TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 2264 ~ 2270
ISSN: 2302-4046

Velocity Perception: Collision Handling Technique for Agent Avoidance Behavior

Nazreen Abdullasim[1], Ahmad Hairul Basori*[2], Md Sah Hj Salam Abdullah Bade[3]
[1]Kulliyyah of Information and Communication Technology, International Islamic University,
53100 Gombak, Selangor, Malaysia
[2]UTM VicubeLab, Faculty of Computing, Universiti Teknologi Malaysia Skudai, 81310 Johor, Malaysia
[3]Sekolah Sains dan Teknologi, Universiti Malaysia Sabah, 88899, Kota Kinabalu, Sabah, Malaysia
Corresponding author, e-mail: ajendgreat@gmail,com[1], uchiha.hoirul@gmail.com[2,]
abade08@yahoo.com[3]

Abstract

Collision avoidance behavior is always about maintaining free collision between virtual objects. It is also about generating evasion routing for the agents in virtual environment such as in crowd simulation. It consists of three processes which are construction of Field of Vision, Collision handling and collision response. Constructing field of vision is always a daunting task and always in enigma for the designer because it is subjected towards agent's perception which is varies to each of them. There are few attempts on designing field of vision based on the agent's dynamic focus toward its surrounding. Therefore, we present a top down approach study from crowd simulation modeling until the collision handling level in order to identify the suitable crowd modeling for our approach. Hence, at the end of this paper we will be able to discuss the possible techniques for constructing agent's field of vision and analyze its potential in crowd simulation environment.

Keywords*: avoidance behavior, collision detection, crowd simulation, autonomous agent*

1. Introduction and Background

Crowd Simulation is a complicated system. Throughout years, there are many development approaches introduced that is called crowd modeling. They are segregated by the different approach taken on defining the virtual environment with the crowd agents. Furthermore, crowd simulation comprises of many elements and one of them is crowd behavior. Crowd behavior is a system that provides actions to the autonomous agents so that it can react to its virtual environment. It adds a sense of realism to the crowd livelihood as if each of the agent has a sense of intelligent that able them to make decision making upon their reaction their surroundings. One of the most basic crowd behaviors is Collision avoidance. Generally Collision avoidance is a mechanism of which the agent will avoid any agent from colliding and avoid intersection with static obstacles. There is a study that distinct collision avoidance as an avoidance mechanism between dynamic objects and obstacle avoidance as a avoidance mechanism between dynamic with static obstacles[1]. However in this paper we will maintain collision avoidance as a general avoidance behavior for both static and dynamic obstacles.

1.1 Cellular Automata

In order to understand the architect of crowd behavior, it is essential to understand its crowd model. There are many approaches of crowd modeling and the most common are Social Force, Cellular Automata (CA) and Rule Based. CA is a common model for crowd simulation in the early computer game development especially for a strategy and turn based games. CA is based on spatial space defragmentation of the virtual environment. It is segments into where it is called as cells [2]. In order to avoid agents intersecting with each other, CA can define the cell to allow one agent to occupy only one cell at a time. Thus by adapting this approach, CA will guarantee free collision/intersection between agent and any static object that define in occupied cells. Although CA is simple compare for many other crowd modeling, however it is not suitable to simulate dense situation since it cannot visualize push or body contact between agents.

Received December 24, 2012; Revised March 3, 2013; Accepted March 10, 2013

1.2 Social Force

Social force was introduced by Helbing that incorporate Newton's law into crowd simulation [3]. It functions as collision avoidance and ensures free intersection between agents. Moreover, social force able to simulate push effect and body contact between particles where CA could not perform. It is a straight forward algorithm to implement in crowd simulation, thus it can simulate a large amount of crowds. However, it is difficult to integrate social force with other behavior such as path following, flee and many other. Furthermore, social force fond toward shaking movement when the agents are in high density situation or at narrow spaces.

1.3 Rule Based

In 1987, Craig Reynolds had introduced Boids that simulate flocking behavior of birds [4]. The simulation is realistic and able to imitate flocking behavior to an extent where each bird has their own independent behavior. Each individual can perform three distinctive actions which are cohesion, separation and alignment. This rule based model is extensible and able to create complex behavior. Throughout the years many researchers introduced their expansion of crowd simulation such as ViCrowd [5] and ClearPath [6] which are based on Craig Reynolds's work. In 1999, Reynolds had extended his work by introducing Steering Behavior into his crowd simulation [7]. This work is important as far as collision avoidance is concern. Collision avoidance was introduced in steering behavior that dedicates only to perform avoidance maneuver action for autonomous agent. However, developing crowd simulation using rule based approach is complicated compare to CA and social force. This is due to the fact that designing behavior for this crowd model need to be concise and yet comprehensive as one behavior may relate to another.

2. Crowd Simulation Design Criterion

According to crowd simulation design criterion (which are flexibility, extensibility, execution efficiency and scalability [8]), rule based is more fulfilling in comparison with other crowd model. Nevertheless, execution efficiency and scalability are depending on the complexity of the behavior algorithm. Although rule based is more complicated in term of its development, it offer more flexibility and extensibility compare to CA and social force. Thus, rule based model is more suitable when designing sophisticated behavior.

Table 1. The Differences Between Crowd Models Pertaining To The Collision Handling

Crowd Model	Flexibility	Extensibility	Scalability	Execution
CA	Rigid to Space partitioning	Based on space expansion	Large	Fast
Social Force	Rigid to Newton's Law	No	Large	Fast
Rule Based	*Continuum and Based on Agent decision*	*Yes*	*Medium*	*Medium*

Designing realistic crowd behavior can be a complicated task. As the crowd simulation getting more realistic, crowd behavior obviously will be more complex and hence affecting the computational cost for computer processor and memory. However, the solution does not necessary solve with more memory and faster processor. It also can be done by simplifying the algorithm. Effectiveness and efficiency are the fundamental design objectives to be considered in a real-time simulation. To maintain the interactive rate performance, the trade-off between precision and speed execution must be balance according to the application [9].

3. Adapting Steering Behavior

Steering Behavior which was introduced by Reynolds is one of the best examples of distributive crowd behavior [1]. Distribution of crowd behavior basically comprises of basic steering behavior and combination those. As for example, flocking behavior is comprises of three basic behaviors which are cohesion, separation and alignment. Distribution factor in rule based will allow it to be combined and thus able to create sophisticated and emergence behavior. Table 2 is the examples of Basic and Combine steering behavior.

Table 2. Example of Basic And Combined Steering Behavior [1], [7]. [10]

Basic Steering Behavior	Combined Steering Behavior
-Seek and Flee	-Crowd path following
-Pursue and evade	-Leader following
-Wander	-Unaligned collision avoidance
-Arrival	-Queuing
-Obstacle avoidance	-Flocking
-Collision avoidance	-Seek and Following
-Containment	
-Wall following	
-Path following	
-Flow field following	
-Cohesion	
-Separation	
-Alignment	

In this paper we will focus on collision avoidance behavior as it is relating toward our research focus. Collision avoidance generally perform avoidance maneuver for the agents from intersecting or colliding with obstacles in the virtual environment. It is a fundamental behavior in crowd simulation because it's been with many other combination of basic behavior in order to create more complex behavior. However, collision avoidance itself is a combination of two basic behaviors which are avoidance with static obstacle and avoidance with dynamic obstacle. According to some researcher, avoidance with static obstacle is known as Obstacle Avoidance and avoidance with dynamic obstacle is known as collision avoidance [1]. Figure 1 is an example of combined steering behavior in openSteer C++ library for seek and flee that incorporate collision avoidance and obstacle avoidance [11].

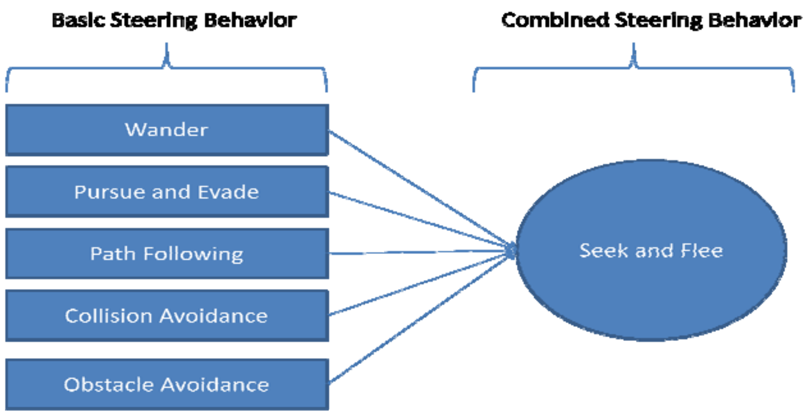

Figure 1: Example of the Structure Of Combined Steering Behavior

3.1 Collision Avoidance behavior description

In order to maintain the believability of crowd simulation, it is normal that each agent should not intersect with each other and not intersect with other object as well. This is for the purpose to visualize the solidity of the correspond object in virtual environment. Usually there will be two types of collision avoidance; that response to static obstacles and dynamic obstacles. However, the mechanics of these two collision avoidances are the same which consist of Construction of agent's perception, collision detection/prediction, and collision response.

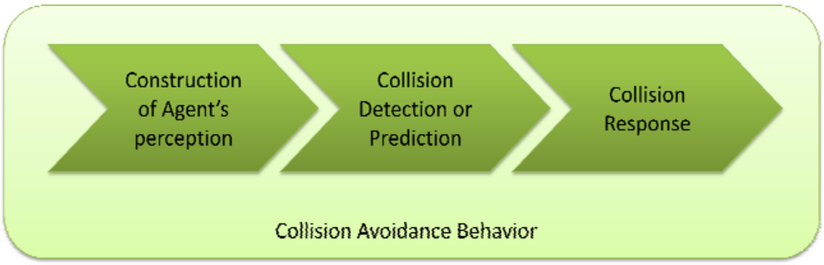

Figure 2. Collision Avoidance Behavior Mechanics

Construction of agent's perception is the first process of collision avoidance behavior. It is about creating a sensor-like area to detect intersecting objects so that the agent would avoid from colliding. There are many approaches of designing the sensor such as using ray-casting, bounding volume technique, spatial partition, and Velocity obstacles technique with each of the approaches come with their collision detection algorithm. Collision detection is about collision testing between the agents and the obstacles which later on will process the collision response where in collision avoidance case is a response that moving the agent away from the obstacle. However, in this paper we will discuss about the construction of the agent's perception.

3.2 Collision Handling with Agent's Perception

The perception in collision avoidance is the field of vision of the agent. It is an area that represents a sensor to detect obstacles. Obstacle can be the agent or any object in the virtual environment. Moreover there are set of rules to be followed when testing collision in virtual environment with multi agent. This is for the purpose to maintain free collision and create priority avoidance between agent with agent and agent with obstacles. Table 3 is the collision testing rules between obstacles (agent and other object) and perception.

Table 3. Collision Testing Rules

Main Object	Collision Testing Object	Test Validity
Perception	Obstacle	True
Obstacle	Perception	False
Perception	Perception	False
Obstacle	Obstacle	True

Collision testing is usually a series of test between each object's edges or vertices. Complex objects apparently have more edges and vertices thus having more testing. This will cause more processing resources and will affect the efficiency of the whole process. Therefore, it is important to simplify the object representation so that the testing is lesser and faster. Generally, both perception and obstacle will be define as bounding volume or basic primitive shape such as sphere and box. Figure 3 is an example of agent with field of vision.

4. Velocity Perception for Collision Handling

There are many methods on constructing agent's perception. In openSteer that simulate pedestrian in steering behavior, the perception is based on the construction of bounding volume and ray-casting [7][1][11]. There are also works on constructing the perception based on spatial partitioning and using robotic adaptation on obstacle avoidance such as reciprocal velocity approach[12][6]. However, there is lack of research on designing the perception based on agent's dynamic focal point. So as to human perception, the simulation of agent's dynamic perception will able to produce more variant reaction toward collision avoidance behavior. Figure 4 and 5 demonstrate the differences between fixed perceptions with dynamic perception.

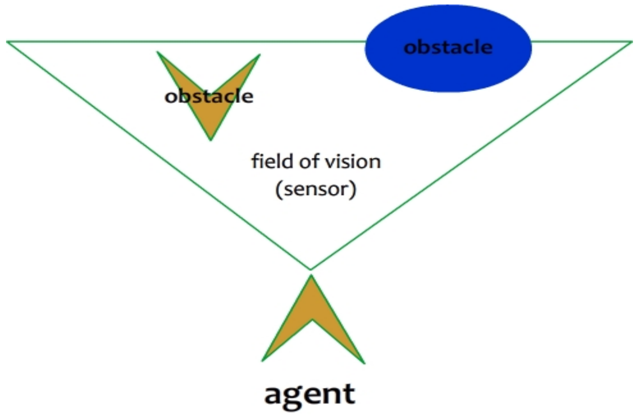

Figure 3. Agent's Field of Vision

Figure 4. Collision Avoidance using Fixed Perception

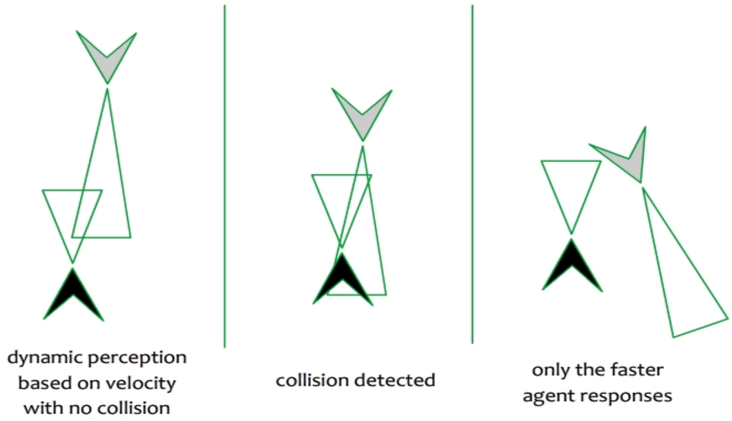

Figure 5. Collision Avoidance using Velocity Perception

4. Discussion and Future Work

In this paper we present additional feature to autonomous agent that the dynamic toward agent's perception focal point may result a different reaction toward collision avoidance behavior. Thus in some scenario such as in figure 5, the faster agent may react first since it has longer focal point relative to its velocity. In addition, the slower does not have to response since its perception does not detect any obstacle by having shorter focal point hence it does not need to go for unnecessary collision testing. The dynamic perception may also be extended it possibility by able to generalize avoidance maneuver behavior since its collision detection generalizing both static and dynamic obstacles as only one type of obstacle.

In our future work, we would like to propose our construction of perception field in crowd simulation application. We also would like to investigate the other possibilities that can affect human focal point and therefore become agent's arguments toward its dynamic perception.

References

[1] I Millington, J Funge. *Artificial Intelligence for Games, Second Edition*. Morgan Kaufmann Publishers Inc., 2009.

[2] J Dijkstra, J Jesurun, H Timmermans. A multi-agent cellular automata model of pedestrian movement. *Pedestrian and Evacuation Dynamics*. 2002; 173–180.

[3] D Helbing, L Buzna, A Johansson, T Werner. Self-Organized Pedestrian Crowd Dynamics: Experiments, Simulations, and Design Solutions. *Transportation Science*. 2005; 39(1): 1–24.

[4] CW Reynolds. Flocks, herds and schools: A distributed behavioral model. 1987; 25–34.

[5] SR Musse, D Thalmann. A Model of Human Crowd Behavior: Group Inter-Relationship and Collision Detection Analysis. *Proc. Workshop of Computer Animation and Simulation of Eurographics.* 1997; 39–51.

[6] SJ Guy, J Chhugani, C Kim, N Satish, M Lin, D Manocha, P Dubey. ClearPath: highly parallel collision avoidance for multi-agent simulation. *Proceedings of the 2009 ACM SIGGRAPH Eurographics Symposium on Computer Animation*. New Orleans. Louisiana. 2009; 177–187.

[7] C Reynolds. Steering Behaviors for Autonomous Characters. *Game Developers Conference.* San Jose. California. 1999; 763–782.

[8] S Zhou, D Chen, W Cai, L Luo, MYH Low, F Tian, VSH Tay, DWS Ong, BD Hamilton. Crowd modeling and simulation technologies. *ACM Trans. Model. Comput. Simul.*, 2010; 20(4): 1–35.

[9] C Ericson. *Real-Time Collision Detection (The Morgan Kaufmann Series in Interactive 3-D Technology)*. Morgan Kaufmann. 2005.

[10] N Pelechano, JM Allbeck, NI Badler. Virtual Crowds: Methods, Simulation, and Control," *Synthesis Lectures on Computer Graphics and Animation*. 2008; 3(1): 1–176.

[11] OpenSteer. Available: http://www.red3d.com/cwr/steer/.

[12] J van den Berg, MC Lin, D Manocha. Reciprocal Velocity Obstacles for Real-Time Multi-Agent Navigation. *IEEE International Conference on Robotics And Automation*. 2008; 1928–1935.