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REVIEW ARTICLE

Brief Discussion of Surveying Technology of Three-dimensional Digital Topographic Map

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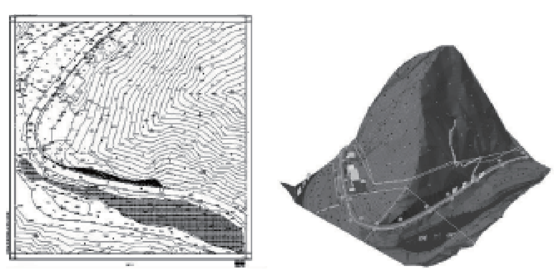
ABSTRACT 3D digital Topographic drawing adopts 3D profile technology and demonstrates geographic space phenomenon to users, reflects the space features of geographic entity in an integrated and accurate manner and thus realizes even more complete, accurate and straight-forward expression of the objective world. It can not only express the plane relationship between space objects, but also accurately describe and express the ground elevation and geometric object height which upgrade the space expression ability and measuring level of digital map and enhance the space acknowledge ability and analytic ability of map. This article aims to elaborate on 3D digital topographic drawing in three aspects: surveying, mapping and application; mainly introduce the mapping methods of 3D topography and geometric object, integrated matching technologies of topographic model and geometric object model and application of 3D digital topographic drawing. It is expected to have a positive promotion role in the development of 3D GIS.

KEYWORDS
Topographic drawing
3D regular grid
Topographic model
Geometric objects model

1. Introduction

2D expression suffers from great limitation; 2D digital topographic drawing simplifies the understanding and expression process of space geographic information but loses the authenticity and completeness of space geographic information. 3D digital topographic drawing mainly adopts large scale ruler to express the geographic information of small area and realizes even more complete, accurate and straight-forward expression of the objective world; in the expression of topography, it is able to reflect tiny fluctuation of surface; in the expression of geometric objects, it is able to directly display the space 3D structure or shape as shown in Figure 1.

In 3D digital topographic drawing, the collection precision of space data is compatible with that of 2D digital topographic drawing; however, it has raised higher requirements with mapping and surveying technologies. It has to not only collect all the characteristic points of all the topographic and geometric objects and height of geometric objects, but also collect more information or data given densely populated sampling points. Besides, the mapping methods of topography and geometric objects differ from 2D digital topographic drawing. The complexity and ambiguity of signs are neglected; the visible effect becomes even straight-forward and delicate.



(a) (b)

Figure 1. Comparison of 2D digital topographical drawing and 3D digital topographical drawing.

2. Obtaining Methods of 3D Space Data

3D digital topographic drawing expresses the geographic

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information in a delicate and complete manner—It is based on the collection of a huge amount of delicate data. Currently, there are four methods to obtain large scale 3D digital topographic drawing's space data:

(1) Digital photography and measuring technology. It aims to build up the space topographic model (3D), measure dense digital elevation data and thus build up 3D digital model. It is applicable to large-scale 3D digital map.

(2) Total station measuring technology. It aims to obtain 3D space data (including Z coordinate); the total station enjoys rather high obtaining precision of Z coordinate. The total station measuring technology is deemed as the ideal method to collect topographic and geometric object characteristic points and lines of 3D digital topographic drawing; it is able to measure the height of geometric object; it is applicable to 3D digital topographic drawing with small scope, large scale and high precision requirements; however, it takes a lot of time and manpower.

(3) GPS RTK technology. GPS RTK technology and total station measuring technology are deemed as main methods to collect data in large scale 3D digital topographic drawing. However, GPS RTK technology is restricted by inadequate satellite signal receiving in the city and abnormality of elevation in the application; it is difficult to obtain the height (h) of geometric object.

(4) 3D space data is obtained with map as the data source. Although it contains generalized geometric object height, yet it is difficult to infer the height accurately; therefore, it suffers from rather poor precision of 3D digital topographic drawing. It is essential to obtain the height of various surface, linear and spot geometric objects—It is the basis of expressing the data of 3D shape. However, the existing collection methods of 3D space data can hardly collect the height of geometric object. It is the difficulty in collecting 3D space data [1,3].

3. Digitalized Theories of Paper Topographic Drawing

AutoCAD is deemed as one of the most successful mapping software; it enjoys the best universality in the digital topographic drawing. The topographic drawing is mainly composed of a series of contour lines, topographic lines, geometric objects and various structural lines. AutoCAD software adopts points, lines and characters to swiftly and conveniently mark and map out any entity. Therefore, it is able to map out all the information of a topographic drawing. In essence, the digital topographic drawing aims to accurately copy all the information of paper topographic drawing into AutoCAD mapping area and record according to its own format. The contour line in the paper topographic drawing (also called basic topographic drawing) is composed of scraggling and smooth curves; sample curve command Spline in AutoCAD is adopted to describe; separate elevation point in the topographic drawing is described by point mapping command: Point. The straight lines in the topographic drawing such as houses and buildings are mapped by straight line command: Line. If all the information of basic topographic drawing is copied into AutoCAD platform and elevation is provided for the information, one digital topographic drawing [2] with 3D coordinate is mapped and same as the basic map.

4. Mapping of 3D Topography and Geometric object

4.1. Mapping of 3D topography

There are three frequently used digital topographic expression methods: contour line model; Triangulated Irregular Network (TIN); regular grid model (Gird) [4]. The contour line model makes use of points in the contour line and directly produces 3D topography—It has obvious stair traces; the contour line can not very well express special land form (such as vertical cutting or ditch). The Triangulated Irregular Network (TIN) refers to scraggling triangle net; it makes use of scraggling sampling points to produce a continuous triangle and vividly express the real surface of topography; it has no grid structural regulations and surface analytic ability is rather poor. The regular grid model (Gird) is featured as even distribution with equivalent distance; 3D regular grid model is able to express the topography in an even straight-forward, delicate and vivid manner (as shown in Figure 2); it enjoys greater strengths in expressing special topography (such as vertical cutting, dry ditch and bulging). 2D digital topographic drawing adopts 2D signs which are difficult to express the space shape or structure of special topography; 3D regular grid topographic model is able to straightly display which neglects the complexity and ambiguity of signs. Therefore, it enjoys even straight-forward and delicate visible effect (as shown in Figure 3).

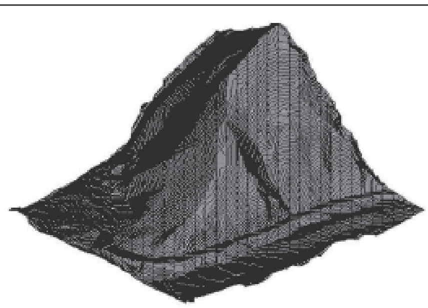

Figure 2. 3D regular grid topography model

3D digital topographic drawing's topographic precision expressing depends on the delicateness of sampling elevation; the resolution of 3D grid depends on the map scale and topographic complexity. An adequate consideration is made to the multi-resolution grid model to express the topography; the plain with simple topography requires for rather large grid while mountainous area with complex topography requires for rather small grid—therefore, it can express the topographic fluctuation in a real manner and data redundancy is smaller.

4.2. Mapping of 3D geometric objects

All the traditional 2D digital topographic drawing of geometric objects are expressed by 2D signs; all the geometric objects are displayed in the same plane with an elevation of 0m; the elevation and height of geometric objects are judged by the elevation line and contour line. This expression method is much more abstract and generalized than 3D digital topographic drawing.

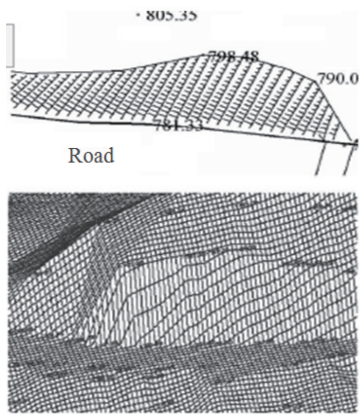

Figure 3. Comparison of 2D vertical cutting and 3D vertical cutting

In 2D digital topographic drawing, it is most difficult to express 3D space shape of linear geometric objects in a delicate and vivid manner. 3D space shape of linear geometric objects not only requires for the turning points in the horizontal level, but also requires for various turning points in the vertical direction: obviously changed points in the elevation or gradient. In the expression of linear geometric objects, 2D digital topographic drawing only adopts specific 2D signs to express horizontal turning points or shapes; however, it can not display real position and shape in the vertical direction. Figure 4 and Figure 5 show 3D digital topographic drawing's strengths in expressing the linear geometric objects.

5. Space Matching and Integration Technology of 3D Topography and Geometric objects

3D digital topographic drawing includes the topographic models and surface and underground geometric object models; the geometric object model must be integrated with the topographic model; various geometric object models must have a certain relationship with the topographic model. How to realize seamless integration between 3D topography and geometric object data based on the topographic and geometric object models is a key technology. If the geometric object fails to coordinate with the topography, the geometric object will float in the air or enter into the surface which does not accord with the expression methods of real space position. Therefore, the following methods must be adopted to realize seamless matching and integration [5].

Figure 4. Visual effect of 3D road.

Figure 5. Visual effect of mine roadway under the surface.

(1) In the measuring of characteristic points of geometric objects, the elevation must be measured in order to adopt as the elevation point. Various characteristic points in the same building enjoy the same elevation; in case of slight difference in the collected elevations, the average elevation is obtained.

(2) In the collection of characteristic point of geometric object, the horizontal turning points are collected and vertical turning points are collected.

(3) All the characteristic points of geometric object are adopted as the elevation points and to produce topographic model of 3D grid.

According to the said topographic and geometric object models and matching and integration methods, 3D space data is collected in the external measuring of a certain test area according to 1:500 precision requirements; the development procedure has mapped out 3D digital topographic drawing (as shown in Figure 1(b)) and realized such functions as 3D calculation and space analysis (as shown in Figure 6).

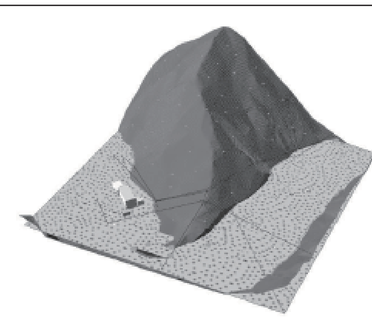

Figure 6. Flood simulation and Yang Yregular grid tytal ty visualization.

6. Application of 3D Digital Topographic Drawing

3D digital topographic drawing enjoys a widespread application prospect in the urban planning and project design; it provides planning and designing personnel with even straight-forward and detailed geographic information to know about the site and launch out design work; the planning and designing results are able to realize straight-forward 3D visibility and offer convenience to the planning and designing personnel in expressing the planning and designing ideas.

7. Conclusion

It is able to accurately describe and express the ground elevation and geometric object height, upgrade the space expression ability and measuring level of digital map and thus enhance the space acknowledge and analytic abilities of map.

3D digital topographic drawing expands traditional 2D digital topographic drawing into 3D geographic space information; it is able to search for plane coordinate and elevation in any characteristic point; understand and express the space structural relationship between objects from the perspective of 3D space. It is able to accurately describe and express the ground elevation and geometric object height, upgrade the space expression ability and measuring level of digital map and thus enhance the space acknowledge and analytic abilities of map. With constant development and improvement in 3D digital topographic drawing, it is bound to enjoy a promising application future in the urban planning and project design.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

References

1. Guo, L., & Yang, Y. C. (2002). Research into 3D Digital Topographic Drawing and Its Application. *Mapping and Surveying Journal, 2,* 57—62.
2. Guo, L, Yang, Y. C., & Tang, H. T. (2009). Exploration in 3D Digital Topographic Drawing, Land Form and Geometric object Expression. *Project Exploration, 37*(4), 67—71.
3. Shi, W. Z., Wu, L. X., & Li, Q. Q. (2007). Model and Calculation Methods of 3D Space Information System. *Beijing; Electronic Industry Press, 4.*
4. Li, Q. Q., Yang, B. S., & Shi, W. Z. (2003). Real-time Obtaining, Formwork Establishment and Visibility of 3D Space Data. *Wuhan: Wuhan University Press, 6.*
5. Li, C. M., Wang, J. Z., & Ma, Z. T. (2008). Theories and Methods of 3D Geographic Space Framework of Digital Urban. *Beijing: Science and Technology Press, 7,* 161—164.