Application and Research of New 3D Simulated Geological Structure in Training and Testing of Track and Field Athletes

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Abstract. Aiming at the modeling problem of numerical simulation under complex geomorphology and geological structure conditions, the paper proposes a modeling idea from part to the whole based on the 3D platform. It uses Brick and Tetrahedron units to generate 3D geological body models under complex geomorphic conditions through programming. The paper uses the interface to simulate the fault plane and combines with the trend plane to construct the strata in the fault's upper and lower walls. It is believed that through mathematical analysis combined with computer programming, geological body modeling under complex geomorphology and geological structure conditions can be realized directly in the 3D platform. At the same time, the paper analyzes the relationship between track and field athletes' physical training and the local geological environment.

Keywords: 3D simulation, geological structure, track and field athletes, physical training, testing.

1. Introduction

With the development of scientific computing visualization technology and geological information computer simulation technology, three-dimensional geological simulation began to be valued in the early 1990s and gradually became the field of mathematical geology, petroleum exploration, geotechnical engineering, GIS, and scientific computing visualization. Research and application hotspots. Three-dimensional geological simulation is a comprehensive application of modern spatial information theory to study the information processing, data organization, spatial modeling, and digital expression of the geometric structure of geological bodies and their internal physical and chemical attribute data, and the use of scientific computing visualization technology to perform real the science and technology of three-dimensional representation and interaction. Therefore, it includes two parts, namely three-dimensional geological modeling, and visualization. The former is the basis of the latter, and the latter is the performance of the former. The application of visualization technology to the management, analysis, and simulation of three-dimensional geological data started early and reached a certain depth in foreign countries. At present, many mature software systems have been launched, such as AVS, gOcad, LYNX, CTech, Earth Vision, etc. This software involves seismic exploration, geological structure modeling, ore deposit simulation, mining evaluation, planning and design, production management, and other fields. Some are general-purpose visualization systems, and some are dedicated systems for the geological field. Many excellent systems are worth learning from.
Such as gOcad is a three-dimensional geological simulation software for geophysics, geology, and engineering applications. Its core module is based on discrete smooth interpolation technology (DSI) for expansion; widely used in mine simulation, LYNX and Earth Vision are used in geology. The body structure modeling is unique, and CTech based on the Kriging interpolation algorithm has done an excellent job in combining geological attribute modeling and geological body structure modeling. Most of the foreign three-dimensional geological simulation systems are expensive, the application is complicated and cumbersome, and the hardware environment requirements are high, which does not conform to our country's actual application. The domestic research and development of 3D geological modeling and visualization systems started late, and the software systems that have been launched are far behind foreign countries in terms of modeling functions and usability. Focus on domestic technical strength in related fields, increase investment, and catch up as soon as possible. The advanced level of the foreign system has no time to delay [1].

3D geological modeling uses computer technology to combine spatial information management, geological interpretation, spatial analysis and prediction, geostatistics, entity content analysis, and graphic visualization in a 3D environment, and used for geological analysis technology. Research in this area has been carried out earlier abroad and has formed a considerable scale. For example, EVSPro is a geological 3D visualization software developed by the American C-Tech company. It is suitable for advanced visual analysis tools in earth sciences and can meet the needs of multiple disciplines such as geology, geochemistry, water resources, and environment, prospecting engineering, oceanography, and archaeology. C-Tech provides accurate 3D data modeling, analysis, and visualization tools to dig deeper into data connotations. Because of 3D platform modeling's difficult problem, especially under complex landforms and geological structures, the author proposes establishing 3D geology with complex terrain and geological conditions through data point collection, trend surface fitting, and computer programming. The body model solves the difficult problem of geological modeling in the 3D platform and analyzes the application of 3D geological modeling in the training and testing of track and field athletes.

2. 3D geological structure simulation system development background
The origin of the world is three-dimensional. Traditional GIS simplifies the real world into a conceptual model of two-dimensional projection on a plane, which is doomed to its limitations in describing three-dimensional space phenomena. Simultaneously, with the deepening of GIS applications, people increasingly require dedicated three-dimensional space to deal with problems. However, three-dimensional space is complicated, and there are considerable differences in three-dimensional applications. With the current research status and technical conditions, it is not realistic to develop a general-purpose three-dimensional GIS. Based on this understanding, MAPGIS provides a three-dimensional visualization development platform with an open architecture-MAPGIS-TDE. It allows dynamic expansion of modeling and analysis functions for specific application areas based on general three-dimensional spatial data models and management functions. Plug-ins to adapt to specific 3D applications [2].

Considering that there are significant differences in data organization, modeling, and 3D analysis in 3D applications in different fields, the design of MAPGIS-TDE reflects the openness of the architecture and the dynamic scalability of functional plug-ins. The structure of the entire MAPGIS-TDE is shown in Figure 1. It can be seen that the system structure of MAPGIS-TDE is divided into 4 levels: MAPGIS kernel module, MAPGIS-TDE primary platform, MAPGIS-TDE construction platform, and application system based on MAPGIS-TDE.
The MAPGIS-TDE primary platform is a three-dimensional data management and a raw display platform based on the MAPGIS kernel module. It includes essential data management tools and essential display drive tools. Essential data management tools provide the management of a three-dimensional spatial database and digital elevation database. Through essential data management tools, the MAPGIS-TDE primary platform provides comprehensive management for 2.5-dimensional and 3-dimensional spatial data. The necessary display driver tool supports two internationally used 3D rendering engines and provides a unified rendering engine interface. The MAPGIS-TDE construction platform is an open and extensible 3D development platform that provides a series of professional modeling, analysis, and visualization tools for 3D applications; users can rely on the professional application-oriented modeling, analysis, and visualization provided by the MAPGISTDE construction platform. Visualize the interface to build your own 3D application system. MAPGIS-TDE reduces application system developers' cost on different 3D rendering engines and can significantly improve development efficiency. MAPGIS-TDE has powerful rendering processing functions and flexible methods and provides various practical processing functions for developers to consider, such as keyboard and mouse drive, path roaming, and other three-dimensional scene interaction methods. When developing a three-dimensional geological modeling and visualization system based on MAPGIS-TDE, developers can construct practical application services and professional models [3]. Besides, they can directly use the accumulation of MAPGIS in two-dimensional graphics and image processing. Robust management and analysis tools can significantly simplify the workload of 3D visualization system development.

3. Overall system design

3.1. System design principles
The development goal of the 3D geological modeling and visualization system based on MAPGIS-TDE is to combine the characteristics and development trends of GIS, MIS, and OA technologies to develop a collection of 3D geological information input, database management, and 3D geological data modeling and visualization analysis functions. The integrated intelligent three-dimensional geological information comprehensive management system enables it to fully meet the needs of three-dimensional geological data management and analysis and provides comprehensive, intelligent and standardized for geological staff, project managers and engineering technicians Basic Platform. The design and development of the system should follow consistency, advancement, practicality, reliability, safety, economy, robustness, visibility, interactivity, scalability, modularity, separation of application modules and data. Under the premise of fully considering the characteristics of geological data such as multi-sources, complexity, and uncertainty, it should also be noted that the purpose of 3D geological
modeling is not only to display the authentic appearance of geological bodies with computers, but also more critical. The aim is to provide a brand-new environment and scientific means for development and research to solve geosciences and practical engineering applications.

3.2. System function module
The 3D geological modeling and visualization system based on MAPGIS-TDE is divided into five modules: geological data management, two-dimensional geological analysis, geological section processing, geological structure modeling, and geological attribute modeling. The specific functions of each module include:

3.2.1. Geological data management. The system uses GIS technology to store and manage a single engineering survey project or regional geological survey results and necessary geographic information based on various maps, images, tables, and text reports. It has realized recording (importing) functions, converting, editing, and querying the data and results obtained from the geographical base map and the geological survey. The system provides the associated storage management function of test table attribute data and graphic data related to drilling, supports the storage and management of various 3D geological simulation results and result data, and provides various necessary information and test results related to drilling Query and other attribute information, and provide query and statistics on various results maps and analysis forms [4].

3.2.2. Two-dimensional geological analysis. For the typical two-dimensional geological analysis applications in current geological work, a two-dimensional professional analysis module that meets the engineering survey industry specifications is provided. The engineering survey professional analysis work that can be assisted to complete includes: generating drill-related drilling layout plans, soil column diagrams, rock column diagrams, and engineering geological section diagrams; generating various contours and various test curves; and the perfect combination of OA can automatically generate engineering survey reports based on the data obtained from the engineering survey.

3.2.3. Geological section treatment. Geological sections (including cross-sections and flat sections) are an essential type of 3D geological modeling data. The data format of geological sections derived from geophysical prospecting is often not standardized, and it is impossible to directly use these data for 3D geological modeling. Therefore, it is necessary to produce, store, and manage geological section data according to the standard data format before modeling. The system's geological section processing module is used to complete this work.

3.2.4. Geological structure modeling. Using flexible and friendly modeling methods and optimized data organization structure, the scattered and local survey data interpretation results with points and lines as the primary form are integrated with three-dimensional space to reproduce the underground geological interface and the space of geological bodies Morphology and combination relationship, and then reconstruct the three-dimensional geological structure morphology model, obtain the accurate three-dimensional solid filling model of the three-dimensional geological body through the subdivision, and vividly express the three-dimensional geological model with three-dimensional graphics images to realize the rotation, translation, Visualized operations such as zoom in and zoom out and real-time roaming [5]. The system comprehensively applies volume visualization technology and traditional visualization technology, draws various isolines and isosurfaces based on the three-dimensional solid model of the geological body, provides the function of expressing various attribute values such as stress and permeability in the geological body, and provides the three-dimensional geological The solid model performs visual simulation functions such as arbitrary sectioning, excavation, virtual drilling, tunnel generation, and virtual roaming (Figure 2), and provides three-dimensional measurement functions including volume, area, and distance calculations.
3.2.5. **Geological attribute modeling.** For the reconstruction of the physical and chemical attribute data inside the geological body, the system provides a variety of spatial interpolation methods (such as reciprocal distance weighting method, Kriging method, etc.) and data processing schemes, enabling users to choose according to different needs and data characteristics, to maximize the convenience of user modeling.

3.3. **System application expansion**

The 3D geological modeling and visualization system based on MAPGIS-TDE provides powerful geological data management, 3D geological modeling, and model visualization functions and provides a visual analysis and design platform for professional and technical personnel. Through the three-dimensional model, the geological body's intuitive image and its morphology and structure that was only contained in the minds of geologists in the past can be displayed in front of planners and geotechnical engineers, which can maximize the intuitiveness and accuracy of the geological analysis. Engineering design and construction plans that conform to geological phenomena' distribution and change, thereby reducing the blindness of human understanding of geological problems and the enormous risks of underground engineering design and construction [6]. In response to urban geotechnical engineering's application needs, a practical engineering-oriented auxiliary design module of pile caps has been developed, well received by urban geotechnical engineering departments. Figure 3 shows the design effect when the system's array pile foundation, cap, and three-dimensional stratum model are combined and displayed.

![Figure 2.](image)

**Figure 2.** Geometry modeling and visualization analysis of geological bodies

![Figure 3.](image)

**Figure 3.** Array pile foundation, pile cap, and model cutting display effect diagram
4. Introduction to the statistical optimization method of 3D geological simulation data

4.1. High-level compatibility method
A high-level compatibility optimization method proposed by scholars is to scan the training image through the data template to obtain the data event repetition number \( R \) and then calculate the relative frequency \( P \) of the data event repetition number in each training image. For each data event in the training image, the relative frequency is normalized to obtain the relative compatibility \( C \) of each training image [7]. Among them, the relative frequency \( P \) refers to the ratio of the number of repetitions of the data event in the training image to the total number of repetitions of the data event in the t training images, namely:

\[
P_j = \frac{R_j}{\sum_{i=1}^{t} R_i}
\]

Relative compatibility \( C \) refers to the ratio of the sum of the relative frequencies of n data events in the j training image to the sum of the relative frequencies of n data events in t training images, namely:

\[
C_j = \frac{\sum_{i=1}^{n} P_i}{\sum_{j=1}^{t} \sum_{i=1}^{n} P_i}
\]

Absolute compatibility \( M \) refers to whether the i data event appears in the j training image. If it does, then \( Y \) is 1, otherwise \( Y \) is recorded as 0. Then calculate the proportion of the training image that contains the data event:

\[
M_j = \frac{\sum_{i=1}^{n} Y_i}{n}
\]

This method believes that the higher the compatibility, the more matching the training images. However, because it only considers the number of conditional data points and does not consider the difference in the spatial distribution of different data points, which leads to errors in the statistics of compatibility between training images and real data events, and accurate optimization of training images cannot be achieved [8].

4.2. The statistical method of repetition probability of data events
The data event repetition probability aims to reflect specific data events' distribution characteristics in the training image. For t candidate training images, use the specified template to scan the condition data to obtain the set \( CE \) of n data events, search for the number of occurrences of the i-th data event \( CE_i \) in the j-th training image, record it as \( R_i \); then calculate the data event The distribution characteristics in each training image, namely the variance of the repetition probability of the data event \( j \) and the non-matching rate of the data event \( UNP_j \) (in the future referred to as the variance of the repetitive probability and the non-matching rate). The number of repetitions of a single data event \( R \) is the proportion of the number of repetitions of all data events in the training image is the probability of data event repetition, namely:
\[ PT_j = \frac{R_j}{\sum_{i=1}^{n} R_i} \]  
\[ \sigma_j = \frac{\sum_{i=1}^{n} (PT_j - \overline{PT_j})}{n} \]

Where \( PT_j \) is the mean value of the repeat probability of data events in the j-th training image. If a matching data event is found in the training image, the indicator value \( U_j \) is recorded as 1. Otherwise, it is recorded as 0. Then calculate the proportion of unmatched data events, that is, the unmatched rate of data events \( UNP_j \):

\[ UNP_j = 1 - \frac{\sum_{i=1}^{n} U_i}{n} \]

The low non-matching rate indicates that the training image matches the actual area with rich geological patterns, and the small variance of the repetition probability indicates that the training image matches the actual area with stable geological patterns. Therefore, a better training image has a lower non-match rate and a smaller repetition probability [9].

5. Modeling case analysis

Figure 4 is a three-dimensional rendering of the entire (including part of the Bohai Sea area) four-layer aquifer after separation using EVS. During operation, you can view the overview of each layer by choosing to display different layers.

![3D map of the aquifer with remote sensing image](image)

Figure 4. 3D map of the aquifer with remote sensing image

Figure 5 not only expresses the three-dimensional aquifer but also combines the fluoride distribution area with the aquifer, allowing users to more clearly understand the distribution of chemicals in the aquifer. The size of the fluoride halo in Figure 5 can be displayed by setting different concentration ranges.
6. Conclusions

3D geoscience simulation is the core research content of 3D geological information GIS visualization. With the development of scientific computing visualization technology and 3D GIS technology, the 3D visualization of geological information will also be further deepened. Through analysis, it is found that under the right geological conditions, the gradual increase in exercise load, the excessive recovery of training, the combination of training process and competition, and prevention of special adult training are the winning rules for young track and field athletes.

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