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Line of Sight Based Visibility Acceleration Method

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Abstract. Real-time fast display of 3D scenes is the basic content of visual simulation and one of the core links. The object-oriented quadtree is used to organize the scene. This method saves the object information with leaf nodes, which can reduce the storage capacity and processing time of the tree and reduce the management burden of the system scene. For the visual cropping acceleration problem, it is proposed based on the line of sight. The cone partitioning cutting method can effectively improve the precision of the cutting, reduce the number of nodes participating in the cutting, and has better cutting efficiency and higher stability. The effectiveness of the method is verified by designing comparison experiments.

1. Introduction

With the development of technologies such as geographic information system, remote sensing technology, satellite technology and computer graphics, the data scale of the model applied to the scene has grown exponentially, and the structure of the scene is more complicated[1]. Although graphics rendering has been well supported in hardware, it still can't solve the problem of scene real-time rendering, Therefore, it also needs to analyze related cutting algorithms.

In recent years, researchers at home and abroad have conducted extensive research on the simplification of large-scale scenarios and the reduction of the amount of data on a large scale. Among them, the literature [2] proposed an adaptive binary tree scene organization algorithm to manage the scene, using the layered cropping method to cut the cone of the scene tree, and the objects operated in the cutting process are the bounding balls and bounding boxes in the nodes. Literature [3] proposed a real-time terrain rendering method based on Hermitian motion prediction. The Hermitian interpolation algorithm is used to predict the viewpoint motion, and the topographic data of the next viewpoint position and the line of sight direction is loaded in advance, which reduces the dynamic loading during real-time rendering, effectively increases the frame rate, and avoids the phenomenon of image stagnation during roaming.

2. Object-oriented Quadtree Scenario Construction

Object-oriented quadtree is a spatial non-uniform meshing algorithm for extending quadtrees. It uses spatial decomposition to build trees and saves object information with leaf nodes[4]. All node operations can be simplified to traverse the tree structure. In the process of constructing the object-oriented quadtree, the model bounding box shown in Fig.1 is used. The length, width and height of the bounding box area are parallel to the coordinate axes of the scene global coordinate system X, Y and Z.

The lower left and upper right coordinates define a region, expressed as a sequence of points: $< A, G >=< (x, y, z), (x', y', z') >$ and $x < x', y < y', z < z'$.

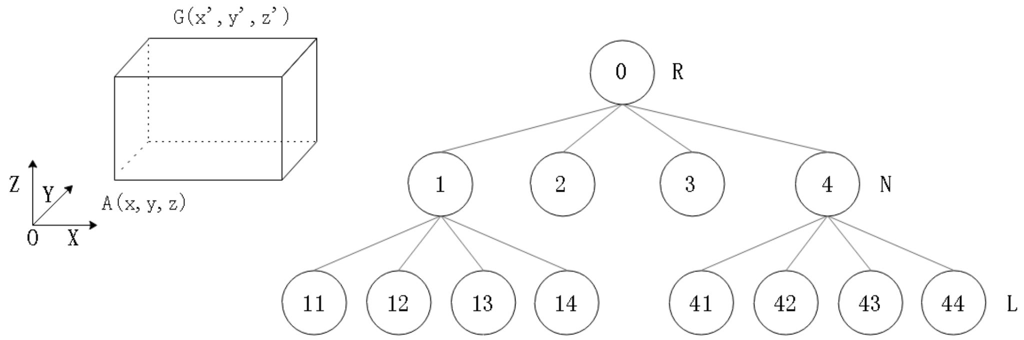

Fig.1 Construction of object-oriented hierarchical quadtree

The establishment of an object-oriented hierarchical quadtree is mainly divided into two phases.

1) The first stage: on the basis of each object structure tree, establish an AABB(Aligned Axis Bounding Box) tree with one-to-one correspondence with the object components, use the component as the basic unit of the tree, and store the basics of the component in each AABB tree node information(nodes).

2) The second stage: establish an object-oriented scene quadtree. Firstly, construct a minimum cuboid bounding box for the three-dimensional scene, find the maximum vertexand (x', y', z') and the minimum vertex (x, y, z), which are used to form the bounding box AABB. The length of AABB along the x-axis, y-axis, and z-axis is respectively denoted as $L_x = |x - x'|, L_y = |y - y'|, L_z = |z - z'|$. Then the cuboid is evenly divided into four sub-cubes and encoded.

3. Line-of-sight Cone-based Cropping Method Based on Line of Sight

In the process of creating a quadtree node, each node must store a bounding sphere and an ABAB bounding box for subsequent visibility judgment. Before performing the cone cutting, firstly, the current position of the camera is centered and the cone area is divided into the high cone area (V-I area), the intermediate cone area (V-II area) and the low-level cone (V-III area) according to the distance from the current camera position. The near clipping distance is denoted as D_{near}, the far clipping distance is denoted as D_{far}, and the distance from the current node to the viewpoint is denoted as $D_{current}$. The schematic diagram of the cone area is shown in Fig.2.

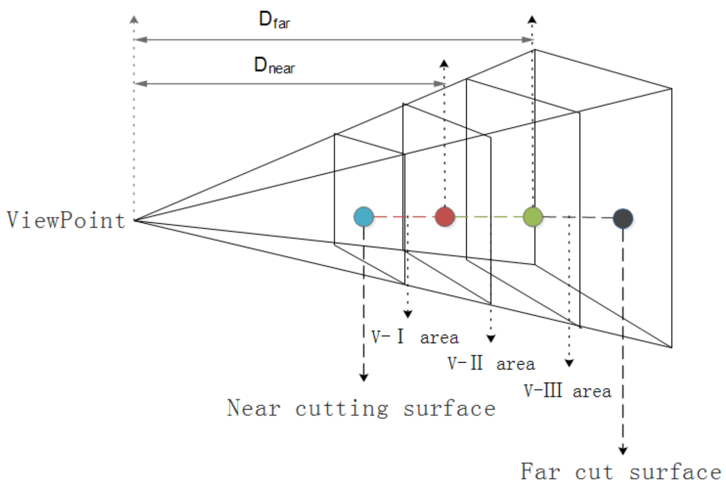

Fig.2 Cone area division

Then, when performing the field of view cropping, the judgment criterion of the viewing area cropping is dynamically adjusted according to the current line of sight $D_{current}$, and the specific process is as follows:

1) When $D_{current} \leq D_{near}$, it indicates that the current node belongs to the high-level cone(V-I). This area requires higher resolution of the scene. In this case, the node should be surrounded by the ball for visibility judgment;

2) When $D_{near} < D_{current} < D_{far}$, it indicates that the current node belongs to the cone intermediate level (V-II). The resolution of the scene in this area is not high. In this case, the visibility can be judged by the mixed mode of first node enveloping the ball and then the AABB enveloping box;

3) When $D_{current} \geq D_{far}$, it indicates that the current node belongs to the lower cone of the cone (V-III). This area has lower resolution requirements for the scene. At this time, the AABB bounding box can be directly used for visibility judgment.

The execution flow of the viewing cone partitioning method based on the line of sight is shown in Fig. 3.

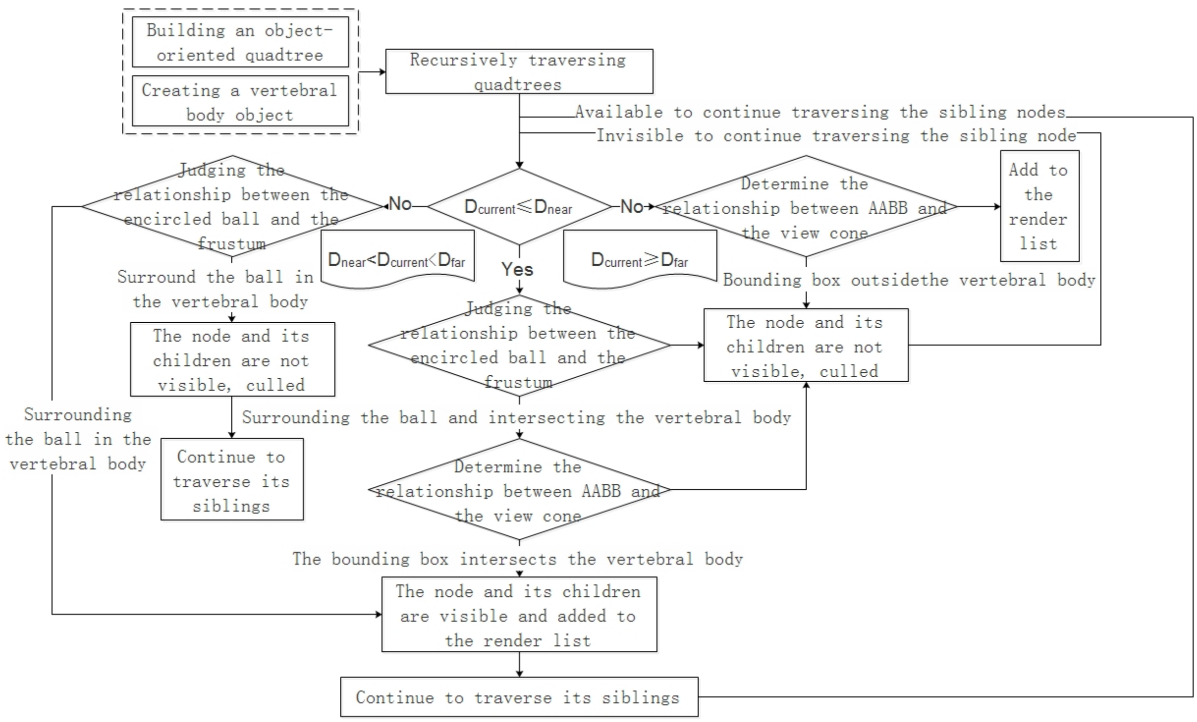

Fig.3 Line-of-sight-based cone partitioning method execution flow

4. Experimental Results and Analysis

In this paper, the experiment is carried out on a PC with Intel Core i7-4790 3.50 GHZ, 8G memory and AMD Radeon HD 7000 series. The experimental environment is the virtual simulation scenario of ship driving (Shanghai section).

In order to verify the superiority of the proposed algorithm, the clipping algorithm proposed in this paper (method 1) and the clipping algorithm based on geometric projection dimension reduction (method 2) and literature [5] proposed in [6] The hierarchical view cone clipping algorithm (method 3) of the ball and the bounding box are compared experimentally on the performance of the cutting. The experimental results are shown in Table 1.

Table 1 Algorithm comparison experiment results

Experimental method	Triangular number	Number of nodes after cropping	Cropping time (ms)	Frame rate (FPS)
method 1	200000	6000	0.0041	67
method 2	200000	6330	0.0057	60
method 3	200000	6500	0.0068	53

Based on the data, it is found that the line-of-sight method based on line-of-sight is less than the clipping algorithm based on geometric projection dimension reduction and the clipping algorithm based on bounding sphere and bounding box in the comparison of cutting time consumption and frame rate. Especially in the case of complex scenes, the advantages of the proposed cropping algorithm will be more prominent.

5. Conclusion

In this paper, the scene organization structure of object-oriented quadtree is used to manage the scene. Its efficient storage structure can effectively reduce the storage capacity and processing time of the tree, reduce the management burden of the system scene, and can be used to divide various kinds of scenes. Then, based on the structure of the scene, the visibility cropping algorithm is studied. In the aspect of frustum clipping, the proposed line-of-sight cone-cutting method can effectively improve the accuracy of cropping and reduce the number of nodes involved in cropping with better cutting efficiency and higher stability.

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