Overlay Analysis in GIS

Spatial analysis is the vital part of GIS. It can be done in two ways. One is the vector-based and the other is raster based analysis. Since the advent of GIS in the 1960s, many government agencies have invested heavily in GIS installations, including the purchase of hardware and software and the construction of mammoth databases. Indeed, GIS provides a very effective tool for generating maps and statistical reports from a database. However, GIS functionality far exceeds the purposes of mapping and report compilation. In addition to the basic functions related to automated cartography and data base management systems, the most important uses of GIS are spatial analysis capabilities. As spatial information is organized in a GIS, it should be able to answer complex questions regarding space. Indeed, functions required for performing spatial analyses that are not available in either cartographic packages or data base management systems are commonly implemented in GIS.

GIS Usage in Spatial Analysis

GIS can interrogate geographic features and retrieve associated attribute information, called identification. It can generate new set of maps by query and analysis. It also evolves new information by spatial operations. Here are described some analytical procedures applied with a GIS. GIS operational procedure and analytical tasks that are particularly useful for spatial analysis include:

- Single layer operations
- Multi layer operations/ Topological overlay
- Spatial modeling
- Geometric modeling
- Calculating the distance between geographic features
- Calculating area, length and perimeter
- Geometric buffers.
- Point pattern analysis
- Network analysis

Overlay Analysis

Overlay analysis is operation in GIS for superimposing the multiple layer of datasets that representing different themes together for analysing or identifying relationship of each layer. Overlay analysis represent the composite map by the combination of different attribute and geometry of datasets or entity. Overlay is the operations of comparing variables among multiple coverages. In the overlay analysis new spatial data sets are created by merging data from two or more input data layers. Overlay analysis is one of the most common and powerful GIS technique. It analyses the multiple layer with common coordinate systems and determine what is on the top layer. Overlay operations combine the data from same entity or different entities and create the new geometries and new unit of change entity.

Overlay operations performs many type of analysis for example cropping pattern in the field, dominance of particular ethnic population in a region, age and sex composition of region, physical landforms of the surface. It is also termed as spatial overlay because it is accomplished by joining and viewing together separate data sets that share all or part of the same area. The result of this combination is a new data set that identifies the spatial relationships. Map overlay is used in both model overlay of vector data and overlay of raster data.

There are four overlay operators in common use:

1. Point-in-area (also known as point in polygon)

2. Line-in-area (also known as line in polygon)

3. Area-on-area (also known as polygon on polygon)

Vector based overlay

Overlay of vector data combine point, line, and polygon features. In this data model operations rely on geometry and topology of surface. Vector based overlay is time consuming, complex and computationally expensive. For example taking the ordering network layer of Ganga Watershed and laying over it with the layer of village. The result would be which orders of stream of Ganga flow in which village.

Point-in-polygon

Point in Polygon Overlay operation will also generate combinative properties of point attributes of one layer and the polygon attribute of the analysis layer. It is a spatial operation in which one point coverage is overlaid with polygon coverage to determine which points falls within the polygon boundaries. After overlay operation, points assume the attributes of the polygons within which they fall. It helps in formulating hypothesis about the spatial relationships between the occurrence of points and the attributes of the polygons. This kind of overlay operation can also be used to calculate number of points located in each of the polygon.

Polygon on polygon overlay operations

In the polygon on polygon overlay operations I need to check before starting the input layer it should topologically correct. If it is correct output map will also correct. In the polygon overlay it is essential to add new intersections and create polygon for new topology. The overlay of 2 layers of polygon will produce large number of polygons and increase the number of intersections zone and arcs. If the new polygon, arcs and set of nodes have been shaped then meaningful set of layer can be extract. It is necessary to keep in mind that area should be common to both input features. Polygon on polygon overlay operations For example, a farmer wants to know which part of field has loam soil for the cultivation of crops. The farmer will overlay the map of loam soil polygons on field polygon to extract a feature that meets both criteria ‘loam soil and in-field’ for the cultivation of crops. The variables is processed by the farmer, both are categorical or nominal data type. Mathematician have developed set of algorithms, termed as Boolean operators for handling with this type of data and GIS analysts exploit in area on area overlay analysis.

Line in area Overlay operations

Line in area overlay operations need to check linear object or attribute which will combine or meagre with area layer. It should be also topological correct. Suppose I have to know about which road is going in forest are or non- forest. Simply I need to overlay the line layer on polygon remaining extracted layer will be result.

Raster based Overlay

Overlay of Raster datasets combine Pixel-based calculations or Map Algebra. It is quick, straight forward and efficient data sets for operations. It is known as cell by cell combination or operation. It is computationally less demanding. Overlay in raster datasets include two or more different sets of data that derive from a common grid. Each separate sets of data are usually specified numerical values. In the raster these values are mathematically merged together to create a new set of values for a single output layer. The raster based overlay is done for create risk surfaces, sustainability assessments, value assessments, and other procedures. For example, raster based overlay divide the habitat of an endangered species into a grid, and then getting data for multiple factors that have an effect on the habitat and then creating a risk surface to illustrate what sections of the habitat need protecting most. If two grids are aligned and have the same grid cell size then it is relatively easy to perform overlay operations. A new layer of values is produced from each pair of coincident cells. The values of these cells can be added, subtracted, divided or multiplied, the maximum value can be extracted, mean value calculated, a logical expression computed and so on. The output cell simply takes on a value equal to the result of the calculation.

The raster data processing methods can be classified into the following categories:

- Local operations
- Neighborhood operation
- Regional operations

Local operations are based on point-by-point or cell-by-cell analysis. The most important of this group is the overlay analysis. In the raster based analysis either the logical or arithmetic operators are used. The logical overlay methods use operators AND, OR, and XOR (exclusive OR). Mathematically AND multiplies the individual cells whereas logical OR and XOR add individual values of corresponding cells. The most important consideration in raster overlay is the appropriate coding of the features in the input layers. The raster overlay is affected by the resolution (cell size) and scale of measurement (nominal, ordinal, interval or ratio). It is advised that the resolution and the scale of measurement of both the input and analysis layer should be compatible. Basic

arithmetic operators in raster overlay operations are ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION.

Local neighborhood operations are also known as focal operations. It uses the topological relationship of adjacency between cells in the input raster layer to create a new layer. This operation assumes that the value of particular cell is affected by the value of the neighboring cell. Hence a moving window of 3*3 cells is generally applied on the input raster layer. The value of the output cell may be either the average of all the cells of the moving window, or the central cell of the window or the median value of the window.

Operators on regions (Regional operators) are also known as zonal operations. Generally a region is defined as the area with homogeneous characteristics. In raster model it has been defined as the collection of cells that exhibits the same attribute characteristics. Though it also uses two input layer but the mode of operation and the purpose is altogether different from the local operations as it use the boundary of one raster layer to extract the cell values from the other raster layer. The major purpose of this kind of operation is to obtain relevant data from an existing layer for further spatial analysis. There is no uncertainty in the location of the region boundaries because they are in perfect registration.

Reclassification

Reclassification is method of changing the attribute values without altering the geometry of the map. In fact it is a database simplification process that aims at reducing the number of categories of attribute data layer. Accordingly, features adjacent to one another that have a common value, will be treated and appear as one class. Reclassification is an attribute generalization technique. Typically this function makes use of polygon patterning techniques such as crosshatching and/or colour shading for graphic representation. It usually uses either logical or arithmetic operators for raster data or arithmetic operator for vector data. After reclassification, the common boundaries between polygons with identical attribute values are dissolved. Consequently the topology will be rebuilt.

In a vector based GIS, boundaries between polygons of common reclassed values are dissolved to create a homogeneous map. The dissolving of map boundaries based on a specific attribute value often results in a new data layer being created. Almost all GIS software provide the capability to easily dissolve boundaries based on the results of a reclassification. Some systems allow the

user to create a new data layer for the reclassification while others simply dissolve the boundaries during data output. The exact process for undertaking a reclassification varies greatly from GIS to GIS. Some will store results of the query in query sets independent from the DBMS, while others store the results in a newly created attribute column in the DBMS.

Application of Overlay Operations

A suitability model can be used to find the best location to construct a new school, hospital, police station, industrial corridors etc. Certain land uses are more conducive than others for building a new school for example, forest and agriculture were more favourable than residential housing in this model. It was desired to locate the school on flat slopes, near recreation sites, and far from existing schools. For the site suitability overlay keep in mind some point

- Selection of criteria
- Reclassify the data as per the criteria
- Overlay (Boolean or Map Algebra)
- Extraction and representation of suitable site.

For example criteria of nuclear waste repository, site should be an area of suitable geology, site must not be easily accessible, site must be away from high population and site must be outside the area of conservation.