3D Map Symbol and It's Modeling

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ABSTRACT

The 3D map symbol has broken through the planimetric expression of map and makes the map expand in content and form of visual expression of geographical phenomenon. In view of the limitation of performance of traditional map symbol, this paper analyzes the present research on map symbol' definition. The data organisation of 3D map symbol has been discussed. And two kinds of map symbol's modeling by using the direct modeling method based on mathematics to describe the regular map symbol, and by using the modeling method based on VRML to describe the irregular symbol have been put forward in this paper.

Key words Map Symbol 3D-Data Model 3D-Data Structure VRML

1. Introduction

As map become the carrier of spatial information, it's function is determined by the entire performance of symbol to a large extent. The development of the contradiction between abstraction and visualization of the map symbol as the map language is from sketch to 2D and to 3D. Because of the confinement of the software and hardware condition of computer, the methods of establishing the 2D symbol libraries and their corresponding symbolization tool-software were used to provide the electronic planimetric map (two dimensions) in order to overcome the shortcoming of paper map in the past. The map itself is undergoing the revolution from theory to concrete product in recent years. The 2D information can not satisfy people's needs with the advent of information time; the development of computer makes the demonstration and description of 3D geometrical and attribute feature of object possible recently; and 3D's description of symbol has brought great challenge for traditional map symbol's design.

2. About Definition of 3D Map Symbol

There are many kinds of symbols, e.g. the lingual, literal, mathematical, physical, chemic symbols, the symbol on the map that people know every well, etc So, the map symbol is the subclass of symbol applied to the map. There is a specialized definition for the Symbol Method according to Glossary Dictionary: "The Symbol Method is one of the thematic map demonstration methods. The numerical characteristics of each mapping phenomenon and geographical distribution features are showed respectively with different shapes and sizes of graphs on the map. There are four classes of symbols which are letter symbol, geometric symbol, drawn symbol and graphical symbol according to difference shapes." The document [1] has given the following description to the essence of map symbol: The map symbol itself can be said to be an object(graph) of a kind of substance and indicates the abstract concept, and this kind of indication is based on the conventional relationship. The map symbol is a special kind of diagram symbol, it shows the property and mutual relation of various objects and phenomena with the form being easily positioned spatially. It has two basic functions. Firstly, it can point out the kind of object and quantity and quality feature. Secondly, it can determine the spatial location of object and phenomenon distribution. Single symbol only has the limited function, but the combination of symbols can express the spatial combination and mutual contact of objects on earth, namely, it gives out the information that the single symbol can not provide. The document [2] considers the map symbol as the special diagram mark on the map used for showing object and phenomenon, and it is formed from point, line and geometric figure. There are three essential factors of the map symbol, namely, shape, size and color. The shape is the most essential factor among them. It is the major mark telling differences between map symbol and also the major basic when people read the map and distinguish different map symbols. The shape is the major vision variable of map symbol, and the major information of shape feature has been concentrated on the outline of symbol. So, description of map symbol just needs to start from gaining the outline of symbol. The document [3] gives the definition of map symbol as following: The map symbol, namely, the map language is an important kind of visualization tool that directly expresses geographical features and phenomena, and is also the basic method by which readers can perceive geographical features and phenomena.

None of the description of above map symbol is perfect. Glossary Dictionary has only given a definition of the Symbol Method. Though there are some referential effects on the definition of the map symbol, the definition of the Symbol Method is not the specialized description in accordance with the map symbol after all. The document [1] has given a description of the essence of map symbol, but the description that "the map symbol shows the quality and mutual relation of various objects and phenomena with the form being easily positioned spatially." has clear 2D map symbol characteristics. The 3D map symbol has changed the requirement of symbol positioning point

compared with the 2D map symbol owing to the strengthened function of its environment. The document [2] focuses on the description of the property of symbol itself, however the essence and effect of symbol are not described. The definition of the map symbol of document [3] is inadequate and lacks strict discussion on the map symbol. So, redefinition of map symbol is necessary under the new condition to be adapted to requirements of 2D and 3D symbol. The author thinks that either 2D map symbol or the 3D map symbol can record, change and transfer the knowledge of various natural and social phenomena, and form the spatial image of reality on the map.

3. Modeling of 3D Map Symbol

3D modeling is the kernel content of establishing 3D map symbol and is also the key node that affects the quality of 3D maps. The model is the skeleton of symbol. Only by establishing the fine, accurate and suitable-detailed model, the fidelity of the 3D map and its symbol can get assured. We know, describing the spatial relation and location of the virtual 3D objects, environment and scene with the computer system is known as modelization. Owing to the fact that the map symbol can be divided into two kinds, i.e. regular symbol and irregular symbol, suitable modeling method must be selected on the basis of characteristics of map symbol.

3.1 Data classification and organization of 3D Map Symbol

The key element of model is the spatial coordinate of feature point in the model. The mathematical model of entity has essentially been established after the spatial coordinates of the feature points have been acquired. In fact, there still exists the problem of expression form and the data structure of model during the application of model. According to the distribution circumstance of the object and phenomenon, the conventional 2D map symbol can be divided into three kinds - point symbol, line symbol and area symbol. The 3D map symbol's data should be organized according to objects represented by 2D symbol which has been abstracted as point, line and area; and be displayed by the form of body when the symbol is to be displayed. The 3D map symbol are formed by four kinds of models: point, line, face and body on the data model[6-9]. The course of 3D data processing is shown as fig 1:
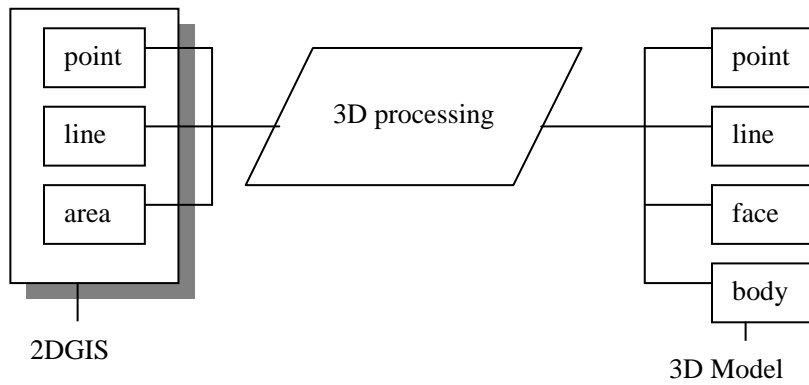
Fig 1. 3D data processing

At present, the existing kinds map databases of various scales have provided the stable and reliable data sources for making of 3D map and it's symbol. Certainly, the data still need to be topologically processed for description of map essential factors. The data from 2D traditional database need 3D processing of encoding and gathering. As for some areal features, the topological data should still be linked and organized clockwise or counterclockwise.

3.2 The direct modeling method based on mathematics

Any complicated graphs or 3D scenes are composed of some primitive(basic picture or graph element) - the point, line and polygon. There are no curves or curved surfaces of genuine significance in the computer. Their simulating models can be approached by straight lines and planes. OpenGL has provided plenty of orders to draw primitives. OpenGL's primitive is the abstract geometrical concept and is not the object in reality. It still need describing with the related mathematical model, then the map symbol model that we need can be generated by a series of processing. So, as for the regular map 3D symbol, we can use the direct modeling method described based on mathematics. The technique of making use of the OpenGL's graphical library to form 3D symbol can be realized in three steps: The first step is the geometrical modeling; the second step is the vivid modeling; the third step is demonstration of 3D symbol on the screen.

1) The geometrical modeling: Checking the data on the basis of the feature of symbol, the 3D geometrical model is formed by acquiring each point's normal vector.

For example a round outline model can be established by following formula:

```
#define PI 3.1415926535897
 GLint circle_points=100;
 glBegin(GL_LINE_LOOP);
 for(int i=0;i<circle_points;i++)
 {
     angle=2*PI*i/circle_points;
     glVertex2f(cos(angle),sin(anble));
 }
 glEnd();
```
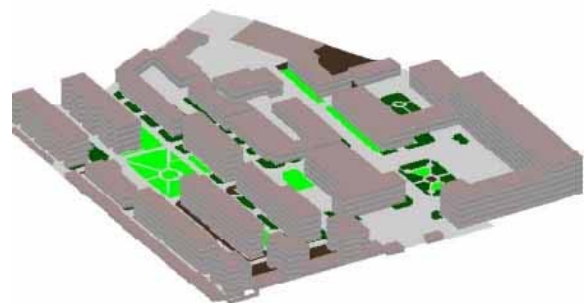

Fig2. OpenGL direct modeling

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2) The vivid modeling: The geometrical model previously formed has to undergo the texture mapping, lamplight illumination, color setting, eliminating etc to make the 3D symbol real and more vivid.

3) The display of 3D symbol: The 3D symbol model which has been established by two previous steps can be displayed on the 2D screen by projection (orthographic projection or perspective projection), setting observation points, and various transformations (including translation, rotation etc). The Fig 2 is the image of OpenGL's modeling based on the mathematical description.

3.3 The modeling method based on VRML

Making use of 3D creation tool to establish 3D map symbol model very is important owing to the fact that many objects are difficult to describe with the mathematical language. There are at present many 3D's modeling tools, such as the well known 3DMAX, AutoCAD etc. 3D's modeling software generates the simple shape by providing the fixed structure of "primitive". The amount and type of primitive are different along with the software differences, e.g. the cube, spheroid, cylinder, cone, ring, regular polygon and 3D polygon. These primitives are the bases for expressing the simple shape or acting as the complicated and compound 3D objects. On these bases, a more complicated series of objects are constructed by techniques of deriving model such as expressing, revolving, linking, fusion, etc[4-5]. Finally, VRML's documents formed by these various modeling software can be used to establish the 3D's map symbol. So, the modeling method of VRML can be used for the irregular symbol that can not directly be described with the mathematical language.

VRML is an ISO's standard with more than 60 kinds of node types. A simple object is formed from four nodes - Shape, Appearance, Material and geometrical primitive (whole shape, external feature, color and the geometric object). Node can be divided into father node and son node, and the relation between them is called "scene levels". Each field of VRML has a default value[4-5]. The Fig 3 is the picture of a cylinder that VRML's document describes.

```
#VRML V2.0 utf8
    Shape {
        Appearance Appearance {
            Material Material {
                diffuseColor 0.1 0.6 0.1
            }
        }
        geometry Cylinder { radius 29.37 height 26.76 }
    }
```

Fig3. VRML's document description of a cylinder

The establishment of 3D map symbol model is chiefly used for expressing and description of 3D

model and does not involve the 3D internal spatial relation processing. As for the data models of the irregular 3D map symbol, We can use by the boundary representation (B-rep) model. A complicated object can be formed from various little planes (triangle faces). 3D data description of this kind of object is defined in VRML's standard. The following is an example of the cube generated by VRML .

```
Shape{    geometry IndexedFaceSet{
        coord Coordinate{
                point [−1 −1 − 1,   1 −1 − 1, 1 1 − 1, −1 1 − 1,
                    −1 −1   1,   1 −1   1, 1 1   1 , −1 1 1]}
        coordIndex [0, 1 ,2, 3, −1,   5, 4, 7, 6, −1,
                1, 5, 6, 2, −1,   4, 0, 3, 7, −1,
                4, 5, 1, 0, −1,   3, 2, 6, 7, −1] }
    }
```

This cube (as Fig 4 shows) is formed from 6 faces. So, coordIndex table has 6 groups. Each group is formed by 4 indexes and separated from the others with -1. The value of each index quotes one of eight points in the table.
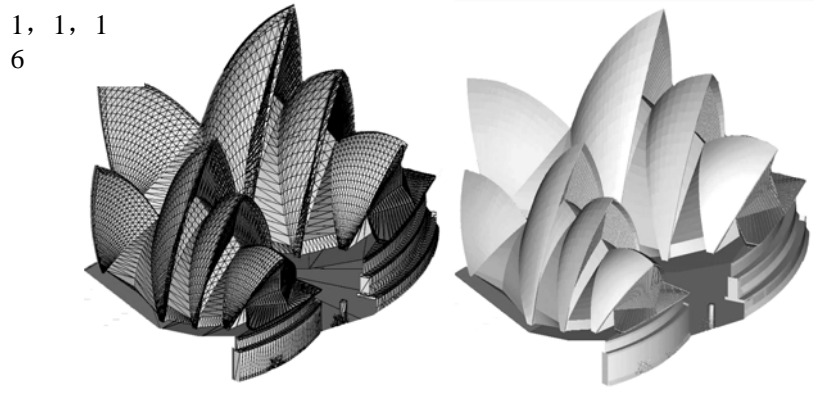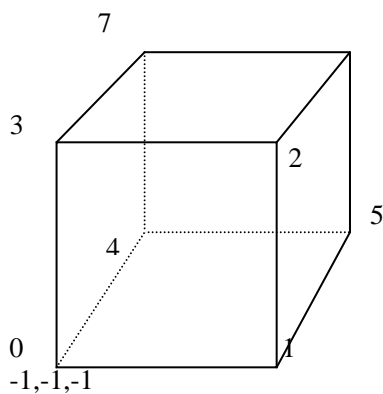

Fig4 The cube formed from 6 faces that VRML describes.   Fig5 VRML-based Modeling and display

Having been generated, the VRML-based data model can be manipulated and processed. The Fig 5 is realized to extract VRML's document and indicate model by programming. The basic concept is that every object is formed from limited faces (planes or curved surfaces) , and every face is defined by limited closing fields surrounded by limited borders (triangles).

4. Conclusion

Original definition of 2D map symbol has not been adapted to the development of 3D map technique, so, it is necessary to go deep into the concept and the definition of 3D map symbol.. 3D modeling is the kernel content of establishing 3D map symbol. The model is the skeleton of symbol. Only by establishing the fine, accurate and suitable-detailed model, the fidelity of the 3D map and its symbol can get assured. Can make use of the plenty of orders that OpenGL provides to draw

primitive, and establishes the 3D map symbol model by a series of processing as for the regular map symbol described with the mathematical model. Making use of 3D creation tool to establish 3D map symbol model is very important owing to the fact that many objects are difficult to describe with the mathematical language. 3D model can be constructed by 3D's modeling software, and VRML's document is exported in order to realize the VRML-based modeling. The 3D technique of computer makes the demonstration and description of 3D geometrical and attribute feature of object possible recently. The development to 3D map is the tendency while cartography and new technique develope mutually. This paper research is the development of the symbol system of map under the 3D condition and establishes.

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