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Construction and Application of Virtual Reality Geographic Information System

Ke Xi-Lin*[1,2,3], Guo Qing-Sheng[1], Zhang Yue-Peng[2,3] ,Zhou Yan[2,3]
[1]School of Resource and Environment Science of WuHan University, Wuhan 430079, China
[2]State Key Laboratory of Geo-information Engineering, Xi'an 710054, China
[3]Xi'an Research Institute of Surveying and Mapping, Xi'an 710054, China
*Corresponding author, email: kexilin_tek@163.com

Abstract

In the paper, virtual reality geographic information system is discussed and the related technologies involves the concept, characteristics, classification, key technology, and the main application and development situation, it analyzes the virtual reality technology and the necessity of combining geographical information system technology. As to the design and development process of the whole system, including the system's user interface, system requirements, the structure of the system design, system development model and related technology are discussed in this paper. In view of the virtual reality geographic information system technology, the 3-D (three Dimensional) spatial data acquisition, 3-D data model and digital terrain model and digital elevation model and 3-D data of level of detail model and the expression of 3-D data visualization, etc, on the basis of theoretical research, with the help of a professional virtual reality modeling software MultiGen Creator, it builts the scenic spot of the 3-D environment. And it presents the virtual scene modeling process on the basis of MultiGenCreator complex modeling, the implementation plan, scene modeling method are also given out.

Keywords*: virtual reality, geography information system, construction, application*

1. Introduction

GIS (Geographic Information System, GIS) is the borderline subject of geography, surveying, cartography, remote sensing, it now is developed towards socialization.

Virtual Reality is referred to as VR, this word is a professor at American scientists Jaron Lanier first put forward in the early 1980s, also known as virtual environment, artificial reality, simulator technology, etc. Its origin can be traced back in the 1960s, until the 1990s it become the concern of the science and engineering technology. With the rapid development of information science, virtual reality technology is based on computer science, mathematics, mechanics, acoustics, optics, mechanics, biology, and even the aesthetic and the social sciences and other disciplines. Comprehensive utilization of the computer virtual reality, tactile feedback, virtual stereo technology, such as highly realistically can simulate the behavior of man in the natural environment. This kind of virtual environment is a kind of environment generated by computer, it can be a real simulation world, and can also be a vision of the world [1, 2].

In the continuous development of virtual reality technology, the research of it involves the content of related disciplines, such as computers, cross and synthesis, this complexity makes it so far, there is no uniform definition. Simply speaking, it can be understood as through the establishment of a virtual environment, and make the person feels as in real environment. Now its recognized précised definition is through using computer technology as the core of the modern high-tech to generate realistic visual, hearing, touch, the integration of the particular range of virtual environment, it can through a natural way and from entity objects in a virtual environment interaction, thus it can produce the real environment of feeling and experience [3-6].

The essence of virtual reality technology is invisible imagination into the form of scenarios, it emphasizes the visibility of lifelike and science, it is a key basic features are its three characteristics of "I", namely that the Immersion characteristic, Interaction features, Imagination features [7, 8].

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2. Necessity of Virtual Reality and Geography Information System

VR and GIS system integration become rich virtual reality world and the best way to enhance the geographic information system performance. VR system has perfect interactive ability and inspired by the idea of multi-dimensional information environment. The GIS has good performance in the processing of spatial relations, the two-dimensional technology, research contents, and methods have become the application prospect and trend.

(1) As to GIS, integration of VR technology can extend existing GIS graphic display function, GIS theory and rich connotation, expanding the area of GIS application; it is the inevitable trend of spatial information visualization virtual expression. VR system is a kind of man-machine relationship, through the visual, hearing, touch, and so on, the user of it can immersive feel the multi-dimensional information interactive visual simulation system of the real world, it can meet the current exploration and study of earth science, now the GIS is developed from simple description to the whole earth space of high and new information technology direction.

(2) As VR system, GIS is the tool in solving the problem of users in the virtual scene. Multi-dimensional information space generated by the VR system is called a virtual environment. Although virtual environment with earth science can produce 3-D geological virtual environment with realistic visual effects, but when the space is too large or complicated, users can only see objects within the scope of vision, it is lack of integral feeling to the environment, it is often in roaming lost feeling and exploration process. At this moment it needs the 2-D navigation system corresponds with the 3-D virtual world, so the expression of the 2-D GIS are indispensable.

(3) From the data level, in order to build large-scale scene in the real world, the virtual scene modeling of objects can be adopted into a unified geographic spatial database in the reference system, and the unified management must be operated by GIS system, GIS has great advantages and potential in 3-D, real-time dynamic, multi-resolution and huge amounts of data space scene simplification, compression, storage and query structure, extraction and information recovery, etc.

In the geological research and practice, people have gradually realized the importance of combination of GIS and VR system in solving practical problems, thus formed the new research field of VRGIS. Integration of technology integration will be no doubt applied for the further combination of the two systems and guide its development direction [9-14].

3. Design of Virtual Reality Geographic Information System

In order to make the system to be fully functional and structural optimized, the following principle should be adopted.

(1) Simple practical principle: the system should be as simple as possible, and suitable for different levels and the knowledge structure of the user. It should have concise design and friendly interface, easy operation characteristics.

(2) Standard principle: the system should meet the basic requirement of VRGIS and standard, system data types, such as coding, schematic illustration should conform to the state and industry standard requirements.

(3) Prospective principle: the information technology is developing very fast, the upgrading of hardware is also very rapidly, software version upgrades also very fast, in the design, the full consideration to the development trend of technology should be given.

(4) The security and stability principle: system has certain fault tolerance and good reminders, some simple mistake will not lead to the system crash.

(5) The rationality principle: in the configuration of software and hardware, the software and hardware should fully consider performance ratio and the rationality of the configuration, and should also consider the realization of the function and the specific application requirements. The maximum various resources consuming problem of computer hardware performance should also be cared of.

(6) The principle of openness and scalability: the system data has exchangeability, provide industry popular data transmission and exchange function. Modular design should be adopted, each function module is independence, and the module of change will not bring much impact to the system.

4. Establishment of Virtual Reality Geographic Information System

With the development of computer graphics technology in recent years, TIN (irregular triangle net) in 3D visualization also got more and more widely used. TIN has the advantage of less data redundancy, it is better to take the terrain features into account, it can fully reflect the terrain complexity details, etc. its weakness is the more complex algorithm implementation, the space operation and its storage. The GRID modeling is another method to built DEM. It features is simple structure, Because of the space point in the plane carried out in accordance with the rules of grid form arrangement, plane coordinates by starting at the origin are calculated, so it just need to record point elevation array, general performance for the vertical value of two-dimensional coordinate arrays,

Today's GIS systems generally support the two methods of data representation. The GRID and the algorithm of TIN have been mature, now it is no longer affected virtual roaming function realization of the key factors of urban landscape. Creator can be able to identify the DEM format for USGS DEM and other specific format, so with all kinds of GIS, RS tools including ArcGIS, MapGis, Erdas and ENVI software to generate DEM, the final format should be converted into USGS DEMO Creator, its internal format generated by USGS DEM and then by using the polygon algorithm and the level of detail (LOD) 3 D terrain can be generated.

In this system, the whole region area is not large, it demands terrain details, final selection by way of irregular triangle net (TIN) to generate DEM. Renderings are as follows: Figure 1 scenic terrain DEM image

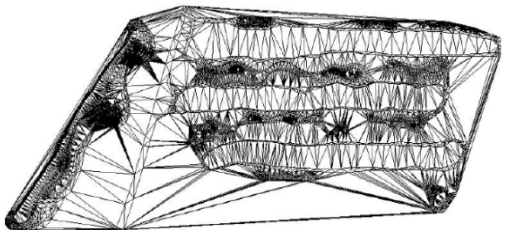


Figure 1. Scenic Terrain DEM Image

4.1. Establishment of Virtual Environment Model

4.1.1. Basic Construction of Environmental Scenario

3-D environment scene building is the foundation of the entire modeling process. On the basis of partition to complete each partition of the specific entity modeling and geometry model of the landscape, big entities to the complex construction, small to roadside flowers grass. Each model described in the object shape is determined by polygon, vertices and triangles, object appearance is determined by its surface texture, color, material, illumination coefficient, etc.

Landform landscape is one of the most important geographical objects in the environment, the terrain model is the basis of virtual geographic environment of three-dimensional space, and it is the carrier of other features. Terrain landform data modeling is to use visual area, according to certain modeling algorithm and describes the changes of continuous relief area and reflects the real process.

When the relief is not big and the terrain of topographical features is not complicated, it can through the way of field investigation and the reference plane design, modeling tools, the basis of using MultiGen plane combination instead of terrain model, namely that the terrain elevation data is zero, then the rest of the modeling can be completed in the terrain surface.

As for more complex terrain, Terrain tools is provided by MultiGen module, the module is a quickly creation and large topography database tool, through using the unified management of project resources (terrain data, texture, cultural characteristics, etc.). It can make topographic accuracy close to the real world, with a high fidelity in three-dimensional culture feature and texture feature. It uses a series of triangulation algorithm and the model of the earth, and automatically builds and transforms the terrain, while it is consistent with the prototype of the geographic location. Through the texture map, photographs of the terrain are generated, including roads, rivers, city or other, the characteristics of the area. Its path discovery algorithm

is superior to linear feature generation algorithm. Terrain modeling is a very complicated process; generally speaking, the analysis of the data preparation, the original model generation, and topography optimization are the key steps.

4.1.2. Physiognomy Building

4.1.2.1. Scenic Area Construction Layout

The entire scenic area mainly consists of several groups of buildings and lakes, in the process of modeling, the coordinates and shape should be relatively accurate. After many experiments, when we get CAD drawing of the scenic spot, CAD drawing is in DXF format, we can import it into the Creator, the basic position is accurately. The unnecessary parts can omitted, keep the scenic area periphery and entity shape, location information, take the CAD as a reproduction, and draw terrain contour line, and then the contour line alone can be saved as a DXF format and PLT format, the outline of the scenic area small rules shape and basic physical location information can achieve the predetermined requirement.

4.1.2.2. Path Modeling

On the surface of the road feature modeling, the key parts are the every paths of each position and road information. Plane road information is easy to express, while surface relief or ways of road information is more difficult to indicate, if we mark the road location in the CAD conversion of creator expressed good terrain file, this location problem can be easy solved. After the positioning of the feature modeling, the creator offers an open module of road tools.

The module has powerful functions, it defines the transverse slope and longitudinal slope of the road, you can define the road cross section of transverse slope and longitudinal slope, turning radius, the geometry structure of the side of the road, and even can be directly transferred external reference to define the way street light, reflector, traffic signs, such as the road geometry model, it also can be directly applied road texture, road greening belt processing and multiple LODs. As to road greening belt, we can adopt the method on the road to establish the subpart.

According to the needs of system simulation, in the paper, we choose the polymesh algorithm and standard sampling rate and set the number of benchmarking, through system calculation, the generated terrain is more reasonable. If the driven sampling rate is too large, the grid effect is not so good; when the sampling rate is too small, area block size XY will be too large, the generated polygon is overmuch, and it will cause slow terrain converting speed, and affect the real-time speed of the scene. Therefore, it needs to weigh the various factors of polymesh algorithm parameters, and set each parameter reasonably. Area block size should be chosen as far as possible big, and then the appropriate sampling rate is necessary.

4.1.2.3.Texture Mapping

The most commonly used in the texture are the aerial photographs, paste the corresponding aerial photographs in the corresponding region even make the visual effect of the terrain model achieve genuine, the related figures are as Figure 2 to Figure 7.

Figure 2. Scenic Landscape Rendering

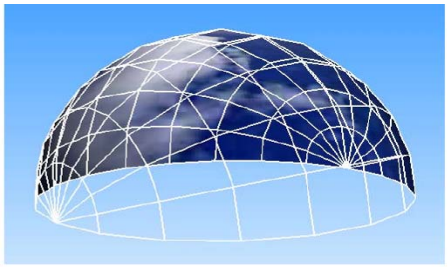


Figure 3. Hemisphere Sky Rendering

Figure 4. Vision Effect

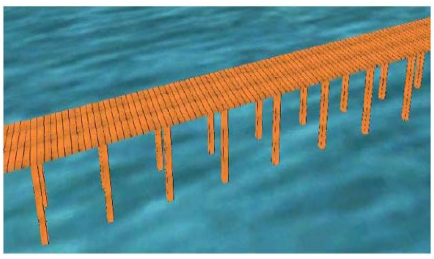


Figure 5. Impending Road Rendering

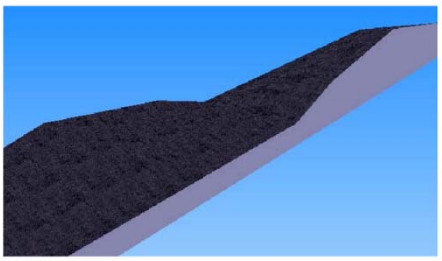


Figure 6. Vertical and Horizontal Road Slope Renderings

Figure 7. Surface Rendering

4.1.2.4. River Modeling

The entire scenic area has three ponds; the area in the entire scenic area is larger. On the surface modeling, it can use the floor plan determine its position, size, shape and other factors, and then it also takes pictures of water ripple, vegetation images even bank surface as the texture images. Ensure the actual effect is the key to the lake ripples of image processing and texture repeat joining together, the small wave texture image repeated in large area, until it covers the whole area. As long as the edge of the graphics is processed carefully, and make it repeatability, feeling of abrupt changes in texture joined together won't be appeared, thus make the whole area look more smooth and nature.

Figure 8. Exhibition Hall Effect

4.2. Environment Landscape Construction

Landscape mainly includes the grass, trees, flowers, street lamps, hedges, flower beds, street signs, fences, etc. Decorated with landscape, realism and fidelity can greatly enhance the scene. But the trees and flowers everywhere, such as dispersed, the number is more, and mostly with irregular shapes, irregular object modeling has been the research hotspot.

If according to the real form of scene modeling in detail, the polygon number will be in the hundreds of millions, it will not only greatly exceed the modeling tool capacity limits, but also will lead to collapse eventually overwhelmed by roaming system.

This system mostly adopts simple geometry to express its appearance, then use texture mapping to ensure the authenticity of scenery. In the below, the grass, trees, flowers and shrubs are taken as examples in the discussion of the above method.

In this system, the grass coverage area is large; it is also the important content in the scene. Relative to other scenarios, the grass can be blurred. There is a direct partial mapping method; it is to set up the grass of the irregular surface deformation, according to certain degree of repetition with grass texture images. But this method is the lack of stereo sense; truth sense will be poor after careful observation.

In the system, it mainly uses another method to solve the problem, due to the size of the grass is different, a variety of shapes and location distribution is different, and so the each block should be modeled. And then it can be divided into surrounding edge and the central area, a certain height (0.1 m~0.2 m) is chosen to ensure stereo sense of the real grass.

As for detail parts such as door, window, railings, it generally adopt the texture mapping method, namely that on the corresponding position of the polygon, it stick on the corresponding texture images, instead of the detailed model. The advantage is that the number of polygons can greatly reduced and model complexity is also reduced, thus it can improve the display speed of the output of the image. Below Figure 9 and Figure 10 are the charts of scenic area exhibition hall and the final rendering.

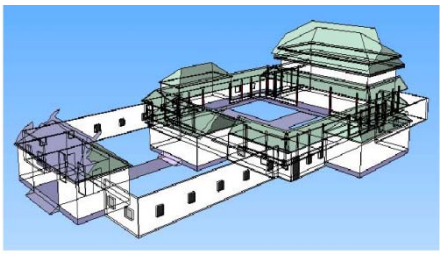
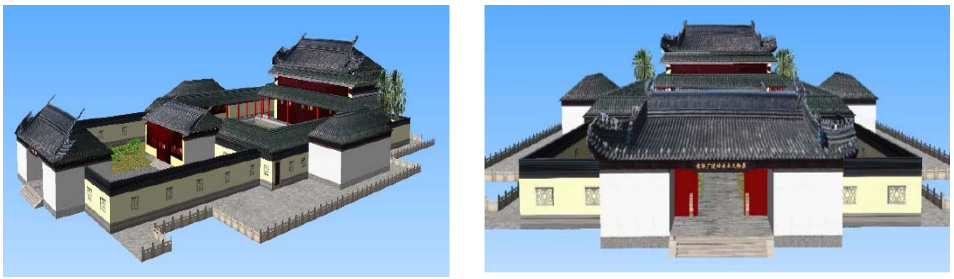


Figure 9. Exhibition Hall Chart



(a) (b)

Figure 10. Exhibition Hall Effect

4.3. Model Optimization

In virtual reality scene, the model is very complex; a large number of polygons takes up a lot of memory space and reduce the speed system of real-time interaction. Although the hardware of virtual reality is greatly improved now, but in the process of the huge amounts of data, the hardware also shows powerless capability. Aiming at this problem, this paper is to

reduce the amount of data processing method in the virtual scene model and optimize the model, in order to improve the rendering speed, reduce the lag time when roaming.

4.3.1. Adjustment of Structure

Before the scene model is set up, all entities in the virtual scene model hierarchy should be determined according to the geometry of each entity in the virtual scene space position, and the structure of the internal relations between models and model. After the scene hierarchy division, it can facilitate the solid model of organization and management, and definite target in model building, thus greatly lightens the load of the model. Even the simplest model also needs to adjust the model of hierarchical structure and to achieve the goal of optimization.

Adjusting principle of the hierarchy view is as follows:

(1) An object may be formed by multiple forms, it does not need to put every body in its own set of nodes, but the object of a certain scale of the body should be put together, under a common set of nodes. As to a file with a hierarchical structure, execution efficiency is higher than files with no hierarchy. Render the body does not belong to top level set of nodes, and then the top under the set of nodes of all forms can be ignored.

(2) Visual adjacent form should also be adjacent in the hierarchy. The same level of data nodes in turn from left to right, when nodes exist and the object is not visible; it can display the node position adjustment.

(3) Try to avoid creating span larger objects in space. Although only fall within our field of vision can draw the part of the object, although we only can see part of the objects, while the system should calculate the object of the big spatial span.

(4) The ultimate goal of model is to reach what extent definition and use what technology. Target implementation model system of restrictions; such as color, polygons, material, light and texture, the background of the model system requirement is as simple as possible, as real as possible; special requirements in the whole model system.

4.3.2. Segmentation Model Unit

Cell division is to divide the virtual scene model into smaller units, only generates a transition zone between two layers of LOD. Before high precision in LOD model generated in the transition zone, and high precision of LOD in every vertex corresponding morphing, its scope is located in the adjacent vertices between two LOD models, they are generally selected adjacent vertex of the low precision LOD model vertices for it recently morphing vertices, thus formed the morphing two edges of the vertices in the process of transition. Before transformation of LOD model, the transition of real-time simulation scenario will display the transition value of the vertex and update the transition gradually, until the next LOD model is displayed.

(1) Shape Retention

As to simplify the algorithm must preserve the shape and surface characteristics of model as far as possible, so the algorithm must first find out the feature information model (e.g., surface curvature, sharp point and feature edge), and then through the fusion of flat area and change characteristics of linear edge to simplify the model. Today, most algorithms adopt the edge collapse is to simplify the model or smaller curvature of the adjacent surface, and also through the threshold method to simplify the control.

(2) Approximation Error Estimates

In order to simplify control process, each step is to simplify all evaluation model of local approximation error, such as some error estimation algorithm adopts local or distance criterion to judge the simplified error; geometry and some algorithms are used to limit the simplified.

5. Conclusion

In the study, it makes the study and discussion of virtual reality geographic information system technology systematically based on the data collection and analysis, and through using real time 3-D modeling tool Creator, visual driver software combined with GIS software, and through using VC language, it designs and implements a realistic 3 D scene model.

In the paper, many kinds of modeling method to construct the virtual environment of scenic spots are adopted, considering the scenic spot, entity model based terrain, environment and other objects of the problem of model establishment.

It also analyzed common problems in the process of virtual environment modeling, the model of structural adjustment, texture mapping, levels of detail, external references and instantiate the technical methods are used in optimizing the entire model. Through using these methods, overall performance of roaming scenarios can be improved significantly; requirements of the real-time rendering can be met.

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