DISCUSSION ON 3D AIDS TO NAVIGATION PLANNING AND SETTING BASED ON GIS AND VR

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ABSTRACT:

As the presentation and development of "Digital Maritime" and "E-Navigation", Aids to Navigation (AtoN) is more and more important to marine navigation safety. In recent years, great advances have been obtained in AtoN applications. However, most domestic AtoN setting systems are based on 2D electronic chart which can not represent AtoN visual effects and its complex "interactive visual effects" in surrounding environment, and thus it is difficult to dynamically arrange and manage AtoN in 3D environment. Existent 3D AtoN simulation systems are mainly for demonstration not for application. Meantime, the previous AtoN information systems are not integrated with GIS, and it is difficult to make full use of GIS analysis functions for AtoN planning and setting. Aiming at this, a new framework of 3D AtoN planning and setting system based on GIS is proposed in this paper. The integration of GIS and VR provides effective 3D visual management, analysis and opening integrated mechanism for planning and setting. Some key techniques and algorithms including 3D environment simulation, dynamic effects, automatic setting and efficiency simulation are discussed in detail. Based on the above algorithms and strategies, a Three-dimensional Aids to Navigation Planning and Setting System was developed and obtained initial application in SheKou port of Guangdong Marine Safety Administration Bureau.

1. INTRODUCTION

AtoN is an information service facility which is set up to help the vessels sail safely, economically and expediently by its visual, sound and wireless signals (IALA, 2005). With the development of "E-Navigation", the Aids to Navigation Information System (ANIS) are more and more important to safety of marine navigation (IALA, 2006). Accordingly, achieving the goal of "rational layout, fast maintenance, advanced techniques and good service" becomes the unremitting pursuit of AtoN governors. The AtoN information construction has become an important topic of the modern navigation (Chai, 2005).

In recent years, the maritime departments in all countries have launched extensive researches of GIS-based navigation application systems, and some have born fruits. In 1996, Norway developed and released the "Waterway Geographic Information System" (Wang, 1998). Since then, worldwide navigation agencies have successfully developed automatic information management systems of AtoN based on GIS platform one after the other. Many countries have taken studies on AtoN layout optimization in GIS environment. For example, in Japan there are at least two floating lights or piles are available for ship positioning in the areas which are 15nmile far from the coastal shore (Cheng, 2006). Moreover, GIS/GPS/GMS technologies have been found a diverse application in navigation aids management in Japan, America and other developed countries. At present, domestic GIS navigation aid information platform has been widely used for remote monitoring, controlling data and maritime management; the digital waterway based on 3DGIS has been developed (Sui, etc., 2006). Relative study about 3D Aid to Navigation based on VR has been started and tried out in Aids to Navigation Department of Xiamen (Peng, etc., 2005). GIS has been employed in maritime information administration to manage and display the ENC (electronic nautical chart) and AtoN data in inland waterways. The Aids to Navigation Information Distribution System Based on WebGIS has been used in the coastal maritime region (Zhang, etc., 2005).

Although great advances have been obtained in AtoN construction, how to effectively realize the rational arrangement and management in the 3D environment is still a puzzled problem. In the "Digital AtoN", the traditional navigation aids elements are shown in digital, virtual and visual mode in the computer visualization environment for our dynamic management and services (Wang, 2004). The real "visual effect" appearance is an important characteristic of AtoN. The AtoN properties such as shape, lights and radio signals merged into the complex 3D ambient marine environment to guide the ship sailing along the coast and out of the port. In 2D electronic chart, AtoN visual effects and its complex "interactive visual effects" can not be represented in surrounding environment (Xiang, 2006).

In this paper, a new framework of 3D Navigation Information System (ANIS) based on GIS is firstly proposed in chapter 2; And typical methods and algorithms for creating and simulating a true 3D setting environment and dynamic special-effects are

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presented in chapter 3; the implementation and application of the 3D Aids to Navigation Planning and Setting System is introduced in chapter4. Lastly the future development of 3D AtoN application systems based on GIS and VR is also prospected.

2. THE FRAMEWORK OF 3D AIDS TO NAVIGATION INFORMATION SYSTEM BASED ON GIS

As a very powerful spatial information management and analysis tools, GIS is now widely applied in urban planning, land use, resources management, mobile navigation, intelligent transportation, facilities management, military reconnaissance and other fields related to spatial information(Xu, 2006).In an integrated GIS information platform, GIS not only provides efficient tools for AtoN planning, setting, maintenance, management, and evaluation and so on, but also provides a opening and integrated environment for AIS (Automatic Identification System), VTS(Vessel Traffic System), CCTV(closed-circuit television) and other systems. Therefore, GIS is an indispensable support platform for ANIS. In this paper a new AINS structure based on GIS and VR is presented, the framework is shown in figure1.

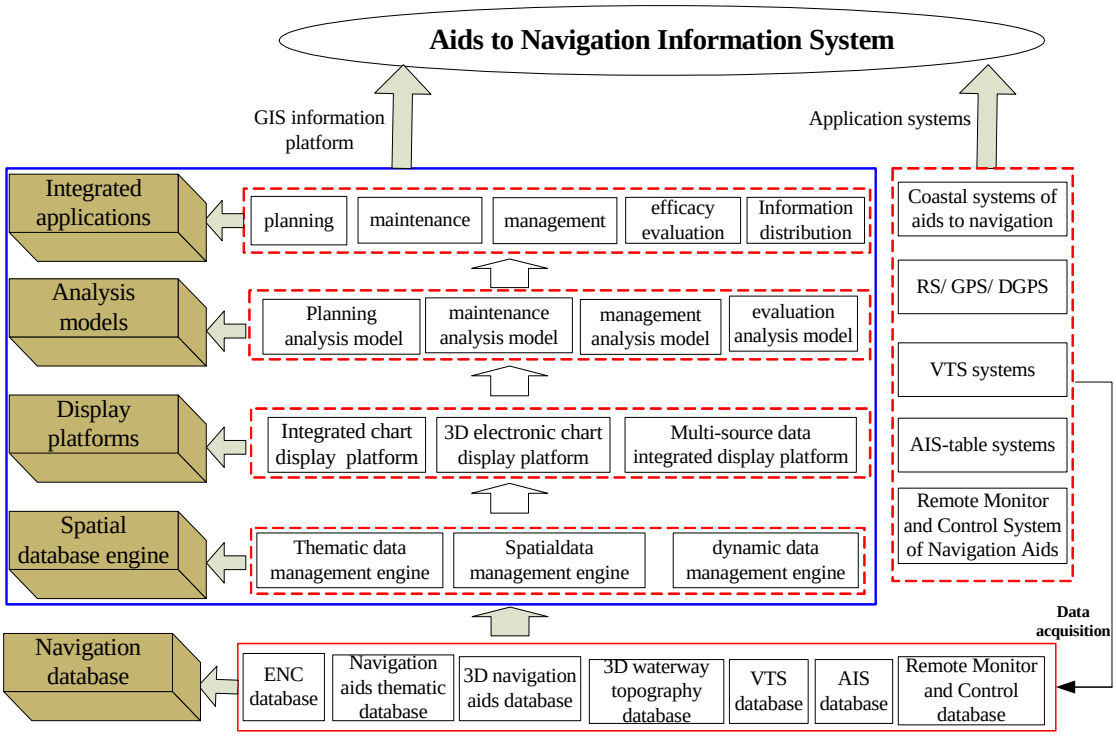

Figure 1.The new framework of Aids to Navigation Information System (ANIS) based on GIS

The core idea of the new system is to build an integrated GIS information platform for 2D/3D spatial and thematic data processing, display, analysis, and information fusion, sharing and management. In this framework, the system is divided into two parts: One is the application systems, such as AIS、VTS and other coastal AtoN application systems; Another is the integrated GIS information platform. The integration of AIS, VTS, DGPS and other application systems can be realized through GIS information platform, and we can achieve the visual maintenance and management of AtoN. The main functions of GIS in AINS can be described in the following aspects:

- Multi-source heterogeneous data management. Data from a variety of applications can be integrated into the united format for storage and management through GIS in order to build uniform AtoN information database;
- Multi-dimensional display platform. GIS can provide different display platform including 2D/3D, single, and remote based on PDA, and so on for spatial information and thematic information;
- Application analysis platform. The spatial and model analysis of GIS can be used to construct a variety of waterway models and AtoN application models for analysis of AtoN planning, layout, maintenance, management and evaluation, and so on;
- Integrated mechanism and platform for application systems. Different application systems including AIS, VTS, and DGPS can be integrated into GIS and all kinds of information can be shared.

3. THE GENERATION OF VIRTUAL 3D ATON SETTING ENVIRONMENT BASED ON GIS AND VR

Unlike traditional 2D AtoN application, the 3D AtoN planning and setting is totally carried out in the true 3D environment and the interactive visual operations can attain well results. In order to lively describe the dynamic waterway environment, a true 3D environment must be built firstly.

3.1 The generation of 3D static geometric environment based on GIS

Considering the complexity of huge soundings data, a new algorithm is adopted to quickly create terrain data of underwater based on the "block method". The main idea of this method is firstly to partition the data along the axis vertical to the direction of sea-port and obtain a lot of neighbour data cell, then to build TIN for each data cell. And the regular grid DEM of each cell is created by random raster conversion algorithm .When processing each data cell, we expand the data boundary to build TIN in order to solving boundary problem. At the same time, in order to ensure that there is no gap inside the data cell, the so-called TIN algorithm considering features is employed. In order to improve the efficiency of TIN query, the authors adopt the grid index and R-trees technology (Sui, etc., 2001). For coastal terrain, the high-resolution images texture mapping method is employed to represent 3D visual effects. Figure 2 is an example of creation of underwater terrain data from chart.

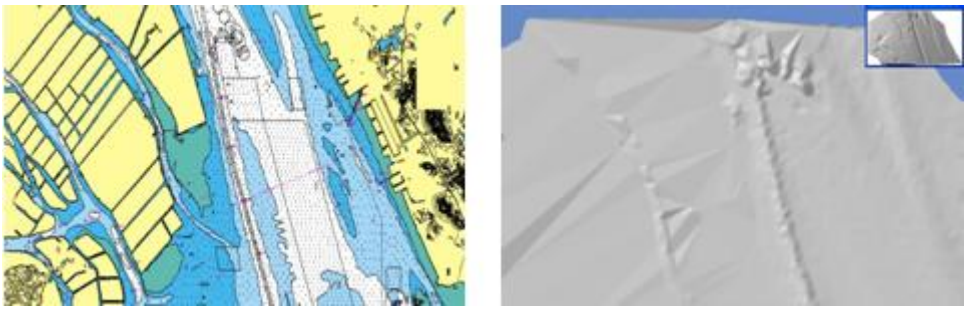

Figure 2.Creation of underwater terrain data (The left is part of chart, the right is the created 3D underwater relief data)

After the coastal and underwater terrain is constructed, some real buildings, channel and port facilities such as AtoN, coastal buildings, bridge, ports, and ships can be built by some 3D modelling software such as 3DsMAX and rendered with the textures processed from the real site photographic pictures. Then these models will be added on the 3D scene according to their real layout. Figure 3 is an example of 3D modelling.

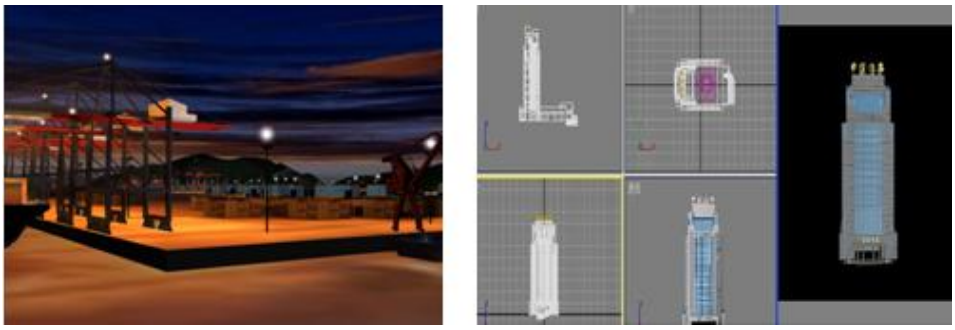

Figure 3.The 3D building and port models modelling

3.2 The simulation of 3D special dynamic-effects

There are two kinds of special dynamic-effects: one is the sea-sky effects, such as the clouds, sky background, the light intensity, weather (like wind, rain, snow and so on), the environment light effects including buildings light source and point light; another is the sea surface effects, such as fog, sea waves, and so on.

In this paper, the particle system is utilized for the design and simulation of the wind, rain and snow. In particle system, the particle cluster is used to describe the irregular objects attributes and its changes. The position of the moving particle cluster is divided into two directions: the horizontal direction and the vertical direction. When we simulated wind, rain and snow, four parameters need to be set: the contour distance between two particle and particle quantities at the vertical direction, as well as the speed and migration offset at the horizontal direction. In specific implementation process, the changes of three-dimensional coordinate data are used to simulate the movement of the particles. Each data that expressing locations of particle data in different the state is different, and thus wind, rain and snow campaign can be simulated from this perspective (shown as figure4).

For the cloud 3D modelling, the Harris light scattering model is employed to complete the 3D cloud real-time rendering and drawing in this paper. For daytime scene illumination, the moon and sun environmental effects are used for rendering the appearance of the geometry, which is controlled by the environmental effects of the interplanetary table. Figure 5 shows one part of whole sea scene effect.

Figure 4. The snow effect at night

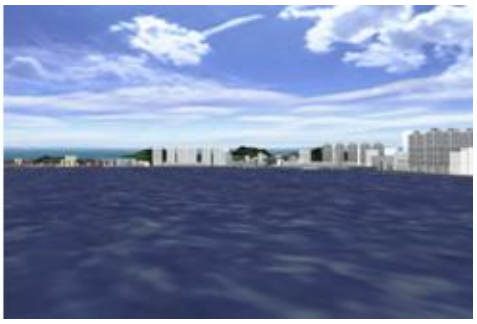

Figure 5.The sea scene effect

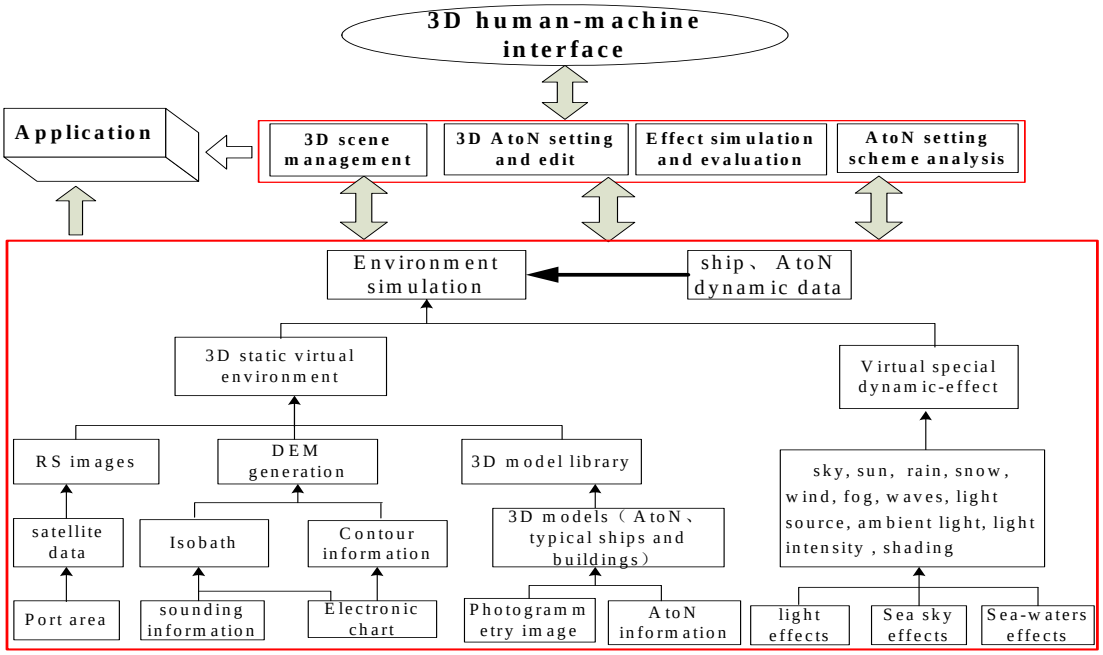

Figure 7.The general framework of the 3D Aids to Navigation Planning and Setting System

3.3 The simulation of 3D AtoN lights

The visual simulations of AtoN lights such as their type, colour, frequency, and cycle simulation are core factors for AtoN setting and planning, which provide integrated visual effect for AtoN layout and efficiency. Thus different real-time 3D environment according to reality for AtoN setting and planning can be set up by creating different dynamic effects in 3D scene.

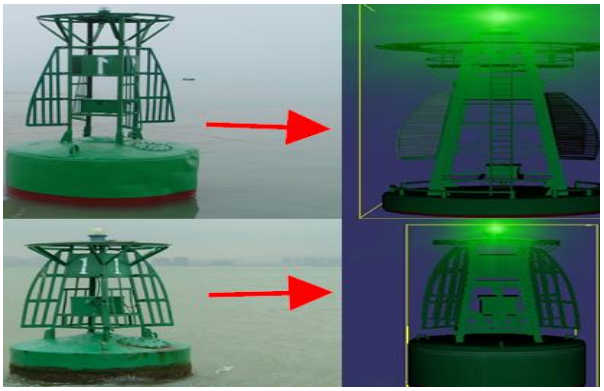

Figure 6. The 3D simulation of different types AtoN (the left is the real AtoN, the right is the 3D models)

The AtoN lights simulation is built based on the AtoN models, and the LED lighting simulation system based on OpenGL is adopted. The OpenGL texture mapping and the data resolution framing format technology of the broadcast is used for controlling light colour and change display (figure6).

4. DESIGN AND IMPLEMENTATION OF 3D ATON PLANNING AND SETTING SYSTEM

Based on above algorithms, the 3D AtoN Planning and Setting System is developed by using GIS and virtual simulation techniques. This system not only represents the real-life port scene, channel navigation and AtoN layout in computer, but also realizes the dynamic analysis and virtual AtoN setting. On this 3D platform, the layout information of the AtoN can be easily observed and the virtual AtoN setting can be carried out to improve AtoN management. The general framework of the system is as follows (figure7):

The main functional modules of the 3D Aids to Navigation Planning and Setting System are described as the follows:

- The 3D scene generation and management module: It is the foundation module of the system, which provides five main functions: data interfaces for data access and export; the external data standardization process is used for projection and coordinate transformation; the 3D models library for 3D models management; the 3D static scene management and operations; the analytical tools is used for AtoN spatial calculation and analysis functions.
- The dynamic environment effect simulation module: It is an important module of the system, which provides four main functions: the sea sky simulation, including the weather (sunny, cloudy, rain, snow, weather conditions), the sky background (including daytime, evening); the sea-waters simulation ,including sea fog (colour, distance), light intensity, weather(intensity control) , waves, and so on; the area light simulation, including the light intensity ,scene brightness; the dynamic AtoN lights simulation, including different AtoN types (point-flicker, line-flicker,, area-zone)and colour.
- The 3D AtoN setting and evaluation module: It is the core module of the system, which contains three major functions: the 3D man-machine interactive platform for preservation of AtoN layout and different setting schemes; the 3D Attribute Table for AtoN features and properties enquiries and management; the visibility analysis for AtoN settings (location, type, quantity); the virtual assessment for AtoN running status when ships leaving and entering into the port.
- The System configuration module: It is an auxiliary module of the system including scenes configuration files and public affairs such as user rights management.

The system has been applied in SheKou port of Guangdong Marine Safety Administration Bureau. The main application system interface is shown in figure8.

Figure 8. The main application interface of the system

5. CONCLUSIONS

A new mode for AtoN setting and management is introduced in this paper. The true AtoN surrounding environment and interactive effects simulation can be realized in the system. At this application platform, we can achieve the AtoN virtual setting and optimize the management in 3D dynamic simulation which reduces the workload and greatly improves the accuracy of AtoN placement and management. However, this system is only initial exploration and a further research is necessary for 3D dynamic-effects and hydro-meteorological virtual environment simulation

With the gradually development of China's three Marine constructions: "Digital Marine, Sun Marine and Transportation Marine", GIS and VR will play a more important role in AtoN information constructions.

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