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SPATIAL DATA MODELS

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Abstract: *Spatial data represents the shape, location, and spatial relationships of geographic features to other features. The form represents the geometry of the objects, the location is described by a list of x, y coordinates of discrete points of the objects, and the spatial connections (topological information) of the geographical objects determine the interaction between them. Spatial (coordinate) information can also include time-related data.*

Key words: *spatial object, cartographic modeling, area object, location, surface*

1. Introduction

Many models for GIS software systems have been developed in recent years. Digital spatial models can be classified into the following large groups: vector model, raster model and object-oriented model. Other well-known GIS models that deserve attention are the TIN (Triangulated Irregular Network) model, the topological model, and the network model, which are a variation of the vector model.

2. Presentation

2.1. Vector model

As we have already seen, the vector data represents the geographical space in a way reminiscent of the cartographic signs from the analog map. The simplest vector data structure is called the spaghetti model. This vector model does not have a specific topology.

The vector "spaghetti" model represents geographical objects and phenomena with points, lines and polygons (fig. 1). The points are represented by pairs of x, y coordinates. Lines are a network of points with coordinates. Polygons are a network of coordinates that define the boundaries of closed areas. To show adjacent polygons, the coordinates of the points on the common boundary are recorded twice. The coordinate values depend on the coordinate system. The coordinates that determine the geometry of each object can have 2, 3 and 4 dimensions: 2 (x and y), 3 (x, y, and z, the last coordinate can be height), 4 (x, y, z and t, where t can represent time or some other property).

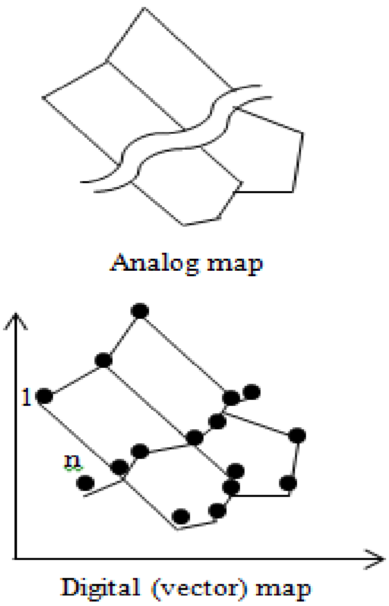


Table of points

Point №	Coordinates
1	x1, y1
2	x2, y2
…	……
…	……
n	xn, yn

Fig. 1 Spaghetti model

Using a vector model, individual (discrete) properties are usually represented, such as object / phenomenon location and area object data. As there are no connections between the individual objects (many points and lines unrelated to each other), this model is not suitable for spatial analysis, but is effective for drawing the cartographic image. Vector data is obtained by digitizing source cartographic and other graphic materials.

2.2. Raster model

Raster data presents objects as a surface that is divided into cells (pixels) of the same size but different color and intensity. Each cell has a width, height and value. The plurality of pixels form a properly structured, two-dimensional grid (matrix) that connects to attribute information. The accuracy of a bitmap image depends on the resolution (number of pixels per unit area).

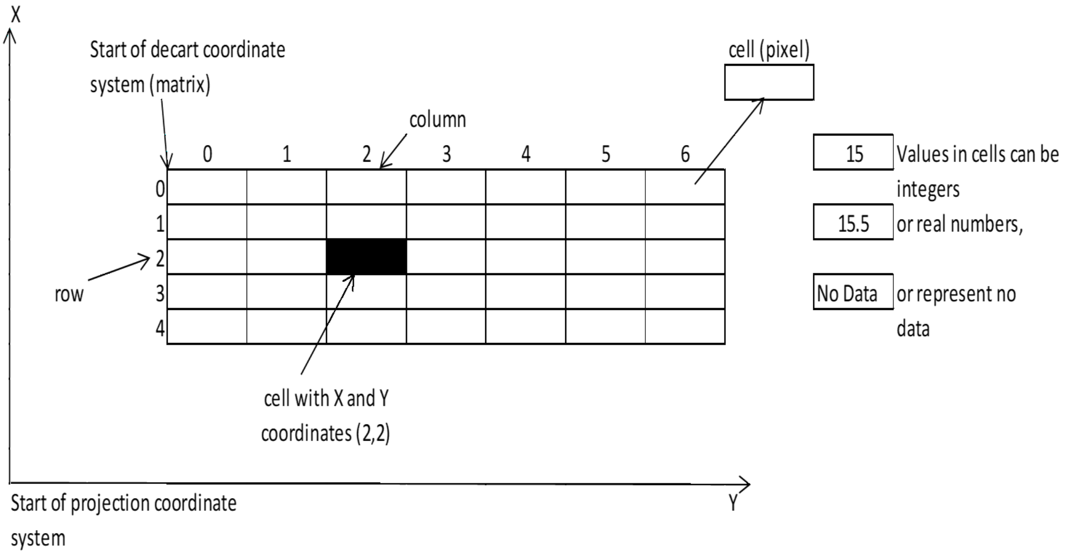


Fig. 2 Raster elements

The spatial location of each cell can be determined in a rectangular Cartesian coordinate system or its position in the matrix. The location of the cells in the matrix is determined by the row and column in which they are located. The beginning is in the upper left corner of the matrix. The rows and columns are mutually perpendicular. The location of the cells in a Cartesian coordinate system is determined relative to the x and y axes in the respective projection (Fig. 2).

A raster model presents continuous numerical values such as heights (Fig. 3, 1) or continuous categories, for example plant species (Fig. 3, 2). Each pixel corresponds to a certain value. Raster data are obtained by scanning source cartographic and other graphic materials, from satellite or photographic images or after interpolation of the numerical values of points with measurements.

The data from the raster models are successfully applied as screen maps, as they look like traditional maps and quickly visualize the information (Fig. 4). They are also widely used to model the spread of diseases or the location of natural resources, as well as to analyze water flow and others.

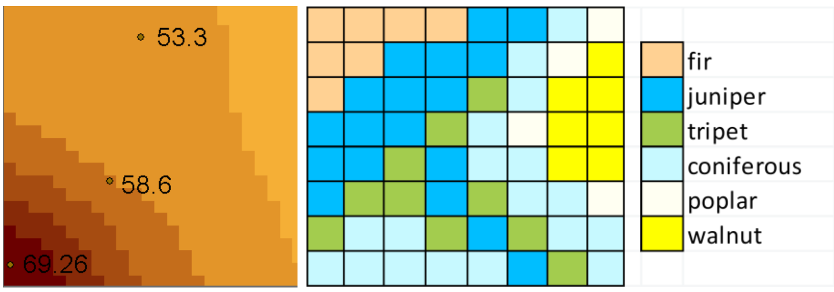


Fig. 3 Raster images

1) Each pixel represents quantities for average hourly levels of sulfur dioxide; 2) Each color represents a different nominal data.

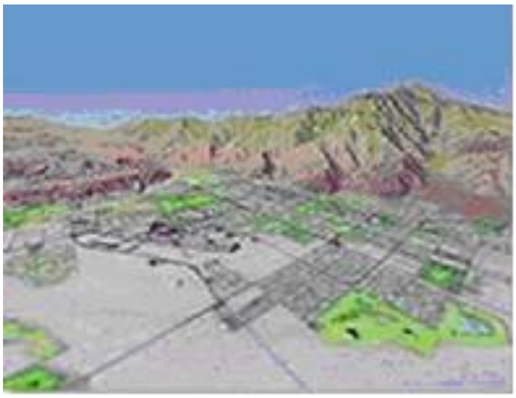


Fig. 4 Combination of vector data (situation) and raster data (relief)

2.3. TIN model

The TIN (Triangulated Irregular Network) model is a vector model of data with a built-in topology. Surfaces can be modeled by a continuous network of interconnected irregular triangles, the vertices of which are defined in space by their x, y and z coordinates (Fig. 5).

The third coordinate in the network of irregular triangles represents continuous real values, which are usually altitudes. There are other statistical areas whose values can express, for example, chemical concentration, groundwater level, or rainfall, temperature, etc.

The triangles are calculated from these point data and represent a continuous three-dimensional surface. They form a network of non-overlapping triangles that completely cover the territory they describe. In the model, each triangle is created if it is possible to be close to the equilateral one.

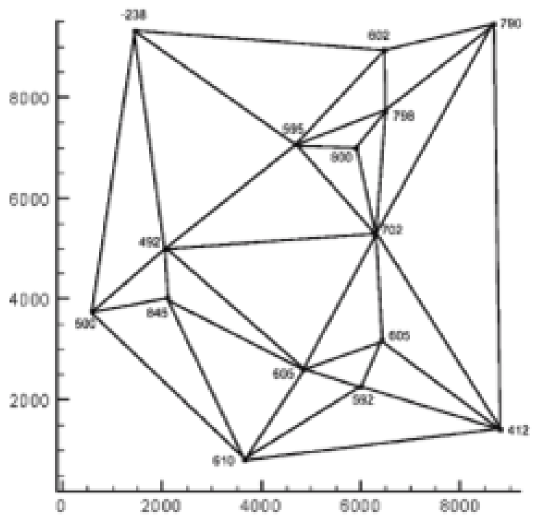


Fig. 5 TIN model

All points defining the triangles are coordinate

A triangle (Fig. 6.) outlines a plane, slope and direction of inclination. The normal to the plane of the triangle is a perpendicular vector and is used for calculations such as illuminance, exposure, and slope. A TIN layer in a GIS can be plotted to show its elements (points, lines, planes) or to visualize its characteristic properties such as altitudes, slope and exposure of the planes that outline the triangles. They are usually the result of a TIN analysis.

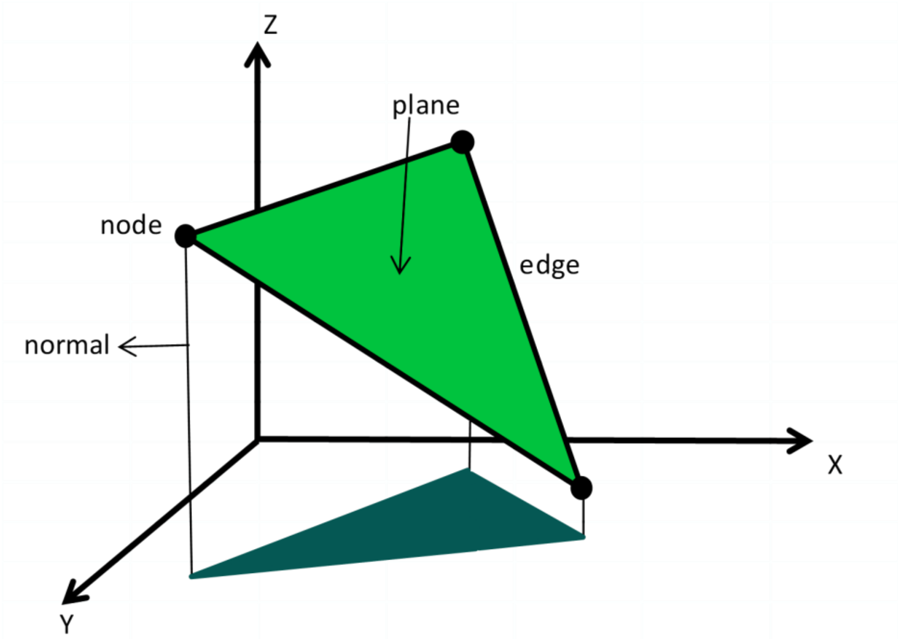


Fig. 6 Perspective view of a triangle in three-dimensional space and its elements

Most often TIN models are used for: modeling and analysis of the relief of the earth's surface; determining a series of surface heights and visibility between two points; determining the slope and exposure; generation of contour lines (isolines) and profiles, watersheds and spillways and volumes. The combination of these factors leads to their wide application in design in road, hydro-ameliorative and hydro-technical construction, in the visualization of the urban silhouette and others.

TIN networks have the advantage of changing the density of the original data, where the surface quickly changes the slope. Areas where the surface is smooth require fewer coordinate points, while where it has more irregularities, more points are required.

It is known from the topological models that by describing the spatial connections between the objects it becomes possible to perform the analyzes described above. As with any topological structure, so for TINs, traditionally, spatial relationship information can be stored in a file or table. The topological structure of a TIN governs the vertex information contained in each triangle and its adjacent triangles.

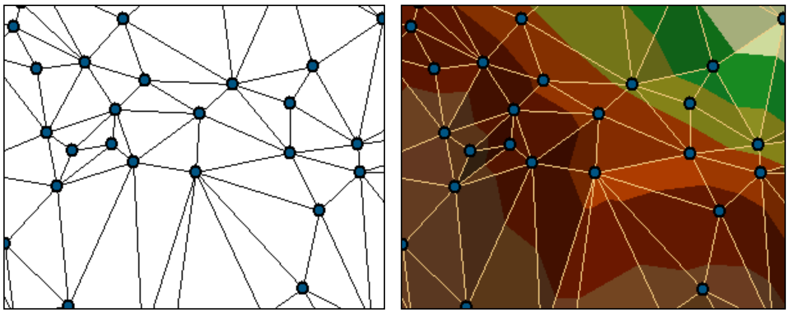
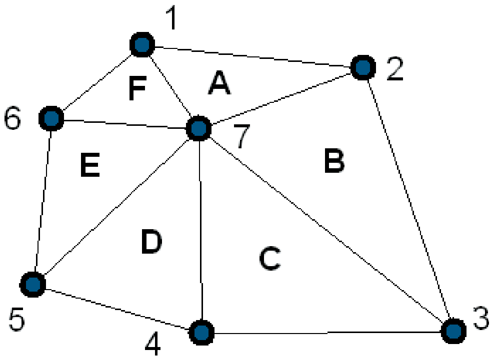


Fig. 7 Example of topological structure in TIN model



Triangle	Top	Adjacent Triangles
A	1,2,7	B, F
B	2,3,7	A, C
C	3,4,7	B, D
D	4,5,7	C, E
E	5,6,7	F, D
F	1,6,7	A, E

Fig. 8 Topology of the connections in the triangles and a table of the vertices that form them

In Fig. 8 shows the topology of a simple network of triangles which is part of Fig. 7. The tables store the coordinate data and the topological connections (data for the vertices, for the lines, for the neighborhood) of the TIN model.

When modeling the terrain, the TIN model is built in the following order: data are collected for the terrain, represented by a network of points with x, y, z coordinates by geodetic, photogrammetric methods or with GNSS technology; the points and lines where the slope of the terrain changes are determined (characteristic points, watersheds and watersheds); areas for water bodies, such as lakes, are excluded. The next step is to create the optimal network of triangles from the point data GIS software. The height inside the triangle is then interpolated from the heights of the points forming its vertices.

3. Conclusion

Because TINs represent a surface with vector objects (points, lines, areas), they can accurately model the discontinuity of the surface with dashed lines. Examples of such lines are rivers, watersheds and roads, where the surface clearly changes its slope. One limitation of TIN is that it cannot represent phenomena such as steep cliffs, caves, etc.

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