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MODELLING OF GEOGRAPHICAL REALITY

Sabin Ivanov

KONSTANTIN PRESLAVSKI UNIVERSITY OF SHUMEN, SHUMEN 9700, 115 UNIVERSITETSKA ST.

e-mail: s.ivanov@shu.bg

Abstract: *From a cartographic point of view, mapping modeling can be defined as a method of creating mathematical models that are similar copies of objects of reality. They are divided into descriptive (visual) and predictive. This is the general classification of cartographic models. Descriptive models show existing objects or phenomena, as well as the links between them, presenting the results in an appropriate form that allows the user to identify them immediately. This type of model is simple and easy to create, and this reason makes it the most commonly used. The second type of cartographic model shows the predictive possibilities of the descriptive model and is called a predictive cartographic model. Predictive models require the introduction of factors and parameters that are important for the functioning of phenomena appearing in a particular territory.*

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

1. Introduction

The term cartographic modeling was first defined in 1979 by Dana Tomlin and Joseph Berry, which refers to a system of cartographic processes that use computer commands. Therefore, the cartographic model is the result of cartographic operations focused on the data to answer questions related to the mapped geographical objects and phenomena. The ideas and rules used in cartographic modeling are taken from mathematics. As a methodology for processing geographic data, cartographic modeling considers map objects as variables included in algebraic equations. In algebra, real variables are represented by the symbols x, y and z. In cartographic algebra, these notations can represent numerical attributes of map elements. From these values, by using mathematical operators such as addition, subtraction, multiplication and division, new numepical values can be obtained. Similarly, in cartographic algebra, maps are transformed or combined into new maps using certain spatial operators.

2. Presentation

2.1. Modeling of spatial objects

Objects in GIS data models are characterized by the following characteristics: type, geometric elements, attributes and relationships. Attributes describe the non-spatial properties of objects that are arranged in tables. The connections between the objects in GIS are the same as in the real model. The difference is that from the digital model in GIS they can be calculated from the coordinates of the objects. The relations (connections) between the objects are practically realized between their separate attributes. In the following lines we will consider the classification of objects according to their type and geometric shape.

Spatial objects from the real world are perceived with different geometric shapes. GIS usually uses two types of objects: simple and topological. Simple objects are vector objects of type point, line, polygon, and surface. For each of these types of objects, point, line and area cartographic signs are generated respectively.

Simple objects are useful in GIS applications because they are easy to create and store, and can be reproduced and presented quickly on a computer screen. On the other hand, in the absence of any connection between the sites, it will mean that operations such as the shortest path, network analysis or polygon proximity cannot be performed without additional calculations. Simple polygon objects are not effective in modeling phenomena represented as fields because the boundaries between adjacent objects can be digitized and stored twice (e.g., two adjacent fields). This shortcoming can be easily overcome by creating topological objects. The structure of simple linear and polygonal objects is sometimes called spaghetti because they look like spaghetti.

Topological objects are essentially simple objects that are structured using topological rules. (DeMers S., 2000).

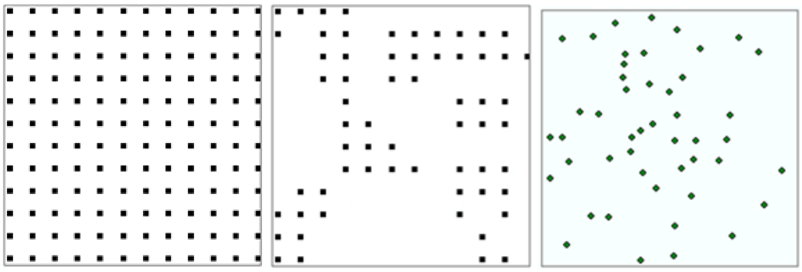
Based on the geometric primitives point, line and polygon, GIS supports the following types of simple spatial objects:

- **Point objects**

These are objects whose area on the scale of the image cannot be displayed. Therefore, it can be said that they have no dimension and symbols are used, which show only the location, but not the shape and size of the object. Such sites are trees, intersections or settlements in small-scale maps. Any spatial object whose location can be a single point in space is called a discrete or discontinuous object. The point objects are represented by pairs of coordinates x, y, which determine the location of the objects on the map. In GIS, they are connected by point drawing primitives (dots), which build different spatial models.

To determine the distribution model, the density of point objects is calculated. It is usually done by dividing the number of points in the total area in which they exist. A clearer idea of the density is obtained by determining the number of points per unit area. If when comparing two territories they have the same number of points per unit area, then the distribution of point objects is the same. It is more common for the points not to have the same distribution on the territory. Each network of point objects is characterized by a different arrangement and distance between them. This also determines the type of spatial model for the distribution of points. In Fig. 1a shows the correct distribution of the point objects. A good example is planting plants at regular intervals. This model differs from the locations of the trees in the forest, which are randomly (accidentally) scattered throughout the territory. The third model characterizes the group distribution of point objects. A typical example is the location of settlements near rivers, lakes or oceans.

Special point objects are the reference points, which serve to describe the geodetic network with x, y coordinates. They provide a common coordinate system of all objects in the database.



a) correctly b) grouped c) randomly

Fig. 1 Point distribution models

- **Linear objects**

A linear object is a series of dotted lines that show its exact location (fig. 2). The width of such objects cannot be displayed on the map scale, such as roads, rivers, administrative boundaries, fences, etc. Therefore, in the model they are presented as one-dimensional. Linear objects are connected to the drawing primitive line. Different types of lines are used to represent objects, which determine the shape and orientation of the objects. Linear segments can be straight, curved by a circle, ellipse or spline.

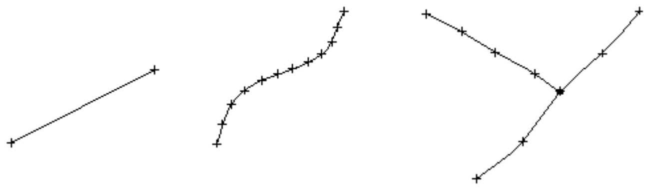


Fig. 2 Types of lines

For completeness, it will be said that in some models linear objects can be represented not only as a series of lines, but also by curves defined by mathematical functions (eg spline lines, arcs of circles, ellipses, etc.). More spatially defined points are needed to describe these complex lines.

- **Polygon objects**

Polygons are closed figures that serve to describe area objects (fig. 3). They have two dimensions - length and width, but not depth. Area objects are depicted on the map with their spatial boundaries surrounding a homogeneous area. The boundaries of the contours are represented by the surrounding lines connected by common nodes (the node is a point where several lines begin or end). The exact location of the object is determined by means of a coordinate point (label) inside the polygon. Therefore, by indicating the location of the polygons, we can determine three additional properties: the lines that make up the object with their shapes and orientations, as well as the area of the territory they enclose.

Like point models, polygon objects can also be properly distributed, grouped, or randomly scattered throughout the area. Depending on the way of shaping in space, polygons are divided into three main types: bordering polygons, separated polygons and internal polygons.

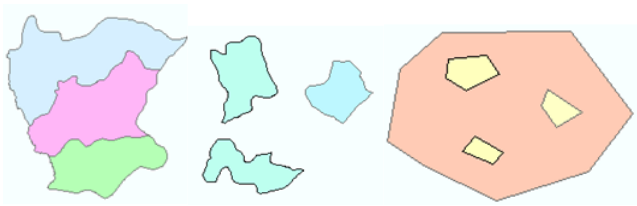


Fig. 3 Types of polygons

2.2. Network modeling

Networks come in a variety of forms, naturally created (such as rivers) or man-made. The second type of networks is used to model the infrastructure. They fall into one of two types of models: transport networks or utility networks. Network models are a set of roads, cables, or pipelines used to move and transport people, materials, energy, goods, or information. In the context of

GIS, networks can be defined as a series of connected linear objects whose attributes are mainly related to the movement or flow in them.

They are divided into three main types: rectilinear, radial and circular (Fig. 4) (DeMers, 2000). In radial or tree models, currents or displacements always have an upward or downward direction. Water and sewage networks are suitable examples of radial networks. Water distribution networks are circular to ensure that interrupting effect of the least number of consumers when it is necessary to stop the water in certain places.

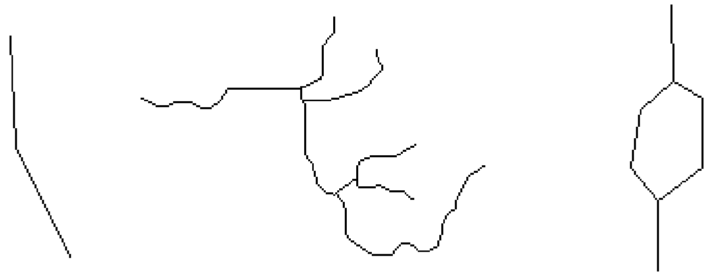


Fig. 4 Types of networks

All types of networks can be defined as networks with one-way and two-way traffic in them. Examples of the first of these are one-way streets that restrict traffic or rivers that flow along the slope of the terrain. In the case of two-way networks, the current can be reversed and then move in another direction.

2.3. Image modeling

Raster technology is an efficient means of gathering large amounts of information from images. Much of the information collected about the Earth is in the form of photogrammetric or satellite images. They can also serve as a background for another (vector) map on the computer screen.

A model of coordinate data that depicts continuous phenomena, such as temperature, precipitation or altitude, can be presented in the form of images.

Both types of images are called rasters. The raster consists of a two-dimensional matrix of cells whose attributes represent qualities (eg color, light reflection) or quantities (eg precipitation).

2.4. Surface modeling

The surfaces have length, width and height, resp. depth, therefore they are three-dimensional (three-dimensional). They are used to represent natural objects such as the relief of the earth's surface or phenomena such as urban population, temperature distribution, precipitation, etc. that they represent. The surfaces are composed of multiple height values (the third coordinate). We say that they are continuous because the possible values for the heights are distributed without disturbing the continuity of the surface. Surfaces are obtained by interpolating between objects of known heights, for example from points with altitudes or horizontals. In them, the third coordinate is represented as an attribute value referring to a single point or isoline in two-dimensional space. Altitude as a third coordinate can represent attribute values such as population, temperatures, precipitation, etc. In fact, the change in height of a three-dimensional object changes from one place to another, and we can measure that change. With this information the volume of the object can be determined. These calculations are very useful, for example if it is necessary to know how much water a tank contains or how much material is needed to build it.

2.5. Location modeling

Probably the most common task is finding a location. The geographic database stores locations such as: addresses, zip codes, names of settlements or x and y coordinates. From the detailed points entered in the model with x, y coordinates and their connection, geographical objects can be modeled.

2.6. Modeling of relationships

The spatial connections between the objects reveal which of: the objects are connected with others; the objects are adjacent to others; the sites are located in a given territory; objects intersect, objects are close to others; the difference in the heights of the objects; the relative position among the objects.

3. Conclusion

The dynamics of processes and phenomena in space and time require the maintenance of data that reflect the time and periods associated with them. Perhaps a partial solution to this problem can be found with the creation of GIS time models. Indeed, one of the most effective tools of GIS is the presentation of the time factor and the possibilities for designing space-time models. The time factor is often overlooked in GIS when dealing with our current situation rather than historical changes. In practice, it is difficult to create a data model that combines the current situation and the changes over a period of time. If the time factor is combined in the GIS data model, we will avoid the risk of losing important historical data.

The inclusion of time in GIS as the fourth coordinate can find several solutions. The most common solution is to present different states of phenomena in separate layers, add new layers to reflect the change of time and compare them. The presentation of the phenomena in the map as a snapshot can be considered as a disadvantage of the standard GIS tools.

References:

[1]. Yanchev K. Presentation of horizontal movements of the Earth's crust by results of geodesic measurements. Journal scientific and applied research, Volume 19, 2020, ISSN: 1314-6289, pp. 62-66.
[2]. Kirilova K. Optimal geopotential models of the Earth's gravitational field for the territory of south-western Bulgaria – Rila mountain. Journal scientific and applied research, Volume 19, 2020, ISSN: 1314-6289, pp. 67-71.
[3]. Ivanov S. Determination of visibility between card points. Journal scientific and applied research, Volume 13, 2018, ISSN: 1314-6289, pp. 36-40.
[4]. Ivanov S. Determining the scale of a topographic map. Journal scientific and applied research, Volume 13, 2018, ISSN: 1314-6289, pp. 41-45.