Motivation

- Particles systems can add nice realism to an environment
  - Fairly simplistic "rules"
  - No collision detection

- NPCs can be implemented in a similar fashion
  - Complex behavior ⇒ more-complex rules
  - Combination of "standard" and special purpose algorithms
Sample Uses of AI in Games

- Bad guys guarding something
- Bad guys looking for you
- Bad guys trying to beat you to something
- Bad guys trying to beat you (literally)
- Good guys working with you
- Other people just minding their own business

Flocks, Herds, and Schools

- A flock consists of a group of discrete boids moving in a visually complex fashion.
- There appears to be some central control, but evidence indicates that the motion is just the aggregate result of individual object motions.
- Problem
  - How do we simulate the motions of a flock in games?
Behavioral Systems

- Special instance of particle systems
- **Flock** is a group of objects that exhibit the general class of polarized (aligned), non-colliding, aggregate motion.
- **Boid** is a simulated bird-like object, *i.e.*, it exhibits this type of behavior. It can be a fish, dinosaur, *etc.*
- Allow each object to determine its own behavior

General Approach

- Each boid maintains
  - An internal state
  - A set of behaviors
- Fits very nicely into a C++ (Java, etc.)
  - **class**
    - Each boid is an instance of this class
- Three main behavioral rules
  - Separation
  - Alignment
  - Cohesion
Three Rules

- **Separation**: Steer to avoid crowding local flockmates
- **Alignment**: Steer towards the average heading of local flockmates
- **Cohesion**: Steer to move toward the average position of flockmates

Three Rules, Restated

- Avoid collisions with neighbors and obstacles
- Attempt to match velocity (speed and direction) of neighbors
- Attempt to stay close to neighbors
- These are not orthogonal
  - Collision avoidance helps establish a minimum distance to neighbors
  - Velocity matching maintains it
Boid Brain

- Each boid has access to whole scene
- Each one only considers flockmates in neighborhood
  - Typically defined using a radius
  - Think of fish in murky water, birds in fog

More Rules?

- What else could you do with this?
More Rules?

- Seek and flee
  - Food vs. Food?
- Pursue and Evade
- Wander
- Arrival
- Containment
- Wall following
- Path following
- Leader following

Problems with Behavioral Techniques

- Trade control for automation
  - Difficult to get \textit{exact} desired effect
- Solution: Follow the leader
  - How to define leader
- Solution: Use only for background
  - Use something else for foreground characters
- Need to consider \textit{every} boid
  - $O(n^2)$ complexity!
  - How can we fix this?
Behavioral Systems: Examples

- Bats and penguins in *Batman Returns*
- All battle scenes in *Lord of the Rings*
- Most battle scenes in *Star Wars*
- Add some stochastic behaviors in order to deter uniformity

References

- http://www.red3d.com/cwr/boids/
- http://www.red3d.com/cwr/steer/
- http://www.devmaster.net/articles/particle_systems/