An Overview about Research on 3D Visualization Technology of Geographic Information Based on Computer Software Development

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Abstract. Geographic Information System (GIS) is an important system of three-dimensional (3D) real-time interactive visualization platform. 3D visualization technology is to display the information to be expressed by a visual effect. The introduction of 3D visualization technology into GIS is a reform of the form of information expression, which can solve the limitation of using graphic symbols to express the 3D space world on a 2D plane. However, most of the visualizations in GIS focus on the 3D terrain visualization based on the surface model, which does not involve the volume visualization of spatial volume data. An overview about visualization technology for geographic information based on computer software is given here, to encourage further development.

Keywords: Computer Software, Geographic Information, 3D Visualization Technology

1. Introduction
3D visualization technology is a combination of computer technology and image graphics, which is an explicit method to express data information through visual effects. GIS is an information system that integrates geography, surveying and mapping, computer science, and other comprehensive disciplines, which can well carry out 3D visualization of geographic information [1].

There are four kinds of 3D visualization technology, namely, geometric modeling, video image production, geometric video image production, and image coverage. Geometric modeling can synthesize various objectives to produce landscape maps with different perspectives, which can be used for trees, buildings, roads, and other features [2]. Video image production is a way to express landscape changes by digital image cutting technology, which contains many subjective characteristics of operators. Geometric video image production is a combination of geometric modeling technology and video image production technology, which can accurately establish the benchmark relationship between film and television images and geographic information. Image coverage is an image processing technology, which can cover the image data to the 3D perspective [3]. 3D visualization modeling technology has many application advantages in the field of Geosciences. After years of development, GIS technology has been more mature, which has penetrated into various fields. Through the geographic space of spatial entities, 3D visualization technology is introduced. Through
3D visualization technology, spatial information can be expressed in real-time, which has become the trend of GIS technology development.

2. Technologies related to 3D Terrain Visualization

2.1. Remote sensing technology
Remote sensing is a technical means to obtain geographic information from space through the sensor to earth observation, which has developed into the infrared, microwave, multi-band, multi-angle technology. Remote sensing technology has been a multi-level, multi-angle, all-round and all-weather geographic information acquisition system, which has laid a solid foundation for high-precision, real-time 3D terrain data acquisition [4].

2.2. Digital Photogrammetry
Digital photogrammetry extracts 3D space from a 2D digital image of an object, which combines of photogrammetry and computer vision. Digital Photogrammetry System (DPS) is a symbol of digital photogrammetry, which is an essential part of digital photogrammetry. Through all kinds of 3D graphics, an intuitive and visual mapping product can be provided, which increases the application field of DPS [5].

2.3. Virtual reality
VR technology is a highly lifelike human-computer interface technology, which expresses the behavior of seeing, listening, and moving in the natural environment. It has two basic characteristics: immersion and interaction. By creating a 3D virtual environment, participants can be fully engaged in the environmental experience. Therefore, VR technology will fundamentally change the interactive operation mode between human and computer system [6]. At present, many commercial virtual reality development tools have come out, which has greatly promoted the technology update.

2.4. GIS
GIS is a spatial information system that collects, stores, manages, analyzes and describes the earth's surface, space and geographical distribution, which has gone through three stages of development, namely, initial test, consolidation and development, and comprehensive application. As a method of computer and spatial data analysis, GIS can be applied to a popular subject. The core of GIS is a spatial database, and 3D geospatial positioning and digital expression are the essential features of GIS. Based on the strong function, GIS has become a hot area of great concern to government departments, commercial companies, scientific research institutions and institutions of higher learning, which has formed an industrial scale.

3. Basic principles of 3D graphic display
The basic coordinate system is the basic system of displaying points in 3D space, which can represent the spatial position of objects in 3D space. The principle of projection transformation is the parallel transformation of objects in 3D space. Projection space and transformation are the transformations of any position of an object in 3D space. Because geographic information collection is working at a high altitude, the foundation of 3D visualization technology of geographic information is to project and transform the collected information, which will form a real spatial structure. The principles are analysed in three aspects.

3.1. Coordinate system
In the 3D field, a 3D coordinate system need to be defined in order to represent points, which is the rectangular coordinate system, as shown in Figure 1(a). The basic problem of 3D display is to convert a point in the world coordinate system to the 2D coordinate on the equipment coordinate system, which requires to transform by observing the coordinate system as the intermediary, as shown in
Figure 1(b). For the observation coordinate system, the $X_e$ axis is the horizontal direction from left to right, the $Y_e$ axis denotes the vertical direction from bottom to top, and the $Z_e$ axis is the direction from the eye to the front.

3.2. Principle of projection transformation

Parallel projection can be divided into positive parallel projection and oblique parallel projection. The projection direction of positive parallel projection is perpendicular to the projection plane, usually three views, which are mainly used in engineering, architecture, mechanical drawing, etc., as shown in Figure 2 (a). Oblique parallel projection is the case where the projection direction and the projection plane are not vertical, as shown in Figure 2 (b).

In the oblique parallel projection mode, the projection equation is shown in Formula 1.

\[
\begin{align*}
\frac{z - z_s}{-1} &= \frac{x - x_s}{l \cos \alpha} = \frac{y - y_s}{l \sin \alpha}, z_s = 0
\end{align*}
\]

Therefore, the projection mode of any point coordinate can be described as formula 2.

\[
(x_s, y_s, z_s, 1) = (x, y, z, 1) \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
l \cos \alpha & l \sin \alpha & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

3.3. Projection space and transformation

No matter for perspective projection or parallel projection, as long as the projection window and projection body size of the projection plane are defined, objects can only display in the projection body, and other objects will be cut off. For orthographic projection, the size from one end of the projection body to the other does not change. Therefore, the distance between the viewpoint and the projection plane does not affect the size of the object on the projection plane. For perspective projection, the size of the object on the projection surface depends on the distance between the observation point and the projection surface. If the distance between the observation point and the projection surface is longer, the projection of the object on the projection surface is smaller, and vice versa. When the distance between the viewpoint and the projection surface is infinite, the effect of the
projection is close to that of the parallel projection. By using the matrix transformation, the oblique perspective projection can be changed into the positive perspective projection. Therefore, the center line of the projection body will be consistent with the normal direction of the projection surface after the staggering transformation.

4. Realization and application effect of 3D visualization technology

4.1. 3D visualization technology function of geographic information
According to DEM, a surface model can be built to show real terrain, which is the realization of 3D visualization technology of geographic information. The function of 3D visualization technology of geographic information is shown in Figure 3. Based on Visual C++ 6.0 and OpenGL, the 3D terrain visualization system is developed.

4.2. 3D terrain display
The image of 3D terrain system can get by loading DEM data file, as shown in Figure 3.

![Figure 3. Function module development](image1)

![Figure 4. Texture model](image2)

5. Conclusion
Many achievements has been made in the field of 3D visualization of geographic information at home and abroad recently, which has formed a comprehensive discipline system. However, China's research in this field is relatively late, which requires constantly improve theoretical accumulations. Development of computer science make practical application of geoscience engineering come true, on the other hand, applications will support and stimulate the optimize of 3D visual modeling technology software. By gradually refining the three-dimensional display, the response to geographic information will be more diversified and intelligent, which will make the geoscience work more vivid, convenient, and efficient.

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