

# Visualizing collision detection techniques in flocking simulations

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**ABSTRACT** –The purpose of this paper is to visualize design considerations of collision detection in flocking simulation. There are several approaches identified by many researchers such as force model, linear interpolation, and bounding volume. We visual some of the collision detection techniques in Flocking simulation to see the performance and early design stage requirement on our future proposal for a new method of collision detection in crowd simulation.

## 1. INTRODUCTION

Simulating crowds in real-time environments such as in 3D game applications can become complex and challenging because the simulation must be visualized in real-time frame rate. One particular area that concerns the most in real-time crowd simulation is crowd animation. In general *Crowd Animation* discusses crowd behavior, crowd navigation, collision avoidance, and gaze behavior. The complexity of the crowd animation algorithm determines the performance in real-time. A simplistic algorithm may produce a fast performance result but on the other hand, may compensate for the realism of the animation.

## 2. COLLISION AVOIDANCE BEHAVIOR

There are several techniques proposed to achieve collision avoidance behavior in crowd simulation. In the earlier days, Craig Reynolds introduced flocking as crowd behavior in crowd simulation [1]. It combines three behaviors which are Cohesion, Separation, and Alignment. Separation behavior is implemented as a collision avoiding mechanic. Later on, he introduced Collision avoidance, obstacle avoidance, and path following for steering behavior in crowd simulation [2]. Helbing introduced Social Force [3] that simulate pedestrian boundary between each other in crowd simulation.

According to this study [4], collision avoidance in crowd simulation mostly designs based on the agent's position hence its distance, direction, and velocity. Some example includes short-term avoidance [5] and multi-resolution [6]. Reciprocal velocity Obstacles (RVO) and Hybrid RVO [7] are considered a novel approach to collision avoidance behavior where the behavior can be implemented in a large crowd situation in real-time. Another approach based on the bounding volume technique in crowd simulation is Motion Oriented Bounding Box (MOBB) [8].

Collision detection is an important mechanic to

execute collision avoidance between objects. The collision detection can be a representation of the object distance, direction, velocity to determine the estimation position of an object during  $n$  times, therefore, predicting intersection to executes collision avoidance behavior.

Table 1 Implementation of the Visualization of Collision Detection Technique in Flocking Simulation

Type of Collision	Average FPS
Without Collision Detection	90
Ray Cast	77
Dynamic Arc	70
Dynamic Triangular	73
Sphere	70

## 3. COLLISION DETECTION TECHNIQUES

Plausible collision detection techniques generally in crowd simulation can be derived from general collision detection as explained by Christer Ericson [9] as Ray-cast, Bounding Volumes, and Spatial Partitioning. Spatial Object Median Splitting (SOMS) [10] a fast calculating distance between objects. A hybrid bounding volume technique by implementing Discrete-Oriented Polytopes (k-DOPs) and Oriented Bounding Box (OBB) approach [11] can be accurate and fast enough for collision detection between objects. Execution from Complex bounding volume can be improved especially when it involves a large quantity of objects. Implementation of *Sweep and Prune* effectively improves the large execution of Align Axis Bounding Volume (AABB) objects [12].

### 3.1 Visual Perception Approach

Another approach of collision detection aside from looking at it as a representation of velocity, direction, and distance; it also can be represented as visual perception. In crowd simulation, collision detection can be as the agent's visual perception. Examining a pedestrian's vision in [13] had the agent's visual perception as an approach to designing collision detection. One example of this concept is Velocity Perception [14]. Similar to MOBB [8], Velocity Perception specifically focuses on the agent's visual perception dynamic.

To visualize how visual perception can be

considered as a collision detection technique in crowd simulation, we developed and implemented several techniques as shown in Figure 1. Figure 1(a) shows the early work from Reynolds [1]. Figure 1(b) is an example of ray casting collision detection. Ray Cast presents as a linear interpolation of the agent's predicted position in few frames ahead. Figure 1(c) extending the ray cast as radius value for its Sphere Bounding Volume. Figure 1(d) implement theta  $\theta$ . It is a degree derives from pedestrian peripheral vision to create an "Arc" or semi-circle as collision detection. On the other hand, instead of "Arc", Figure 1(d) interpolates ray cast information to construct a triangle bounding volume as its collision detection.

In Table 1 we able to show the result of variation of collision detection technique visualization in Frame rate per second (FPS). The development was based on [15] Flocking simulation on Processing. Runs on Intel i7 6700 8GB RAM, NVIDIA GTX 1050Ti.

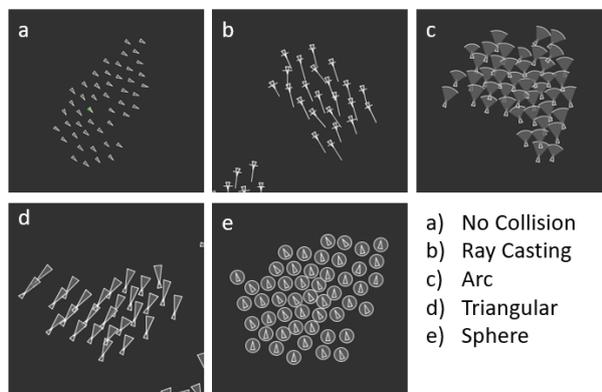


Figure 1 Visualizing collision techniques in flocking simulation

#### 4. SUMMARY

Collision detection is an important mechanic to simulate plausible collision avoidance behavior in crowd simulation. There are many approaches such as social force, bounding volume technique, and linear interpolation of the agent's velocity. However, there are still many improvements that can be considered in visual perception approach as an effective collision detection in crowd simulation. We will be considering this approach for our next collision detection design proposal.

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