

Design and implementation of integrated platform for 3D marine information in South China Sea

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ABSTRACT

At present, there are some problems in marine data, such as low utilization rate and poor visualization effect. Based on B/S development mode, open source 3D engine Cesium and WebGL and other computer related technologies, this paper designs and develops a visualization platform integrating marine observation data and marine environmental field data, effectively manage and use the marine data of the South China Sea, provide data and information products and services, make full use of visualization methods to display the South China Sea marine data, and provide strong support for economic development and scientific research in the South China Sea, real-time monitoring of the South China Sea marine environment, disaster warning, etc.

Keywords: South China Sea, B/S, vector environmental field, scalar environmental field

1. INTRODUCTION

Due to its special geographical location, abundant resources and unique strategic advantages, the ocean has an irreplaceable unique position in China's political, economic, military and other fields¹. With the deepening of the exploration of the ocean, the marine information data obtained by human beings are also increasing at the speed of geometric progression, but these data sources are diverse. Various detection equipments were widely distributed in the omni-directional, multi-level and three-dimensional measurement space from the air, sea surface, underwater to the seabed. Data processing and storage methods are obviously multi-source and heterogeneous²⁻⁴. How to effectively use these multi-source heterogeneous marine information data and intuitively display the information hidden in the data is an important research content of marine data visualization⁵.

The South China Sea is the main marine field in China, which contains rich marine resources. The monitoring and exploitation of resources in the South China Sea has become an important strategy and basic national policy for China's economic development⁶. Cesium is an open source 3D map engine, with the characteristics of cross platform and cross browser, which can reduce costs and improve efficiency, and is suitable for lightweight application scenarios⁷⁻¹⁰. WebGL is a new generation of Web3D graphics standard, which has the advantages of no need for client plug-ins and GPU rendering graphics¹¹. This paper takes the South China Sea as the research object, based on GIS and computer technology, breaks through the visualization technology of vector field and scalar field of marine environment, and completes the construction of marine three-dimensional information integrated platform in the South China Sea, which solves the problems of low utilization rate and poor visualization effect of multi-source heterogeneous marine data. It provides strong support for the economic development and scientific research of the South China Sea, as well as the real-time monitoring of the marine environment and disaster early warning of the South China Sea.

2. PLATFORM DESIGN

2.1. Overall architecture design of the platform

Based on the B/S architecture, GIS and computer technology, the platform integrates the multi-source heterogeneous data of high-resolution remote sensing image, DEM, tilt photography, marine environment and marine monitoring on a unified spatial scale to realize the query and visual display of marine facilities, marine survey, marine observation and marine

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environment data. The platform adopts a three-tier architecture, including data layer, service layer and presentation layer. The specific platform architecture is shown in Figure 1.

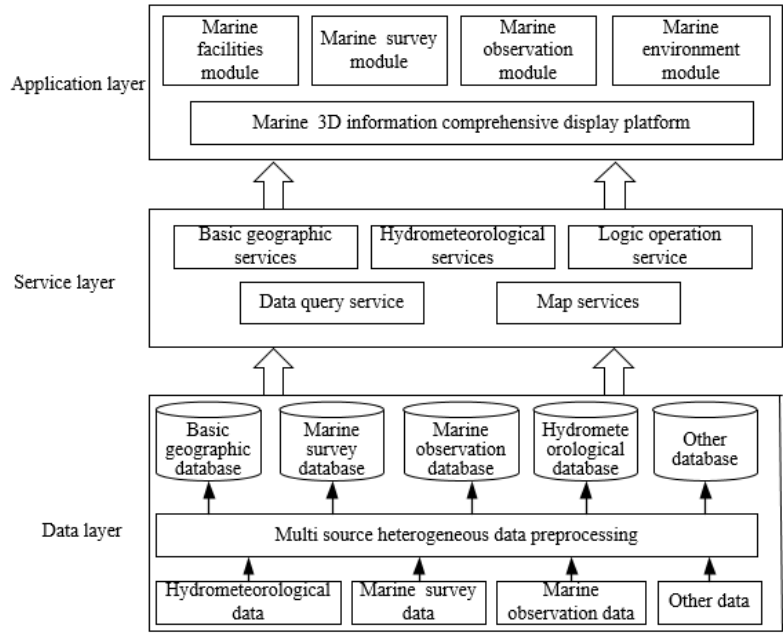


Figure 1. Platform architecture diagram.

The data layer is the basis of the whole platform, including basic geographic data, marine hydrometeorological data, marine survey data, marine observation data and other data. First of all, data preprocessing is needed to store and manage heterogeneous marine data.

The service layer adopts Web service technology, establishes the link between browser and data, provides data query, model operation and other services for users, and realizes fast query and personalized retrieval of data. The service layer mainly includes basic geographic services, hydrometeorological services, data query services, logical operation services and mapping services.

The application layer is based on the service layer and visualization technologies such as Cesium and WebGL to realize the visualization operation of fast loading, browsing and query analysis of marine facilities, marine survey, marine observation and marine environment data, so as to provide users with efficient and accurate marine 3D information visualization services.

2.2. Platform function design

The platform includes five modules: basic map management module, marine facilities module, marine survey module, marine observation module and marine environment module. Basic map management module includes base map switching, 3D measurement and other functions; Marine facilities module mainly includes visualization of offshore wind turbine and submarine pipeline; Marine survey module mainly includes the visualization of side scan data, borehole data and water depth data; Marine observation module mainly includes the visualization of buoy monitoring data, ship monitoring data and other marine observation data; Marine environment module is the key technology to study the visualization of marine environment field, including wind field, flow field, wave, sea temperature and other data. The specific construction content is shown in Figure 2.

3. KEY TECHNOLOGIES OF THE PLATFORM

3.1. Real time rendering technology of seabed topography

The seabed terrain generally fluctuates greatly and is uneven. Therefore, the terrain simulation data is irregular, which is different from the regular row and column grid data. In this paper, Delaunay technology is used to quickly complete the

terrain modeling of irregular mesh data, and combined with the vertex array index binding technology of WebGL (Web Graphics Library) 3D rendering engine, the amount of vertex data calculation in the process of rendering triangular patches is reduced, so as to realize the efficient and fast rendering of large-scale marine terrain data¹².

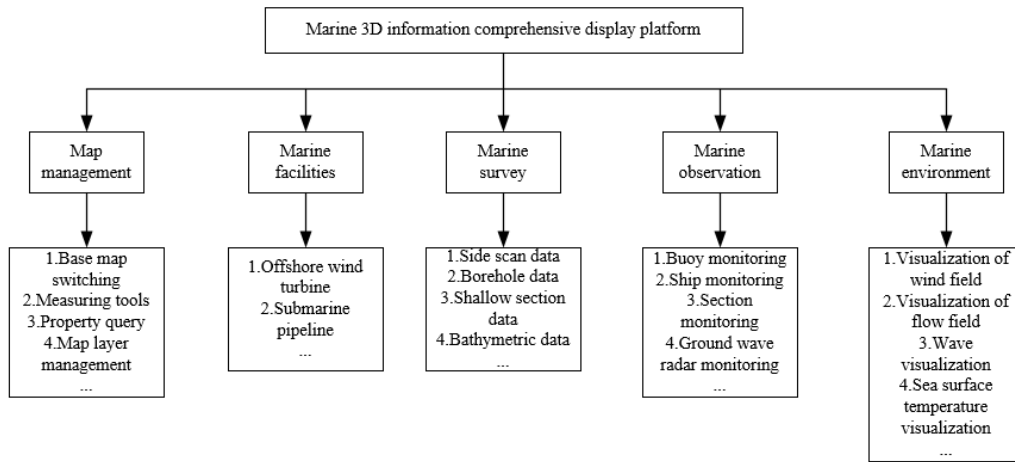


Figure 2. Main function design drawing of the platform.

Illumination environment is an important factor that must be considered in the process of 3D rendering of complex ocean terrain. WebGL mainly realizes lighting effects by means of face normal and vertex normal¹³.

The effect of face normal is shown in Figure 3. It can be seen from the figure that the face normal only consider the reflected light of a single face unit. Due to the difference of terrain bumps, there will be a great difference in the reflection of light from adjacent face units.

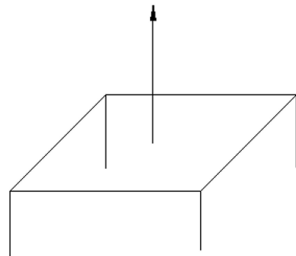


Figure 3. Face normal.

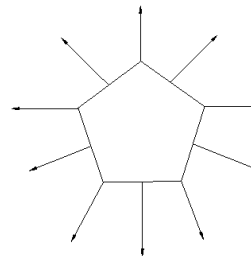


Figure 4. Vertex normal.

In order to make the overall lighting effect smoother, this paper uses vertex normal to realize the difference effect of lighting effect and terrain height highlighting, and uses GPU point rendering and GLSL (Open GL Shading Language) advanced shading language to color the differentiated colors of different terrain height values. The rendering effect of seabed terrain is shown in Figure 5.

3.2. Data organization and management of ocean flow field based on pyramid model

In view of the characteristics of large range, high resolution and low visualization efficiency of marine flow field data, this paper designs a large scene high-resolution flow field data pyramid preprocessing algorithm¹⁴. In the process of flow field data visualization, the large-scale flow field data is segmented and divided into several smaller sub blocks. Without affecting the visualization performance of flow field, according to the drawing needs, the data are dynamically transferred in to improve the visualization efficiency of flow field¹⁵.

Firstly, the original flow field data are sampled and data layers with multiple scales are established. These data layers are like a pyramid. The bottom layer is the original data, and each subsequent layer is the data after thinning.



Figure 5. Effect drawing of seabed topography.

Secondly, the whole flow field data is divided into $m \times n$ sub blocks, and each sub block is the same size. This method solves the problem that a large range of flow field data can not be transferred into memory at one time. However, when the amount of original data is too large and the number of sub blocks is very large, the number of storage files and data redundancy are greatly improved. Therefore, this paper uses the method of sampling and blocking to organize flow field data¹⁶.

As shown in Figure 6, the hierarchical structure of hierarchical blocks looks like a pyramid, so this scheme is usually called pyramid model, which is the most widely used large-scale data organization method at present.

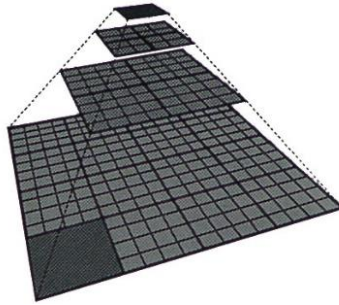


Figure 6. Wind field visualization.

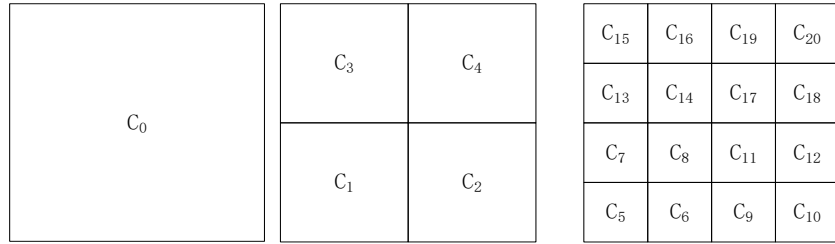
The pyramid model has higher and higher resolution from top to bottom, and the representation range remains unchanged. It can meet the needs of the flow field visualization system for terrain data with different resolutions in real time. Although the pyramid model increases the data storage space, it can reduce the total time required to complete the flow field data rendering. The tile pyramid model can further reduce the amount of data access, so as to improve the overall performance of the system.

A key link of pyramid model is spatial division, that is, how to divide the pyramid vertically and horizontally. The spatial division mode directly determines the storage mode and index mode of large-scale flow field data, and finally affects the scheduling efficiency of flow field data.

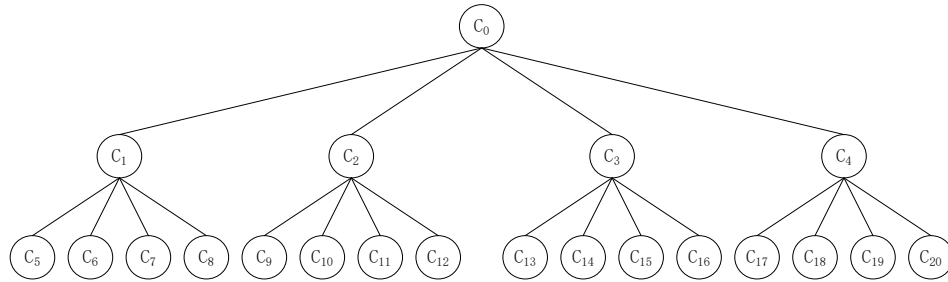
In this paper, the quadtree structure is used to realize the spatial division of the pyramid model, as shown in Figure 7. Figure 7a shows the transverse block method of flow field, Figure 7b shows the transverse stratification method of flow field.

4. PLATFORM IMPLEMENTATION

The implementation effect of the main functions of the platform is shown in Figure 8, in which Figure 8a is the visualization effect of submarine cable pipeline; Figure 8b is the visualization effect of side scan data; Figure 8c is the visualization effect chart of shallow section data; Figure 8d is the visualization effect map of seabed geological data; Figure 8e is the rendering of marine depth effect; Figure 8f is the visualization effect chart of ground wave radar data.



(a) Transverse block of flow field



(b) Longitudinal stratification of flow field

Figure 7. Spatial partition scheme of pyramid model based on layered and block.

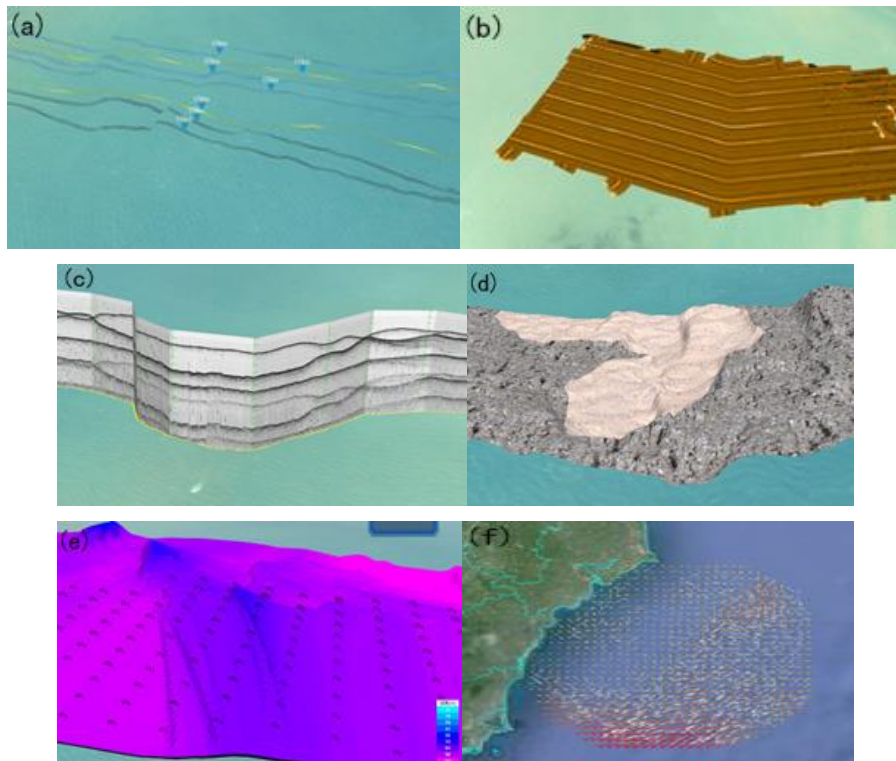


Figure 8. Effect drawing of platform.

5. CONCLUDING REMARKS

Aiming at the problems of low utilization rate and poor visualization effect of multi-source heterogeneous marine data, this paper proposes a method to solve the problem of low 3D visualization degree of vector field and scalar field data in marine environment field based on GIS visualization and computer related technology, and designs and develops a

visualization platform integrating marine observation data and marine environment field data, effective management and use of marine data in the South China Sea and full use of visualization tools to display marine data in the South China Sea provide strong support for economic development and scientific research in the South China Sea, as well as real-time monitoring of marine environment and disaster warning in the South China Sea.

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