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Virtual Huanghe River System: Framework and Technology

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Abstract: Virtual Reality provides a new approach for geographical research. In this paper, a framework of the Virtual Huanghe (Yellow) River System was first presented from the view of technology, which included five main modules —data sources, 3D simulation terrain database, 3D simulation model database, 3D simulation implementation and application system. Then the key technologies of constructing Virtual Huanghe River System were discussed in detail: 1) OpenGL technology, the 3D graphics developing instrument, was employed in Virtual Huanghe River System to realize the function of dynamic real-time navigation. 2) MO and OpenGL technologies were used to make the mutual response between 3D scene and 2D electronic map available, which made use of the advantages of both 3D scene and 2D electronic map, with the macroscopic view, integrality and conciseness of 2D electronic map combined with the locality, reality and visualization of 3D scene. At the same time the disadvantages of abstract and ambiguity of 2D electronic map and the direction losing of virtual navigation in 3D scene were overcome.

Keywords: Virtual Reality; Virtual Huanghe River System; dynamic real-time navigation; mutual response between 3D scene and 2D electronic map

1 Introduction

Huanghe (Yellow) River basin is located in 32°–42°N, 96°–119°E. The area of the catchment is more than 752,000km^2. The river is 5464km long with a drop in elevation of 4830m. Among the whole area, the mountainous and stone area accounts for 29%, loess and hills area 46%, sandy area 11% and plain area 14%, respectively. Different natural landscapes exist in this area. The Huanghe River flows through the Loess Plateau, where the soil is eroded seriously (Wang, 2002; Li, 2005).

With the rapid increase of the population and the development of the economy in the Huanghe River basin, the pressure the Huanghe River bears increases dramatically. The period of runoff suspending in the lower reaches of the Huanghe River has prolonged since the late 1970s, which demonstrates that the basin's ecosystem has deteriorated. The following also showed that the ecological situation of the Huanghe River is getting worse and worse: 1) The downstream riverbed obviously shrinks and the ability of discharging flood reduces sharply. 2) The riverbeds of the main and tributary streams of the upper and middle reaches shrink constantly. 3) The imbalance between supply and demand of water resources of the Huanghe River is aggravated. 4) Water quality deteriorates as the sewages entering into the Huanghe River increase gradually and the pollution of Huanghe River basin has already been worse than that of 20 years ago (Jiang, 2006; Liu et al., 2005; Li et al., 2004; Wang et al., 2003).

Virtual Reality technology is a kind of man-machine interface technology of simulating man's behaviors such as vision, audition and movement, etc. in the natural environment. With the 3D helmet, data glove, 3D mouse, data clothing and stereo earphone, etc., people can be totally immersed in a special 3D digital image environment created by the computer. So people can operate and control this environment to serve a given purpose (Wang et al., 1996; Hu, 2005). The traditional visualization methods of the Huanghe River include paper map and modern map (i.e., electronic map), which emphases spatial data displaying on the screen. On the contrary, Virtual Reality, with multi-sensing (such as seeing, listening, touching and moving, etc.), immersion, interaction and autonomy, focuses on 3D dynamic real-time displaying of the map (Shi, 2002; Su et al., 2004). By Virtual Reality, not only models can be built in multi-dimension data space but also highly abstracted knowledge can be acquired and new concept can be formed by the user.

2 Design of Virtual Huanghe River System

2.1 Project design

Figure 1 is the technology flow designed for the Virtual

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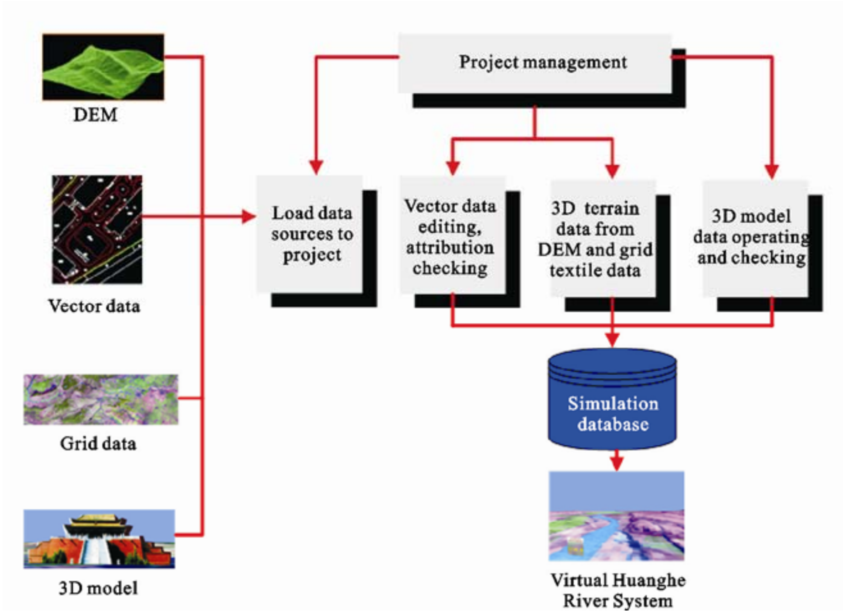

Fig. 1 Technology flow of Virtual Huanghe River System

Huanghe River System.

The Virtual Huanghe River System included five major modules—data sources, 3D simulation terrain database, 3D simulation model database, 3D simulation implementation database and application system.

Data sources included various DEM data, terrain element vector data, geographical texture data, 3D model data and geographical element texture data. The 3D simulation terrain database mainly realized terrain scene display. The 3D simulation model database mainly realized 3D model display. The 3D simulation implementation database mainly realized various kinds of mutual operation (such as keyboard navigation and route navigation) in the 3D scene. And the work of application system included the realization of the 3D target management and the mutual response between 3D scene and 2D electronic map.

2.2 Data sources and software tools

The data sources of Virtual Huanghe River System included 30m-resolution ETM+ image of the Huanghe River (September 2001), 1∶50,000 DEM data of Henan Province, the texture pictures of the Huanghe River, the urban architecture layout of Henan Province, the building models and digitized maps of Henan Province. The data processing software included ESRI ArcGIS 8.3, ArcView 3.2, ERDAS IMAGE 8.6, MapInfo 7.0, Terra Vista 4.0, Multigen Creator 2.5.1 and Adobe Photoshop 7.0, etc.

The Virtual Huanghe River System was based on OpenGL 2.0 and MO 2.2. Microsoft Visual C++ 6.0 was the developing tool.

Virtual Huanghe River System was mainly constructed in Henan Province.

3 Key Technologies

3.1 Transformation of map projection

In order to realize the 3D navigation in Virtual Huanghe River System, the transformation of map projection should be conducted at first.

Based on the fact that DEM data field is made up of regular grid, the triangle could be selected as the basic mesh to approach the terrain surface. $2*(m-1)*(n-1)$ triangle meshes could be gained from m rows and n columns of DEM data and the whole scene was displayed by filling these triangle meshes one by one.

For OpenGL, transformation was the key of the display module, in which 3D Descartes coordinates were transformed to 2D coordinates that can be showed on the screen. From 3D space to 2D space, the following steps were needed: viewing transformation, modeling transformation, projection transformation and viewport transformation. After the four steps, an object in a 3D space could be expressed by the corresponding 2D one and showed correctly on the 2D computer screen (Neider et al. , 2002; Mason, 2001). OpenGL transformation flow is showed in Fig. 2.

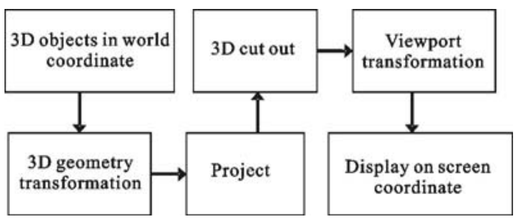

Fig. 2 OpenGL transformation flow chart

3.2 3D navigation

In the 3D navigation system, the viewport was the "avatar"of the eyes and its function was similar to the camera of the real world. In fact navigation in 3D space was a kind of 3D drawing process by constantly moving the viewport and changing the sight direction (i.e., the observing direction) which could be oriented through the viewport position. So with constantly changing viewport and viewport position, 3D scene navigation could be realized. Keyboard navigation and route navigation were two typical kinds of 3D scene navigation.

3.2.1 Keyboard navigation

Keyboard navigation meant that users navigated in the 3D scene using the computer keyboard. With this method users could observe the scene comparatively flexibly and accurately in all directions.

Usually the command of keyboard navigation included turning left, turning right, going forward, going backwards, rising, descending, looking up, looking down, moving to left and to right. If we used left hand coordinate with Z axle up, Z axle represented the height. When we turned left, turned right, looked up or looked down, the viewport remained unchanged and only the sight direction changed; when we rose or dropped, only the height of the viewport increased and decreased; when we moved to left or to right, viewport was paned and the sight direction remained unchanged.

3.2.2 Route navigation

Route navigation meant that users navigated in the 3D scene by employing the route which was edited and set in advance. 3D navigation system usually depended on mouse to select control points on the 2D map. The procedure to set up the route was as follows: first, used the mouse to select a series of control points on the map; second, appointed the height and the flying speed for each control point; then transformed the equipment coordinate to logic coordinate; finally, the array of logic coordinate of control points could be acquired.

A navigation route was a curve in the 3D space and the curve was determined by interpolation. Because the route represented by the curve can be expressed by the broken line, the method of the linear route can be applied.

Figure 3 shows two navigation scenes of Virtual Huanghe River System.

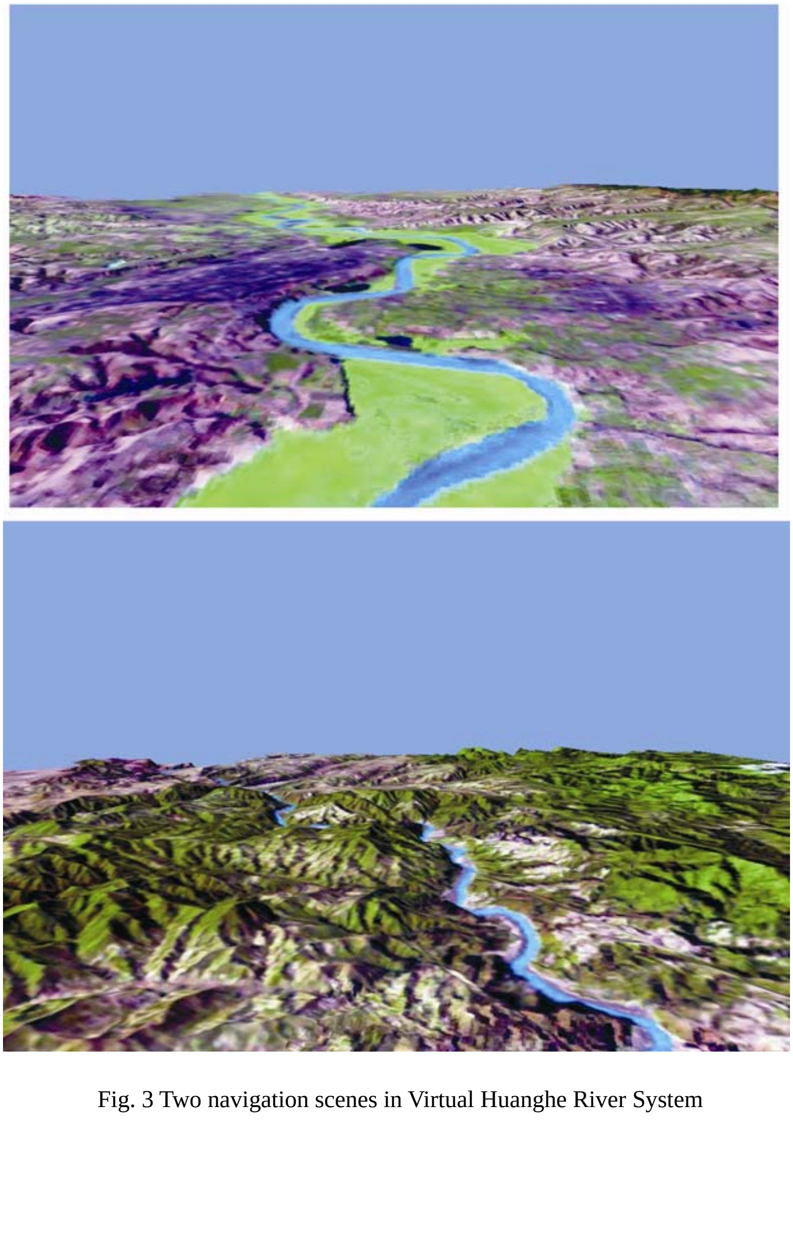

Fig. 3 Two navigation scenes in Virtual Huanghe River System

3.3 Mutual response between 3D scene and 2D electronic map

The idea of mutual response between 3D scene and 2D electronic map has been widely used in 3D virtual military training. When a soldier was trained in the 3D virtual military system, an additional 2D map was also required to identify his direction in this environment. In addition, this idea has also been widely used in the intellectual traffic navigation system and some electronic games.

The mutual response between 3D scene and 2D electronic map in this paper was realized by combining MO and OpenGL.

While using MapObjects to develop Virtual Huanghe River System, the Control of MapObjects was added to VC++ program first. And at the same time the corresponding classes such as CMoRectangle, CMoLine, CMoLayers, CMoRecordSet and CMoFields etc. were loaded (ESRI，1996; Wang, 2000). As a result the functions of scaling and navigation, etc. of the electronic map could be realized.

```
For example:
Case: // Zoom In
{ CMoRectangler (m_ map.Track2Rectan2gle ( ) ) ; //m_map is the variable of MapObjects
 //r is the selected area
if (LPDISPA TCH (r))
m_map. SetExtent (r); //SetExtent implemented the function of Zoom In in the area of r.
break;
}
case: //Pan the map
{ m_map.Pan ();
Break;
}
```

By combining the position in OpenGL and the above-mentioned method of projection transformation from 3D scene to 2D map, synchronic display between 3D scene and 2D map could be realized. On the one hand, in order to realize the localization function in 3D scene, commands such as "select", "pick" and "feedback" of OpenGL were used. On the other hand a small "plane" of MO's dynamic layer on 2D map was used to show the actual direction and the position in 3D space.

Figure 4 shows a scene of the mutual response between 3D scene and 2D electronic map in Virtual Huanghe River System.

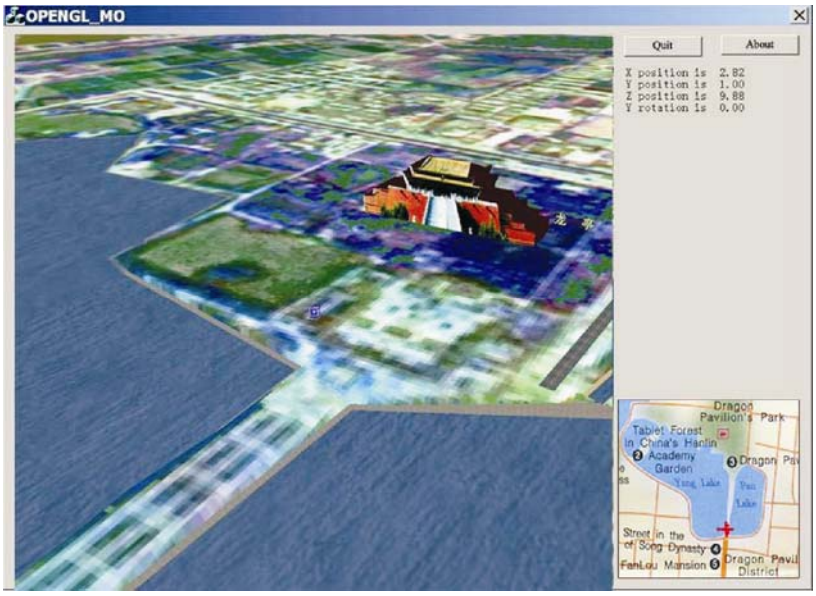

Fig. 4 A scene of the mutual response between 3D scene and 2D electronic map in Virtual Huanghe River System

4 Conclusions and Prospects

(1) This paper provided a feasible method to realize the Virtual Huanghe River System and discussed the key technologies in detail. This integrate system could play an important role in the fields such as scientific research, pollution control and environmental protection of the Huanghe River, and would have the value in urban planning, city traffic management, city simulation, large building navigation, military training, and surveying and

mapping.

(2) OpenGL technology was implemented in order to realize the real-time dynamical display. MO and OpenGL technologies were applied to realizing the mutual response between 3D scene and 2D electronic map. As a result the advantages of 3D scene and 2D electronic map were brought into full play. The macroscopic view, integrality and conciseness of 2D electronic map and the locality, reality and visualization of 3D scene were combined. Also at the same time the disadvantages of abstract and ambiguity of 2D electronic map and the direction losing of virtual navigation in 3D scene were overcome.

(3) As the technology of the broadband network is developing fast, the application in the network of the Virtual Reality becomes possible. But the large amount of data of 3D scene is still difficult to deal with now. The speed of network in the future will be no longer a problem, so Virtual Huanghe River System based on network is a field that is worth studying. The programming of mixing VRML, JAVA and JAVA3D is a new technological trend and will be the focus of our work in the future.

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