Expression model of multi-resolution 3D geographical space

Lou Ning[1], Zheng Xiaobo[2], Yang Yongchong[1*]

[1] *School of Geodesy and Geometrics of Xi'an University of Science and Technology, Xi'an, Shanxi, 7110054*

[2] *Construction, Office of Xi'an Aeronautical University, Xi'an, 100083*

Received 6 February 2014, www.tsi.lv

Abstract

Aiming at improving deficiencies in multi-resolution two-dimensional expression of geographic information method, this paper studied method of multi-resolution 3D expression of geographical information, putting forward grid method to express different regional landforms separately and a method of expressing different regional ground objects on level of detail in three aspects as shape, texture and properties, plus an example to simulate and illustrate. Multi-resolution 3D expression of geo-information has broad application prospects in smart city and city planning, which has a certain exploring value for the massive information, for its expression and visualization.

Keywords: Multi-resolution, 3D visualization, Geographical Space Model, 3D terrain model, 3D ground object model

1 Introduction

The distribution of geographic entities in space is not uniform, and organization and expression of the geographic phenomena should be consistent with the geographical distribution. Therefore, the expression and visualization of geographic information will inevitably involve multi-resolution. In a digital environment, a geographic information can be expressed in different regions with different "scales" or resolutions. This kind of digital map is called multi-resolution digital maps. (Yang Yongchong, 2005, 2006)

In a two-dimensional digital map, where the geographic information is expressed in a multi-resolution, there are two aspects of disadvantages: the first is that the expression of the multi-resolution landforms is mainly described by a contour. The result of the expression is that this contour is intensive in the regions expressed in detail, while sparse contours correspond to weakly expressed regions. However, in the actual application of a contour line, intensive contour lines represent an area of a steep slope; sparse contour lines represent an area of moderate slope. If landforms are expressed by a contour of multi-resolution, doubts can be appeared (see, Figure 1).

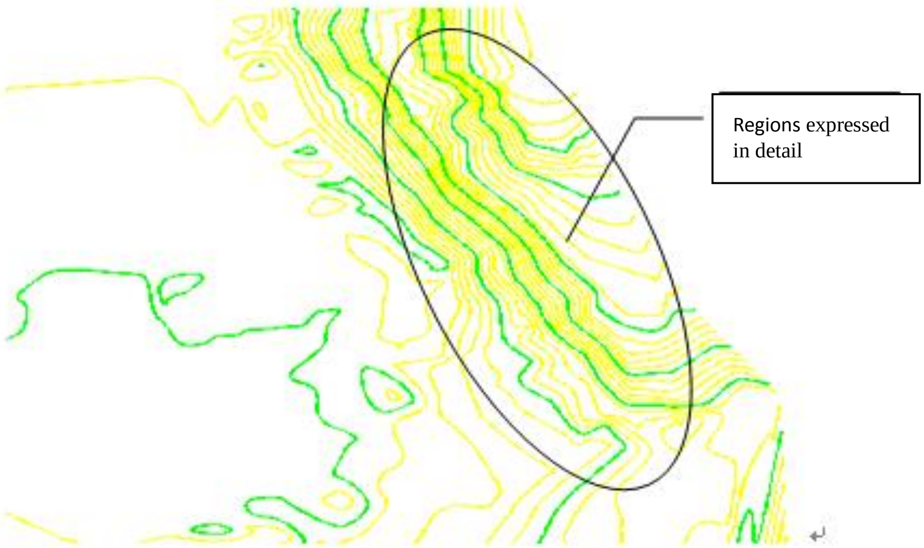

FIGURE 1 Landforms of different regions expressed by contour lines.

*Corresponding author - E-mail: 290272930@qq.com

In addition, in two-dimensional multi-resolution map, point, line, surface graphics are used to express the position information of a ground object. A height information and a spatial shape information of object cannot be accurately and intuitively expressed by a planar graph.

With the further expansion and improvement of the theory of spatial information, an expressing of geographic information by 3D spatial model becomes more intuitive, and more complete. In the 3D spatial model, referring to practical application, we can divide the entire expression area is into key areas and secondary areas. Then we make expression and visualization with different degrees in various areas, i.e. the multi-resolution 3D geographic spatial model.

This paper mainly studies the method of expressing terrain and ground objects in 3D multi-resolution.

2 Method of expressing multi-resolution regional terrain

There are three kinds of expressing geographic information in 3D multi-resolution: the 3D contour method, the triangulation method and the grid method.

2.1 THREE-DIMENSIONAL CONTOUR METHOD

The 3D contour (i.e. solid contour line) has obvious traces of steps. So it cannot express gully, steep ridge and other special landforms satisfactorily (see Figure 2). In addition, the feature of a closed contour is not suitable for the expression of multi-resolution terrain.

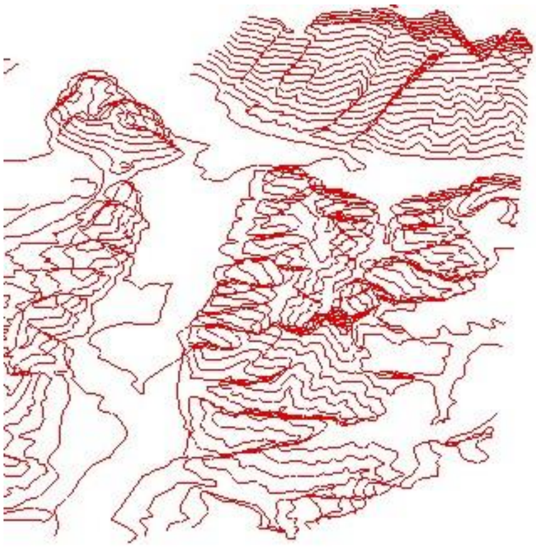

FIGURE 2 Three-dimensional contour method

2.2 THE TRIANGULATION METHOD

Triangulated irregular network (TIN) can reflect a complex terrain in a good way. It can also reduce the data redundancy. But because of the irregular shape and size of triangle, TIN has the same problem as contour line since triangle is relatively smaller when expressing complex terrain, and relatively larger when expressing flat terrain triangular (see Figure 3) So it may cause misunderstanding just like contour line. Therefore, it is not suitable for the expression of multi-resolution terrain.

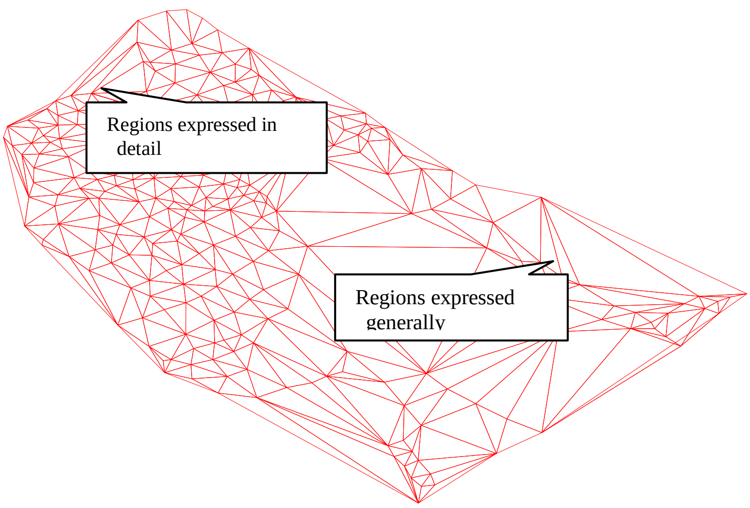

FIGURE 3 Geomorphology expressed by the triangulation method

2.3 THE GRID METHOD

The regular grid model is relatively regular. Big grids are used to roughly express landforms, and small grids are used to detailed express landforms. Regardless of differences in the complex of landforms, it is easy to distinguish which areas are detailed expressed, and which areas are approximately expressed. So different sizes of grid can be used in multi-resolution to express different geomorphic information in different areas (see Figure 4).

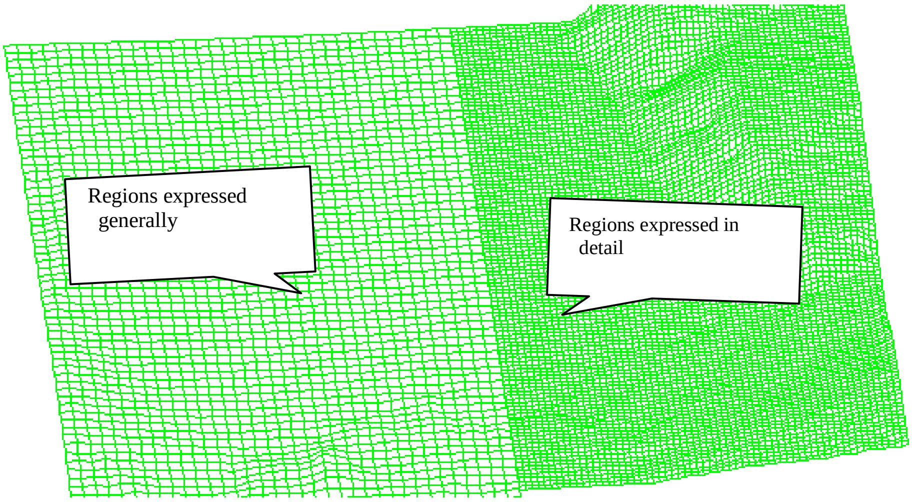

FIGURE 4 Using multi-resolution 3D regular grid method to express geomorphology

3 The method of expressing multi-resolution regional ground object

Spatial objects are complex and diverse. The expression method and the expression content are different in the key expression area and secondary expression area of multi-resolution 3D object. The differences lie in expression of its shapes, textures and properties.

3.1 MULTI-RESOLUTION OF SHAPE

Shape refers to the shape and contour of geographic entities. When doing visualization of geographical spatial information, shape is an important visual variables. map interpreter can recognize different qualitative and quantitative specifics of point, line and surface elements according to the shape.

In geographic information expressed in 3-dimensional multi-resolution, object shape represents for its true shape in key areas. Therefore, the expression is very detailed and accurate, obtaining highly precise information. In addition, in the secondary areas, the approximate expression of object shape is often done through combining small-area ground object for large-area ground objects, and method of abandoning the small-area objects, simplifying object contour and other combing method (see Figure 5)

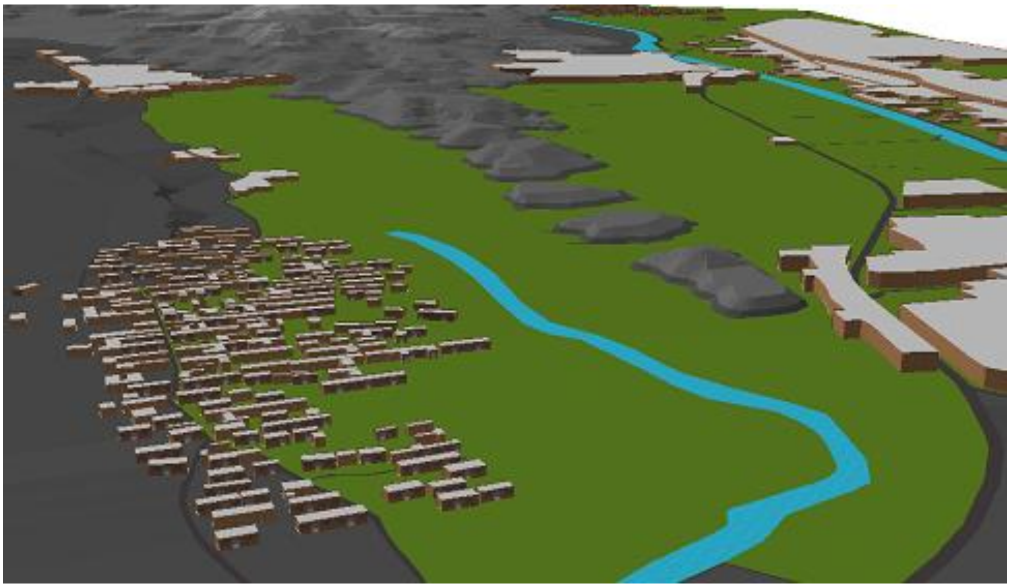

FIGURE 5 Shape information of ground objects expressed in 3-dimensional multi-resolution

3.2 MULTI-RESOLUTION OF TEXTURE

Different entities in a geographical space have different details on its surface. Through these details, which are also textures we can recognize different geographic entities, judging differences between entities of the same shape. And by "sticking" texture, the geospatial entities generated can be realistic and three-dimensional.

In the expression of Multi-resolution 3D object, real texture of geospatial entities are used to express the detail information of ground objects in key areas. This expression is consistent with the objective entity, laying stress on the authenticity of the object. In the secondary areas, general textures in the texture database are used to generally express information of geographical entities, reflecting general properties of the object, stressing its existence.

2.4 THE MULTI-RESOLUTION OF PROPERTY

The different Geospatial entity has different properties information is an important feature to cognize ground objects and to distinguish between them.

In the expression of 3D multi-resolution geographic information, properties values of spatial entities are expressed in different degree. With the regard to ground objects in key areas, geographic entity properties information is very detailed and accurate, enabling map interpreter to obtain the most detailed entity information. In the secondary areas, the entity's overall information and properties information are only briefly described. In key areas such as the area on the left side of Figure 5, you can not only query to properties information of village, but query to properties information of every household in the village. But in the secondary area on the right side of Figure 5, only the properties information of village can be queried.

4 Conclusions

Geographical terrain and ground objects are of complexity and diversity. In key areas and secondary areas where geographic information are expressed in multi-resolution 3D, small grids are used to express important regional geomorphology in detail and big ones secondary areas in general, regardless of complexity degree of the terrain and ground objects. In the key areas, shape and texture of 3D models look close to geography spatial entities and properties are also detailed. In secondary areas, houses are expressed in an abstract way. After the cartographic generalization, and by using general building textures and expressing only the main information concerning the properties, map interpreters are provided with a compendium of information from its shape, showing the macro feature of the generally expressed regions. This is the geographical space model expressed in multi-resolution 3D.

The method of multi-resolution 3D expressing of geographic information has a wide application prospect in engineering and city planning. As long as there are key areas and the secondary area s in graphics areas, you can use the method of 3D multi-resolution to express geographic information.

References

[1] Yongchong,Yang, Zhida Guo 2005 *Bulletin of Surveying and Mapping* **7** 13-16

[2] Yan Zhou, Qing Zhu, Duo Huang 2006 *J. Science of Surveying and Mapping* **5** 15-18

[3] Lan Guo 2002 *J. Bulletin of Surveying and Mapping* **5** 10-11

[4] Chengming Li, Jizhou Wang, Zhaoting Ma *2008 The Principle and Method of 3D Geo-spatial Framework of Digital City* **1** Beijing: Science Press

[5] Lan Guo, Yongchong Yang, Hongtao Tang 2009 *J. Geotechnical Investigation & Surveying* **37**(4) 67-71

[6] Yongchong Yang, Nan Hu, Lan Guo 2011 *J. Bulletin of Surveying and Mapping* **1** 75-77

[7] Junqiao Zhao 2013 *J. Acta Geotaetica et Cartographica Sinica* **1**

[8] Qingyuan Li, Zongjian Lin, Chengming Li 2002 *J. Science of Surveying and Mapping* **6** 17-21

[9] Xin Yang, Guoan Tang, Xuejun Liu, Fayuan Li, Shijie Zhu 2009 *J. Acta Geographica Sinica* **9**

[10] De Floriani L, Magillo P, Puppo E 2000 *Compressing Triangulated Irregular Networks. GeoInformatica* **6** Berlin-Heidelber: Springer

Authors

Ning Lou, 10 1978, Xian Yang, Shan Xi province, China

Current position, grades: MSc, lecturer
Scientific interest: Digital map; GIS and its application

Xiaobo Zheng, 03 1986, Xian Yang, Shan Xi province, China

Current position, grades: assistant
Scientific interest: digital map; the visualization of geographical information

Yongcheng Yang, 10 1966, Gaolan County, Gansu province, China

Current position, grades: Professor
Scientific interest: Geographic Information Engineering and cartography