Flocking

Nat Guy

(Some slides borrowed from John See at Multimedia University, Malaysia)

Flocking

- Moving together in coordinated groups
- Birds in flocks, fish in schools, land animals in herds
- Murmuration of starlings:
  - https://www.youtube.com/watch?v=eakKfY5aHmY

Applications to Games

- NPCs can move in cohesive groups
  - Meadow of grazing sheep
  - Hunting flock of birds
  - Ants, bees, fish
- Other types of computer-controlled NPCs
  - Humans, orcs, catapults
  - Squadrons of aircraft
  - Friendly soldier squads
  - Crowds of people loitering

Behavioral Modeling of Flocking

- Craig Reynolds developed flocking model in 1986
- “Boids” model
- Presented at SIGGRAPH 1987: “Flocks, Herds, and Schools: A Distributed Behavioral Model”
- Later went on to do flocking animation for DreamWorks and Sony

Examples in Media

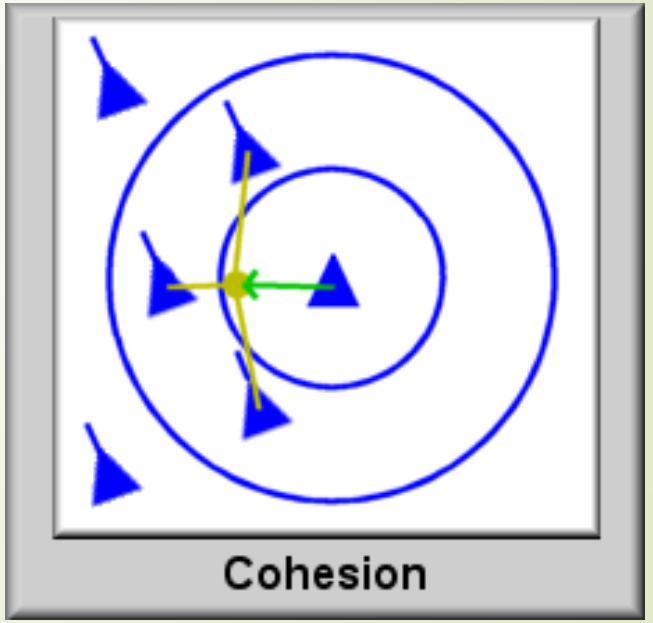
- First used for bats and penguins in Batman Returns (1992)
  - https://www.youtube.com/watch?v=Mo_1rAaj7FE#t=5
  - https://youtu.be/jCVwdeAobYc?t=15
- Jurassic Park (1993)
  - https://www.youtube.com/watch?v=nM-RPO10aPY
- Assassin's Creed (various)
  - https://www.youtube.com/watch?v=ACWIRMePpxk#t=597
- Countless other films and games
- Autonomous robotics:
  - GRASP Lab at UPenn:
    - https://www.youtube.com/watch?v=UQzuL60V9ng#t=27

Simple Rules of Flocking

- Leaderless flock of agents
- Each agent calculates its movements independently
- Agents can only see a few agents around them, their “neighborhood”
- 3 simple rules:
  - Cohesion
  - Alignment
  - Separation

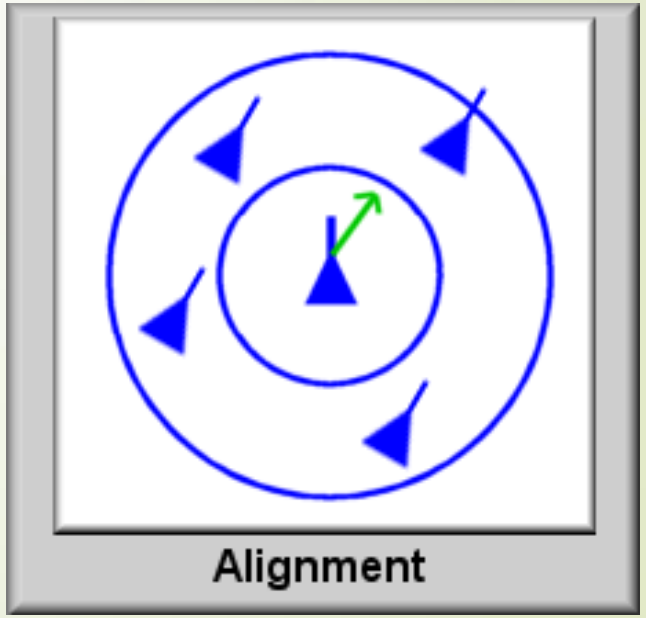
Cohesion

- Each unit steers towards the average position of its neighbors
- Units are attracted to one another as long as they are within range



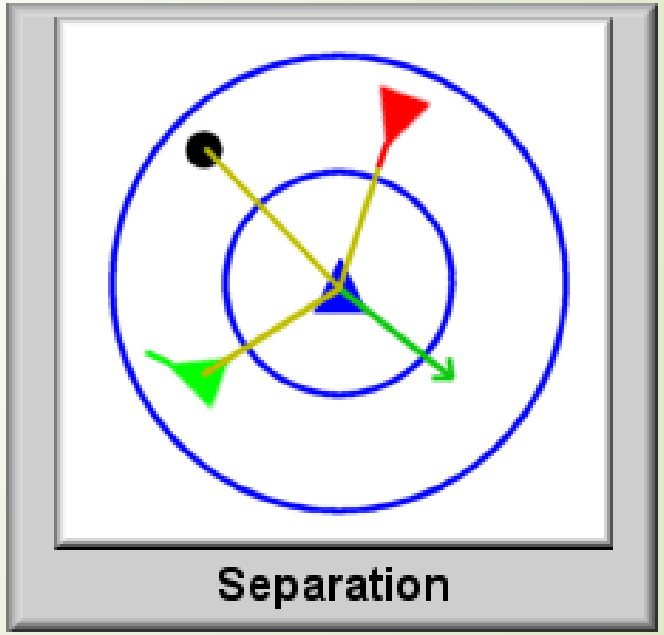
Alignment

- Each unit steers so as to align itself to the average heading of its neighbors
- Matches direction of units around it that it can detect



Separation

- Each unit steers to avoid hitting its neighbors
- Units are repelled by non-member units or obstacles. Repel effect can be inversely proportional to distance from unit

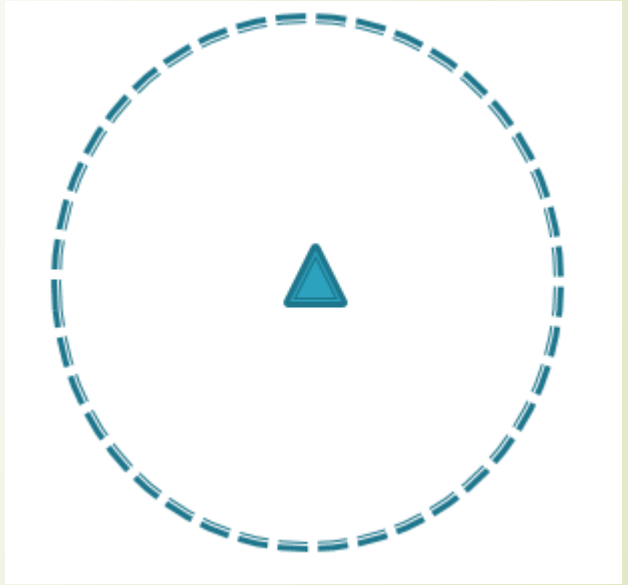


Mackerel “Baitball” Video

- https://www.youtube.com/watch?v=r1m6IKiO26c#t=82

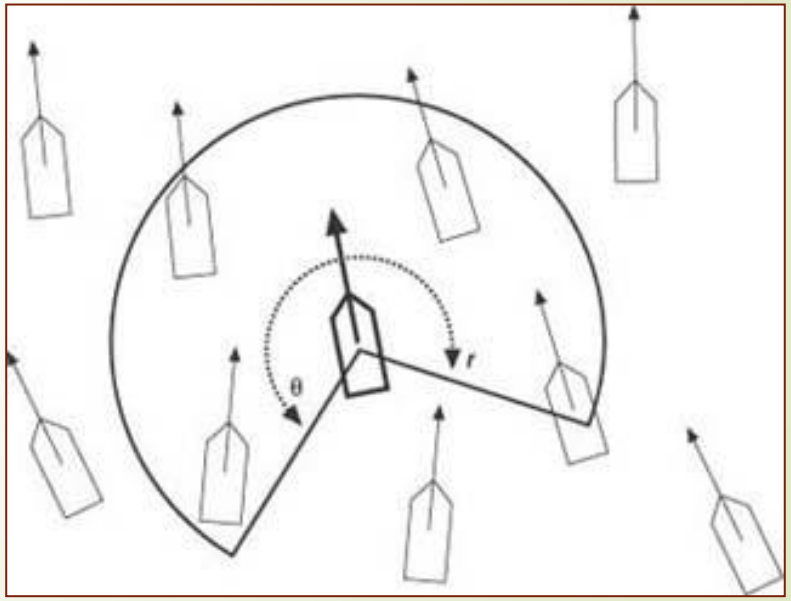
Neighborhood

- Range in which units can detect other units



Visibility

- Visibility constrained by field of view
- Also can be constrained by limited number of influencing neighbors
- Each unit is aware of its local surroundings
- Each unit does not necessarily know what the entire group is doing at any given time



Other Extensions

- Avoiding obstacles
- Avoiding predators
- Following leaders
- Making specific formations (circle, “flying V,” etc.)

Implementation

- In each game loop
  - Cycle through all units in the flock to acquire data (direction, speed, etc.) from unit's neighbors
  - For each unit, update with net steering force from the three rules
- Each unit must update its list of current neighbors each game loop

Cohesion Implementation

- Calculate **average position** – vector sum of neighbors' respective positions divided by total number of neighbors
- Determine direction to turn and angle to steer towards
- Steering force = (direction) * (steering force) * (angle of steering)

Alignment Implementation

- Calculate **average heading** – vector sum of neighbors' respective alignments divided by total number of neighbors
- Determine direction to turn and angle to steer towards
- Steering force = (direction) * (steering force) * (angle of steering)

Separation Implementation

- Steer away from any neighbor that is within view AND within prescribed minimum separation distance (i.e., too close)
- Because this steering force is corrective, direction multiplier goes the opposite way
- Separation factor can be used to increase force with smaller separations
- Steering force = (direction) * (steering force) * (separation factor)

2D Flocking Demo (written by Nat in Python)

- https://youtu.be/ipgdxQoVXWA
- Note how the flocking pink agents respond to the presence of the single green agent, once it appears.
- (Sorry about the video capture quality!)

Further Resources

- Craig Reynolds's Boids page
  - http://www.red3d.com/cwr/boids/