Ocean Simulation Based on Particle System

Gen Li\textsuperscript{2}, Jing Zhang\textsuperscript{1, *} and Jing Yang\textsuperscript{2}
\textsuperscript{1}School of Information Science and Engineering, University of Jinan, Jinan 250022, China
\textsuperscript{2}College of Computer Science and Technology, Harbin Engineering University, Harbin 150001, China
* Corresponding author e-mail: ise_zhangjing@ujn.edu.cn

Abstract. With the continuous development of computer simulation technology, marine environment simulation has been widely used in many fields, and how to produce a realistic marine environment is a key issue. Aiming at the problem that the ocean surface has poor realism and complicated calculation in the traditional ocean wave modeling method, this paper analyzes the marine environment in detail, conducts research on the departure modeling method based on particle system, establishes the ocean model, and uses Unity3D. The engine eventually built the real ocean environment. Finally, through comparative experiments, it is proved that the method has higher operating efficiency under the condition of ensuring high simulation degree, which confirms the timeliness and feasibility of the model, and provides a reference for the marine three-dimensional simulation problem.

1. Research status at home and abroad
In recent years, researchers have done a lot of work on real-time simulation of ocean scenes. In 2007, Yuksel used wave particle method to simulate wave propagation, and proposed a rigid body force model to achieve bidirectional coupling between rigid body and water surface. In 2009, Cords used mobile grid technology and particle-based rigid body simulation method to simulate the interaction between ocean and object, but the method is based on the static surface of the sea. Once the sea surface fluctuates greatly, it will produce more obvious artifacts. In 2010, Chentanez used a combination of particle and mesh to simulate the interaction scenario of large-scale waters in real time. In the same year, Liu Shiguang and others in China proposed the PML method, which simplified the ship into a hollow cylinder, simulating the interaction between the ocean and the ship. Zhao Xin used the Kelvin wave theory to model the two-dimensional ship traveling wave, and extended the model to the 3D model by introducing the particle system to model the bow and stern waves respectively, which is more realistic than the simulation effect of the ship traveling wave. In 2018, Chentanez proposed a method of coupling Euler's method, height field and particle to simulate the interaction of large-scale fluids.

2. Particle System
In the simulation of marine environment, there are many irregular wave effects. They not only have complex logic structures, but also change dynamically and in real time. It is difficult to simulate with traditional geometric methods. The particle system is one of the most mature theories used in
computer graphics to describe irregular objects, and it is also the best visual method in the field of visual simulation to simulate natural phenomena and special effects. The basic idea of the particle system is to use a large number of tiny primitives with certain life and various attributes as basic elements to describe irregular objects. Each particle has color, shape, size, speed, direction, life cycle and so on. Attributes and many of them can be functions of time. The particle system is a dynamic rather than static system. The process of dynamic change is the process of many new particles and the extinction of old particles. The particles change shape during the movement, which shows the dynamic changes of scene morphology and features.

3. System Design
Vision is an important part of virtual reality, and its function is equivalent to one's eyes. 3D real scene is the core and key to realize the whole vision system. 3D scene can only have a better sense of presence in real-time display. Can immerse users in it. The first is to build a model of each entity in the 3D vision system. It can be implemented in two ways, one is through programming, and the other is through 3D modeling software. Because the programming in the program is very Difficulties, and using 3D modeling tools to achieve is much simpler, so this article mainly uses Unity this game engine to complete the creation and setting of the scene, as well as the driving and rendering of the entire 3D view.

4. Marine Environment Simulation
The marine environment refers to the overall marine environment from sea and air to the bottom of the sea, including many aspects, such as: waves, beaches, sea color, tides, floating objects, land, etc. These are directly related to human vision, this information the more realistic the simulation, the stronger the realism. These information needs to be rendered in real time. This is a very wasteful running process. It should be created by multithreading. The system provides time slices for threads in a circular way, because the time slice is quite short, so the user feels it seems that multiple threads are running at the same time, which improves the efficiency of the application.

5. Ocean Model
There are four ocean models in Unity.

The first is Marine Ocean Fixed Location, which can generate a sea of static fixed areas such as seaports; the second type is Marine Ocean Observer Centered, which is centered on the viewpoint and sets a fixed length as the radius to dynamically generate the ocean grid. The third is Marine Ocean Surf Zone, which is used to generate a fixed ocean area for the shore wave effect. The fourth type is Marine Ocean Technique, which can generate large areas of irregular ocean areas.

In this paper, we choose the third ocean model. Because the virtual ocean scene is very complicated, it must be simplified. It is mainly implemented by LOD (level of detail) level hierarchy technology. It is displayed according to the node of the object model. The position and importance of the environment, determine the resource allocation of object rendering, reduce the number of faces and details of non-important objects, and thus obtain efficient rendering operations. When the observer is far away from the ground object, the object is not loaded. Only when the distance of the local object from the observer is less than a certain fixed value, the ground object model is dynamically added. In the virtual ocean, the ocean wave is the most important element in the scene, and the authenticity of the simulated wave is often determined to a large extent. The credibility of the simulation results. There are many modeling methods for ocean waves, and there are many computer simulation methods for various methods.

In general, ocean wave modeling methods can be divided into four categories, which are geometry-based modeling, dynamic model-based modeling, physics-based modeling, and wave-based spectrum modeling. Used by marine modules in Vega Prime. The method is based on the modeling of the wave spectrum, and a high-field similar to the real wave spectrum distribution is synthesized by Fast Fourier Transform (FFT). The Longuet-Higgin model is a model describing the two-dimensional irregular
long-wave wave model. Yes: Fluctuation is seen as a superposition of simple cosine waves with infinitely many unequal frequencies, different amplitudes, different initial phases, and different angular directions on the X, Z plane and the X axis. The formula is shown below, Where $\delta (x, y, t)$ is the sea surface height of the $(x, y)$ position at time $t$, $a_i k_i \omega_i$ is the amplitude, wave number and angular frequency of the $i$th harmonic, respectively; $\theta_i$ is the main wave direction, and $\varepsilon_i$ is the initial Phase.

$$\delta(x,y,t) = \sum_{i=1}^{n} a_i \cos [k_i(x \cos \theta_i + y \sin \theta_i) + \omega_i t + \varepsilon_i]$$

6. Simulation of Marine Special Effects

Marine special effects mainly include dozens of effects such as ship track, seawater foam, reflection, and shore wave. These effects are difficult to simulate by traditional geometric modeling methods, mainly using particle systems to achieve the following for example, the simulation of marine special effects is introduced. The ship's stern wave is located at the head of the ship. It is a wave formed by the collision of seawater and the bow. It is difficult to achieve by geometric modeling. Here we use the particle system to Simulation. The formation of the wavy wave is approximately V-shaped, and the particles move in this V-shaped region. There are two types of wavy models in the Vega Prime, one is the angle form of the bow wave effect, and the other is the flat mode bow. Wave effect. First set the maximum particle number of the particle system, the number of particles is not fixed, but the total number of particles can not exceed the set maximum. Secondly, set the time interval of particle release, to the time of particle release, Re-add a certain number of new particles. Then, set the life cycle of the particles. When the life is over, the particles will die. The motion of the particles in the scene is not then, it is a random process. Combined with the influence of wind speed, wind direction and other factors at the time, each particle is emitted at a speed and angle, following the principle of gravity, and moving back to the surface after a period of time. To simplify the calculation, in the particle system Regardless of the impact of collisions between particles on the properties of particles, that is, the properties of the particles will not change from generation to extinction. The final ocean simulation and performance comparison experiments are as follows:

![Figure 1. Final ocean simulation.](image)
Table 1. Performance comparison experiments.

| Simulation model         | Used memory (Mb) | FPS |
|--------------------------|------------------|-----|
| Model of this paper      | 9.8M             | 90  |
| Perlin-Noise Model       | 10.3M            | 85  |
| FFT Model                | 9.5M             | 79  |

Through the above experiments, it can be found that the particle model based ocean model proposed in this paper has higher FPS and less rendering time, based on the similar operating memory. This proves that the method has better operating efficiency while ensuring high simulation.

7. Simulation experiments
The software environment of this experiment is Windows XP, Visual Studio 2017 and Unity3D engine. By using the Ocean module of Unity3D, the multi-threading technology is used to truly simulate the marine special effects. The particle system can show various special effects very well. In the marine environment, the simulation results of the particle system are introduced. In the experiment, the maximum number of particles is set to 175, the release time of the particles is 0.1 second, the number of particles released is 12, and the life cycle of the particles is 0.8 seconds. The simulation results visually present the special effects of the waves, waves and waves, and the effect is ideal and realistic. It is suitable for real-time visual simulation of virtual sea battlefield, and also provides a reference for further research of virtual ocean.

Acknowledgement
This research is supported by funding of National Natural Science Foundation of China (NSFC) (2017–2020, No. 51679058).

References
[1] Yuksel C. Wave particles [C] // Acm Siggraph Computer Animation Festival. 2007.
[2] Liu S, Xiong Y. Fast and stable simulation of virtual water scenes with interactions [J]. Virtual Reality, 2013, 17(1):77-88.
[3] Chentanez N, Muller M, Kim T Y. Coupling 3D Eulerian, Heightfield and Particle Methods for Interactive Simulation of Large Scale Liquid Phenomena [J]. IEEE Transactions on Visualization and Computer Graphics, 2015, 21(10):1116-1128.
[4] Mastin G A, Watterberg P A, Mareda J F. Fourier Synthesis of Ocean Scenes [J]. IEEE Computer Graphics and Applications, 1987, 7(3):16-23.
[5] Foster N, Metaxas D. Modeling water for computer animation [J]. Communications of the ACM, 2000, 43(7):60-67.
[6] Zhao L, Yongxin F. Applications and Solutions of Virtual Marine Environment Spatio-Temporal Visualization Service [C] // Intelligent Networks and Intelligent Systems (ICINIS), 2012 Fifth International Conference on. IEEE, 2012.
[7] Su-Jun L I, Bing Y, Ling-Da W U. Modeling and Rendering of Ocean Scene Based on Gerstner-Rankine Model [J]. Journal of Engineering Graphics, 2008, 29(2):77-82.
[8] Zhou X N, Zhou G Y. Simulation of SPH water flow based on DEM data [J]. Geospatial Information, 2015, 13(2):86-90.
[9] Wen-Long L, Jing Z. Optimization of the Wave Particle Mode Based on SPH by the MC Algorithm [J]. Journal of Ocean Technology, 2017.