.

Data types and values:

1. Nominal data values are values that provide a name or identifier so that we can discriminate between different values, but that is about all we can do. Specifically, we cannot do true computations with these values. An example are the names of geological units. This kind of data value is called categorical data when the values assigned are sorted according to some set of non-overlapping categories. For example, we might identify the soil type of a given area to belong to a certain (pre-defined) category.

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. Household income, for instance, could be classified as being either 'low', 'average' or 'high'. Clearly this is their natural sequence, but this is all we can say—we cannot say that a high income is twice as high as an average income.

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 20◦ C is not twice as warm as 10◦C, and thus centigrade temperatures are interval data values, not ratio data values.

4. Ratio data values allow most, if not all, forms of arithmetic computation.

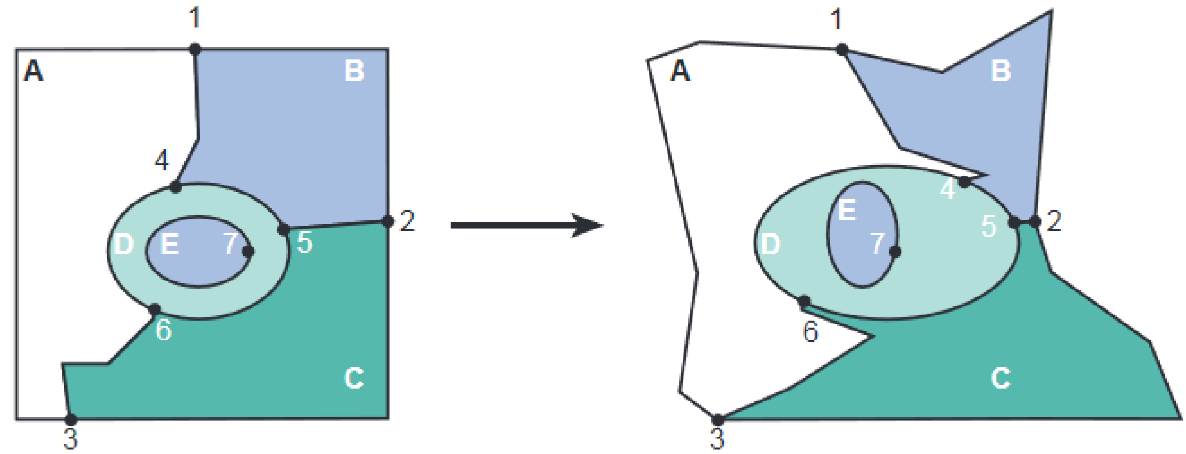
Q1e. Write a note on Topology and spatial relationships.

Ans: 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 Eis still inside area D,

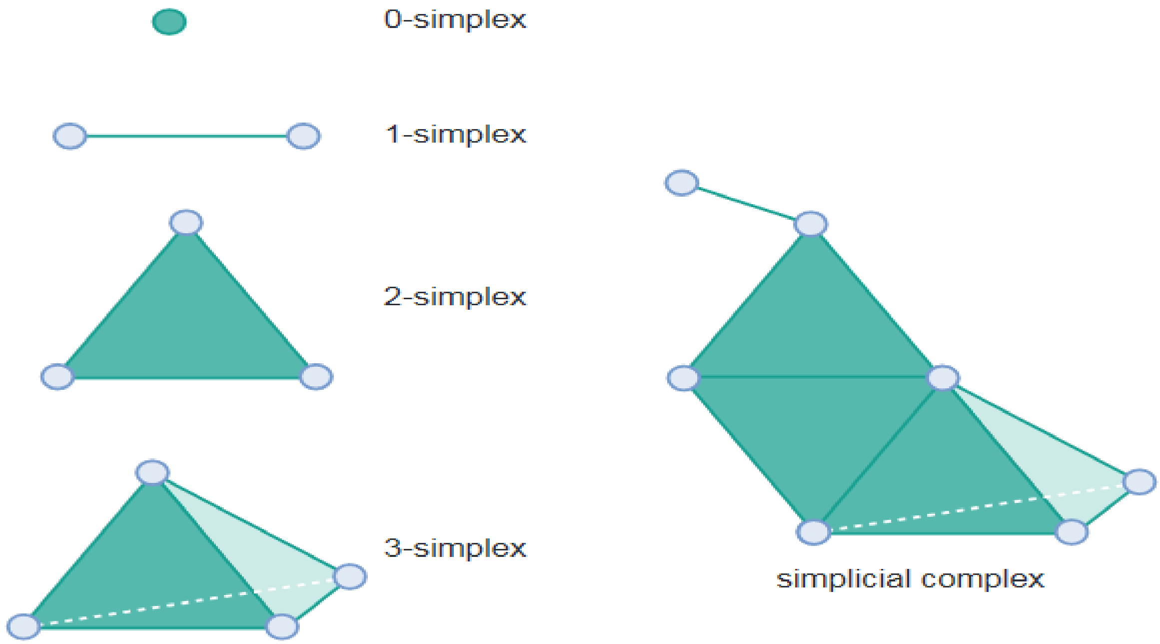
•The neighbourhood relationships between A,B,C,D, and E stay intact, and their boundaries have the same start and end nodes, and

•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.

Topological relationships:
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.



Q1f. Explain the temporal dimension using suitable example.

Ans: Geographic phenomena are also dynamic; they change over time.

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?

Representing time in GIS:

• Spatiotemporal data models are ways of organizing representations of space and time in a GIS.

• The most common 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

Different 'concepts' of time:

• 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. Derive temporal relationships between events and periods such as 'before', 'overlap', and 'after'.

• 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.

• Linear, branching and cyclic time: Time can be linear, extending from the past to the present ('now'), and into the future. 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.

• Time granularity: When measuring time, granularity is 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.

• 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'.

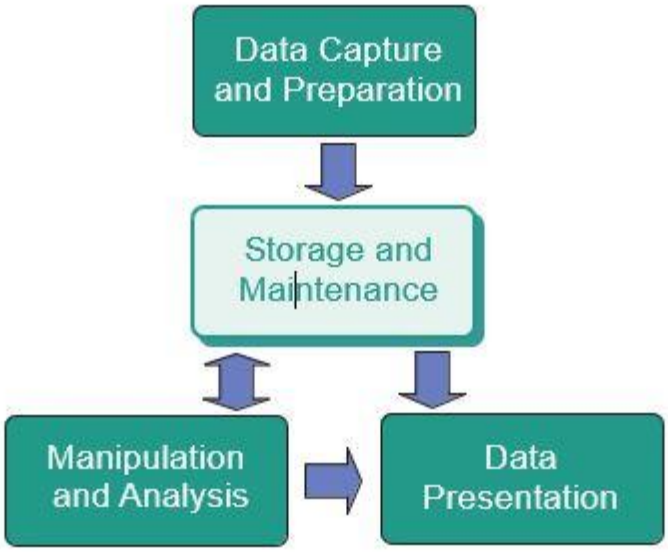
• Change detection: Studies of this type are usually based on some 'model of change', which includes knowledge and hypotheses of how change occurs for the specific phenomena being studied. It includes knowledge about speed of tree growth.

• Spatiotemporal analysis: 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.

Question 2

Q2a. List the functional components of GIS. Explain any two of them in details.

Ans:



Spatial data capture and preparation:

The functions for capturing data are closely related to the disciplines of survey-ing engineering, photogrammetry, remote sensing, and the processes of digitiz-ing, i.e. the conversion of analogue data into digital representations. Remote sensing, in particular, is the field that provides photographs and images as the raw base data from which spatial data sets are derived

Method	Devices
Manual digitizing	coordinate entry via keyboard digitizing tablet with cursor mouse cursor on the computer monitor (heads-up digitizing) (digital) photogrammetry
Automatic digitizing	Scanner
Semi-automatic digitizing	line-following software
Input of available digital data	CD-ROM or DVD-ROM via computer network or internet (including geo-webservices)

Spatial data storage and maintenance

The way that data is stored plays a central role in the processing and the eventual understanding of that data. In most of the available systems, spatial data is organized in layers by theme and/or scale. For instance, the data may be organized in thematic categories, such as land use, topography and administrative subdivisions, or according to map scale.

Raster representation	Vector representation
Advantages	
simple data structure simple implementation of overlays efficient for image processing	efficient representation of topology adapts well to scale changes allows representing networks allows easy association with attribute data
Disadvantages	
less compact data structure difficulties in representing topology cell boundaries independent of feature boundaries	complex data structure overlay more difficult to implement inefficient for image processing more update-intensive

Spatial query and analysis:

The most distinguishing parts of a GIS are its functions for spatial analysis, i.e. operators that use spatial data to derive new geoinformation. Spatial queries and process models play an important role in this functionality. One of the keys uses of GISs has been to support spatial decisions. Spatial decision support systems (SDSS) SDSS are a category of information systems composed of a database, GIS software, models, and a so-called knowledge engine which allow users to deal specifically with locational problems.

Spatial data presentation:

The presentation of spatial data, whether in print or onscreen, in maps or in tabular displays, or as'raw data', is closely related to the disciplines of cartography, printing and publishing. The presentation may either be an end-product, for example as a printed atlas, or an intermediate product, as in spatial data made available through the internet.

Q2b. Explain the various reasons for using DBMS in GIS.

Ans: Database management systems:

A database management system (DBMS) is a software package that allows the user to set up, use and maintain a database

Reasons for using a DBMS:

There are various reasons why one would want to use a DBMS for data storage and processing.
A DBMS supports the storage and manipulation of very large data sets.
Some data sets are so big that storing them in text files or spreadsheet files be-comes too awkward for use in practice. The result may be that finding simple facts takes minutes, and performing simple calculations perhaps even hours. A DBMS is specifically designed for this purpose.

A DBMS can be instructed to guard over data correctness.

an important aspect of data correctness is data entry checking: ensuring that the data that is entered into the database does not contain obvious errors. For instance, since we know the study area we are working in, we also know the range of possible geographic coordinates, so we can ensure the DBMS checks them.

A DBMS supports the concurrent use of the same data set by many users

Large datasets are built up overtime, which means that substantial investments are required to create and maintain them, and that probably many people are involved in the data collection, maintenance and processing. These data sets are often considered to be of a high strategic value for the owner(s), which is why many may want to make use of them within an organization.

A DBMS provides a high-level, declarative query language.

A query is a computer program that extracts data from the database that meet the conditions indicated in the query. A DBMS supports the use of a data model. A data model is a language with which one can define a database structure and manipulate the data stored in it.

A DBMS includes data backup and recovery functions to ensure data availability at all times.

As potentially many users rely on the availability of the data, the data must be safeguarded against possible calamities. Regular back-ups of the data set, and automatic recovery schemes provide an insurance against loss of data.

A DBMS allows the control of data redundancy.

A well-designed database takes care of storing single facts only once. Storing a fact multiple times—a phenomenon known as data redundancy—can lead to situations in which stored facts may contradict each other, causing reduced useful-ness of the data.

Q2c. Write short note on spatial Data functionality.

Ans: spatial Data functionality. (SDF):

The main problem was that there is additional functionality needed by DBMS in order to process and manage spatial data. As the capabilities of our hardware to process information has increased, so too has the desire for better ways to represent and manage spatial data. During the 1990's, object-oriented and object-relational data models were developed for just this purpose. These extend standard relational models with support for objects, including 'spatial' objects.

Currently, GIS software packages are able to store spatial data using a range of commercial and open source DBMSs such as Oracle, Informix, IBM DB2, Sybase, and PostgreSQL, with the help of spatial extensions. Some GIS software have integrated database 'engines', and therefore do not need these extensions.

ESRI's ArcGIS, for example, has the main components of the MS Access data-Spatial DBMS base software built-in. This means that the designer of a GIS application can

choose whether to store the application data in the GIS or in the DBMS

GIS and spatial databases

Spatial data can be stored in a special database column, known as the geometry column, (or feature or shape, depending on the specific software package), as shown in Figure This means GISs can rely fully on DBMS support for spatial data, making use of a DBMS for data query and storage (and multi-user support), and GIS for spatial functionality. Small-scale GIS applications may not require a multi-user capability and can be supported by spatial data support from a personal database.

Parcel	PId	Geometry	OwnerID
	3421	"MULTIPOLYGON(((257462.704979333 464780.750851061,257463.89798...)))"	435
	8871	"MULTIPOLYGON(((257409.813950544 464789.91585049,257407.896903...)))"	550
	2109	"MULTIPOLYGON(((257785.714911912 464796.839972167,257782.59794...)))"	1040
	1515	"MULTIPOLYGON(((257790.672100448 464807.13792585,257788.608078...)))"	245
	3434	"MULTIPOLYGON(((257435.527950478 464803.92887633,257428.254887...)))"	486
	6371	MULTIPOLYGON(((257432.476077854 464813.848852072,257433.147910...)))"	950
	2209	"MULTIPOLYGON(((257444.888027332 464826.555046319,257446.43201...)))"	1840
	1505	"MULTIPOLYGON(((256293.760107491 464935.203846095,256292. 00881...)))"	145

Fig. Geometry data stored directly in a spatial database table.

Q2d. Explain the relational data model using suitable example.

Ans: *A data model is a language that allows the definition of:*

1. *The structures that will be used to store the base data,*
2. *The integrity constraints that the stored data has to obey at all moments in time, and*
3. *The computer programs used to manipulate the data.*

For the relational data model, the structures used to define the database are at-tributes, tuples and relations. Computer programs either perform data extraction from the database without altering it, in which case we call them queries, or they change the database contents, and we speak of updates or transactions

Relations, tuples and attributes

A table or relation is itself a collection of tuples (or records). In fact, each table is a collection of tuples that are similarly shaped

An attribute is a named field of a tuple, with which each tuple associates a value, the tuple’s attribute value.

An attribute’s domain is a (possibly infinite) set of atomic values such as the set Of integer number values, the set of real number values, etc.

When a relation is created, we need to indicate what type of tuples it will store. This means that we must

1. Provide a name for the relation,

2. Indicate which attributes it will have, and

3. Set the domain of each attribute.

Finding tuples and building links between them

A key of a relation comprises one or more attributes. A value for these attributes uniquely identifies a tuple if we have a value for each of the key attributes, we are guaran-teed to find no more than one tuple in the table with that combination of values. It remains possible that there is no tuple for the given combination.

Q2e. Differentiate between vector data and Raster data.

Ans: The way that data is stored plays a central role in the processing and the eventual understanding of that data. In most of the available systems, spatial data is organized in layers by theme and/or scale.

In a GIS, features are represented with their (geometric and non-geometric) attributes and relationships. The geometry of features is represented with primitives of the respective dimension: a windmill probably as a point, an agricultural field as a polygon.

Vector data types describe an object through its boundary, thus dividing the space into parts that are occupied by the respective objects. The raster approach subdivides space into (regular) cells, mostly as a square tessellation of dimension two or three. These cells are called either cells or pixels in 2D, and voxels in 3D. The data indicates for every cell which real world feature it covers, in case it represents a discrete field. In case of a continuous field, the cell holds a representative value for that field.

Raster representation	Vector representation
Advantages	
simple data structure simple implementation of overlays efficient for image processing	efficient representation of topology adapts well to scale changes allows representing networks allows easy association with attribute data
Disadvantages	
less compact data structure difficulties in representing topology cell boundaries independent of feature boundaries	complex data structure overlay more difficult to implement inefficient for image processing more update-intensive

Q2f. Explain the various reasons for using DBMS in GIS.

Ans: Spatial Data Infrastructure (SDI):

Many organizations are forced to work in a cooperative setting in which geographic information is obtained from, and provided to, partner organizations and the general public. The sharing of spatial data between the various GISs in those organizations is of key

Data sharing importance and aspects of data dissemination, security, copyright and pricing require special attention. The design and maintenance of a Spatial Data Infrastructure (SDI) deals with these issues.

An SDI is defined as "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data". Fundamental to those arrangements are in a wider sense the agreements between organizations and in the narrow sense, the agreements between software systems on how to share the geographic information.

Standards exist for all facets of GIS, ranging from data capture to data presentation. They are developed by different organizations, of which the most prominent are the Inter-national Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC).

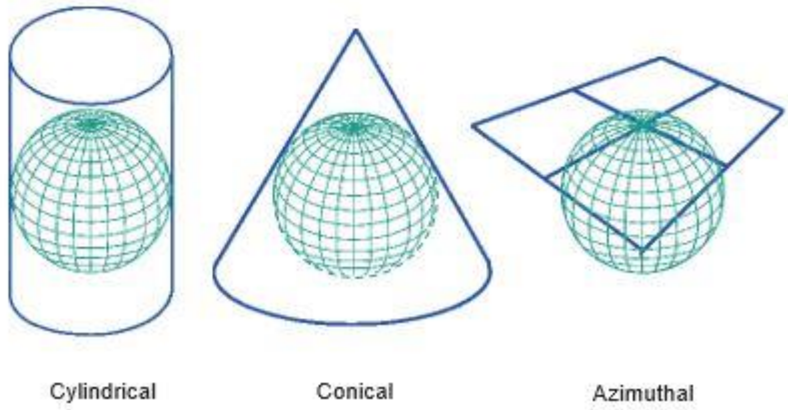
Question 3

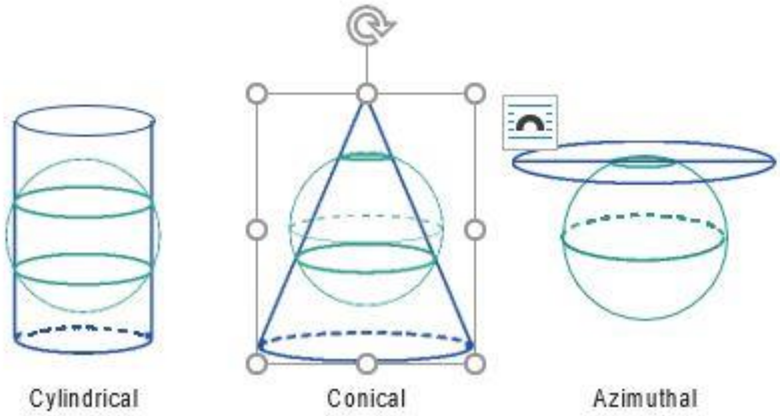
Q3a. What are the different classification of map projection? Explain any two?

Ans: A map projection is a mathematically described technique of how to represent the Earth's curved surface on a flat map.

Classification of map projections

Hundreds of map projections have been developed, each with its own specific qualities. These qualities in turn make resulting maps useful for certain purposes. By definition, Some map projections can be visualized as true geometric projections directly onto the mapping plane, in which case we call it an azimuthal projection, or onto an intermediate surface, which is then rolled out into the mapping plane.





Normal cylindrical projections are typically used to map the world in its entirety. Conical projections are often used to map the different continents, while the normal azimuthal projection may be used to map the polar areas. Transverse and oblique aspects of many projections can be used for most parts of the world. It is also of importance to consider the shape of the area to be mapped. Ideally, the general shape of the mapping area should match with the distortion pattern of a specific projection. If an area is approximately circular it is possible to create a map that minimises distortion for that area on the basis of an azimuthal projection. The cylindrical projection is best for a rectangular area and a conic projection for a triangular area. So far, we have not specified how the curved horizontal reference surface is projected onto the plane, cone or cylinder. How this is done determines which kind of distortions the map will have compared to the original curved reference sur-face. Thedistortionpropertiesofamaparetypicallyclassifiedaccordingtowhat is not distorted on the map

Q3b. Write short note on GPS.

Ans: The NAVSTAR Global Positioning System (GPS) was declared operational in 1994, providing Precise Positioning Services(PPS) to US and allied military forces as well as US government agencies, and Standard Positioning Services (SPS) to civilians throughout the world. Its space segment nominally consists of 24 satellites, each of which orbit our planet in 11h58m at an altitude of 20,200 km. There can be any number of satellites active, typically between 21 and 27. The satellites are organized in six orbital planes, somewhat irregularly spaced, with an

angle of inclination of 55–63 with the equatorial plane, nominally having four satellites each (see Figure 4.28). This means that a receiver on Earth will have between five and eight (sometimes up to twelve) satellites in view at any point in time. Software packages exist to help in planning GPS surveys, identifying expected satellite set-up for any location and time.

GPS's control segment has its master control in Colorado, US, and monitor stations in a belt around the equator, namely in Hawaii, Kwajalein Atoll in the Marshall Islands, Diego Garcia (British Indian Ocean Territory) and Ascension Island (UK, southern Atlantic Ocean).

The NAVSTAR satellites transmit two radio signals, namely the L1 frequency at 1575.42 MHz and the L2 frequency at 1227.60 MHz. There are also a third and fourth signal, but they are not important for our discussion here. The first two signals consist of:

The carrier waves at the given frequencies,

A coarse ranging code, known as C/A, modulated on L1,

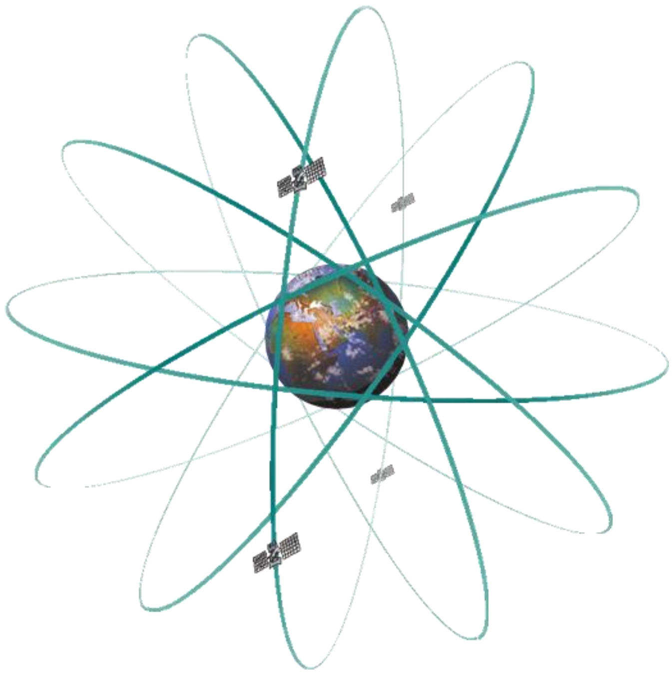
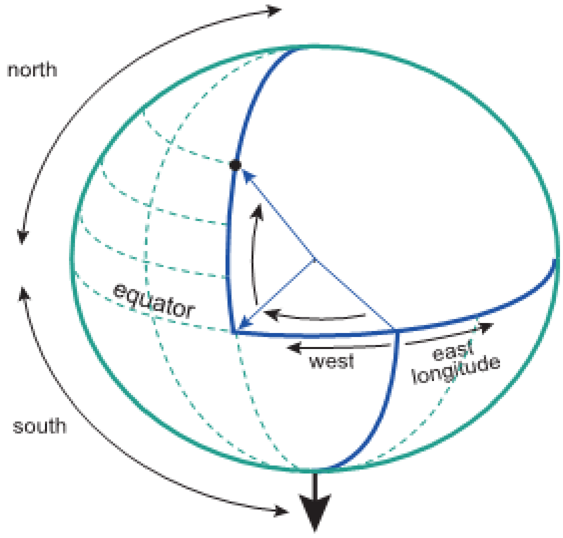


Fig: Constellation of satellites, four shown in only one orbit plane, in the GPS system.

Q3c. Explain 2D geographic coordinate system using suitable example.

Ans: The most widely used global coordinate system consists of lines of geographic latitude (phi or or ') and longitude (lambda or). Lines of equal latitude are called parallels. They form circles on the surface of the ellipsoid4. Lines of equal Latitude and longitude longitude are called meridians and they form ellipses (meridian ellipses) on the ellipsoid.



The latitude () and longitude () angles represent the 2D geographic coordinate system. Normal through P’ and the equatorial plane. Latitude is zero on the equator (= 0), and increases towards the two poles to maximum values of = +90 (N 90) at the North Pole and = -90 (S 90) at the South Pole.

The longitude() is the angle between the meridian ellipse which passes through Greenwich and the meridian ellipse containing the point in question. It is measured in the equatorial plane from the meridian of Greenwich (= 0) either eastwards through = + 180 (E 180) or westwards through = -180 (W 180).

Latitude and longitude represent the geographic coordinates (;) of a point P’ (Figure 4.10) with respect to the selected reference surface. They are always given in angular units. For example, the coordinates for City hall in Enschede are:5

= 5213026:200N; = 653032:100E

Q3d. What is trend surface fitting? Explain.

Ans: Since the data are continuous, we can make use of measured values for inter-polation. There are many continuous geographic fields—elevation, temperature and ground water salinity are just a few examples. Commonly, continuous fields are represented as rasters, and we will almost by default assume that they are. Alternatives exist though. The main alternative for continuous field representation is a poly line vector layer ,in which the lines are isolines. We will also address these issues of representation below.

The aim is to use measurements to obtain a representation of the entire field using point samples. In this section we outline four techniques to do so:

1. Trend surface fitting using regression,

2. Triangulation,

3. Spatial moving averages using inverse distance weighting

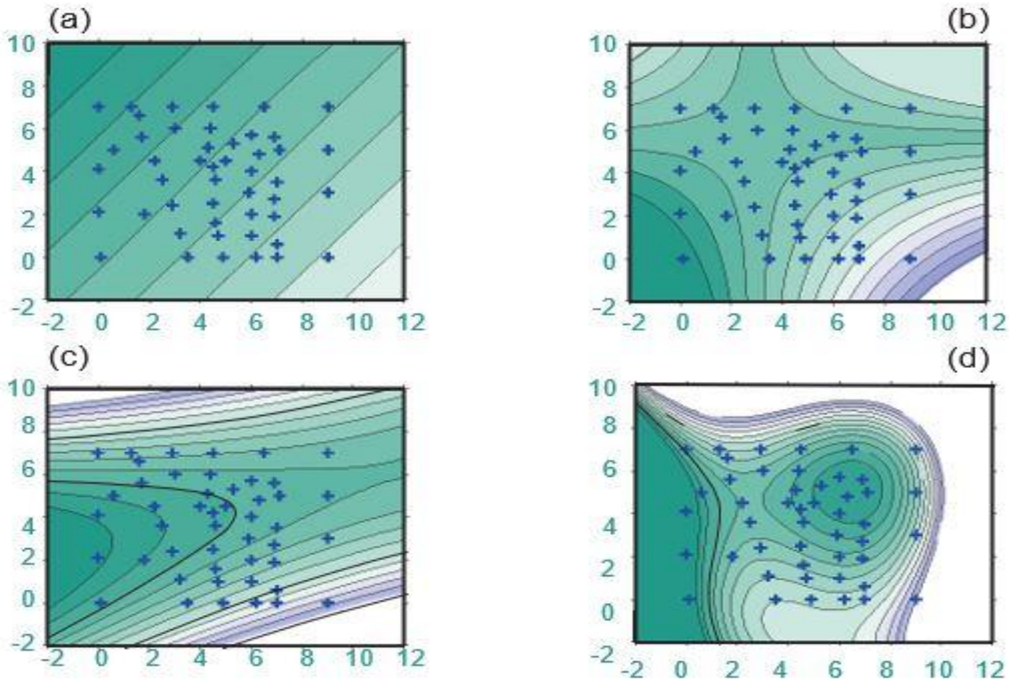
4. Kriging.

Trend surface fitting:

In trend surface fitting, the assumption is that the entire study area can be repre-sented by a formula f(x;y) that for a given location with coordinates (x;y) will give us the approximated value of the field in that location.

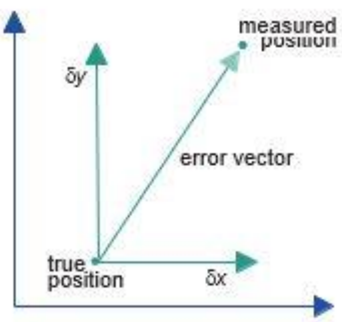
The key objective in trend surface fitting is to derive a formula that best describes the field. Various classes of formulæ exist, with the simplest being the one that describes a flat, but tilted plane:

f(x;y) = c1 x+c2 y +c3:



Q3e.How Root mean Square is used to mean location accuracy? Explain.

Ans: Location accuracy is normally measured as a root mean square error (RMSE). The RMSE is similar to, but not to be confused with, the standard deviation of a statistical sample. The value of the RMSE is normally calculated from a set of check measurements (coordinate values from an independent source of higher accuracy for identical points). The differences at each point can be plotted as error vectors, as is done in Figure 5.3 for a single measurement. The error vector can be seen as having constituents in the x- and y-directions, which can be re-combined by vector addition to give the error vector representing its locational error.



For each checkpoint, the error vector has components x and y. The observed errors should be checked for a systematic error component, which may indicate a (possibly repairable) lapse in the measurement method. Systematic error has occurred when

$x = 0$ or $y = 0$.

The systematic error x in x is then defined as the average deviation from the true value:

$$x = \frac{1}{n} \sum_{i=1}^{n} x_i$$

Q3f. Write short note on Krigging.

Ans: Krigging

Kriging was originally developed my mining geologists attempting to derive accurate estimates of mineral deposits in a given area from limited sample measurements. It is an advanced interpolation technique belonging to the field of geostatistics ,which can deliver good results if applied properly and with enough sample points. Kriging is usually used when the variation of an attribute and/or the density of sample points is such that simple methods of interpolation may give unreliable predictions.

Kriging is based on the notion that the spatial change of a variable can be de-scribed as a function of the distance between points. It is similar to IDW interpolation, in that it the surrounding values are weighted to derive a value for an unmeasured location. However, the kriging method also looks at the overall spatial arrangement of the measured points and the spatial correlation between their values, to derive values for an unmeasured location.

The first step in the kriging procedure is to compare successive pairs of point measurements to generate a semi-variogram. In the second step, the semigram is used to calculate the weights used in interpolation. Although kriging is powerful technique, it should not be applied without a good understanding of geostatistics, including the principle of spatial autocorrelation.

Question 4

Q4a. List the four classification of analytical function of GIS. Explain any one in details.

Ans: There are many ways to classify the analytical functions of a GIS. It makes the following distinctions, which are addressed in subsequent sections of the chapter:

1. Classification, retrieval, and measurement functions. All functions in this category are performed on a single(vector raster) data layer, often using the associated attribute data.

2. Overlay functions. These belong to the most frequently used functions in a GIS application. They allow the combination of two (or more) spatial data layers comparing them position by position, and treating areas of overlap—and of non-overlap—in distinct ways. Many GISs support over-lays through an algebraic language, expressing an overlay function as a formula in which the data layers are the arguments.

3. Neighborhood functions. Whereas overlays combine features at the same location, neighborhood functions evaluate the characteristics of an area surrounding a feature's location. A neighborhood function 'scans' the neighbor hood of the given feature(s), and performs a computation on it.

4. Connectivity functions. These functions work on the basis of networks, including road networks, water courses in coastal zones, and communication lines in mobile telephony. These networks represent spatial linkages between features.

Q4b. Write short note on automatic classification

Ans: **Automatic classification**

User-controlled classifications require a classification table or user interaction. GIS software can also perform automatic classification, in which a user only specifies the number of classes in the output data set. The system automatically determines the class break points. Two main techniques of determining break points are in use.

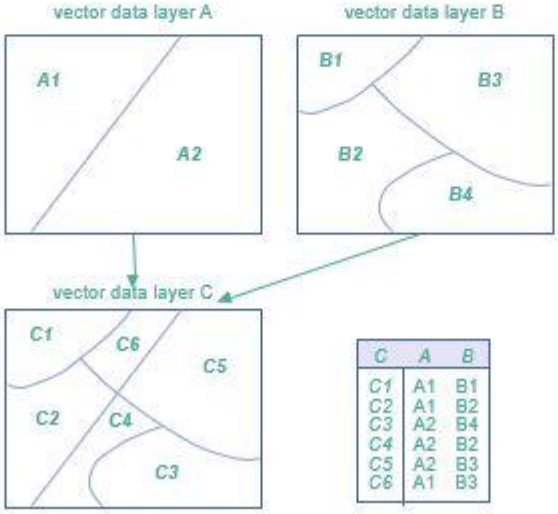
1. Equal interval technique: The minimum and maximum values vmin and vmax of the classification parameter are determined and the (constant) interval size for each category is calculated as (vmax vmin)=n; where n is the number of classes chosen by the user. This classification is useful in revealing the distribution patterns as it determines the number of features in each category.

2. Equal frequency technique: This technique is also known as quantile classification. The objective is to create categories with roughly equal numbers of features per category. The total number of features is determined first and by the required number of categories, the number of features per category is calculated. The class break points are then determined by counting off the features in order of classification parameter value

Q4c. Explain vector overlay operation using suitable diagram.

Ans: **Vector overlay operators**

In the vector domain, overlay is computationally more demanding than in the raster domain. Here we will only discuss overlays from polygon data layers ,but we note that most of the ideas also apply to overlay operations with point or line data layers.



C	A	B
C1	A1	B1
C2	A1	B2
C3	A2	B4
C4	A2	B2
C5	A2	B3
C6	A1	B3

The standard overlay operator for two layers of polygons is the polygon intersection operator. It is fundamental, as many other overlay operators proposed in the literature or implemented in systems can be defined in terms of it. The result of this operator is the collection of

all possible polygon intersections; the attribute table result is a join

Q4d. Explain using example how vector raster operation can be performed using decision table?

Ans: Raster overlay operators

Vector overlay operators are useful, but geometrically complicated, and this sometimes results in poor operator performance. Raster overlays do not suf-fer from this disadvantage, as most of them perform their computations cell by cell, and thus they are fast.

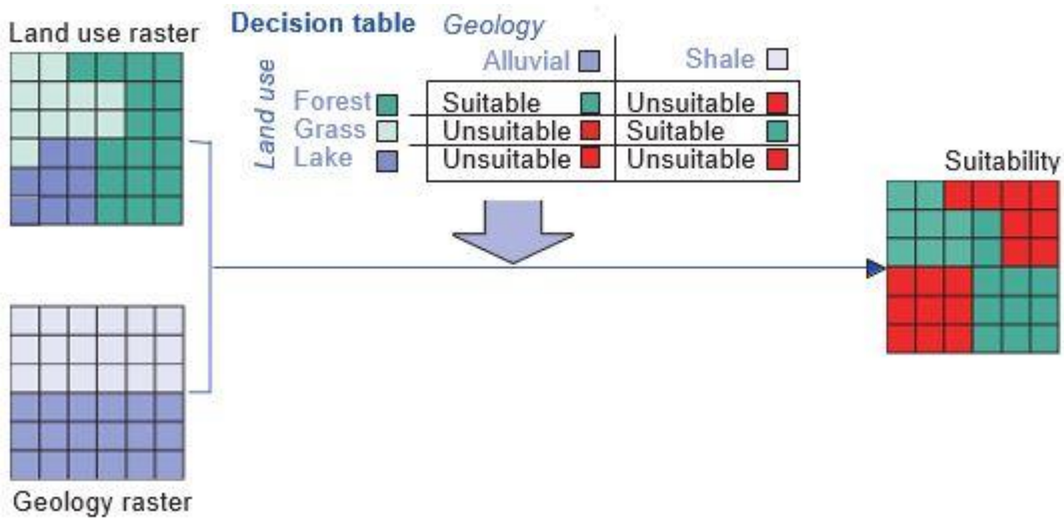
GISs that support raster processing—as most do—usually have a language to express operations on rasters. These languages are generally referred to as map algebra

When producing a new raster we must provide a name for it, and define how it is computed. This is done in an assignment statement of the following format:

Output raster name := Map algebra expression:

Example:

Suitability := CON((Landuse = \Forest" AND Geology = \Alluvial") OR (Landuse = \Grass" AND Geology = \Shale"); \Suitable";\Unsuitable")



4e. List ant five types example where advanced computation on continuous fields are required.

Ans: Applications

There are numerous examples where more advanced computations on continuous field representations are needed. A short list is provided below.

Slope angle calculation The calculation of the slope steepness, expressed as an angle in degrees or percentages, for any or all locations.

Slope aspect calculation The calculation of the aspect (or orientation) of the slope in degrees (between 0 and 360 degrees), for any or all locations.

Slope convexity/ concavity calculation Slope convexity—defined as the change of the slope (negative when the slope is concave and positive when the slope is convex)—can be derived as the second derivative of the field.

Slope length calculation with the use of neighborhood operations, it is pos-sibletocalculateforeachcellthenearestdistancetoawatershedboundary (the up slope length) and to the nearest stream (the down slope length). This information is useful for hydrological modelling.

Hillshading is used to portray relief difference and terrain morphology in hilly and mountainous areas. The application of a special filter to a DEM produces hillshading. Filters are discussed on page 6.4.4. The colour tones in a hillshading raster represent the amount of reflected light in each location, depending on its orientation relative to the illumination source. This illumination source is usually chosen at an angle of 45 above the horizon in the north-west.

Q4f. Perform the raster overlay operation to find R3

R3=CON(R1=3 AND(R2>=45 and R2<=60),1,0)

R1 Soil Type Raster R2 Rainfall Raster(mm)

Ans:

1	1	1	3	3	4	4	7	7
1	1	3	3	4	4	4	7	7
1	3	3	3	4	4	4	7	7
3	3	3	3	4	4	4	5	5
5	5	3	3	3	3	3	5	5
2	2	3	1	1	1	3	4	4
2	2	3	1	1	1	3	4	4
7	2	3	1	1	1	3	4	4
7	7	3	3	3	3	3	4	4

70	70	70	70	60	60	60	60	50
70	70	70	70	80	80	80	50	50
50	50	50	80	80	80	50	50	50
50	50	90	90	90	90	60	50	50
50	35	35	35	50	45	60	60	70
35	35	35	50	50	45	60	60	70
45	35	35	50	45	45	60	60	60
45	35	45	45	45	45	60	70	70
45	45	45	45	60	60	70	70	70

R3=CON(R1=3 AND(R2>=45 and R2<=60),1,0)

0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0
0	0	1	0	0	0	1	0	0
0	0	1	0	0	0	1	0	0
0	0	1	0	0	0	1	0	0
0	0	1	1	1	1	1	0	0

Question 5

Q5a. What is the relationship between Map and GIS

Ans: There is a strong relationship between maps and GIS. More specifically, maps can be used as input for a GIS. They play a key role in relation to all the functional components of a GIS.

As soon as a question contains a "where?" question, a map can often be the most suitable tool to solve the question and provide the answer. "Where do I find Enschede?" and "Where did ITC's students come from?" are both examples.

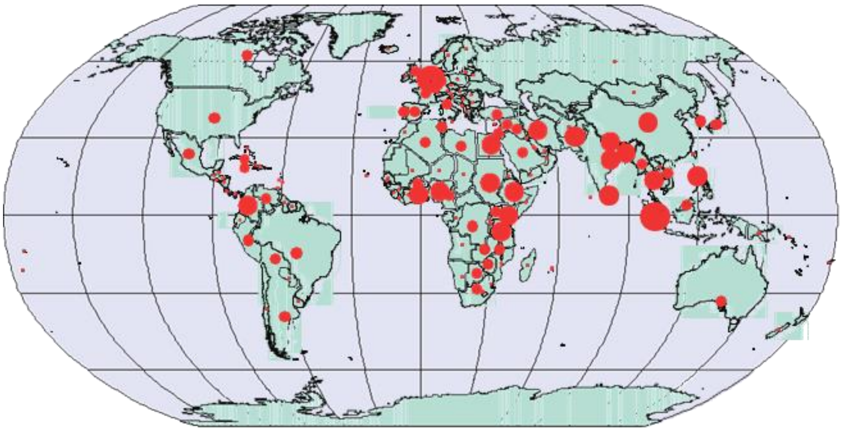
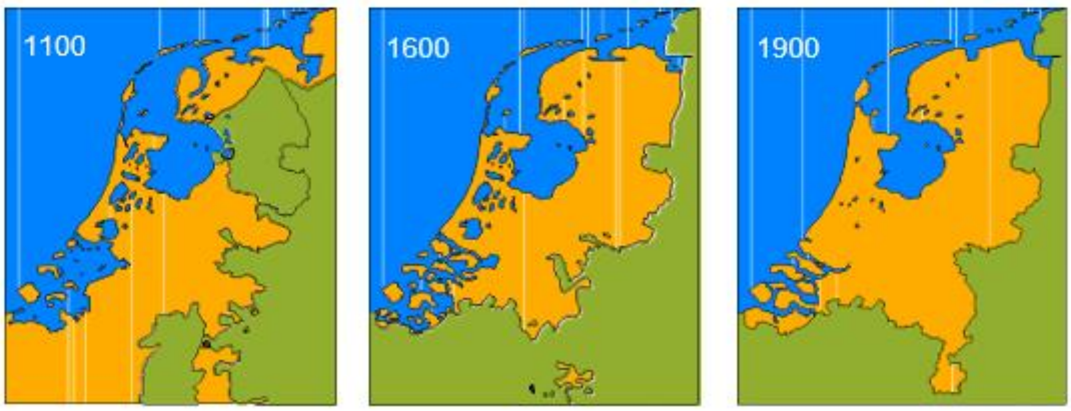


Figure 7. 1: Maps and location— "Where did ITC cartography students come from?" Map scale is 1: 200;000;000.

However, maps can do more than just providing information on location. They can also inform about the thematic attributes of the geographic objects located in the map. An example would be "What is the predominant land use in southeast Twente?" The answer could, again, just be verbal and state "Urban." However, such an answer does not reveal patterns

A third type of question that can be answered from maps is related to "When?" For instance, "When did the Netherlands have its longest coastline?" The answer might be "1600," and this will probably be satisfactory to most people. However, it might be interesting to see how this changed over the years



Q5b. Explain the visualization process in GIS

Ans: The characteristic of maps and their function in relation to the spatial data handling process was explained in the previous section. In this context the carto-graphic visualization process is considered to be the translation or conversion of spatial data from a database into graphics. These are predominantly map-like products. During the visualization process, cartographic methods and techniques are applied. These can be considered to form a kind of grammar that allows for the optimal design and production for the use of maps, depending on the application

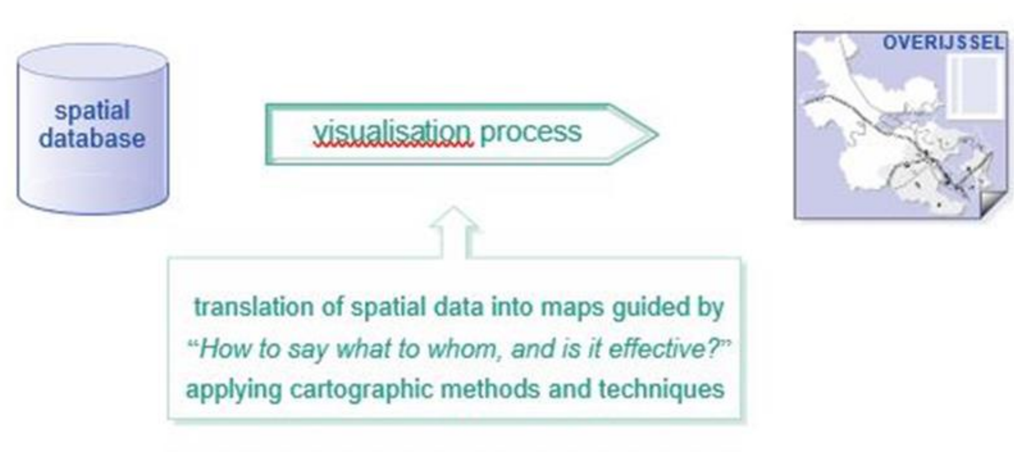


Figure 7.8: The cartographic visualization process.

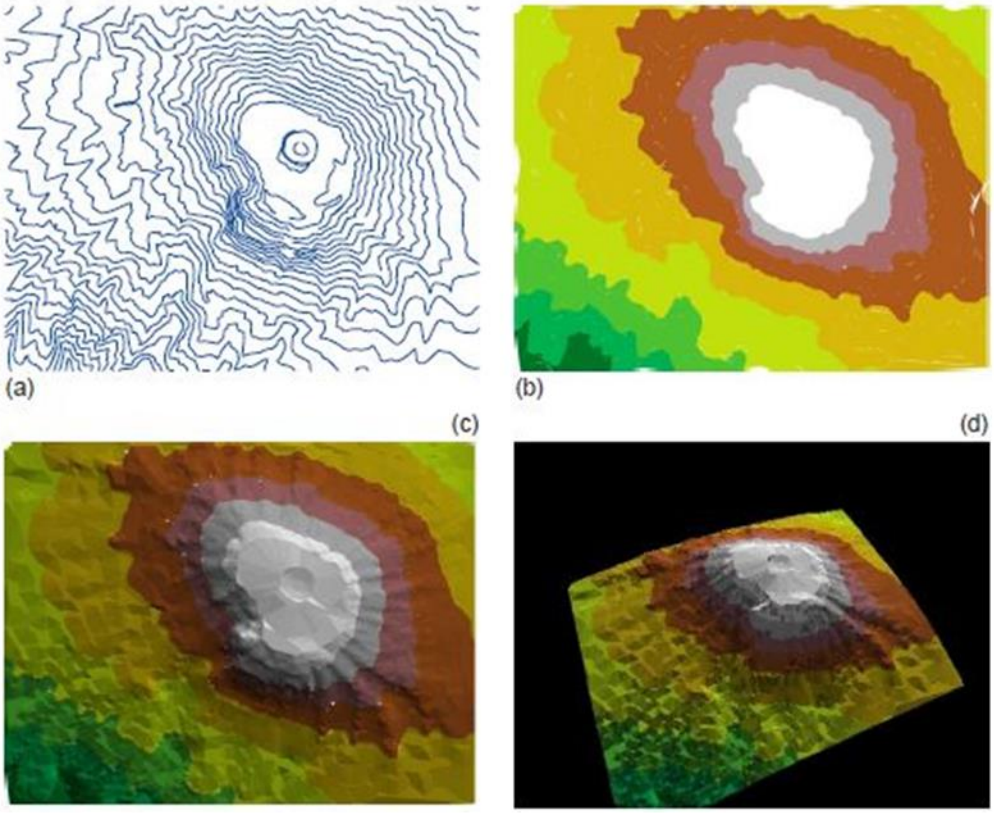
The visualization process can vary greatly depending on where in the spatial data handling process it takes place and the purpose for which it is needed. Visualizations can be, and are, created during any phase of the spatial data handling process as indicated before. They can be simple or complex, while the production time can be short or long.

Q5c. How to map terrain elevation? Explain

Ans: Terrain elevation can be mapped using different methods. Often, one will have collected an elevation data set for individual points like peaks, or other characteristic points in the terrain. Obviously, one can map the individual points and add the height information as text. However, a contour map, in which the lines connect points of equal elevation, is generally used. To visually improve the information content of such a map the space between the contour lines can be filled with colour and value information following a convention, e.g. green for low elevation and brown for high elevation areas. This technique is known as hypsometric or layer tinting.

Three- dimensional appearance

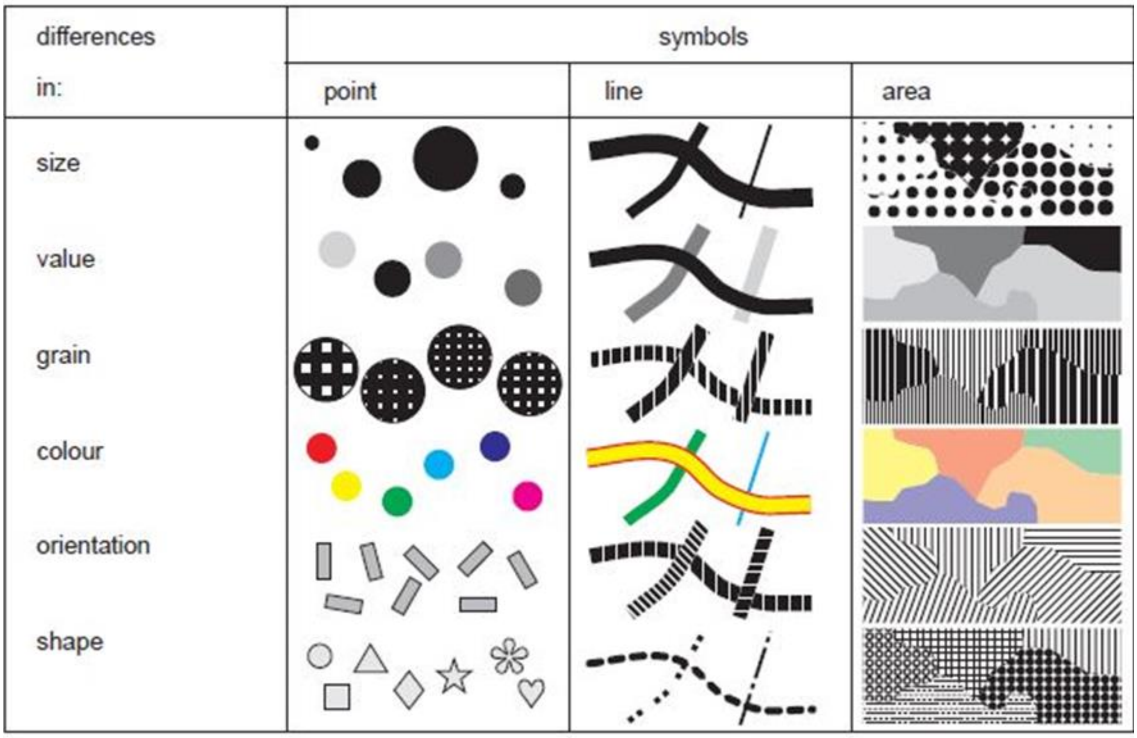
The shaded relief map uses the full three-dimensional information to create shading effects. This map, represented on a two-dimensional surface, can also be floated in three-dimensional space to give it a real three-dimensional appearance of a 'virtual world'



Q5d. What are Bertin's six categories of visual variables?

Ans: Basic elements of a map, irrespective of the medium on which it is displayed, are point symbols, line symbols, area symbols, and text. The appearance of point, line, and area symbols can vary depending on their nature. Most maps in this book show symbols in different size, shape and colour. Points can vary in form or colour to represent the location of shops or they can vary in size to represent Symbology aggregated values (like number of inhabitants) for an administrative area. Lines can vary in colour to distinguish between administrative boundaries and rivers or vary in shape to show the difference between railroads and roads. Areas follow the same principles: difference in colour distinguishes between different vegetation stands.

The variations in symbol appearance are only limited by the imagination they can be grouped together in a few categories. Bertin distinguished six categories, which he called the visual variables, and which may be applied to point, line and area symbols



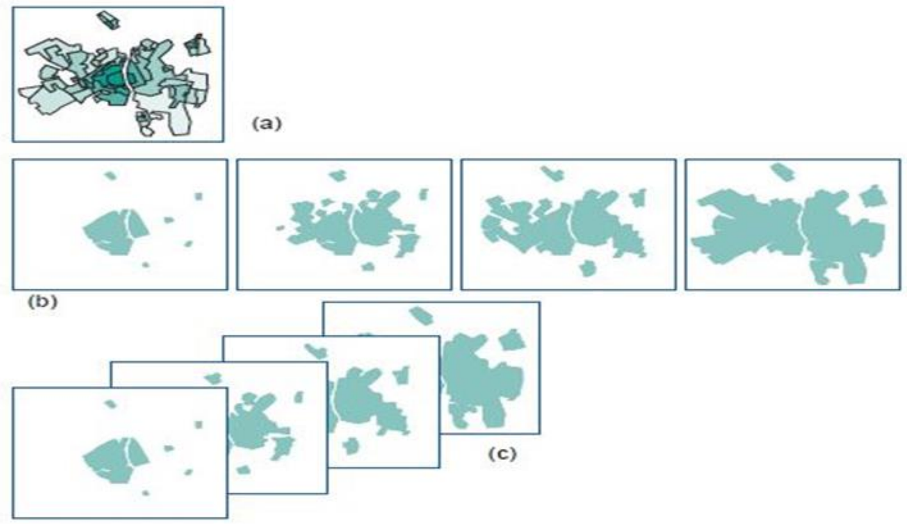
Q5e. How to distinguish between three temporal cartographic techniques? Explain.

Ans: Temporal cartographic techniques:

1. Single static map: Specific graphic variables and symbols are used to indicate change or represent an event. Figure(a) applies the visual variable value to represent the age of the built-up areas;

2. Series of static maps: A single map in the series represents a ‘snapshot’ in time. Together, the maps depict a process of change. Change is perceived by the succession of individual maps depicting the situation in successive snapshots. It could be said that the temporal sequence is represented by a spatial sequence, which the user must follow, to perceive the temporal variation. The number of images should be limited since it is difficult for the human eye to follow long series of maps (Figure(b));

3. Animated map: Change is perceived to happen in a single image by displaying several snapshots after each other just like a video cut with successive frames. The difference with the series of maps is that the variation can be deduced from real ‘change’ in the image itself, not from a spatial sequence (Figure (c))



Q5f. Write short note on Map cosmetics..

Ans**:** Most maps are correct from a cartographic grammar perspective. However, many of them lack the additional information needed to be fully understood that is usually placed in the margin of printed maps. Each map should have, next to the map image, a title, informing the user about the topic visualized. A legend is necessary to understand how the topic is depicted. Additional marginal information to be found on a map is a scale indicator, a north arrow for orientation, the map datum and map projection used, and some lineage information, (such as data sources, dates of data collection, methods used, etc.).

Further information can be added that indicates when the map was issued, and by whom (author / publisher). All this information allows the user to obtain an impression of the quality of the map and is comparable with metadata describing the contents of a database or data layer.

Space constraints

On paper maps, these elements (if all relevant) must appear next to the map face itself. Maps presented on screen often go without marginal information, partly because of space constraints. How-ever, on-screen maps are often interactive, and clicking on a map element may Fundamental requirements reveal additional information from the database. Legends and titles are often available on demand as well.

Text

Text is used to transfer information in addition to the symbols used. This can be done by the application of the visual variables to the text as well. Another common example is the use of colour to differentiate (at nominal level) between hydrographic names (in blue) and other names (in black). The text should also be placed in a proper position with respect to the object to which it refers.

Contrast and visual hierarchy

Maps constructed via the basic cartographic guidelines are not necessarily visually appealing maps. Although well-constructed, they might still look sterile. The design aspect of creating appealing maps also has to be included in the visualization process. 'Appealing' does not only mean having nice colours

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