

DESIGNING OF SYMBOL SYSTEM FOR 3D CITY MAPS

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Summary

The report considers the designing of Symbol System for 3D City Maps. A comparative characteristic between symbol system of 2D and 3D City Maps is done. A topic concerning classification of mapping objects is considered. The principles of coding, grouping and hierarchic organization of objects' database are proposed.

The rules for symbol designing are defined. A structure of vector and raster data for symbol designing is proposed. Some research experiments concerning the designing and modeling of symbol system are done. More than 50 symbols are created and a 3D map of central part of Sofia City, capital of Bulgaria is designed. The map consists more than 300 objects, including roads, buildings, green areas and symbols with 70 000 faces and 40 000 vertices. Different kind of images are processed and prepared for texture palette used for symbol modeling. The symbols are used for representing of city objects as surveying points, transport stations, traffics signs and lights, information labels, symbols for special buildings and others. The using of symbol system for 3D cartographic modeling could save time, work and money and would bring the ergonomic and economic effects for map designers.

Two AVI files created using the designed map for visualization purposes show animated maps.

Introduction

The use of three-dimensional (3D) City Maps increase in many fields of science and practice - city planning and architecture, education, design and advertisement, telecommunication, tourism, transport, meteorology, police, military, etc. The most of proposed 3D City Maps contain some symbols for representing of different small objects of city environment, for example, trees.

The purpose of this research is formalisation of the logic for cartographic representation of information in 3D maps applying a symbol system. This is achieved by defining:

- rules for creating a quality symbol system
- economically effective norms for working with 3D maps by various users.

A 3D map is determined as a digital, mathematical defined, three-dimensional virtual representation of the Earth, surfaces (e.g. luminous body's), objects and phenomena in nature and society. Represented objects and phenomena are classified, designed and visualised according to a particular purpose. On the base of this definition, the theory of symbol system for 3D maps is build and the design and usage of 3D symbols is demonstrated. The schemes and figures (shown below) are a result of an elaborated investigation of the traditional cartographic systems and application of 3D computer graphics in cartography.

1. Survey of the need for a 3D symbol system

The utilisation of 3D maps in various areas of urban planning and management is surveyed and clarified. Investigation among 15 Bulgarian firms, working in the field of GIS, geodesy and cartography is completed and analysed. 94% of them consider the cartographic symbols an important issue and even propose areas of utilisation. "The producers were challenged with questions regarding traffic, public and information signs and marks. The majority of them accept the idea of additional guiding information on streets of a 3D model" [Zlatanova, S., T. Bandrova, 1998]. The results of investigations revealed an urgent need of 3D symbols and at the same time lack of a formally defined 3D symbol system.

2. Comparative characteristic between symbol system of 2D and 3D City Maps

The traditional symbols are divided in three groups: point, line and area ones. The symbols in 3D maps can be divided in point and texture ones. They can be treated as 2D and 3D symbols according their dimensionality. The full comparative characteristic can be seen in the following table:

Table 1. Comparative characteristic between symbol system of 2D and 3D City Maps

<u>Comparative indications</u>	<u>Symbols for 2D maps</u>	<u>Symbols for 3D maps</u>
1. Objectiveness	Point, line and area symbols	Point and texture symbols
2. Dimensionality in situation	2 dimensions	2 or 3 dimensions
3. Scalability	Scalability of symbol	Real dimensions of symbol (average for representation object)
4. Representation of dynamics of objects and phenomena	Symbols for dynamics, map-diagrams, locality of diagrams	Unlimited usage of all symbols in animated environment
5. Colors in representation	CMYK - for published maps RGB - for screen maps	RGB visualization
6. Classification according the shape	Art, geometric and letters symbols	Volume and plane symbols
7. Classification according the orientation	North and according the terrain	Real orientation
8. Qualified and quantified analyses	Usage of 2D GIS	Usage of 3D GIS
9. Information capacity	Limited by the scale	Limited by hardware systems
10. Standardization	In state level	No solved

Table 2 Classification of mapping objects

3. Classification of mapping objects

The basic types, kinds and sub-kinds objects and their qualitative and quantitative characteristics, which will be mapping, can be defined by hierarchy-code presentation. The proposed coding is in unison with European standards for exchange of information and leads to clear structuring of all landscape objects. The proposed grouping and classifying of objects is shown in table 2 and eventual establishing as Bulgarian Standard will leads to ergonomic and economic effectiveness.

4. A 3D symbol system

The comparison between the symbol systems for 2D and 3D maps has contributed to definition of basic requirements for creating 3D symbols:

- 1) The symbols should be similar to the real objects, which are represented in 3D map. (see Figure 1). There is no legend as in conventional 2D map but there is a description for every symbol in the database. When an object has different representations, the symbol should be similar to the most know one or has got different variations for special purposes - for example: representation of different restaurants in 3D map;

<u>Code</u>	<u>Name of type object</u>
1000	Situation
1100	Geodetic base
1110	Astronomic point
1120	Triangulation point
1130	Polygon point (PP)
1131	PP, stabilized by a wooden picket
1132	PP, stabilized by a concrete block
1133	PP, stabilized by an iron tube
1140	Axis point

1500	Transport objects
1510	Railway
1520	Roads
1521	Highway

1527	Shaped pathway

2000	Hydrographic objects

3000	Relief

4000	Pipelines
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Fig. 1 A photo and symbols of mapping objects - transport station and telephone

- 2) Minimum polygons should be used when a new symbol is built. Since a lot of art elements, text, volumetric shapes are used in some symbols, additional memory is required for every symbol (see Figure 2);

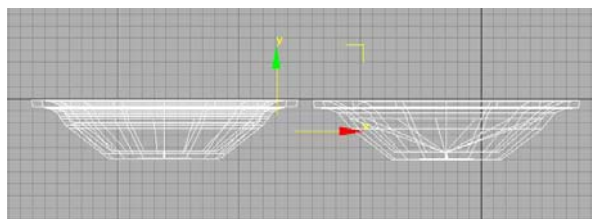


Fig. 2 A usage of modifier 'optimize' for redusing of fases in designing of a symbol

- 3) The symbols should be created in their real dimensions. Usually, dimensions are calculated as an average of some real object's dimensions. The dimensions could be bigger or smaller than average ones if the user has such requirements. In this case the cartographer should scale before projected symbols.
- 4) The symbols are designed for different purposes depending on user's needs. This requirement leads to designing of symbols in different sub-objects, resolutions or LOD.

The all requirements in traditional cartographic system, which are suitable for 3D, will be used in 3D symbol creation as well.

Systematisation and classification of objects (see Table 2) and designing of symbol system is based on a number of conditions, counting in map creation: contents, purpose, method of usage, peculiarity of visual perceiving, esthetical requirements, hardware and software possibilities. Accounting all of this complexity of combining the above conditions, an order and links in steps of symbol creation are proposed (see Figure 3).

The following steps for symbol creation for 3D map are distinguished.

- Gathering information for an object (quality and quantity characteristics, images, textures);
- Analysing information and collecting data for each object;
- Designing symbols by visual and metric analysis applying computer graphics techniques;
- Visualising the symbols in virtual environment;
- Obtaining synthesised information for object.

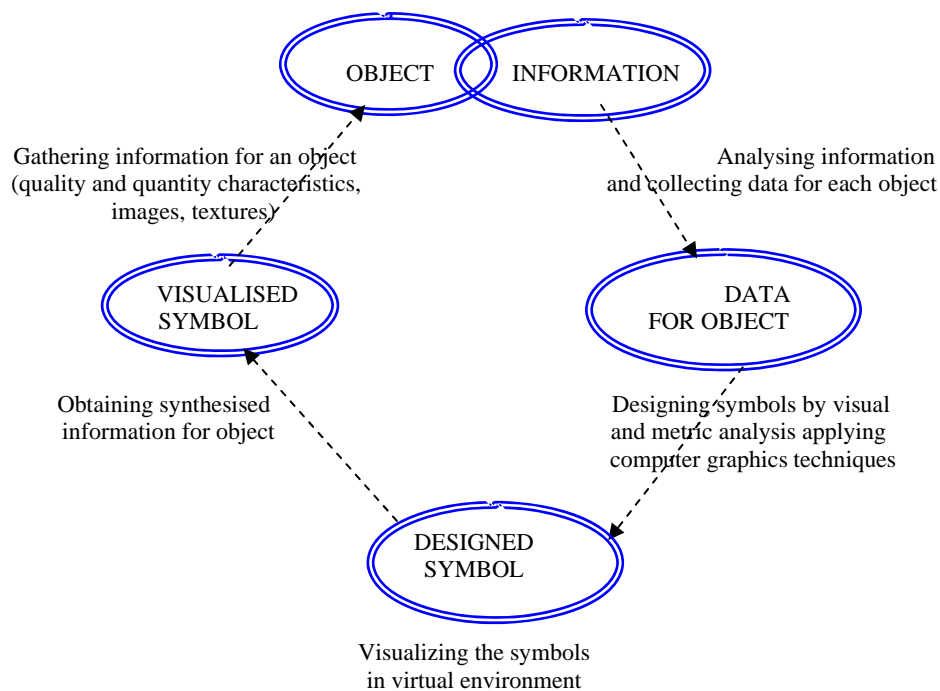


Fig. 1 Steps for creating of symbol for 3D map

5 Data organisation

5.1. Persistent data

Since some of the 3D symbols (e.g. lamppost, information boards, etc.) are difficult to recognise, I propose utilisation of emanating symbols. Thus parameters, indicating which 3D symbol emanates light, are organised at the database level. The design of some symbols is proposed in order to ensure independent from existing illumination sources lighting. 200 photos of traffic signs, 4 - for trees, 1 - for grass and some of information boards are scanned and further processed. They are prepared for texture palette using in the symbol creation by method of texture mapping (see [Zlatanova S., 1998]). Other textures are designed by art software, e.g. symbols for telephone, electric transformer, etc. The vector data are organised using *vertices* (X, Y, Z co-ordinates), *faces* (included RGB colour presentation or texture), *primitives* and different kinds of *modifiers*. A table with text information for every symbol is related with its code (identifier). Every identifier is a number in hierarchical indexing and classification of objects, e.g. a polygon point is in a geodetic network.

5.2 Data structure

A data structure (see Appendix 1) for organisation of vector and raster data representation of symbols is proposed on the base of existing of 3D data structures - a "basic data model", adopted from Tempfli and Pilouk and "core tables of relational database" [Tempfli, K., 1998]. The symbol contains primitives, class and LOD. The table of a primitive contains code, modifier, belonging to a symbol. The faces define the geometry of symbols. The face table contains a code, primitive in left and in right, colour and texture. Faces are defined by the edges. The arc code connects the edge table with the arc table. The arc table contains begin and end vertex. The vertex table contains a code and co-ordinates X, Y, Z. Vector data is extended with raster data by the texture table. It contains code, file name and where it is saved. A face can contain texture description or colour RGB definitions. Most of symbols are designed using such data organisation. Some of them do not contain primitive table and/or texture (colour) table.

6. Implementation

Applying the proposed method, a symbol system containing 100 symbols (points and texture) is created. Some of them are designed for objects represented in Bulgarian maps, and others - for Austrian ones. Figure 2 shows some snapshots of symbols in maps, created by the method "From paper to virtual map" (see [Bandrova, T., K. Ivanova, 1999]). The symbols are designed with different resolution, i.e. LOD, which allows the users to select interactively the most appropriate representation with respect to the purpose of the 3D map (see Figure 3). The usage of VRML for the

visualisation of 3D symbols on the Web is proposed and experimented. Animation demonstrating a virtual walk-through 3D map with symbols is created. The animation contains 3090 frames that are visualised for 1 min., 43 sec.

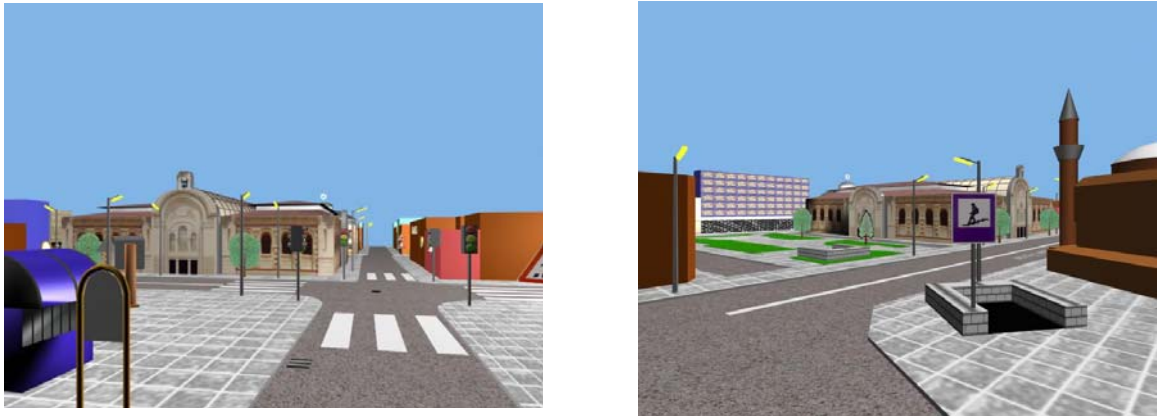


Fig. 2 3D maps of central Sofia designed by the help of symbol system

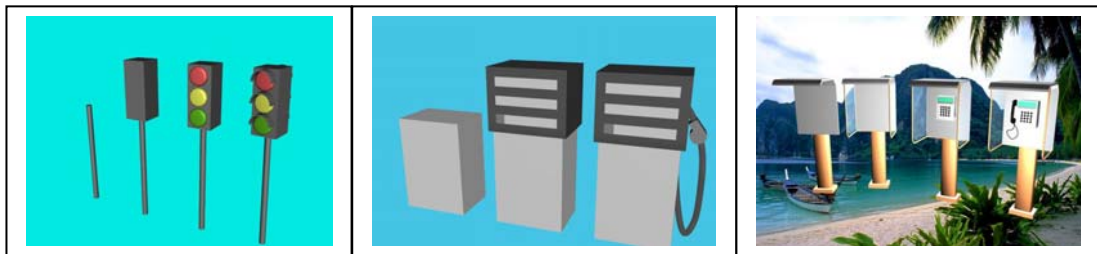


Fig. 3 Different resolution (LOD) in symbol designing and visualising

7. Conclusions & contributions

The theoretical base of cartographic symbol system in 3D modelling is developed. This is a result of extensive investigations portraying the lack of formally defined 3D symbol system.

The model presenting the new position of the map language in the process "creating - using of map" provides the map designers with a firm tool for understanding 3D maps and the place of symbol system. Furthermore the symbol system has to be designed for a particular map with an awareness of the purpose of the map and the end-users.

The requirements and stages for symbol design are specified. They provide cartographers with a standard approach for developing symbol systems for 3D city maps. The analytical calculation of complexity of volumetric symbols leads to design of simple realistic symbols with a good information capacity.

The data structure for organisation of vector and raster data facilitates the development of cartographic information systems and software for 3D maps.

The proposed 3D symbols contributes to:

- quickness, simplicity, and economy in the building up of 3D maps;
- ability for representation of "small" objects in city environment;
- representation of quantity and quality differences between objects of different dimensions

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Appendix 1: Organisation of vector and raster data representation of symbols for 3D maps

