Construction of 3d Model of Complex Geological Structure Deposits under Big Data

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Abstract. The traditional mining hand-drawn graphics were slow, inefficient, and the use of two-dimensional CAD graphics to display three-dimensional space was obviously not strong, and it was easy to misunderstand. To this end, a three-dimensional model of complex geological structure deposits under big data was constructed, and a complex geological structure deposit database was established to provide diversified information; CD-TIN technology was used to generate one-time constraint TIN, for saving time in fabricating; Extracting the structure of the deposit and standardizing the original geological map to construct a three-dimensional model of the complex geological structure deposit under the big data; Through experimental research and analysis, the proposed three-dimensional model of complex geological structure deposits under the big data realized the establishment and visualization of the deposit model, which was highly feasible, improved the speed and efficiency of the deposit space model, and had high definition with an increase of 38% over traditional methods.

1. Introduction
With the continuous development of information technology, the application of computer-related technology to the mining industry has become increasingly popular, which has led to the development of mining from traditional experience to scientific development, enabling quantitative and qualitative analysis [1]. Digital mining has transformed traditional mining into modern mining. Digital mine means that the mine-related information is constructed into a mine information model that can easily and quickly retrieve and display all the information of any part of the mine by using three-dimensional coordinates as the main line. At present, many mining companies cannot fully utilize the engineering geological data, which causes the mine staff to have many adverse effects in the process of prospecting, mining engineering design, production management, and mine safety production, thus seriously affecting the economic benefits of mining enterprises [2]. There are many specific reasons for the above problems, mainly due to the large amount of geological data, different data sources and more unstructured data. Studying and realizing the mine digital information system and constructing the three-dimensional model of the deposit space are of great significance for solving the above problems and the sustainable development of mining enterprises.

2. Construction of 3d Model of Complex Geological Structure Deposits under Big Data

2.1 Establishment of Database of Complex Geological Structure Deposits
The geological database is the precondition for realizing the digitization of mines, and it is the basis for physical geological interpretation, reserve estimation, and convenient and fast data management.
Therefore, once the geological database is established, geological engineering and other information such as drilling trajectory, lithology and description, grade value, tunnel sampling trajectory, fault, etc. can be displayed in three-dimensional space to understand geological phenomena in three-dimensional space [3]. On the SURPAC side, you can directly view, edit, append, and extract various types of information data, manage the database, and batch process the data. The geological database is a data set that combines the geological data information such as the position of the orifice, the inclination information, the sample information, the lithology information and the engineering geological information according to a certain organic relationship to jointly represent the complete information of the drilling.

The sources of exploration data are diverse and complex, but one of the most important and representative of these data is drilling engineering data. Other types of exploration data can be abstracted into borehole data after corresponding calculation and conversion. The characteristics of the drilling project are that there are many control points such as the starting point of the sampling section and the boundary point of the rock formation along the direction of the trace [4]. In order to meet the needs of storing, querying and modifying drilling data and drawing and 3D data display, the drilling engineering data is integrated into a database, which is divided into 4 tables for storage, which are orifice data table, inclination data table and sample. Analyze data sheets and lithology data sheets.

According to the defined geological database data (table) structure requirements, a large number of basic data of the geological database was entered. A total of 274,146 records of 285 effective boreholes were recorded in the geological database, including 2288 for the collar table, 130767 for the geology table, 125671 for the sample table, and 14420 for the survey table.

2.2 Generate a One-Time Constraint Tin
The conventional construction method of CD-TIN is “two-step method”, that is, first establish an unconstrained TIN model for the constraint data set, then add constraint line segments, and optimize and adjust to form CD-TIN [5]. The “two-step method” has the disadvantages of low inherent time efficiency. By reading the literature, the differences and associations between the conventional triangulation and the constrained triangulation are studied, and the difference between the unconstrained data domain and the constrained data domain is proposed. The algorithm has a one-time generated CD-TIN algorithm with high computational efficiency and actual effects in line with the basic requirements of the urban terrain model.

The basic principle of the one-time generation CD-TIN algorithm is: starting with the constraint edges formed by the constraint points, respectively searching for the left and right data points that meet the requirements, and growing to the left and right triangles based on the constraint edges, starting from the newly generated triangle edges. At the beginning, generate left and right triangles until the complete CD-TIN [6] is built. Finally, based on the unconstrained line segment, the optimization judgment is made, and the triangle to be optimized is optimized by the conventional method. The CD-TIN algorithm is built once, and the initial TIN is built according to the constraint data. On this basis, the CD-TIN is generated, which saves the time for re-constructing the network, and the actual construction time is ideal.

2.3 Extraction of Complex Geological Structure Deposit Structure
To obtain a three-dimensional world deposit frame, it is necessary to first establish a coordinate system for observation, which defines the direction of the observation plane or projection plane corresponding to the camera, and then converts the object to the observation coordinate system and projects onto the observation plane [7]. The relationship between the camera's observation plane coordinate system and the real three-dimensional spatial position coordinates and the clipping window coordinate system [8]. Where $P(X,Y,Z)$ is the coordinate of any point in space, relative to the O-XYZ coordinate system.

There is a projection position $p(x)$ in the camera's realistic plane coordinate system by the operation of the camera's framing, this is the projected coordinates of the spatial point $P$ in the photo. Here is the extraction of the key points by extracting the coordinates of the key points in the photo, and then
obtaining the spatial coordinates of the key points to realize the extraction of the deposit.

The point \( p(x, y) \) on the observation plane has the following geometric relationship with the corresponding point \( P(X, Y, Z) \) in space:

\[
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix} = \lambda R \begin{bmatrix}
x \\
y \\
-\mathbf{f}
\end{bmatrix} + T \quad (1)
\]

In the formula, \( \lambda \) is a scale factor; \( R(a_i, b_i, c_i) \), \( i = 1, 2, 3 \) is a rotation matrix, indicating the orientation of the camera coordinate system in the space coordinate system; \( T = (a, b, b)^T \) is a translation variable, indicating the position of the camera coordinate system in the space coordinate system.

### 2.4 Standardized Processing of Original Geological Map

#### 2.4.1 Map Vectorization

Geological maps are the main technical documents used by mining enterprises to express planning, design and production process in production. Geological maps are used as information carriers in the whole process of ore body delineation, infrastructure planning, mining and cutting engineering design and mining process planning and implementation. Digitalization of geological map is an important part of mine digitization. There are two forms of digitized geological map: raster image (or bitmap image) and vector image. Because the vector image has a series of advantages, such as not being affected by the resolution, the digitization of geological maps in this study refers to the vectorization of geological maps, and the vectorization of geological maps is the basis of solid modeling of deposits.

#### 2.4.2 Picture 3d

When introducing an external file into Surpac, it is often inconsistent in spatial position, which is caused by the different coordinates of the origin selected in the drawing. Surpac software uses real three-dimensional spatial data, the coordinates in the file and the location of the workspace is completely consistent. Since all geological maps are drawn in a certain proportion, the actual engineering coordinates in the vector graphics are not necessarily the actual geographical coordinates they represent. Especially the section drawing can not reflect the actual three-dimensional state of the drawing in the three-dimensional system because it was previously represented by two-dimensional coordinates. Therefore, before importing surpac, it is necessary to transform and check the three-dimensional coordinates of these maps.

The 3D transformation of geological map includes the 3D transformation of plane plan and section map. For the transformation of plane drawing, there are mainly the following steps: first, select two points, query the X, Y coordinates of these two points; Secondly, input the command of 2D map conversion, input the coordinates queried and the actual coordinate values of the two points. Third, change the Z coordinates of the map to the horizontal elevation actually represented by the map. If there is an angle between the original drawing coordinate network and the system coordinate network, the drawing must be rotated according to the angle before the aforementioned transformation.

The 3D transformation of cross section map is more complicated than the 3D transformation of plane plan. The first step is to change the Y coordinate of the profile into Z coordinate, because the Y coordinate represents the elevation value of the three-dimensional system in the two-dimensional coordinate. The second step is to select two points on the section map and query the X and Z coordinates of the two points (generally different from the mark). In the third step, the X and Z coordinates of the projection of two points determined in the second step (coordinates marked on the drawing) are queried on the plane map. Fourth step, input the line file coordinate conversion command, input the coordinate values of the second and third step points, complete the line file 3D conversion. As shown in Figure 1, the 3D transformation map of the 80-85 line ore body after digitalization is shown.
The geological entity model can be divided into two types: one is an open, layered, unclosed surface model, which belongs to this type of modeling of surface, rock and fault; The second is a closed space entity or hollow body wireframe solid model, which belongs to this type of modeling of surrounding rock and ore body.

The three-dimensional solid model of mine is one of the key contents of digital mines and the basis for realizing digital mines. The solid modeling method usually has three methods: the hatching method, the merging method and the connected segment method. In this thesis, the rock mass of 53-85 line is mainly used as the research object to construct the spatial entity model of the Mikeng iron ore. The geologic deposit image detected by the 3D solid model is shown in Fig.2.

As shown in Figure 2, when detecting the image of the geological deposit, the Mapgis map is first formed, and the map is converted into a .dxf format file by using the conversion function of the Mapgis software, and the contour boundary of the rock layer is drawn by the polyline in the AutoCAD file. Save as .dxf format; Then convert the .dxf file into a 3D coordinate in Surpac and save it as a .str format file. And clear the duplicate points, jumpers and coalescence points in the line file; then separate the line files by number or connection trend, form the DTM entity file respectively, and finally verify and correct the physical model to build the mine, surface model, ore body model, fault model, surrounding rock model and roadway model.

2.5 Spatial Metrics and Profile Studies
The spatial measurement and the cutting of the profile are the model analysis functions that geologists urgently need after the construction of the geological interface model. Spatial metrics based on complex geological interface models, including spatial distance measurement, spatial direction calculation, area calculation, volume calculation and production calculation.

With space two points \( P_i(x_i, y_i, z_i) \) and \( P_j(x_j, y_j, z_j) \) the spatial distance \( D_{ij} \) and its projection lengths \( D_{ijy} \), \( D_{ijz} \), and \( D_{ijy} \) in the \( XY \) plane, the \( XZ \) plane, and the \( YZ \) plane are:

\[
D_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2}
\]

\[
D_{ijy} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}
\]

\[
D_{ijz} = \sqrt{(x_i - x_j)^2 + (z_i - z_j)^2}
\]

\[
D_{ijy} = \sqrt{(y_i - y_j)^2 + (z_i - z_j)^2}
\]

The direction between any two points \( P_i(x_i, y_i, z_i) \) and \( P_j(x_j, y_j, z_j) \) of space can be
represented by two angle parameters \((A_{ij}, B_{ij})\), where \(A_{ij}\) is the angle between the connecting line \(P_iP_j\) and the \(Z\) axis, \(B_{ij}\) is the angle between the projection line of the line \(P_iP_j\) on the \(XY\) plane and the positive direction of the \(Y\)-axis, as shown in Figure 3.

![Figure 3 Space distance and direction metric](image)

Figure 3: Space distance and direction metric

### 3. Experimental Analysis

In order to verify the three-dimensional model construction method of complex geological structure deposits designed in this paper, the experiment was specifically carried out. Taking the digital ground model of Dahongshan Copper Mine as the experimental object, Dahongshan Copper Mine has 183 small ore blocks.

![Figure 4 Comparison of the clarity of the spatial 3D model](image)

Figure 4: Comparison of the clarity of the spatial 3D model

As shown in Figure 4, the geological topographic data provided by the Dahongshan Copper Mine is vectorized and imported into the three-dimensional model system of the deposit space designed in this paper and the traditional model system for construction and comparison. Through the study of experimental data, it can be found that the three-dimensional model system of the deposit space designed in this paper has high definition, and can clearly present each fault and mine. The traditional construction method has a low definition. There is no way to display the entire Dahongshan copper mine, and the model design designed in this paper is 38% higher than the model designed by the traditional method.

### 4. Conclusions

The three-dimensional model of the deposit is the basis of the “digital mine” and one of its core contents. The spatial three-dimensional solid model of the deposit and the establishment of the block model provide a new platform for the study of the Ma Hang deposit, which changes the traditional way of thinking. Let designers and managers study and analyze the shape of the deposit in three-dimensional space, and accurately estimate and evaluate the internal spatial characteristics of the deposit from the perspective of three-dimensional space. Therefore, the various characteristics of the ore body can be thoroughly studied, and the ore-forming rules of the ore body can be obtained; At the same time, the three-dimensional digital model realizes the transformation of the grade estimation and the reserve calculation from the traditional manualization to the computerization, which makes the estimation result objective, the estimation speed is fast, the precision is high, and the work efficiency is greatly improved. The establishment of the model can improve the scientific decision-making of enterprises and the controllability of production process, realize the scientific management of modern
mines, and provide a technical support platform for the construction of digital mines.

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