Application of improved algorithm based on sphere OBB hybrid hierarchical bounding box in Teaching

Wei Zhao¹, Huiyan Qu¹,*

¹Virtual Reality College of Jilin Animation Institute, Changchun, Jilin Province, China

*Corresponding author e-mail: quhuiyan68@163.com

Abstract. In this paper, on the premise of analyzing the theoretical knowledge of collision detection algorithm, the advantages and disadvantages of several commonly used hierarchical bounding box methods are compared and analyzed, and then the traditional collision detection algorithm is studied. This paper presents a new collision detection algorithm. After preprocessing, the first order collision detection based on the separation axis theorem is used to exclude a large number of disjoint spatial model objects through preprocessing. The purpose of adding primary collision detection is to further investigate disjoint object pairs, and prepare for the final detailed detection stage. The pre-determined OBB bounding box is used for fast collision detection, and its storage structure and mode are optimized quickly. After preprocessing, it effectively eliminates the obviously disjoint space object pairs, reduces a large number of operations, and improves the detection efficiency.

1. Algorithm description

With the increasing number of models in virtual scene, the requirement of collision detection location is also increased. In the traditional test algorithm, any element in the tested model needs to be updated, which takes a lot of time, which affects the real-time performance. Therefore, many scholars at home and abroad have improved and innovated the traditional test algorithm in varying degrees, among which the two-tier structure and hierarchical structure are the representative.

The double-layer structure is to construct a double-layer structure on each node of the bounding box tree. Its disadvantage is that it is easy to cause data redundancy and affect the operation efficiency. However, the hierarchical structure is different from the double-layer structure. It divides the bounding box tree into several levels according to certain rules, and then uses different bounding boxes for intersection test, but this will cause the intersection of different types of bounding boxes, Different degrees increase the complexity of the test. If only bounding box algorithm is used for collision detection of a given model object, it is necessary to construct bounding boxes for all model objects in the virtual space, and then conduct pairwise test, which undoubtedly increases the computational cost and weakens the real-time effect of the test site.

2. Algorithm analysis

Because the hierarchical bounding box consists of large bounding box and small bounding box, the hierarchical bounding box technology is able to reduce the number of collision detection and thus reduce the test time consumption. The bounding box trees can reduce the time complexity of high complexity models to log level in the process of detection, regardless of coarse order or fine order. Its basic train of thought for the tested model is surrounded by either to model structure complexity is
lower than its body full surround and cover, and then the model of one layer is divided into several parts, and then used bounding volume continuous several subdomains surrounded, to model the breakdown process if no special requirements, with the final results to stop the premise for the most basic elements of the module, normally we see triangle mode for the most basic module of model, in establishing good hierarchy tree save the bounding box information, achieve purpose layer upon layer close to the actual measured model. This article improved hybrid bounding box of the Sphere, two categories, OBB bounding box together, layering the hierarchy tree, is divided into the upper, middle and lower three layers, the upper choose Sphere as a root node bounding box, because it constructs a single simple nature, coupled with parallel rotating movement after implementation changes to compose new easily qualities, make its can be faster to eliminate no reciprocal cross foundation yuan, middle to hybrid bounding box is composed of Sphere and OBB, because the two types are measured model can make than most closely characteristics of press close to, and intercrossing model being tested to the minimum bounding box number, in this way, Primitives in upper hybrid bounding volume intercrossing process, can be through the leaf node is mixed with middle of Sphere and OBB bounding volume displays its outside nodes for further intercrossing test, finally, use single OBB bounding box at the bottom. Figure 1 shows the flow of a complete round of tests run by the hierarchical enclosing tree. The detailed steps are as follows:

1. Build a hierarchical binary tree of the enclosing body.
2. The detected primitives need to find an arbitrary discrete point, and then perform the collision detection of the constructed bounding volume level binary tree;
3. Calculate the upper layer of the binomial tree at the level of the enclosing body;
4. Execute (2) and (3) until the collision detection of all discrete points is completed, that is, complete the whole process of collision detection.

**Figure 1.** The procedures of the hierarchical bounding tree run a round of the test
3. Algorithm process

Using hierarchical bounding box is faced with the problem of how to construct level to, including its structural need to spatial domain maximum limit to reduce the store information for a more worth to consider problem, this paper proposes hybrid bounding box contrast before the traditional algorithm, and still continue to choose 3 three layer structure, but a mixture of improved bounding box except the middle structure adopts single bounding box form, compared with using hybrid bounding box, narrowed the intercrossing detection complexity and update process to burden, so as to achieve the reciprocal cross examination time, improved its exchange rate, make it more simple, because of the Sphere, OBB bounding box has a higher degree of fitting than AABB enveloping box, etc. Figure 2 shows the flow chart of the improved hybrid hierarchy bounding box algorithm.

Wx, Wy: respectively represent the test nodes in the bounding box tree of the two models containing collision test; Gx, Gy: are the set of child nodes corresponding to node Wx and Wy respectively; B(Wx),B(Wy): represents the bounding box containing the sets Wx and Wy; Qx,Qy: are the basic elements of Wx and Wy respectively.

![Figure 2 Improved Algorithm flow chart of hybrid hierarchical bounding box](image_url)
4. Experimental results and analysis

4.1 The experiment platform

The thesis algorithm is completed by PC (CPU for 3.4ghz, memory for 2GB, video memory for 512M), using VC6.0 platform and OpenGL to complete. Since the improved algorithm is aimed at the study of rigid body object, the Rapid algorithm is selected for comparative analysis of the final efficiency.

4.2 Analysis of experiment scenes and results

The algorithm in this paper is adapted to scenarios with different complexity. The six figures in Figure 3 represent the collision of complex space object models simulated by circles and squares. The total number of detected ground triangular modules varies from 1468 to 9867.

![Figure 3](image-url)

Figure 3 The diagram of a collision between a circular and a square model of a complex space object

in virtual space model test, the OBB bounding box collision test is used for processing in advance, preliminary tests using test based on the separation axis theorem premise, precise testing using improved hybrid hierarchical Sphere - OBB bounding box algorithm test, when the improved algorithm of collision detection after pretreatment compared with Rapid algorithm when test results (as shown in Table 1 and Figure 4), omit an improved algorithm of collision detection pretreatment can be found in the test efficiency improved a lot, more quickly, Rapid algorithm has obvious gap.
Table 1. The test schedule of the omitted preprocessing improved algorithm and the rapid algorithm

| Number of triangular facets | Rapid/ms | The improved algorithm of preprocessing is omitted /ms |
|-----------------------------|----------|-------------------------------------------------------|
| 1000                        | 4.5462   | 4.3241                                                |
| 3000                        | 7.9825   | 7.6213                                                |
| 5000                        | 12.1240  | 11.8735                                               |
| 7000                        | 14.8913  | 13.6412                                               |
| 9000                        | 19.1320  | 16.9287                                               |

Figure 4. The test time comparison between the omitted preprocessing improved algorithm and the Rapid algorithm

(2) If you add pretreatment before this article improved test algorithm OBB box of fast testing phase, by fellow triangle number of primitive data, and finally get the average test time comparison results as shown in Table 2 and Figure 4-Figure 5, the experimental results show that the triangular primitive increased number of cases, an improved algorithm of collision detection after joining pretreatment compared with Rapid algorithm while the average detection time curve is relatively slow, but the average test time was shortened greatly, speed efficiency improved significantly.

Table 2. Test time of improved algorithm and the Rapid algorithm

| Number of triangular facets | Rapid/ms | Improved algorithm/ms |
|-----------------------------|----------|-----------------------|
| 1000                        | 4.5462   | 4.2283                |
| 3000                        | 7.9825   | 7.4978                |
| 5000                        | 12.1240  | 11.4318               |
| 7000                        | 14.8913  | 12.9731               |
| 9000                        | 19.1320  | 15.9854               |
Figure 5. Comparison of test time between improved algorithm and Rapid algorithm

5. Acknowledgements
This work was financially supported by Jilin province department of education research project: "Research on the training mode and operation mechanism of excellent engineer" ,SZ1603 , Jilin province department of education science and technology research project "fast media interaction technology key technology research" JJKH20170990KJ, Jilin province department of education, science and technology research key project "rapid collision detection technology of group animation" JJKH20201224KJ, Jilin province department of education, science and technology research project "fast image interaction based on virtual reality technology" JJKH20201225KJ fund.

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