# Fish Schooling Animation System for Constructing Contents of Cyber Aquarium

Jong-chan Kim* · Eung-kon Kim*

ABSTRACT

The goal of researching a proper crowd animation is to design system that is satisfied with the reality of scenes, performance of system, and interaction with users to show the crowd vividly and effectively in virtual underwater world. In this paper, we smartly expressed the behavior patterns for flocks of fish in virtual underwater and we made up for the weak points in spending time and cost to produce crowd animation. We compared with the number of mesh, the number of fish, the number of frame, elapsed time, and resolution and analyzes them with the fish behavior simulating system. We developed a virtual underwater simulator using this system.

Keywords

Crowd Animation, Virtual Underwater, Behavior Pattern, Flocking Simulation

## Ⅰ. Introduction

Real world is a swift changing world and there are too many people, animals, and transportation devices. It is important to set up the crowd behavior patterns to represent for moving crowd naturally in cyber space. Crowd animation means a character animation technique that places focus on the reality of scenes, performance of system, and interaction with users to provide numerous moving characters in cyber space much more vividly, effectively, and easily. The term of 'crowd' means a set of someone gathering in a place or moving somewhere. The simulation of these crowd behaviors for applying to animation, cyber space, or games is crowd simulation. Although there are crowd in a same place and in a same purpose, the individual of the crowd has each different thought and behavior. Many researchers have been interested in representing these behaviors naturally matrix of early crowd simulation was an animal flocking model proposed by Reynolds in 1987. After 10 years, in1997, Benford, Greenhalgh, and Lloyd proposed a model of crowds in cyber space, and Brogan and Hodgins proposed a model of group behaviors, showing active researches. In 1999, Musse, Garat, and Thalmann proposed a method to control crowds in real time, and Schweiss, Musse, Garat, and Thalmann developed an architecture to control crowds using rule based behavior system. When we produce the animation of these characters by the method to express the movements of many objects depending on hands, we need much more time and cost. The study of automation for animation should be needed to generate crowd behavior scenes realistically and effectively. Though the processing a scene of crowd and the behavior system of crowd, related to the processing techniques of crowd behavior in VR contents, have been implemented so far, the research

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for developing the natural crowd behavior simulator can not be still satisfying. Therefore, we should develop the fish behavior simulation to take the role of each behavior and react to each other to present the objects in cyber underwater. In this paper, we smartly expressed the behavior patterns for flocks of fish in cyber underwater and we made up for the weak points in spending time and cost to produce crowd animation. We compared with the number of mesh, the number of fish, the number of frame, elapsed time, and resolution and analyzes them with the fish behavior simulating system. We developed a cyber underwater simulator using this system.

## II. Related Works

### 1. Tendency of researching crowd animation

Reynolds released his study about flocking simulation at SIGGRAPH, for the first time in computer graphics in 1987. He simulated flocks of bird and automatized the movement of flocking birds, applying to particle system considered a bird as a particle. Because it is difficult to simulate every object in a group, he generated flocking behaviors according to local approach among them[1][2][3]. The point of flocking simulation is classified into three. There are collapse avoidance among birds, speed adjustment among birds, approach tendency to move to the center of flock. Tu modeled a virtual underwater world based on physical world. There are many artificial fish in the virtual underwater world. He modeled bodies of fish for these fish and made the fish move automatically in the virtual underwater world using AI[4][5]. The elements of design for artificial fish are follows:

- Physics: Spring-mass model
- Locomotion: Motor controllers
  (Force of tail and pectoral fin for orientation)
- Perception: Visual sensor
- Behavior: Behavior routine by mental state
  (Hungry, Libido and Fear constant)

### 2. Rule based behavior method and event triggered approach method

Anyone who does something has a cause. If the cause of behavior is offered, the result follows as a behavior. Rule based behavior technique comes from this approaching method. This method defines the rule of behavior according to the conditions if the object in the cyber world is triggered by any requirements. Therefore, the behaviors which are not in the defined rules can not be done. In event triggered approach method, the movement of whole group has group attributes and the movement of individual object has partial attributes. When an object is given a specific event, the object do the work according to the condition. And this partial attribute can affect the behavior of all the group members. This method is different from rule based behavior method. Rule based behavior is similar to some basic actions, but event triggered approach method uses the event occurred by users randomly.

## III. Ecosystem of virtual underwater world

An ecosystem is all the plants and animals that live in a particular area together with the complex relationship that exists between them and their environment. The concept of underwater ecosystem emphasizes the relationship among organs or the relationship of organs and physical environment. Underwater ecosystem is divided into predators and preys. When two kinds of fish have the relationship of eating and being eaten, those who eats others are predators, those who are eaten by others are preys. In their relationship, the more the number of predators are, the less that of preys are, and the less

predators, the more preys.When any animals were killed by predator or parasite, those who hurt others are natural enemies of those who are hurted. Predators wouldn't eat other predators. So predators don't detect predators, run away, swim in groups, and mate fish. Predators cruise constantly under water and don't leave to anywhere. Preys consist of small fish generally. Preys have the behavior patters such as schooling each other and fleeing from predators. Schooling behavior of fish is to swim to the same direction. All the fish adjusts its speed or direction with members of a group and moves automatically keeping at a certain distance. When a group of preys meet obstacles, they do avoid action immediately. They divide into two groups and if the obstacle disappears, the fish gather again. While early preys wander from place to place in underwater, if they encounter a predator, they swim to leader or divide into two groups to flee somewhere. The danger can decrease when preys flee from predator, gather in a group, or put behind predator. Fig 1. shows predator, shark and prey, small fish.

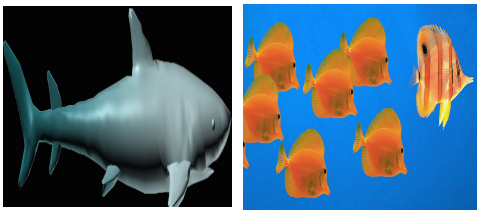


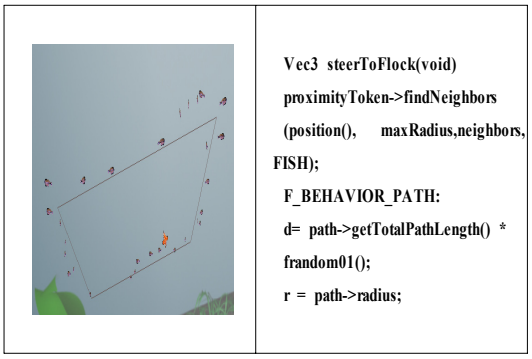
Fig. 1 Predator and preyer

## Ⅳ. Fish Schooling Algorithm

Behavior rules of crowd defined the behavior patterns of fish around them as follows :

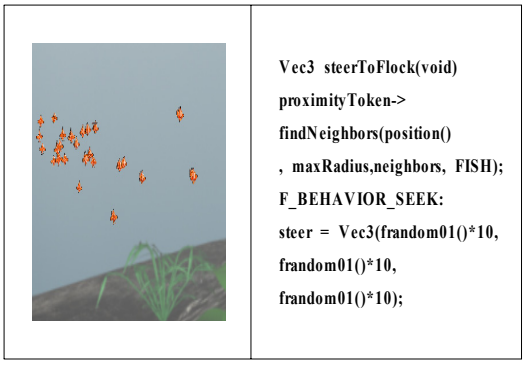
- Wander : Fish are freely moving without any rules.
- Separation : Fish are moving away one another.
- Alignment : Fish are moving in keeping a certain form.
- Cohesion : Fish are moving to one point.
- Hunt : If a fish is predator, it chases to prey.
- Flee : Fish are running away from predator.
- Collision /Avoidance : Fish are avoiding the other fish or land obstacles.
- Path Following : Fish are moving to a certain direction.
- Leader Following: Fish are following the fish of leader.
- Seek : Fish are wandering to find prey.
- Pursuit : Fish are searching for prey.

Fig. 2 is the display of path follower behavior. Fig. 3 is the display of seek behavior. Fig. 4 is the display of leader follower behavior.



```
Vec3 steerToFlock(void)
proximityToken->findNeighbors
(position(), maxRadius,neighbors,
FISH);
F_BEHAVIOR_PATH:
d= path->getTotalPathLength() *
frandom01();
r = path->radius;
```

Fig. 2 Path follower behavior display



```
Vec3 steerToFlock(void)
proximityToken->
findNeighbors(position()
, maxRadius,neighbors, FISH);
F_BEHAVIOR_SEEK:
steer = Vec3(frandom01()*10,
frandom01()*10,
frandom01()*10);
```

Fig. 3 Seek behavior display

```
Vec3 steerToFlock(void)
proximityToken->
findNeighbors(position(),
maxRadius,neighbors, FISH);
F_BEHAVIOR_LEADER:
if(this != leader)
return cohseionW*2 +
alignmentW/2.2+
Vec3::forward*1.5;
return separationW +
Vec3::forward * 1.5;
```

Fig. 4 Leader follower behavior display

## V. Performance analysis of FSM animation system

Each object have not only simple geometric information, but also much semantic information and the meaning of interaction in 3D environment for constructing virtual underwater world.

Fish Schooling Animation System used Windows XP OS, Intel Pentium D 2.8Ghz Processor, GeForce 7600GS in nVidia, DDR2 256M Graphic Card, and 1GByte DDR2 SDRAM. We used Microsoft Visual C++ 6.0 and OpenGL API. as developing tools. We analyzed the number of fish, the number of mesh, the number of frame, elapsed time, and resolution to measure the performance of Fish Schooling Animation System (FSM).

We checked how many the function called, when rendering has finished and SwapBuffers function was called, to count number of frames per second. Schooling behavior animations applied in this experience are wander, separation, alignment, cohesion, flee, path following, leader following. Fig.5 shows the fish schooling behavior simulator Interface.

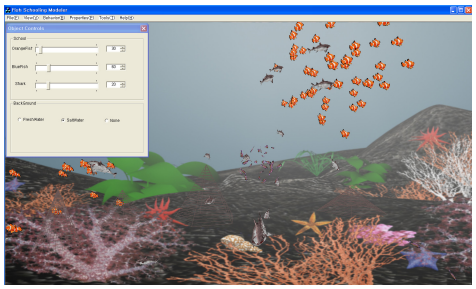


Fig. 5 Fish schooling behavior simulator interface.

### 1. Analysis of schooling behavior patterns

A fish to be used Wander behavior has 24 meshes. When the number of meshes is 240, the frame rate was measured 144 frame/sec in 1024*768 resolution display. When the number of meshes is 900, the frame rate was measured 72 frame/sec. When the number of meshes is 4800, the frame rate was measured 24 frame/sec. To use Separation behavior, a fish has 24 meshes. When the number of meshes is 240, the frame rate was measured 132 frame/sec in 1024*768 resolution display. When the number of meshes is 900, the frame rate was measured 36 frame/sec. When the number of meshes is 4800, the frame rate was measured 12 frame/sec. Figure 6,7 shows the results schooling behavior for Wander and Separation.

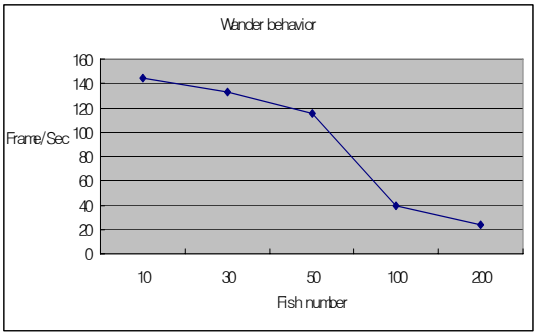



Fig. 6 The results wander behavior

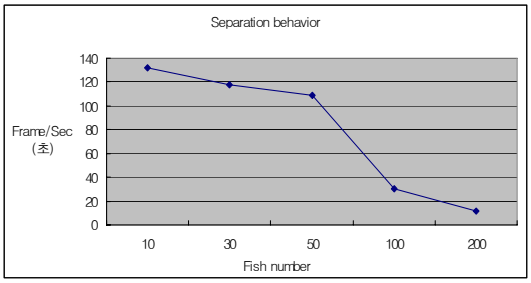



Fig. 7 The result separation behavior

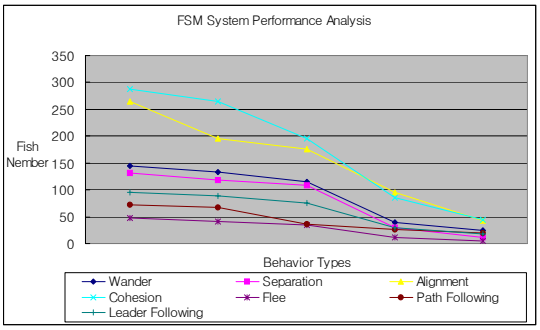



Fig. 8 Results of analysis for FSM behavior patterns.

## 2. Performance Analysis

Making each movements of schooling behavior possible needs our efforts. The charge of cost and time with past crowd animation was great, but FSM animation system will reduce the cost and time. The results of experiments for FSM animation system shows that the frame rates are more excellent than 30 frames required in visual media like character animation and film.

| Fish number<br>Schooling behavior | 10 | 30 | 50 | 100 | 200 |
|---|---|---|---|---|---|
| Wander | 144 | 133 | 115 | 40 | 24 |
| Separation | 132 | 118 | 109 | 30 | 12 |
| Alignment | 264 | 196 | 176 | 96 | 42 |
| Cohesion | 288 | 264 | 196 | 86 | 45 |
| Flee | 48 | 41 | 35 | 12 | 5 |
| Path Following | 73 | 68 | 36 | 26 | 20 |
| Leader Following | 96 | 88 | 75 | 29 | 18 |

Table 1. FSM System frame numbers

Table 1 presents the results of measurement for frames per second, Fig. 8displays the results of analysis for FSM behavior patterns.

## Ⅵ. Conclusion and Future Works

The reality of scenes, performance of system, and interaction with users are needed to construct the cyber underwater. In this paper, we developed a fish schooling animation system that was applied by basic schooling and generated group events dividing prey from predator through self-control behavior. Users can generate slider and input dialogue box easily and simulate the crowd behavior interactively according to input parameters. We define some basic rules for behavior patterns of schooling fish, and show the movement of fish among them. The system has easy-use interface and absorbs users in virtual underwater world on PC. In the future works, the environment in 3D around fish such as the movement of seaweed and the current will have to display realistically. The system should model objects using crowd behavior algorithm and matching fluid expression with environment and control crowd behaviors automatically in real time. Special effects including fluid expression, 3D modeling, andbodily sensation should be developed to provide schooling fish with realistic expression, actuality and diversity of contents organization. As users become interested in the entertainment of actual practice, this system will help underwater world to be great contents using VR techniques and will help to develop a new business model in IT industries.

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