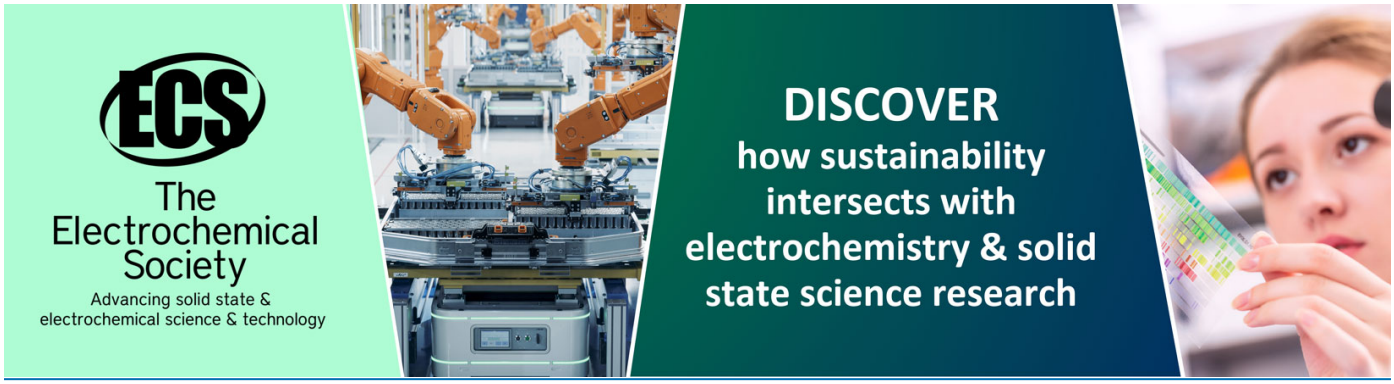
Research on key technologies of 3D visualization of marine environmental field



Research on key technologies of 3D visualization of marine environmental field

Huadong Ma[1,2 *], Ping Wang[1,2], Yubo Wen[1,2] and Chenxi Yang[1,2]

[1] South China Sea Information Center, State Oceanic Administration, Guangzhou, Guangdong, 510000, China

[2] Key Laboratory of Marine Environmental Detection Technology and Application, Ministry of Natural Resources, Guangzhou, Guangdong, 510000, China

[*]Corresponding author's e-mail: mahd@scs.mnr.gov.cn

Abstract. In view of the slow rendering speed and poor effect of 3D visualization of marine environment field, this paper studies the 3D visualization of vector field and scalar field of marine environment based on particle system, second-order Euler integral algorithm, linear interpolation method and 3D GIS visualization technology. Firstly, the particle motion model is constructed based on the second-order Euler integration algorithm, and the multi-scale transformation model is constructed based on the perspective perception, and the multi-scale visualization model of the vector field of marine environment is established. Secondly, the mesh is generated by bilinear interpolation, and the color mapping model and the hierarchical color setting scalar field visualization model are established. Finally, based on the technology of 3D GIS, the 3D visualization of marine environment field is realized, and the rendering speed and rendering effect are improved, which provides the basis for the efficient utilization of marine environment information.

1. Introduction

The ocean is an important part of the earth system, which plays a very important role in regulating global climate change and maintaining ecological balance. Marine environmental information is composed of marine atmosphere (pressure, temperature, wind, etc.), sea surface (wave, current, tide, etc.), marine water body (temperature, salinity, density, etc.) and seabed (geology, landform, etc.). The study of marine environmental information is of great significance for the analysis of the spatiotemporal law and influence mechanism of marine phenomena [1]. With the continuous deepening of the exploration of the ocean, the marine environment information data obtained by human beings are also increasing at the speed of geometric progression. Various detection devices are widely distributed in the air, sea surface, underwater to the seabed, with obvious multi-source and heterogeneity in data acquisition, data processing and storage methods [2-4]. 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 visualization [5].

With the continuous integration of GIS technology and virtual reality technology, the research of 3D virtual ocean has achieved initial results. This paper analyses the data processing of marine environment field, and constructs the visualization model of marine vector environment field based on particle system and the visualization model of marine scalar environment field based on linear interpolation, aiming at the problems of slow and poor effect of 3D visualization of marine environment field data at b\s end,

and makes fast calculation and rendering by using the relevant technology of 3D GIS, The realization of real-time 3D rendering of marine environment field provides the basis for the efficient utilization of marine environment information.

2. Research status of visualization of marine environmental field

There are two main research directions in the visualization of marine environment field, one is the visualization of scalar field and the other is the visualization of vector field. The data of marine environment vector field mainly include ocean wind field, ocean flow field and ground wave radar data. The vector field data has both size and direction. There is no visual expression model of vector data directly available in nature, but most of the data such as ocean stroke field and flow field are vector field data, so it is necessary to find effective solutions [6]. At present, there are mainly three kinds of methods for vector field visualization: one is geometry based visualization methods, such as point icon method, vector line and vector surface method, particle flow method, etc. Zhiwei Li et al. [7] by constructing ocean space-time process objects and using texture filling, the vector expression of ocean environment field is realized in the form of point, line, surface and volume There are always some problems in the expression of environmental field, such as the lack of continuity and the lack of expression of environmental field features; The second is texture based visualization methods, such as point noise method [8], line integral convolution (LIC) method [9], image-based flow field visualization method [10], etc. among them, line integral convolution method is the most widely used in this kind of visualization method, and Yingyi Ma et al. [11] Based on LIC and olic algorithm, introduces human visual perception theory, However, this kind of algorithm has the problems of huge computation and low efficiency, which is difficult to meet the real-time rendering effect; The third is feature-based visualization method, which is mainly based on meaningful feature shapes such as phenomena and changes in the vector field. Enya Shen et al. [12] proposed an interactive fuzzy feature extraction algorithm to realize the three-dimensional visualization of process features. However, this kind of method relies too much on the environment field information, and the visualization effect is poor when the environment field feature information is not obvious.

The visualization of scalar field mainly includes color mapping, contour, contour and volume drawing. Shenghua Xu and others [13] realize the 3D visualization of scalar field in marine environment by constructing the point and surface dynamic model; Wen Dong et al [14] realized 3D visualization of marine scalar field elements by building a box model with variable height, contour tracking and color mapping; Qiang Sun et al [15] adopts tile idea, optimizes the data visualization effect by using hierarchical details and data dynamic scheduling methods, realizes the functions of dynamic visualization of time process, attribute query of element points and curve of point process of marine scalar field data, which plays a certain auxiliary role in marine environment analysis; Wenpeng Xin et al [16] Based on WebGL technology, the grid image representing sea temperature is attached to the surface of the earth body as a map on the 3D Earth platform, and the corresponding temperature data is displayed on the corresponding coordinates, and the spatiotemporal visualization expression of the data of the scalar field ocean temperature field is realized. The above research on the visualization of scalar field in marine environment can realize the 3D visualization of scalar field data, but the phenomenon of particle sense and pixel sense is more serious in the visualization process, and the boundary between marine environment field and land is not prominent.

In this paper, based on the above research, three-dimensional visualization of ocean vector environment field is realized by particle system, particle motion model is constructed by second-order Euler integral algorithm, and multi-scale transformation model is constructed by perspective perception; Based on bilinear interpolation, the grid of marine environment scalar field is generated, and the color mapping model and hierarchical color visualization model of marine environment scalar field are established. Finally, based on 3D GIS technology, the 3D visualization of marine environment field is realized.

3. Visualization of ocean vector field based on particle system

The basic idea of particle system is to use a large number of particles with certain attributes, random distribution and motion to simulate fuzzy and irregular objects [17]. The motion of each particle in the particle system is used to express the change of fuzzy objects, such as ocean current, wind field, water flow, etc., which can show the dynamic change and overall shape of irregular natural phenomena.

3.1. Particle flow algorithm based on second order Euler numerical integration method

Particle tracking belongs to the field of fluid dynamics. By using the current particle position and velocity function, the particle trajectory is calculated by the integral method. The specific formula is as follows:

$$y(t+\Delta t) = y(t) + \int_{t}^{t+\Delta t} v(p(t),t)dt \tag{1}$$

Among them, y (t+△t) is the position of the particle at the time (t+△t), v(p(t),t)is the velocity function. In order to make the streamline tracking smoother, the second order Euler numerical integration method is used to track the particles, and the particle motion model is obtained:

$$\overline{y}_{t+\Delta t} = y_t + v(y_t)\Delta t \tag{2}$$

$$y_{t+\Delta t} = y_t + \frac{1}{2}(v(y_t) + v(y_t))\Delta t \tag{3}$$

After obtaining the motion model of particles, it is necessary to control the life cycle of particles. In this paper, we control the birth and death of particles through grid, so as to control the number and density of particles during visualization. The specific process is shown in figure 1.

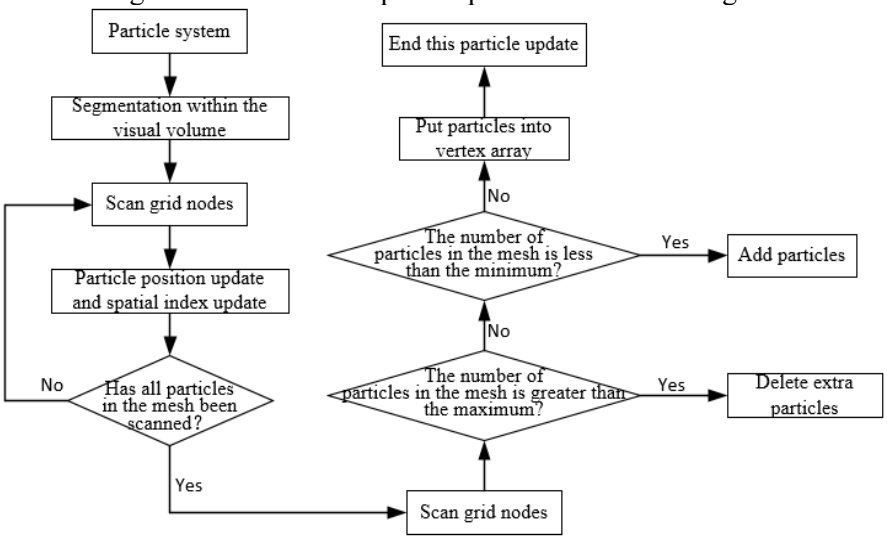


Figure 1. Particle motion control process.

3.2. Multi scale transformation model considering visual perception

For web page rendering, the screen space is fixed and will not change with the change of perspective. However, the change of perspective will change the geographical space, and the level of detail of visualization is different in different geographical spaces. Based on this principle, this paper constructs a multi-scale transformation model considering the perception of perspective, and obtains the current perspective characteristic value by changing the user's perspective. Based on the angle eigenvalue, the level of detail of the object is generated. For the vector field, the number of particles is the level of detail. In this paper, 9 groups of height eigenvalues and particle number are set, as shown in Table 1:

Table 1. The relationship between the viewing angle height and the number of particles.

Height of View (meter)	6000000	3000000	2000000	1500000	1000000	900000	600000	400000	200000
Number of particles (thousand)	1.5	1.5	1.2	1	0.8	0.7	0.65	0.6	0.3

When the angle of view is high enough or low enough, the perception of human eyes will be weakened, so this paper sets the angle height space, when beyond the angle height space, the number of particles will not change. Based on the above sample data, this paper uses polynomial fitting algorithm to determine the relationship between the angle height and the number of particles. The specific results are shown in formula 4 and figure 2.

$$Particles_{nums} = -0.4456h^4 + 2.0835h^3 - 3.3135h^2 + 2.4707h - 0.0262 \quad (4)$$

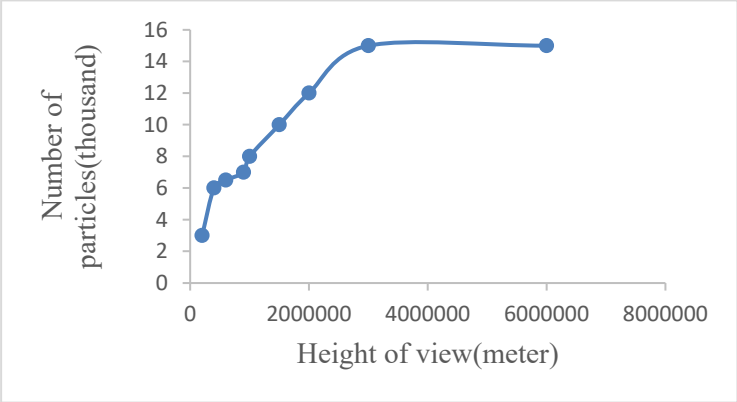


Figure 2. Fitting graph of relationship between viewing angle height and particle data.

In this paper, the 3D dynamic visualization of the marine wind field is carried out based on the particle system method. The visualization effect is shown in figure 2, figure (a) is the particle visualization of the ocean wind field in small scale, and figure (b) is the particle visualization of the ocean wind field in large scale. It can be seen from the figure that there are obvious differences in the number of particles and expression details when scaling the viewing angle in small scale and large scale. In large scale, the specific characteristics of vector field can be clearly seen, while when scaling to small scale, more detailed information can be displayed.

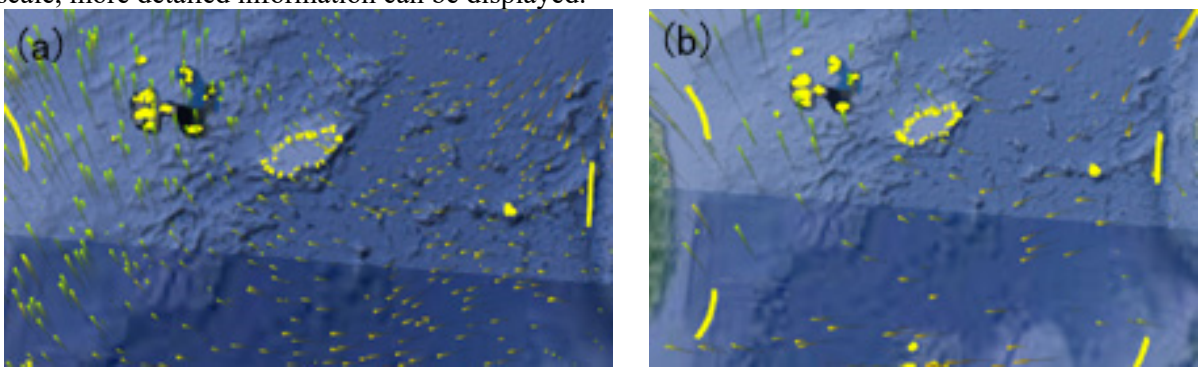


Figure 3. Wind field visualization.

4. Visualization of ocean scalar field based on linear interpolation

When the traditional scalar field is visualized based on the surface process, the sense of particle and pixel appears due to the low resolution. In order to solve this problem and make the visualization effect smoother, this paper uses bilinear interpolation algorithm to process the scalar field data. The basic principle is to interpolate and analyse the four values around the current grid, and then get the current grid value. The specific model is shown in formula 5, formula 6 and figure 4.

$$f(P)=\frac{y_2-y}{y_2-y_1}f(R_1)+\frac{y-y_1}{y_2-y_1}f(R_2) \tag{5}$$

$$f(R_i)=\frac{x_2-x}{x_2-x_1}f(Q_{i1})+\frac{x-x_1}{x_2-x_1}f(Q_{i2}) \tag{6}$$

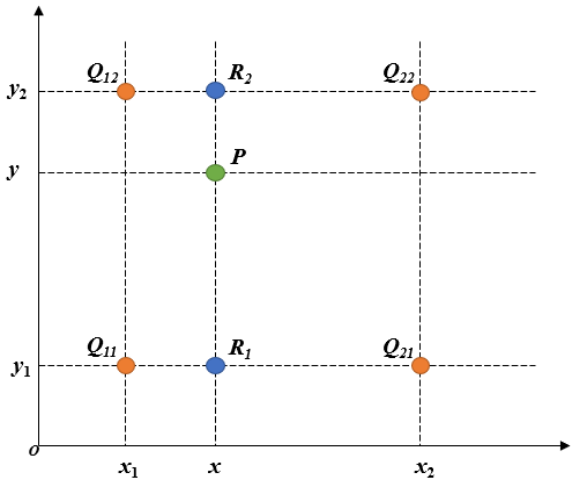
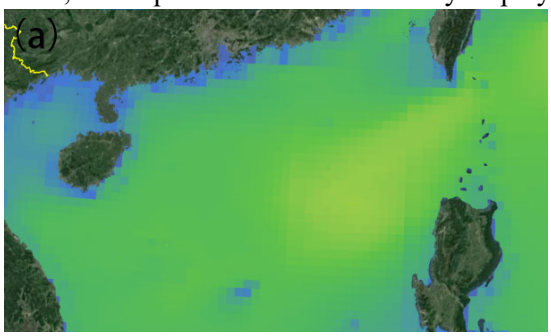
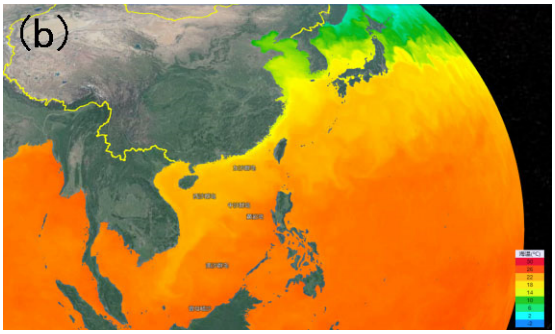


Figure 4. Bilinear interpolation diagram.

Based on the above model, it is necessary to carry out hierarchical color setting in surface rendering. In order to eliminate the uneven grading caused by abnormal values in hierarchical color setting, this paper uses the values of three standard deviations of normal distribution mean value as the maximum and minimum values to participate in the hierarchical calculation, and finally realizes the smooth transition of color in rendering.

The visualization results of ocean scalar field data (ocean wave and sea surface temperature) based on this method are compared with those of traditional methods, as shown in figure 5. Figure (a) and figure (b) show the effect of traditional methods on ocean wave and sea surface temperature visualization, respectively, with strong particle sense and pixel sense. Figure (c) and figure (d) are based on the scalar field visualization algorithm based on linear interpolation proposed in this paper to realize the effect of ocean wave and sea surface temperature visualization, which overcomes the particle sense and pixel sense phenomenon in the traditional scalar field data visualization process, and can display the scalar field smoothly. The boundary between the sea and the land can also be very prominent. In addition, ocean phenomena can be clearly displayed.





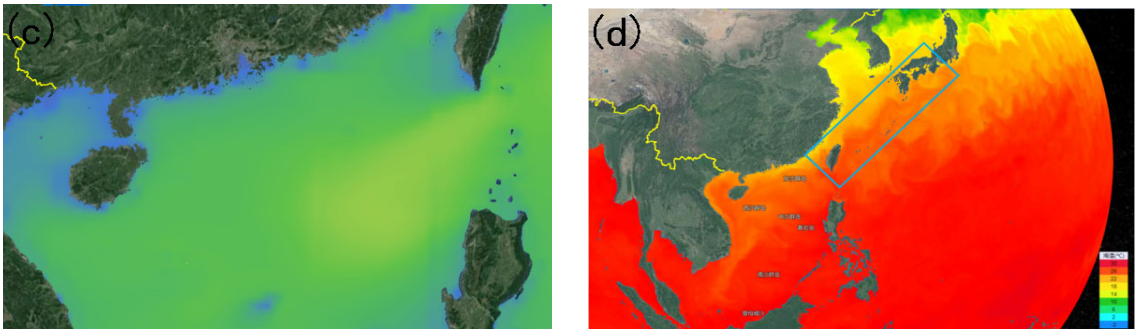


Figure 5. Comparison of scalar field visualization based on this method and traditional method

5. Concluding remarks

This paper takes marine environmental field as the research object, starting from scalar field visualization, vector field visualization, multi-scale changes and three-dimensional visualization, and researches a new method of three-dimensional dynamic visualization of marine environmental field based on the B\S mode. The experimental results show that the method in this paper has good results in terms of calculation speed and rendering effect. The method in this paper will provide new ideas and methods for the research of B/S-side marine environment simulation and three-dimensional dynamic visualization of marine environment fields. At the same time, the three-dimensional dynamic visualization based on this method can also provide marine-related services, such as early warning and disaster mitigation, offshore Path planning, etc. provide relevant basis.

Acknowledgments

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