Geotechnical Engineering Design and Visual Research Based on 3D Geological Model

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Abstract. In geotechnical engineering, the geotechnical mass is in a three-dimensional state of stress, and the three principal stresses all play an important role in the stability of the slope. At the same time, with the influence of the excavation, blasting vibration, rock joint crack and fault around the slope, the structure and stress state of rock and soil mass change constantly. Therefore, in order to reflect the actual situation more truly, the influence of the three principal stresses on the stability of geotechnical engineering must be analysed and studied as a three-dimensional problem.

Keywords: Geotechnical Engineering, Geological, Construction, Visualization Technique

1. Introduction

From a macro point of view, the main realization process of visualization includes data preprocessing, data modeling, and graphics generation and so on. Using visualization technology to the modeling of rock mass is essentially to the spatial characteristics of graphic simulation of rock mass and reducing the traditional complex abstract symbols, in a more intuitive image expression of building regional geography virtual environment, realize the user and the interactive operation simulation system, can greatly improve the ability of spatial analysis and research.

2. Research and application of 3d visualization technology

At present, there are a variety of commercial software for visualization of 3d seismic data, and good results have been achieved in practical applications. The famous ones in foreign countries include Earth Cube of Landmark Company, Geoviz of GeoQuest Company, and VoleGeo of Paradigm Company, which basically represent the highest level of 3d visualization application in seismic exploration today[1-4]. Domestic petroleum exploration bureau of 3DV, baoding shuanghu Software Company developed three dimensional seismic computer interpretation system, the two kinds of
interpretation software contain three dimensional visualization display and mapping tools. It is hard to say which of this software is more advanced because they are different in function. CSG structure of 3d visualization technology is shown as figure 1.

![Figure 1. CSG structure of 3d visualization technology](image)

The main functions of this structure are: Seismic data loading, data cube animation browsing, a variety of display mode (conventional 2 d section/section, 3 d space profile/slice, cassette data volume, etc.), display control (mobile, scaling, rotation), the regulation of various visual display parameters (according to the scope, scale, opacity, color, light source, scale, vertical amplifier, data interception, background color, etc.), and fault section, horizon and fault plane, according to the time domain data such as transparent (seismic attribute), according to the definition and stripping, daughter of fault and horizon to pick up, the seed point definition and automatic tracking, carved along the horizon, Multi - attribute data body visual overlay display.

3. Basic principles of 3d visualization technology

3D visualization is based on voxel display and transparency control work platform, it provides a 3 d display platform, according to the strength of the function is an important part of the show to explain the work of 3 d visualization is the core of voxel display and adjust the transparency, color, transparency, light, movement is the four elements of 3 d visualization technology[5].

3.1. Voxel display

There are two basic methods for the preparation of 3d visualization software, one is based on surface volume rendering, the other is based on voxel modeling unit rendering, and voxel as the visualization unit is a popular and advanced method at the present stage. The TEN structure of 3d visualization technology is shown as figure 2.
**Figure 2.** The TEN structure of 3d visualization technology

Voxel has the following characteristics:

- Voxel is a three-dimensional image whose size is equal to the spacing of the surface element and the small three-dimensional body controlled by the sampling interval.
- In voxel-based visualization, each data sampling point is converted into a voxel, and each seismic trace into a voxel queue.
- In addition to T and amplitude values, each voxel has a set of values corresponding to the original three-dimensional data body, which is an RGB color value and transparency variable.
- Transparency can be adjusted through the opacity variable.

3.2. Transparency adjustment

Transparency is the degree of transparency, which is shown by the visual voxel. It is a new property completely different from the information extracted based on the seismic data volume. The adjustment of transparency is carried out according to the statistical characteristics of the amplitude value distribution of the seismic data. For a three-dimensional data body, the peripheral and peripheral data are usually seen, and the internal phenomena are obscured. If a transparent box is used, its interior will be clear.

4. Research content of 3d visualization in geotechnical engineering

4.1. Three-dimensional modeling system of rock mass

Due to the complex nature of the objects in geotechnical engineering, it is necessary to study the applicable three-dimensional data structure and effective modeling technology, which can not only fully reflect the characteristics of the stratum, but also facilitate the data management and operation, which is the basis of realizing the efficient display and analysis of the system. Three-dimensional geotechnical model based on ochre is shown as figure 3.
The recognition and study of the 3d spatial data model shown in figure 3 largely determine the development and application of the 3d visualization system. Many scholars have carried out a lot of exploration and research work for this purpose. However, due to the huge and complex 3d spatial data, there is still far from a consensus on 3d data model. There are many data models about three-dimensional space entities and their relations with each other, but the proposed data models show advantages in solving some fields or a certain topic. It is almost impossible to describe or express all three-dimensional space entities and their spatial relations in the objective world with a universal model. The three-dimensional vector data structure proposed by li yuanqing et al. can describe the slope geological entity reasonably and has obvious advantages. This vector data model is used to build the three-dimensional slope model.

4.2. Three-dimensional numerical simulation and analysis of rock mass

In the three-dimensional numerical simulation analysis, the physical and mechanical model is firstly established, and the three-dimensional physical and mechanical model is established according to the location of the sliding body according to the landform and structural characteristics of the landslide. Then, the three-dimensional model is divided into the units needed for calculation. The basic principle and calculation method of finite element method are applied for calculation and analysis, and the following formula is adopted for calculation:

\[ f_1(x) = \frac{S_h}{h} \int f(t) dt = \frac{1}{h} \int_{x-h/2}^{x+h/2} f(t) dt \]  

(1)

In addition to modeling, 3d numerical simulation analysis should also have a powerful post-processing function. Visualization technology can be used to analyze the results and generate various forms of 3d contour map, chromatogram, vector map and other graphics. In the study of the stability analysis method of rock mass, the three-dimensional numerical simulation of rock mass is a simple, practical and accurate method. The three-dimensional visualization of geological entities can enable geologists to intuitively see the relationship and distribution of the geometric forms of geological phenomena and accurately conduct mechanical calculation and analysis.

4.3. Study on three-dimensional visualization of rock mass structure

Geological information of various rock mass structural planes is obtained from field measurements or instrumental observations. However, this information are all discrete data, and it is difficult for geologists to directly use these data to analyze the distribution rules of structural planes in rock mass, or to seek their cross-cutting relationship with each other. Faced with these valuable measured data, geological engineers will no doubt ask how to use these data to infer the development and distribution of structural planes in the study area and the spatial association. Since geologists used to use graphics to express their understanding of geological bodies in the past, it is natural to hope that computers can be used to automatically display the distribution of such information in the rock mass.

In today's geological application technology, the computer screen shown in the graphic and image, is an effective method for a description of rock mass structure information, through the structural plane three-dimensional visualization graphics display, can make the geological engineer to visually see surface geometry of the space structure, the relationship between the rock mass and distribution,
and accurately for scientific analysis, geological problems to make reasonable and scientific conclusions and decisions.

5. Conclusion

Geotechnical engineering is a complex system. The visualization of geotechnical engineering requires a large amount of high and new technology and extensive professional knowledge, involving multiple disciplines and technical fields. Due to the high efficiency and intuitiveness of 3d visualization technology for large amount of data processing, it is of great significance in the application research of geotechnical engineering. With the in-depth study of geotechnical engineering, visualization technology will be increasingly applied in this field.

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