Research on Automatic Profile Generation Based on 3D Model

Mingwen Chi

Department of Information Engineering, Baotou Light Industry Vocational Technical College, 19 Jianhua road, Qingshan district, Baotou.
Email: 154878935@qq.com

Abstract. In this paper, the technology of profile generation based on 3D model is studied. The main steps are as follows: (1) the location where the profile needs to be generated in 3D model design; (2) Using 3D data cutting technology to realize the generation of geological lines in profile; (3) Read the basic exploration data related to profile position in the database; (4) According to the data generated in the first three steps, the cross-section is automatically drawn after data coordinate transformation. The above method can quickly generate the geological profile of any location according to the 3D geological model, which is helpful for geological analysis and provides reference data for engineering design.

Keywords. 3D model; Section; automatically generate.

1. Introduction

Geological maps are a scientific means of graphical representation of geological phenomena [1]. Complicated geological maps are used in basic geological survey, resource exploration, engineering investigation, mine design and exploitation, urban planning and other aspects [2, 3]. There are many kinds of geological maps, among which the geological profile is the most basic expression of geological content, the basis and forerunner of the whole geological work results, and the map frequently drawn by geological engineers [4, 5].

Geological profile is the traditional way of drawing the manual way, late mature GIS theory development of the last century, people started to interactive graphics vector method is adopted to improve the compilation of geological maps, automation of semi-automatic maps are drawn began to grow, and most USES the manual intervention, semi-automatic rendering with the aid of expert knowledge in developing professional geological map [6, 7]. In this process, most of the geological maps compiled are independent of each other, and even if there is any connection, it is still fuzzy inference, unable to achieve accurate positioning, and unable to eliminate the incompatibility of data between several sections [8]. At present, some profile makers directly connect boreholes with different exploration lines, which ensures the compatibility of data between sections, but leads to another new problem. For example, the pinch-out processing of some lens bodies presents serious irrationality, that is, it is possible to connect pinch-out points directly to the corresponding horizons of adjacent boreholes. Although the incompatibility of data is avoided in this way, the principle of violating geological inference appears. Therefore, it is very necessary to develop a set of semi-automatic mapping software of geological section directly based on 3D digital geological body, which can not only guarantee the compatibility of data between multiple sections, but also make accurate inference according to expert knowledge [9, 10].
2. Data Source and Generation Process of Profile

At present, database is basically used to manage basic exploration data in the drawing of cross-section at home and abroad, and engineering geological cross-section is established automatically or manually according to the exploration data (mainly drilling data), and its data storage is also carried out in a two-dimensional environment. This paper proposes that the profile data includes not only the basic exploration data from the database, but also the cut data from the 3D model, and can also receive external data. Therefore, there are three main sources of data for automatic profile drawing in this paper: (1) basic exploration data; (2) Cutting data of 3D model; (3) Other external data. According to the characteristics of the above data sources, the automatic generation process of the profile is designed: (1) read the basic exploration data in the database according to the position of the profile exploration line; (2) Using the exploration line and the 3D model to cut, to obtain the 3D profile geological lines; (3) coordinate transformation from three-dimensional data to two-dimensional plane data; (4) Read other profile data that need to be supplemented; (5) Automatic formation of profile vector data and profile file according to the above data.

3. Database Data Reading

According to the traditional way of data source, first of all, the basic exploration data will be stored in the database. The data mainly involved in the drawing of the profile include drilling data and all kinds of experimental data. This part of data is the supplementary content of the profile.

In this paper, the data of borehole and adit are taken as examples to illustrate the method of data acquisition. Firstly, the spatial coordinates of borehole and adit data are read from the database, and then converted into planar coordinates through coordinate transformation. Here, borehole is taken as an example to describe. There are two kinds of drilling holes: straight hole and inclined hole. The drawing of straight hole is determined according to the coordinate of drilling orifice and hole depth. But for inclined hole, it can be determined by conversion according to survey parameters recorded by borehole. The specific conversion method is as follows: Figure 1 shows the vertical projection schematic diagram of the borehole, and figure 2 shows the horizontal projection schematic diagram of the borehole. Among them, the thick line is the projection line of the borehole, the other lines are auxiliary lines, n is the number of survey segments, d is the deviation distance of the borehole, L is the projection length of the borehole elevation, φ is the azimuth Angle of the borehole, θ is the inclination Angle of the borehole, Li is the length of each survey segment, and θ I is the inclination Angle of each survey segment.

![Figure 1. Vertical projection of borehole.](image)
The specific length and location marking of the borehole drawn in the profile can be calculated by the following formula:

\[
\begin{align*}
    d &= \sqrt{\left( \sum_{i \in \text{lines}} L_i \sin \theta_i \sin \Phi_i \right)^2 + \left( \sum_{i \in \text{lines}} L_i \sin \theta_i \cos \Phi_i \right)^2} \\
    L &= \sum_{i \in \text{lines}} L_i \cos \theta_i \\
    \Phi &= \arcsin \frac{\sum_{i \in \text{lines}} L_i \sin \theta_i \sin \Phi_i}{\sum_{i \in \text{lines}} L_i \sin \theta_i \cos \Phi_i} \\
    \theta &= \arcsin \frac{\left( \sum_{i \in \text{lines}} L_i \sin \theta_i \sin \Phi_i \right)^2 + \left( \sum_{i \in \text{lines}} L_i \sin \theta_i \cos \Phi_i \right)^2}{\sum_{i \in \text{lines}} L_i \cos \theta_i}
\end{align*}
\]

4. Cut and Obtain 3D Model Data

On the basis of the established 3D model, the relevant stratigraphic or structural information can be obtained by cutting the profile position lines to provide the basic geological data for the profile. The main technology is the intersecting operation of the object. The basic process is as follows: firstly, the position of the exploration profile is determined according to the exploration line; generally, lines are used to store the sequence of position points; surfaces are used to represent strata or structural units; and then, the intersecting line between lines and surfaces is used to determine the relevant stratigraphic or structural information of the profile position. For example, as shown in figure 3, LINE1 is used to represent the position of the exploration line, while Polygons represents the sequence of surfaces that constitute geological bodies, in which the sequence points of LINE1 determine the position of the broken section. In the 3D model, the elevation of sequence points has no practical significance and is only set for visualization. Secondly, Line1 and Polygons are used to obtain the intersecting line LINECs, so that LINECs can be used as geological line data in the exploration section. According to this principle, this paper needs to solve the main problem is the algorithm of line and surface intersection, line and surface intersection, can be regarded as the line projection to the surface of the operation. In addition, in order to more intuitively show the corresponding relationship between the exploration profile and other exploration profile information, the intersection of the exploration line and other geological lines in the profile is also required, so the problem of intersection between lines is also needed to be solved.
The intersection algorithm of spatial line and surface and the algorithm of line and line intersection are used to form spatial profile data, as shown in figure 4.

5. Extract Other Data

In general, the object management of 3D modeling software system adopts layer management, and the data is extracted directly through layers. According to the needs of different functions, it can be accurately obtained according to attributes. According to the different properties of the object, it can be extracted in the following ways:

(1) According to the color extraction, objects of different types and purposes can be marked with different colors according to the user's operation habits, which can be obtained by RGB color value or by the color number defined in AutoCAD. The former method can distinguish more types of objects, up to $255^3=16777216$. The latter method can only distinguish 256 kinds of color numbers;

(2) According to the type of the object to extract, this method is generally only used in the basic editing process, can be divided into: text, dot symbol, line, polygon, regular surface and volume;
(3) According to the attribute acquisition, this method is the most critical extraction method of the system. The system adopts the B-Rep model and uses the coding method to distinguish the category of the object. Each object has its own attribute value, which can uniquely identify its category. This can be obtained by the property name when the object is extracted. In addition, an object can have several attributes, with double or multiple "identities". In order to distinguish the two attributes, the system stipulates that the two attributes are separated by commas (,), so as to avoid repeated storage of data.

(4) According to the batch extraction of layers, the system can define one or several layers as professional layers, which are specially used to store one or several types of data. When lifting, the system can directly batch extract according to the layers. This method is efficient, easy for users to operate, and is also a common method of data extraction in the system.

6. Application Examples
Based on the 3D model and basic data of a hydropower station, the automatic drawing and verification of the cross-section are carried out in this paper. The geological line data in the 3D model obtained by cutting the 3D model is shown in figure 5. After converting the 3D data, the profile formed by reading the basic exploration data in the database is shown in figure 6.

Figure 5. Geological profile model with cut geological lines.

Figure 6. Automatically generated geological data profile.
Acknowledgments
The research of this paper was funded by the Science and Technology Research Project of Higher Education in Inner Mongolia Autonomous Region (Project No.: NJZY20162).

References
[1] Li G J, Liu L, Niu Z P. 2021 Research and Development of 3D Geological Model Technology for Waterway Engineering Based on Civil 3D [J/OL] Port & waterway engineering 1-6 https://doi.org/10.16233/j.cnki.issn1002-4972.20210630.036.
[2] Li C. 2004 Computer Automatic Generation Technology of Geological Section and Histogram [D] Xi'an University of Science and Technology.
[3] Wu C L, Liu G, Tian Y P, et al. 2005 The theory and method of informationization of geological and mineral exploration [J] Earth Science 30 (3) 359-365.
[4] Wu C L, Wang X Q, Liu G, et al. 1996 Design principle and application of geological and mineral point source information system [M] Wuhan: China University of Geosciences Press.
[5] Di W M. 2002 computer aided drawing of geological profile and plan [J] Gold science and technology 36-39.
[6] Zhang Y H. 2020 A new method of Drawing Topographic line of geological section by programming with LISP language [J] China Science and technology information (16) 92-94.
[7] Wang D Z. 2000 Development and application of engineering geological profile software [J] Engineering geological computer application 2 6-9.
[8] Farin G. 1993 Curves and Surface for Computer Aided Geometric Design A Practical Guide [M] 3rd Edition. Acedemic Press.
[9] Li X J, He Y F, Wang G C, Xu L P, Chen Y. 2017 stratigraphic distribution model self matching rofile dynamic generation algorithm [J] Geophysical and geochemical exploration 41 (05) 939-945.
[10] Cai Q, Wang Y N. 2017 study on automatic generation method of hydrogeological profile based on Component GIS [J] Management and science and technology of small and medium-sized enterprises (last Xunyuan) (05) 141-142.