Application of Collision Detection Algorithm in 2D Animation Design

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Abstract

The purpose of collision detection which includes interference detection or contact detection is used to automatically generate a report when a geometric contact or 2D Animation is about to occur or has occurred. The geometric model includes polygon objects, curves, or algebraic curves. Especially in the two-dimensional animation design process, collision detection can greatly improve the visual effects. This paper introduces the problems that need to be paid attention to designing the collision detection system; it also analyzes and compares the current main collision detection algorithms, finally, this paper expounds the advantages and disadvantages of the commonly used algorithms such as hierarchical bounding box algorithm and spatial segmentation. The principles and implementation of the ray algorithm described in detail. The ray algorithm is optimized for the regular objects such as sphere and cylinder, which greatly simplifies the calculation and greatly improves the efficiency of the algorithm.

Keywords: Collision detection, Geometric contact, 2D Animation, Hierarchical bounding box.

1. INTRODUCTION

2-D Virtual animation is the use of virtual reality technology in the form of animation, which is based on the virtual reality and animation technology. We understand the meaning of virtual reality, and 2D animation can fully understand the concept of virtual reality animation. Flash is a 2D vector animation software-authoring tool that designers and developers can use to create presentations, applications, and other content that allows for user interaction (Waldon et al., 2014). Flash can contain simple animations, video content, complex presentations, and applications. Flash is especially useful for creating content over the Internet because its files are very small. Flash does this by making extensive use of vector graphics. Bitmap graphics are larger because each pixel in the image requires a separate set of data to represent it. Vector graphics require much less memory and storage space than bitmap graphics because they are expressed as mathematical formulas rather than as large data sets.

It has even encountered some problems in FLASH, computational geometry, robotics and automation, engineering analysis, computer graphics, virtual reality and so on, and has even become one of the key issues. For example, robot control and planning, collision detection can help robots avoid obstacles in the surrounding environment, is a very crucial part. Accordingly, many collision detection algorithms also appear in different fields, and some algorithms have been applied to practice. There are three main purposes for collision detection, which are detecting whether there is a collision among the models (Kapadia et al., 2016). The collision occurs to collide and find the distance between the models. Collision detection is an important issue in the field of computer animation, physics simulation, computational geometry, FLASH and other fields. The task of collision detection is to determine if contact or penetration has occurred between two or more models. Accurate collision detection not only enhances the authenticity of the virtual environment, but also plays an important role in enhancing the immersion of the virtual environment, and the complexity and real-time of the virtual environment put forward higher requirements on the collision detection. Therefore, it is necessary to study the collision detection algorithm in augmented reality system. In most applications, real-time collision detection is required. For example, the virtual reality requires that the system can interact with the user. This not only requires real-time drawing but also real-time collision Detection, showing the changes after the collision; and for tactile feedback system, need to be tested 1000 times per second. Therefore, the main purpose of the study is to reduce the complexity of the algorithm. The computational cost of the collision detection algorithm mainly depends on the complexity of these two aspects. Static detection is the most basic problem; the key is to solve the intersection of different detection problems, such as convex polyhedron, concave polyhedron, non-closed polyhedron, and deformable models. It is also an important aspect to reduce the number of static detection algorithm invocations to improve the efficiency of the algorithm. It should be called as soon as the collision is
imminent. Augmented Reality (HMI) is a man-machine interface that can naturally interact with people and the virtual environment generated by computer. Its application development prospect is very broad, and its market potential is immeasurable (Pan et al., 2017). At present, it has been initially applied in many fields such as aerospace, mechanical design, scientific computing, film and television entertainment, chemical medicine and military training. Many applications cannot be replaced by other technologies. In general, the current augmented reality technologies are not yet mature and the current state of development is far from the actual needs of all occupations. Augmented reality much work still needs to get full application research.

2. GRAPH-BASED REAL-TIME COLLISION DETECTION ALGORITHM

The real-time collision detection algorithms based on graphics are mainly divided into two categories: hierarchy bounding box and space segmentation method. Both types of algorithms use a hierarchical model. The goal is to reduce the number of geometric objects that need to be intersected as much as possible to improve the real-time performance of the algorithm. Due to the large storage capacity and poor flexibility, the space segmentation method is usually applied to the collision detection of geometric objects distributed more evenly in sparse environments. The hierarchical bounding box method is more widely used in collision detection in complex environment. The core idea of Hierarchical bounding box approach is to describe complex geometric objects approximately by using simple bounding box with slightly larger geometry and geometric features, so that only the intersection of bounding box overlapping objects need further intersection testing. In addition, the construction of the tree hierarchy can be more approaching the geometric model of the object until the object geometry is obtained (Jackson, 2017). Typical hierarchical trees mainly include AABB (aligned axis bounding box) level tree, level tree, OBB level tree and K-DOP (discrete orientation polytope) level tree. Others include mixed-level tree surrounded by trees.

**Table 1** Comparison of several typical bounding boxes

<table>
<thead>
<tr>
<th>Method</th>
<th>Construction Difficulty</th>
<th>Storage Quantity</th>
<th>Intersection Test Complexity</th>
<th>Tightness</th>
<th>Update Calculation While Rotating Objects</th>
<th>Deformable Body Collision Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>AABB</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Spheres</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>OBB</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>K-DOP</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

3. OVERALL DESIGN

The use of Flash production MTV is a very new project, which gives a new visual feeling, planning system functional modules are as follows (He et al., 2015). 2D Animation module has the title. The main is to tell the audience the name of the MTV song, singer, MTV producer and other information. MTV content includes the performance of the song meaning, highlighting the theme, expression of emotion, a complete storyline; Trailer is indicating the production of the MTV purpose, and indicating the end of the song (Hu et al., 2017). Audio module includes music and lyrics. Music is the beautiful voice we have. Lyrics are songs in the form of words, and a way to show it. Structure is as follows.

![Figure 1. 2D Animation module](image)

3.1 Plane Collision Detection
The principle of collision detection algorithms for two basic graphs is presented below. General rules of object collisions can be processed into rectangular collisions, the principle is to detect whether two of rectangles overlap (Chen et al., 2014). Rectangle 1 is the argument, the coordinates of the upper-left corner are \((x_1, y_1)\), Width is \(W_1\), height is \(H_1\). Rectangle 2 is the argument that the coordinates of the upper-left corner are \((x_2,y_2)\), Width is \(W_2\), height is \(H_2\). The coordinates that can be mathematically processed into a comparison center point at the time of Detection are \(x\) and \(y\). The relationship between the distance and the width in the direction is that, the absolute value of the distance from the two-rectangle center point in the \(x\) direction is less than or equal to the rectangle width. The absolute value of the distance from the \(y\) direction is less than the rectangle height.

\[
x \text{ direction: } \left| \left( x_1 + \frac{w_1}{2} \right) - \left( x_2 + \frac{w_2}{2} \right) \right| < \left| \frac{w_1 + w_2}{2} \right|
\]

\[
y \text{ direction: } \left| \left( y_1 + \frac{h_1}{2} \right) - \left( y_2 + \frac{h_2}{2} \right) \right| < \left| \frac{h_1 + h_2}{2} \right|
\]

In the program, you just need to convert the above conditions into code, which can be achieved (Chen and Liu, 2016; Ion-Eugen et al., 2017). However, rectangular collisions are just a rough method of collision detection, because many actual objects may not be a regular rectangle. In space, the trajectory of the same point distance to two points is planar. The plane is defined as follows.

\[
X \cdot X = d
\]

this vector representation is equivalent to the usual parameter expression method, and the parameter expression describes a planar formula as follows: \(ax + by + cz + d = 0\). Simply use the vector of normals \(Z\) instead of \(A, B, C\).

\[
\text{PointOnRay} = \text{Raystart} + t \times \text{Raydirection}
\]

\[
X \cdot X = d
\]

We can get it as follows.

\[
X \cdot \text{PointOnRay} = d
\]

\[
(X \cdot \text{Raystart}) + t \times (X \cdot \text{Raydirection}) = d
\]

Therefore, we get \(t\).

\[
t = (d - X \cdot \text{Raystart}) / (X \cdot \text{Raydirection})
\]

\[
t = (X \cdot (X - \text{Raystart})) / (X \cdot \text{Raydirection})
\]
Figure 2. Intersection test of rays and planes

T is the distance from the beginning of the ray along the direction of the ray to that plane. Therefore, you can calculate the impact point by substituting the T for the Ray formula. If t is a negative number, it indicates that the impact point is at the back of the starting point of the ray, that is, in the direction of the ray back to hit the plane, which only shows that there is no intersection between the Ray and the plane.

3.2 Collision simulation between spheres

To calculate collisions with a stationary object, we need to know the following information: Collision Point, Collision Normals, Crash Time. It is based on the following physical laws; the collision angle of incidence equals the reflection angle. It is shown in the following illustration.

The reflection direction is calculated by the following formula.

\[ R = 2 \times (-I \cdot N) \times N + I \times 1 \]

Note that both I and N must be unitized vectors.

Figure 3. Collision simulation

Figure 4. Speed changes after the collision
3.3 2D animation scene production

The new movie clip named screen saver, into the video editing state, the prairie pictures were placed in each layer, press F8 into components, in the timeline we can adjust the appearance and the end of the order, to do animation, be done fade in Fade out of the switching effect. Because the scene animation content is more complex, we can make the following animation more convenient, the new movie clip movie clip named background movement.

Collision detection using ray method, the program has 6 planes, 3 cylinders, and 10 balls. Demo program based on OPENGL screenshots are as follows.

![Figure 5. Ball and cylinder collision](image1)

Collision detection using ray method, the program has six planes, three cylinders and 10 balls. Demo program based on OPENGL screenshots are as follows.

![Figure 6. The ball collides with the plane or the ball collides with the ball](image2)

4. CONCLUSIONS

With the popularity of large-scale 2D games and the further development of the field of virtual reality, many experts and scholars have devoted themselves to the research of collision detection algorithms. There are varieties of algorithms, but all have some limitations. More accurate and smaller algorithms have become the goal of many scholars. Hierarchical bounding box method has welcomed by many people, but easily becomes the bottleneck of the program under a large amount of data and affects the result. In this paper, collision detection between the sphere and the plane, the sphere and the cylinder, the sphere and the sphere is realized. By optimizing the mathematical calculation, the algorithm is faster and more efficient. Now based on the ray of the main rules of the object, the collision detection algorithm for irregular objects remains to study.

REFERENCES
Chen M.C., Kong X.S., Chen K. (2014). Application of statistical analysis software in food scientific modeling, Advance Journal of Food Science and Technology, 6(10), 1143-1146.