Starlings
Boids Flocking Mathematical Model
COP 290

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Contents

1 Objective

Murmuration refers to the phenomenon that results when hundreds, sometimes thousands, birds in a flock fly in swooping, intricately coordinated patterns through the sky. Starlings are migratory birds who show this phenomenon very well.

2 Boid's Model

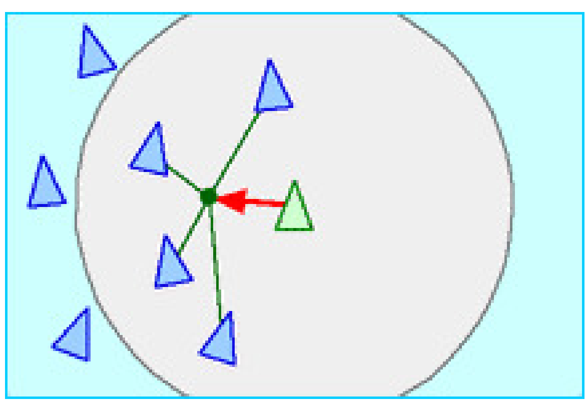
Each Boid has a certain set of properties associated to it -

- **Position** - (x, y) coordinates
- **Velocity** - (v_x, v_y)
- **Acceleration** - (a_x, a_y)
- **Boid Size** - Size of boids on canvas
- **Max Speed** - Limits max Speed of the boids prevent unreal velocities
- **Max Force** - Limits max force applied on boid to stop extreme cohesion or separation

3 Boid's Properties

These are the set of constraints under which the flocking movement occurs. These properties are only applied on the boids within a certain radius of vicinity.

3.1 Cohesion



Cohesion is the tendency of a boid to remain with its neighbours by moving toward the average position of the group of neighbours. Effect of cohesion on velocity of boid can be derived as a component of force towards the centre of position of group as a function of distance of boid from the centre of group of its neighbours

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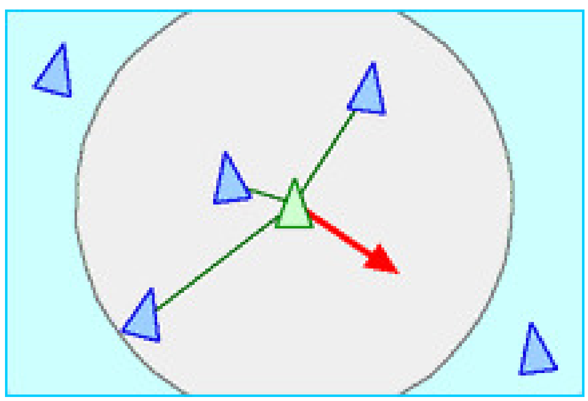
Data : A boid.
Result : The course of the boid in updated.
$goal \leftarrow (0,0)$;
$neighbours \leftarrow$ getNeighbors(boid);
for each $nBoid$ in $neighbours$ **do**
  $goal \leftarrow goal + positionOf(nBoid)$
end for
$goal \leftarrow goal \ / \ neighbours.size()$;
$steerForward(goal, boid)$;

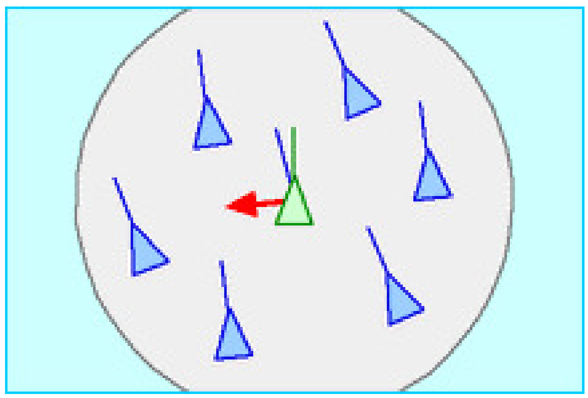
3.2 Separation



Separation is the tendency of a boid to maintain a particular minimum distance from its neighbours. This repulsive force in opposite direction from a body to boid. A body can be another boid or an obstacle. It can be calculated as a function of inverse of the distance between a body and the boid.

Data : A boid.
Result : The course of the boid in updated.
$goal \leftarrow (0, 0)$;
$neighbours \leftarrow$ getNeighbors(boid);
for each $nBoid\ in\ neighbours$ **do**
    $goal \leftarrow goal + positionOf(Boid) - positionOf(nBoid)$
end for
$goal \leftarrow goal\ /\ neighbours.size()$;
$steerForward(goal, boid)$;

3.3 Alignment



Alignment is the tendency of aligning the velocity of a boid with the direction of average velocity of the fellow neighbour's. Alignment deciding force for boid can be calculated as a function of angle of average velocity of neighbouring boids and velocity of the boid.

Data : A boid.
Result : The course and velocity of the boid is updated.
$dCourse \leftarrow 0$;
$dVelocity \leftarrow 0$;
$neighbors \leftarrow$ getNeighbors(boid);
for each $nBoid\ in\ neighbours$ **do**
    $dCourse \leftarrow dCourse + getCourse(nBoid) - getCourse(boid)$
    $dVelocity \leftarrow dVelocity + getVelocity(nBoid) - getVelocity(boid)$
end for
$dCourse \leftarrow dCourse\ /\ neighbours.size()$;
$dVelocity \leftarrow dVelocity\ /\ neighbours.size()$;
$boid.addCourse(dCourse)$
$boid.addVelocity(dVelocity)$

4 Other Functions used in Program

4.1 Display

Generates graphics of boid/obstacle to be displayed on canvas.

4.2 Run

Applies all the properties of boid in one step.

4.3 Flock

Applies result of force due to above properties to the boid.

4.4 Update

Maintains movement of boid, changes its velocity and position.

4.5 Bounce/ Wrap

Allows boids to reflect off the walls or wraparound to the other side.

5 Conclusions and Improvements

These properties initially theorized by Prof. Craig Reynolds lack in some departments to simulate real life starling behaviour:-

- Starlings only notice their counterparts in front of them rather then all around them. To tackle this problem we should also include field to view into account, allowing them to only interact with boids in a certain degree of angle in front of them. This will allow them to move in V-formation.

- When are boids are moving in an congested environment, they have to interact with a large amount of counterparts. However if we limit this to a certain amount of boids, their movement would be more fluid.

References

Craig W. Reynolds. Flocks, herds, and schools: A distributed behavioral model. In *Computer Graphics*.

F. Heppner and U. Grenander. A stochastic nonlinear model for coordinated bird flocks. 1990.