Leadership and Self-Propelled Behavior based Autonomous Virtual Fish Motion

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Outline

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- Methodology
  - Cohesion
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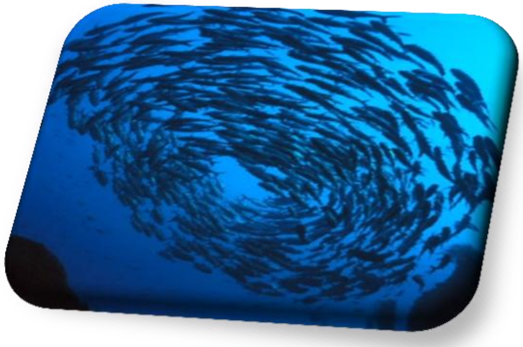
V I D E O

Introduction

- Flocking
  - Collective motion of a large number of self-propelled agents.
  - Stateless Algorithm

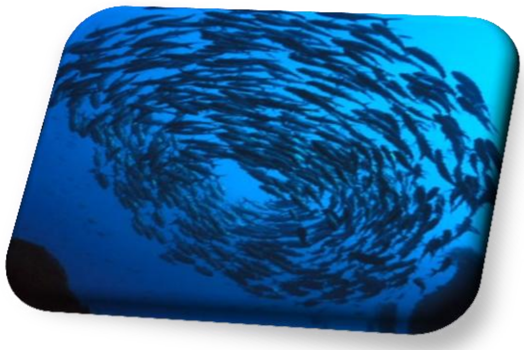
- Motivation
  - Steering behaviors
  - Leadership
  - Simulation with interactive interface



Introduction

- Application
  - Low cost duplication in movies
  - Developing real computer game environments

- Contribution
  - Natural and beautiful
  - Lower memory requirement
  - Enhancing experiences of user



Related Works

- Boids
  - C. W. Raynolds [Raynolds87]
  - Approach to computer simulation of flocking/herding/schooling behavior.
  - Implementation of a “control structure” for each individual.

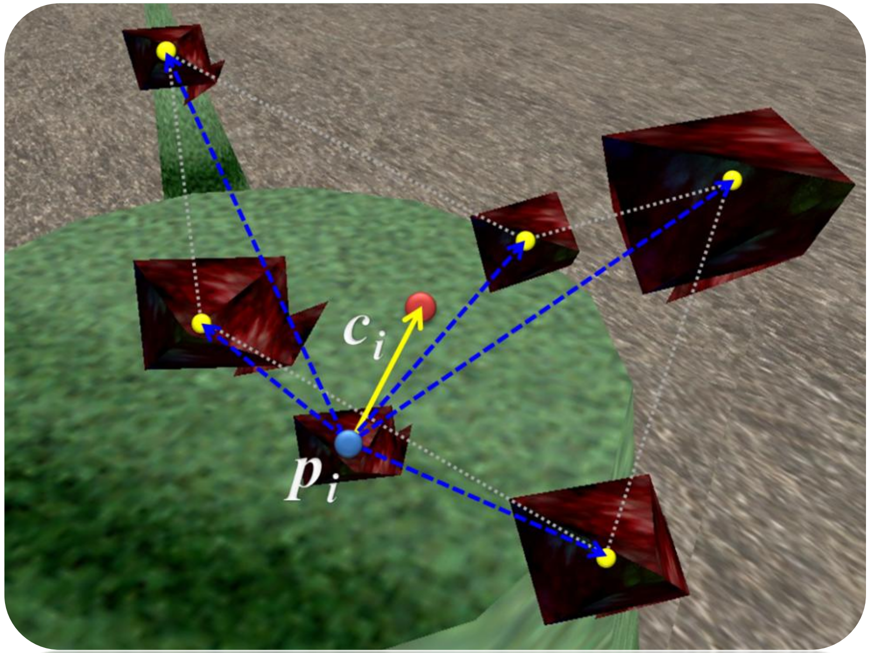
- Effective leadership and decision making in animal groups
  - Iain D. Couzin, et al [Couzin05]
  - Animal Groups make consensus decisions by performing data analysis of group motion.

Problem Statement

- Flocking
  - Moving as a group
  - Keeping distance from each other
  - Avoiding obstacles or enemies
  - No information is given to

- Leadership
  - Simulating a group movement towards a given point.
  - The goal information is only given to a leader.
  - Other starshes are also affected by the leader step by step.
  - All starshes move to the goal together at last.

Methodology



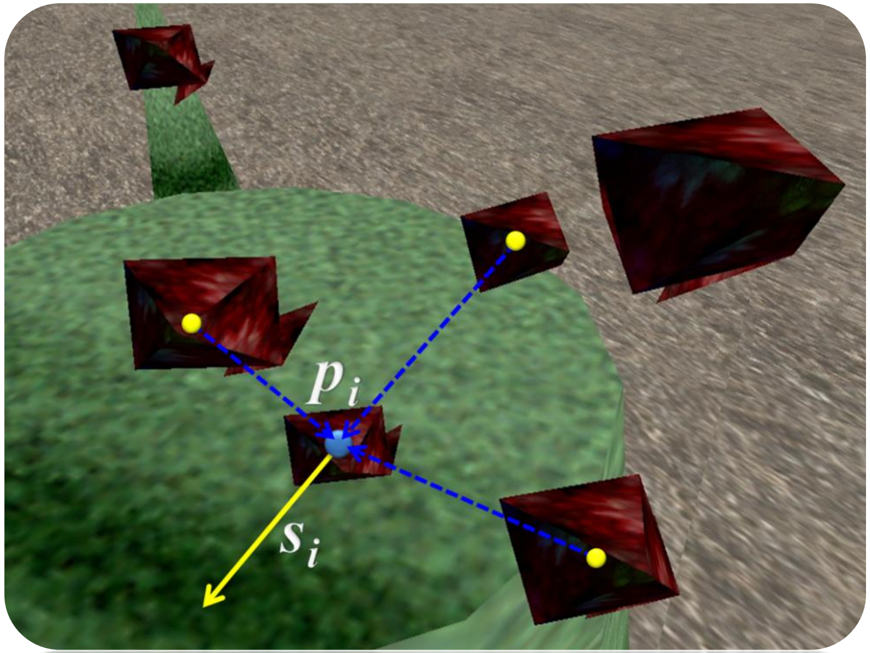
1. Cohesion

$$c_i(t+\Delta t) = k_c \sum_{j \neq i} \frac{p_j(t) - p_i(t)}{|p_j(t) - p_i(t)|}$$

c_i	:	**Cohesion vector**
k_c	:	Weight of cohesion
p_j	:	Starshes' position
p_i	:	Each starsh's position

- Starshes attempt to proceed into the center of its group.
- Each starsh turns its direction to the other starshes within its defined range excluding itself and approach to make a flock.

Methodology



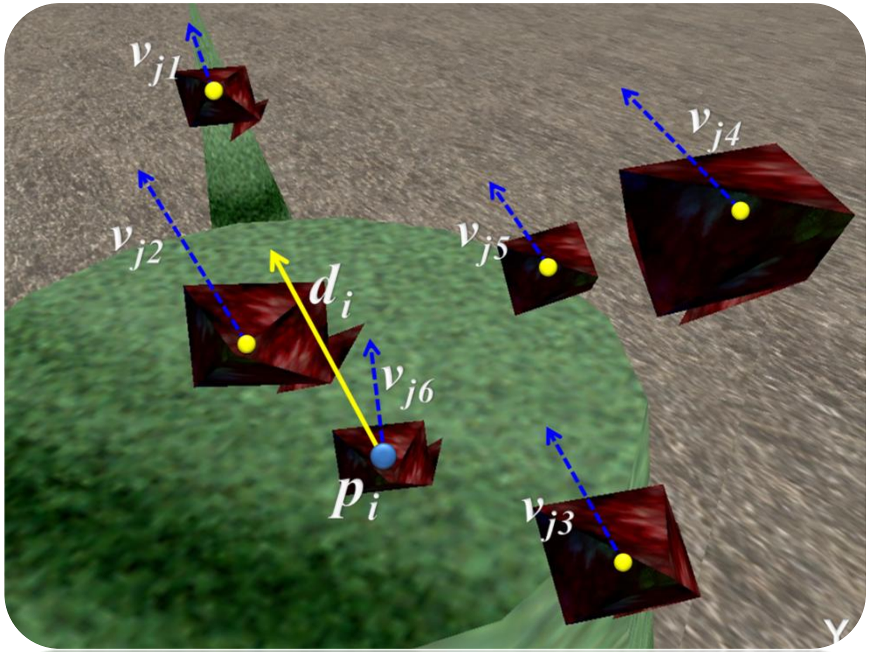
2. Separation

$$s_i(t+\Delta t) = -k_s \sum_{j \neq i} \frac{p_j(t) - p_i(t)}{|p_j(t) - p_i(t)|}$$

s_i	:	**Separation vector**
k_s	:	Weight of separation
p_j	:	Starshes' position
p_i	:	Each starsh's position

- Starshes tend to keep a distance from the other starshes from colliding with another.
- If a starsh is within a defined range from another starsh, it takes the separation vector to get out of the scope.

Methodology



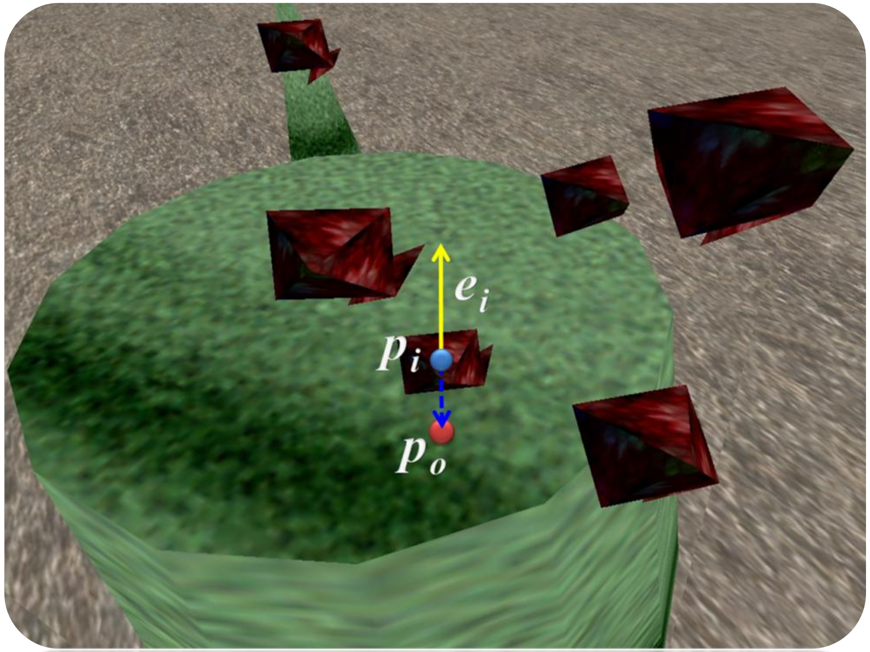
3. Velocity

$$d_i(t+\Delta t) = k_d \sum_{j=1} \frac{v_j(t)}{|v_j(t)|}$$

d_i	:	**Velocity vector**
k_d	:	Weight of velocity
v_j	:	**desired velocity of each starsh at moment**

- Starshes maintains the same velocity with the normalized sum of velocity of other starshes within its local neighborhood including itself.
- It makes a group of starshes as it is marching with a same direction.

Methodology



4. Escape

$$e_i(t+\Delta t) = k_e \frac{p_i(t) - p_o}{|p_i(t) - p_o|}$$

e_i : Escape vector

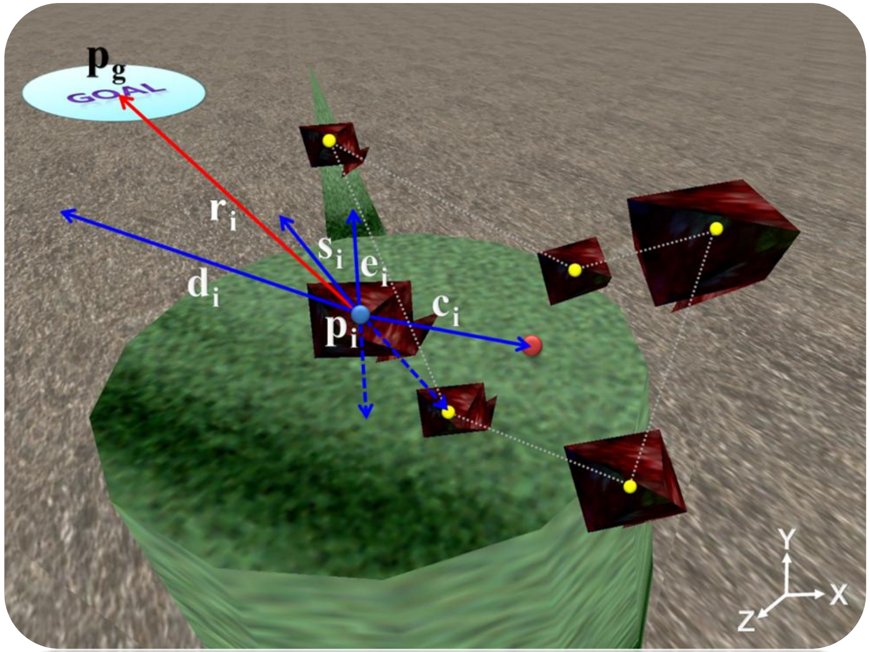
k_e : Weight of escape

p_i : Each starsh's position

p_o : position of an obstacle

- Each starsh regulates its movement when it finds an obstacle within its defined range to prevent collision.
- This can be also applied when starshes find their enemies.

Methodology



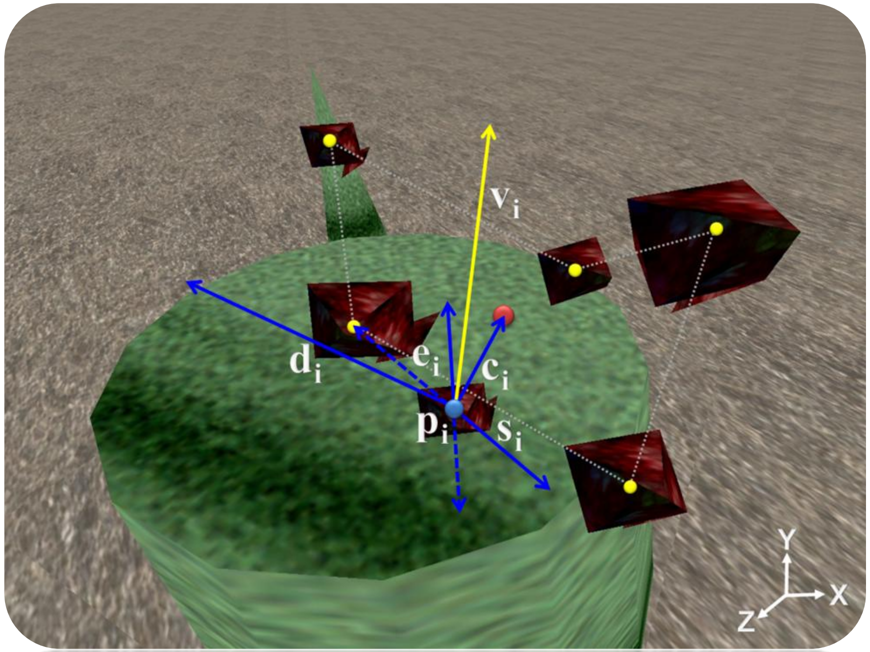
5. Goal

$$r_i(t + \Delta t) = k_r \frac{p_g - p_i(t)}{|p_g - p_i(t)|}$$

- r_i : **Goal vector**
- k_r : Weight of goal
- p_i : Each starsh's position
- p_g : position of the goal

- An additional vector towards the goal is given to the leader.
- It influences other starshes and leads them to the goal.

Methodology



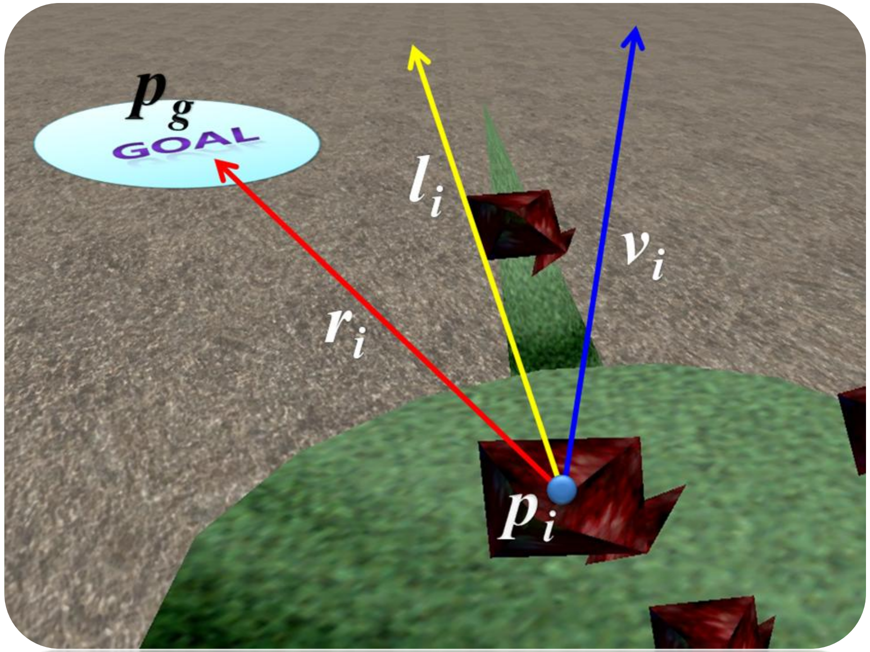
Starsh Vector

$$v_i = c_i + s_i + d_i + e_i$$

$\boldsymbol{v_i}$	:	**Starsh vector**
c_i	:	Cohesion vector
s_i	:	Separation vector
d_i	:	Velocity vector
e_i	:	Escape vector

- The desired direction of a general starshes which is not a leader is the sum of all the vectors.

Methodology



Leader Vector

$$l_i = r_i + v_i$$

l_i : Leader vector

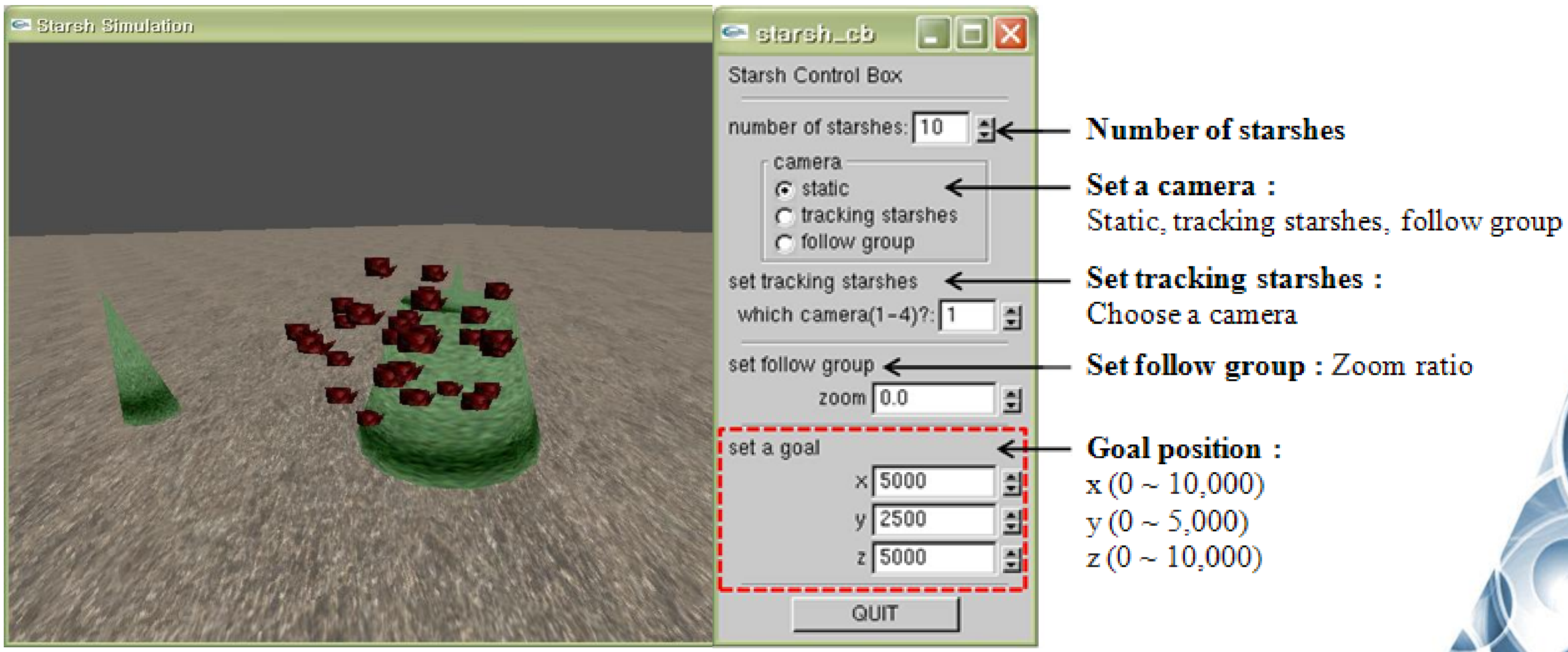
r_i : Goal vector

v_i : Starsh vector

- The desired direction of leader starsh is the sum of starsh vector and goal vector

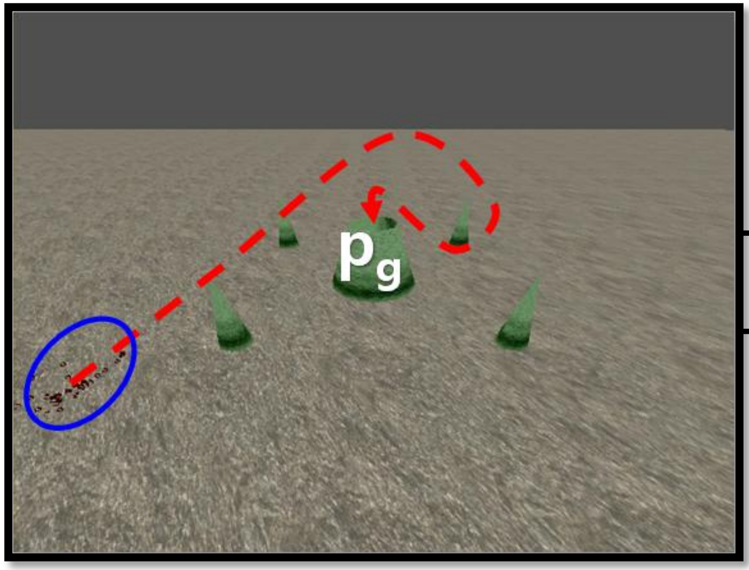
Experimental Results

- OpenGL based simulation program with a control box.
- Using control box, we can set the number of starshes, camera, zoom ratio, and the goal position.

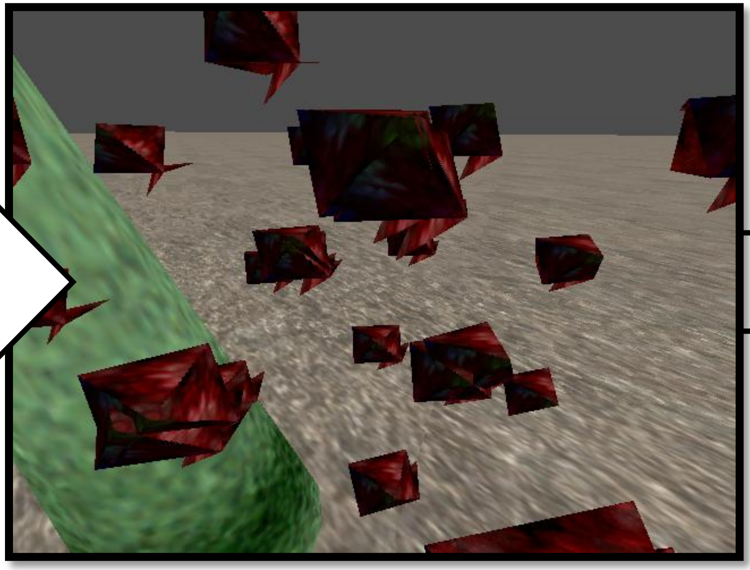


Experimental Results

- In the beginning, starshes are initially generated at the same point and have different velocities.



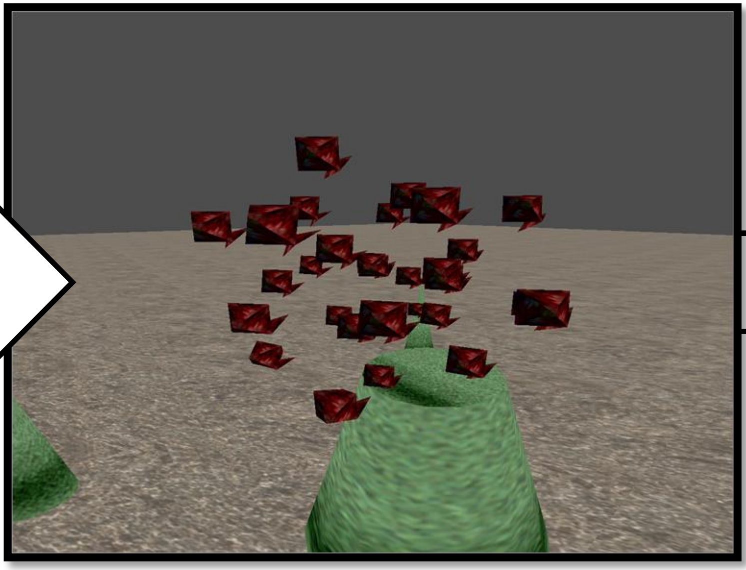
The motion progress



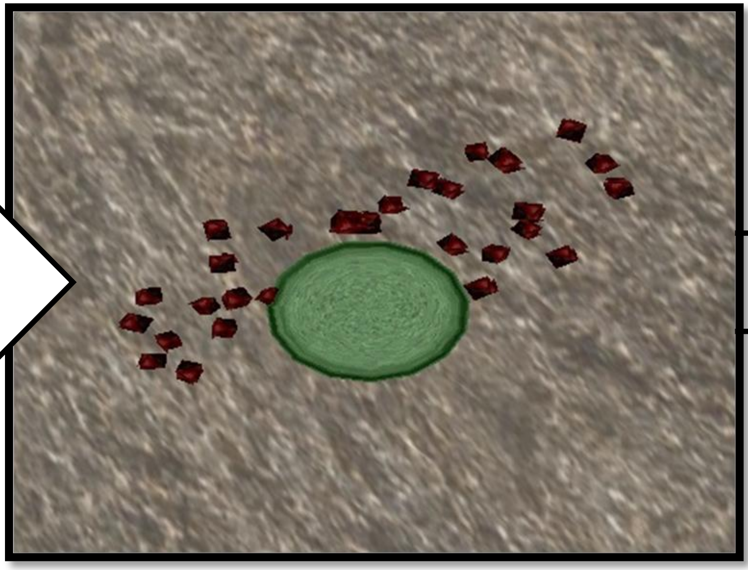
Cohesion and separation

Experimental Results

- After that, the five behavior vectors are applied to the shoal motions.



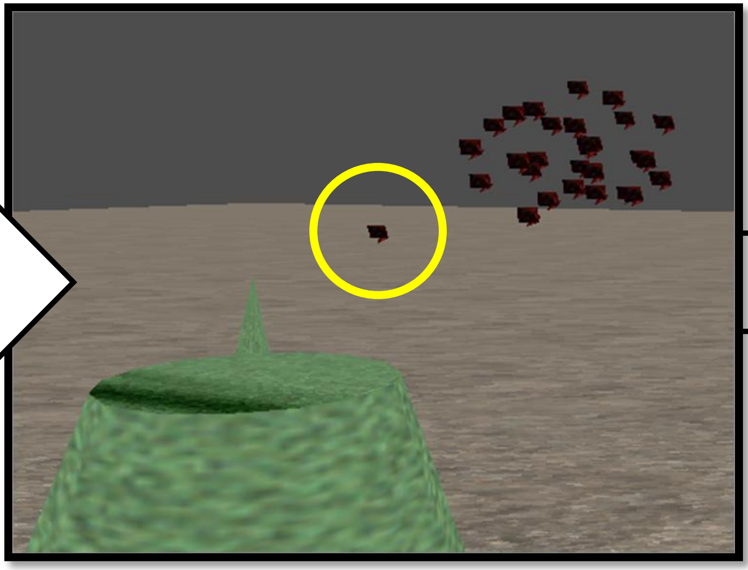
Match Velocity



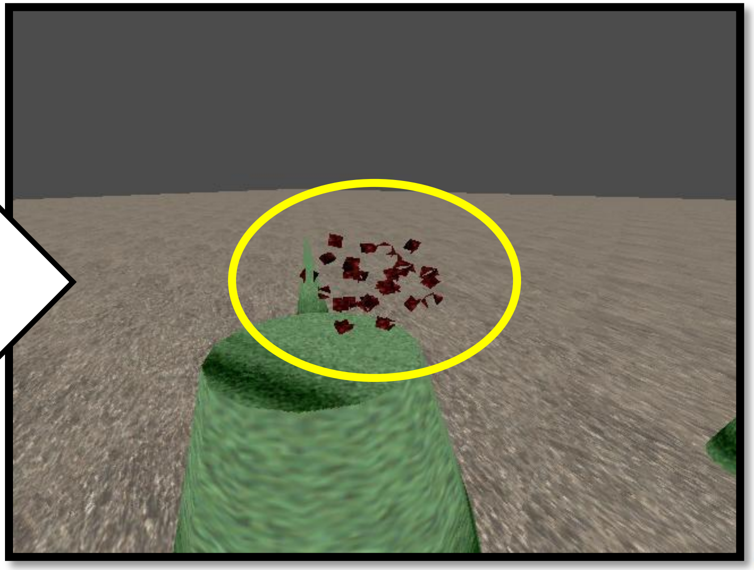
Escape from an obstacle

Experimental Results

- Leader starsh is attracted to the given goal position and leads other starshes to the goal.
- As time goes by, all starshes are affected by the leader starsh and go toward the goal step by step.



Leader starsh



The goal stage

Conclusion

- Virtual fish designed by the steering behaviors.
- Leadership in a shoal motion.
- Interaction of the simulation program.
- Natural and beautiful
- Lower memory requirement.
- Developing computer games and movies.

D E M O

Q & A