Boids

COS 426

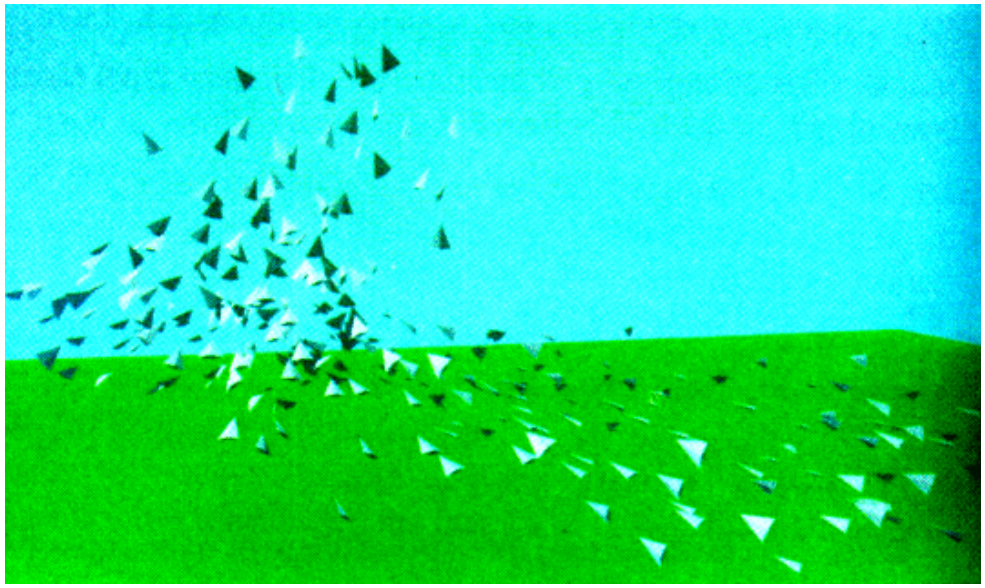
Boids

- Overall idea
  - Simulate group behavior by specifying rules for individual behavior (self-organizing distributed system)

"... and the thousands off fishes moved as a huge beast , piercing the water.
They appeared united, inexorably bound to a common fate.
How comes this unity?.. "
- Anonymous.

Boids

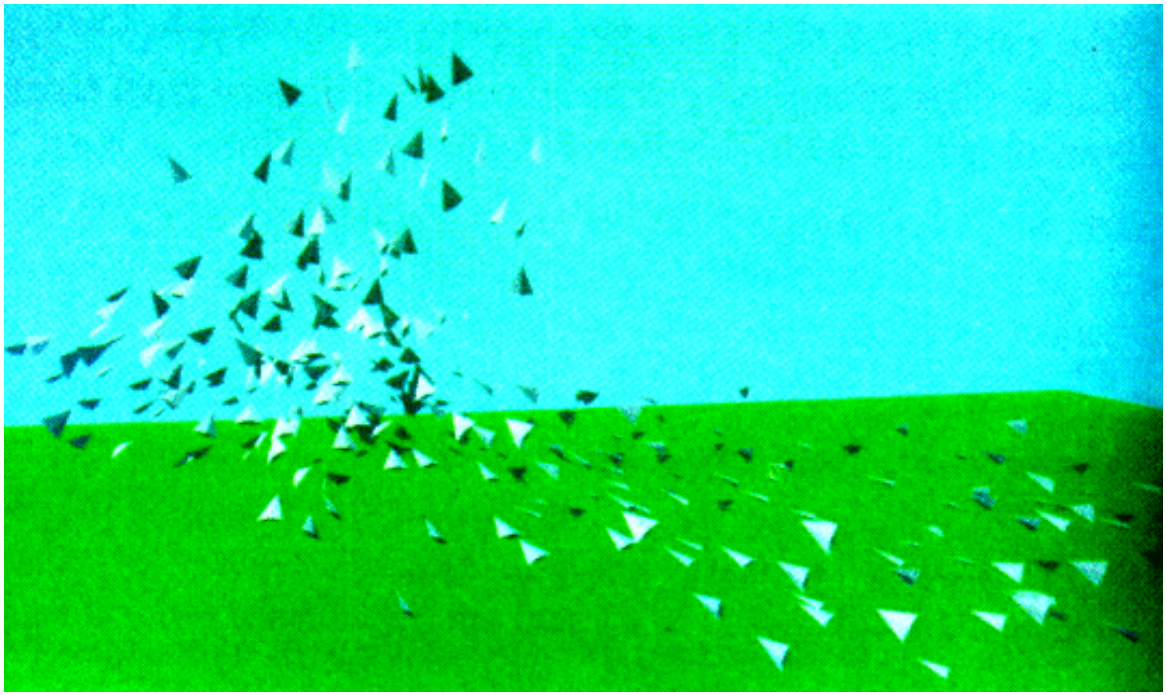
- Powerful, simple model
  - No central control
  - Only simple rules for each individual
  - Complex, emergent phenomena
  - Self-organization, swarm intelligence



Reynolds

Boids

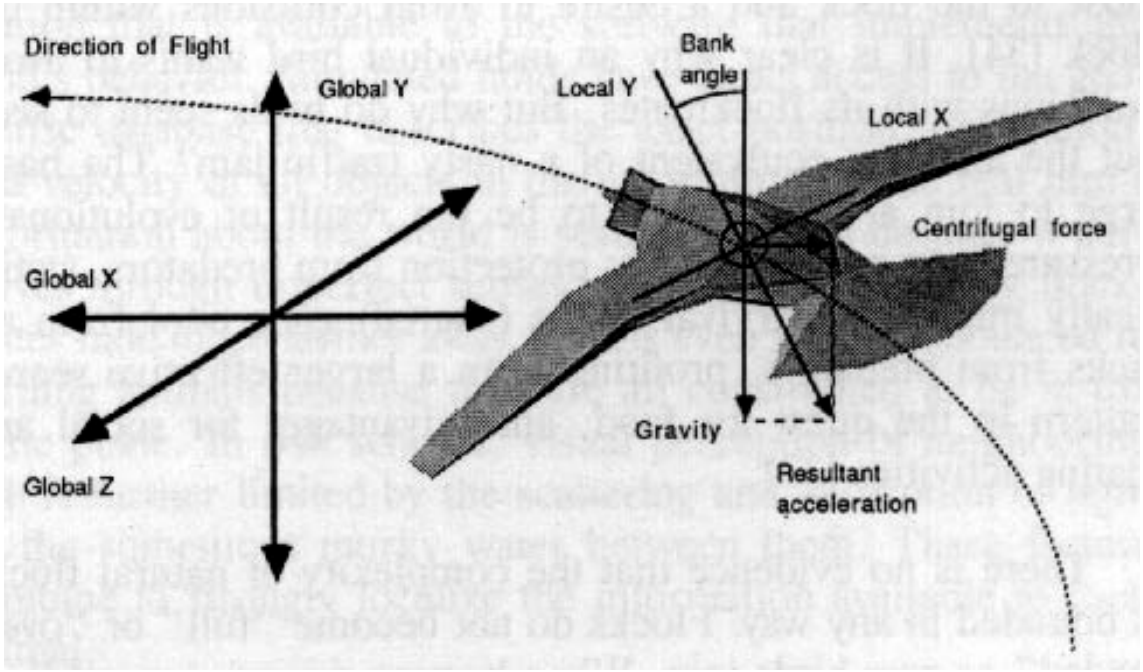
- Computer graphics motivation
  - Scripting of the path of many individual objects using traditional computer animation techniques is tedious.



Reynolds

Boids

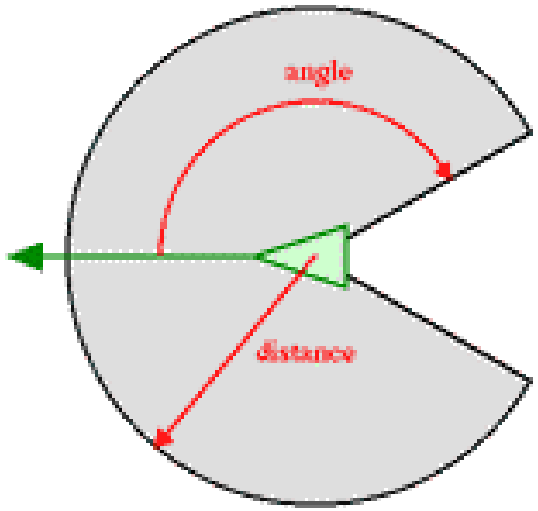
- Like a particle system, except …
  - Each boid may be an entire polygonal object with a local coordinate system (rather than a point)

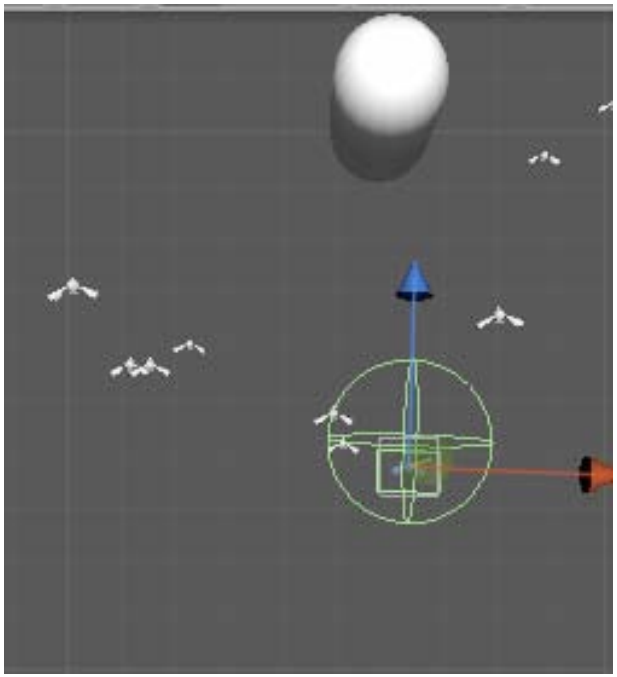


Reynolds

Boids

- Like a particle system, except …
  - Each boid can “perceive” a local region around it, e.g., a spherical neighborhood

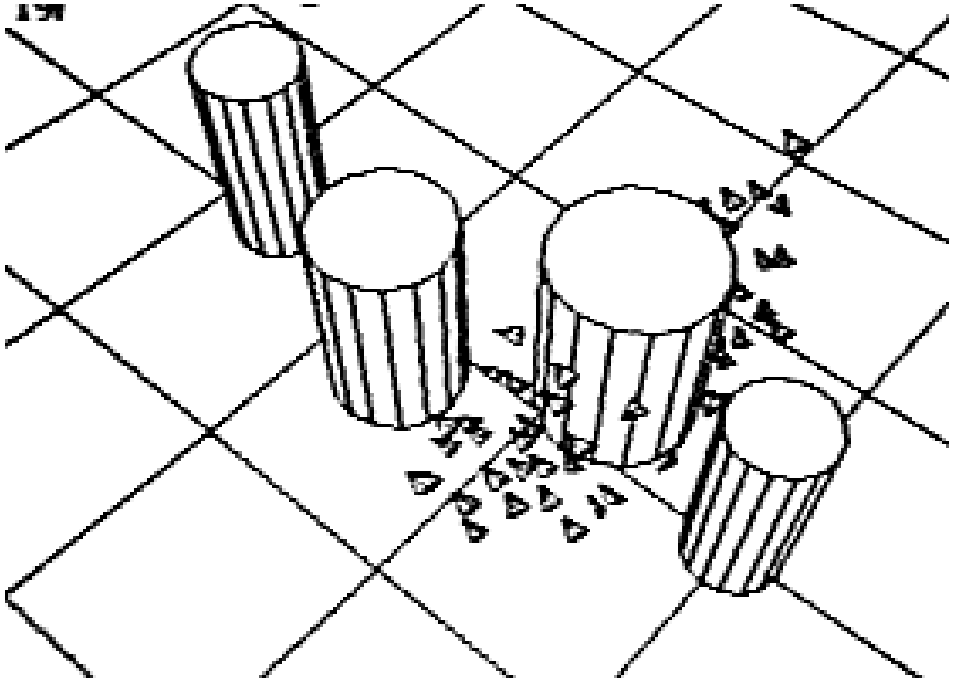




http://www.arges-systems.com

Boids

- Like a particle system, except …
  - Each boid exerts “intentional forces”



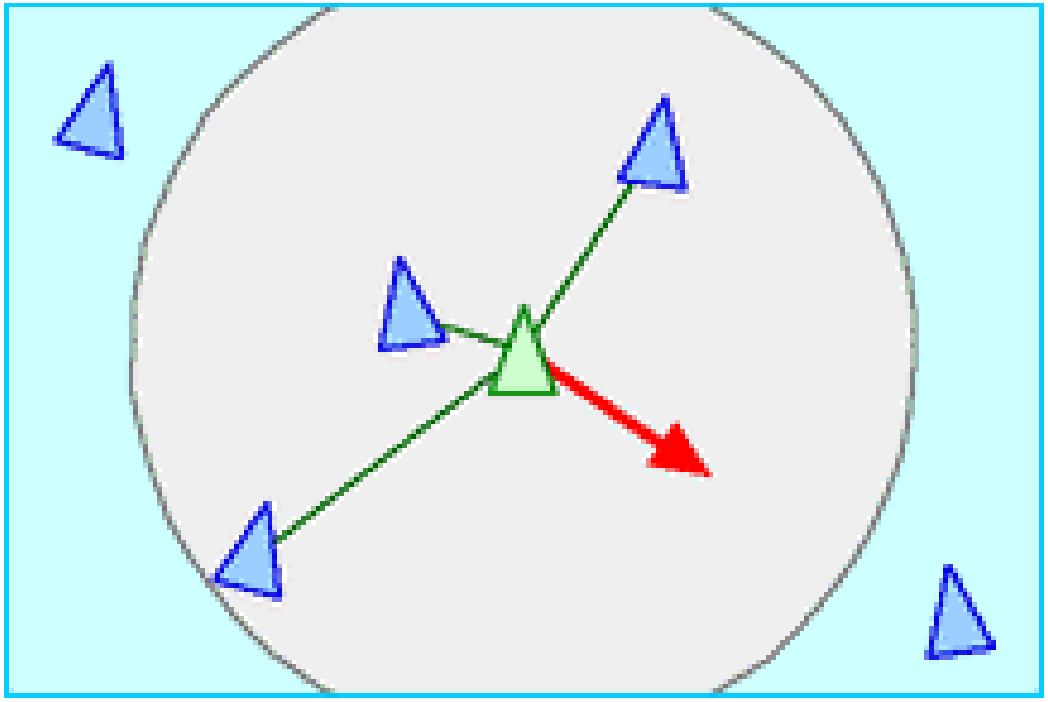
Reynolds

Flocking

- Complex flocking behaviors can be modeled with simple “intentional forces”
  - Separation
  - Alignment
  - Cohesion

Flocking – 3 Behaviors (1)

- Separation = collision avoidance:
  avoid collisions with nearby flockmates



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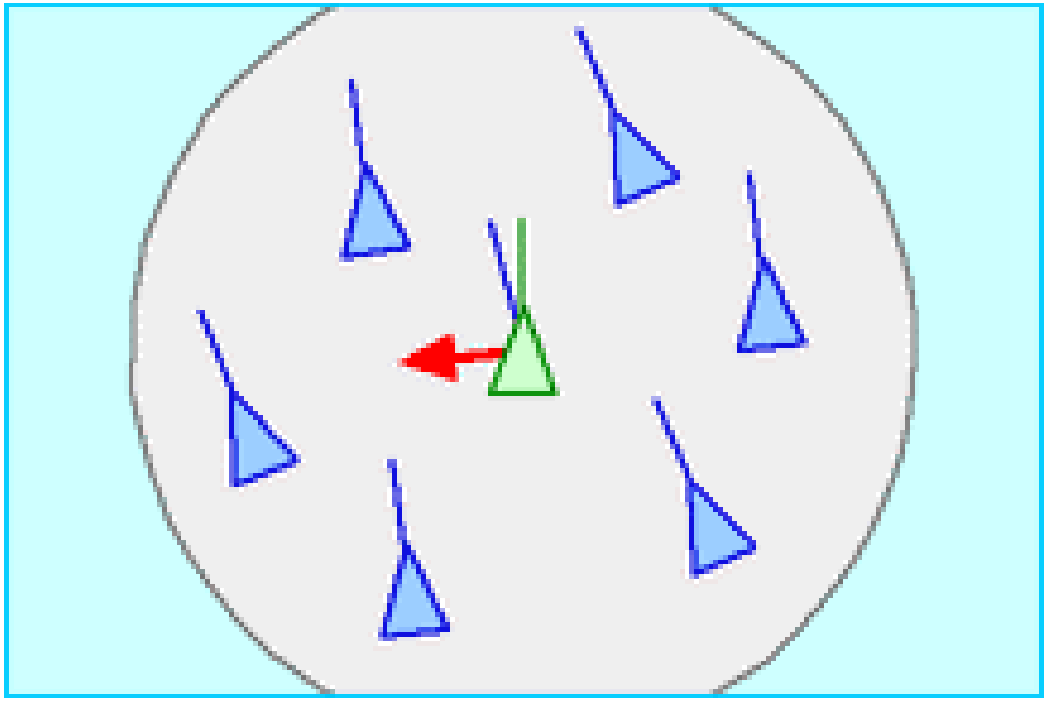
Flocking – 3 Behaviors (2)

- Alignment = velocity matching:
  attempt to match velocity with nearby flockmates



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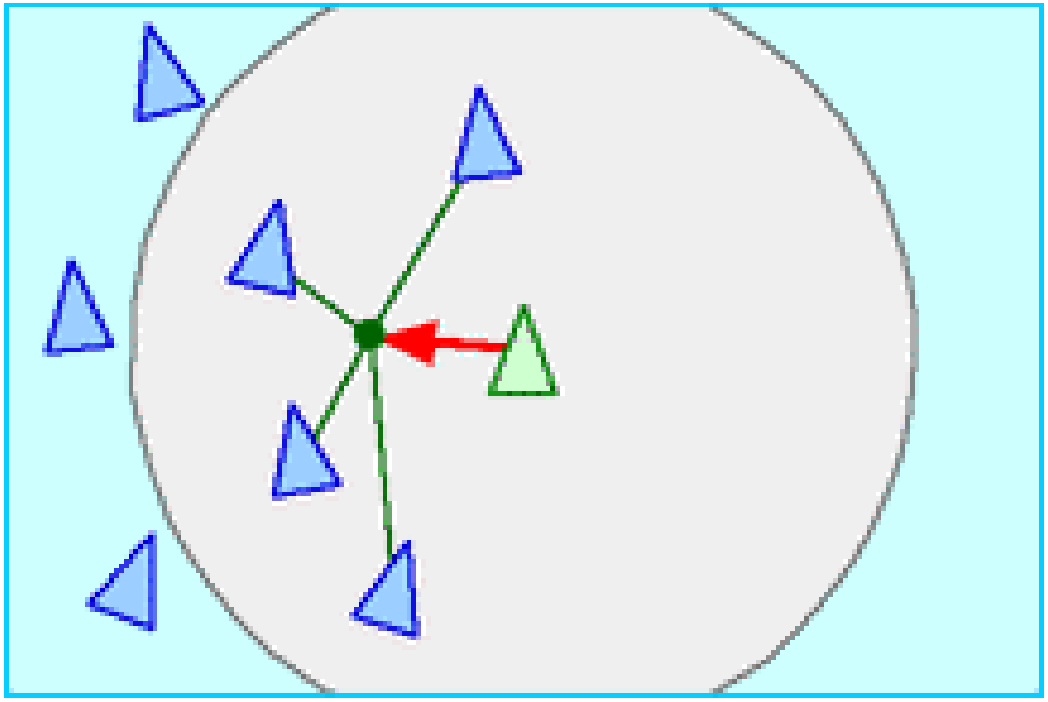
Flocking – 3 Behaviors (3)

- Cohesion = flock centering:
  attempt to stay close to nearby flockmates



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Other Examples (single behavior)

- Example behaviors
  - Seek
  - Flee
  - Evasion
  - Pursuit
  - Wander
  - Arrival
  - Obstacle Avoidance
  - Containment
  - Wall Following
  - Path Following

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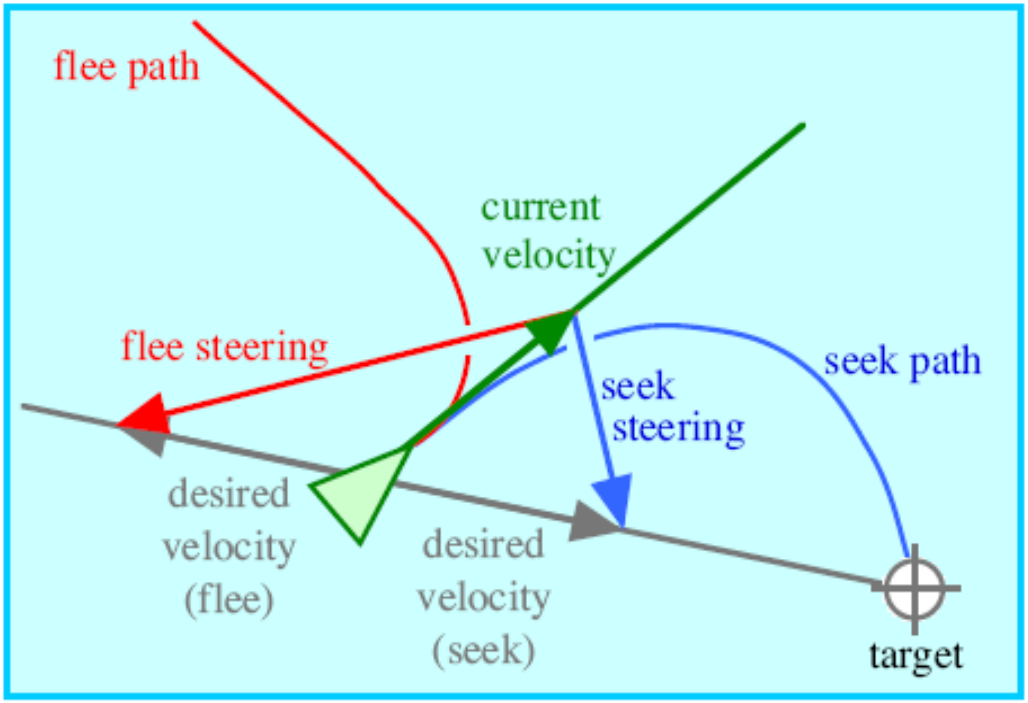

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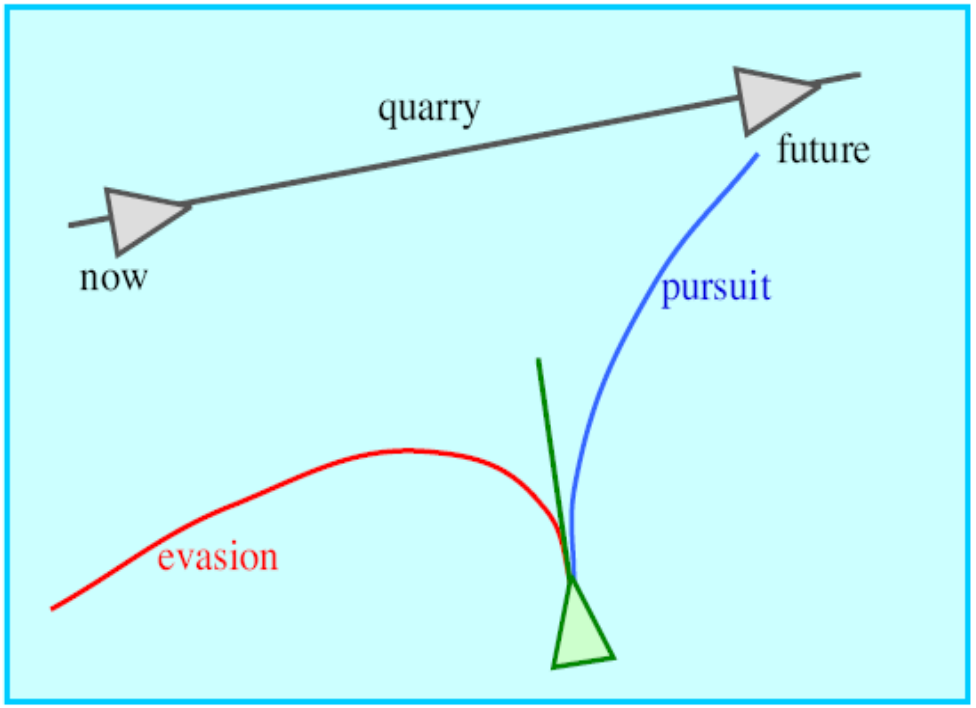

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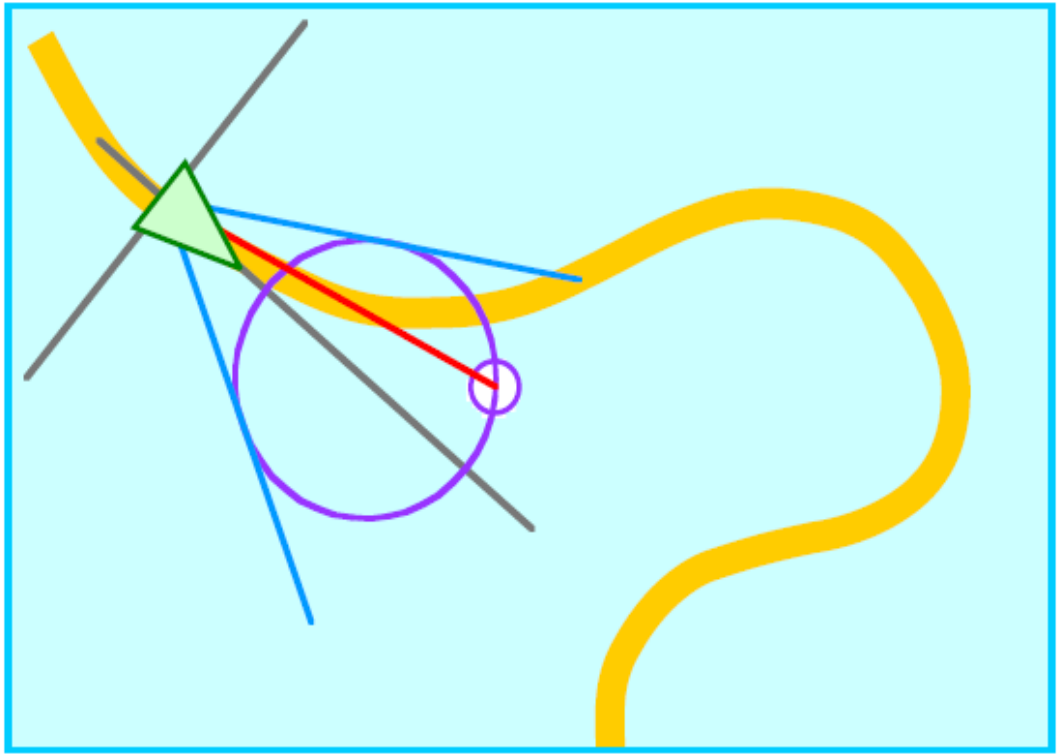

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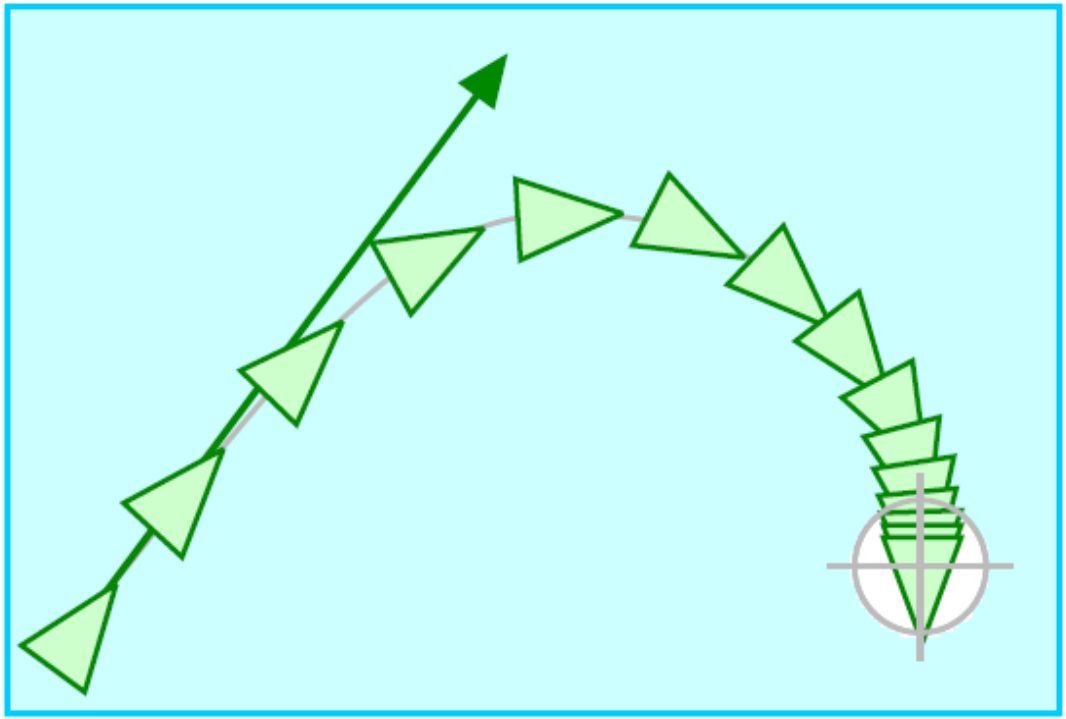

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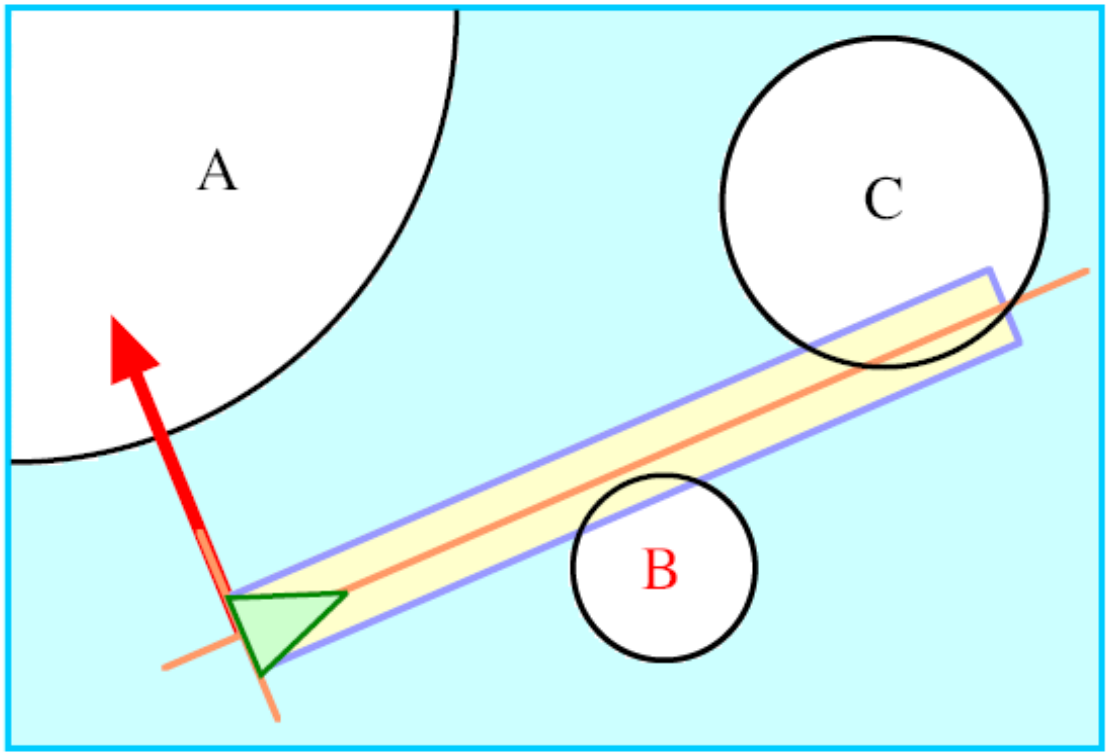

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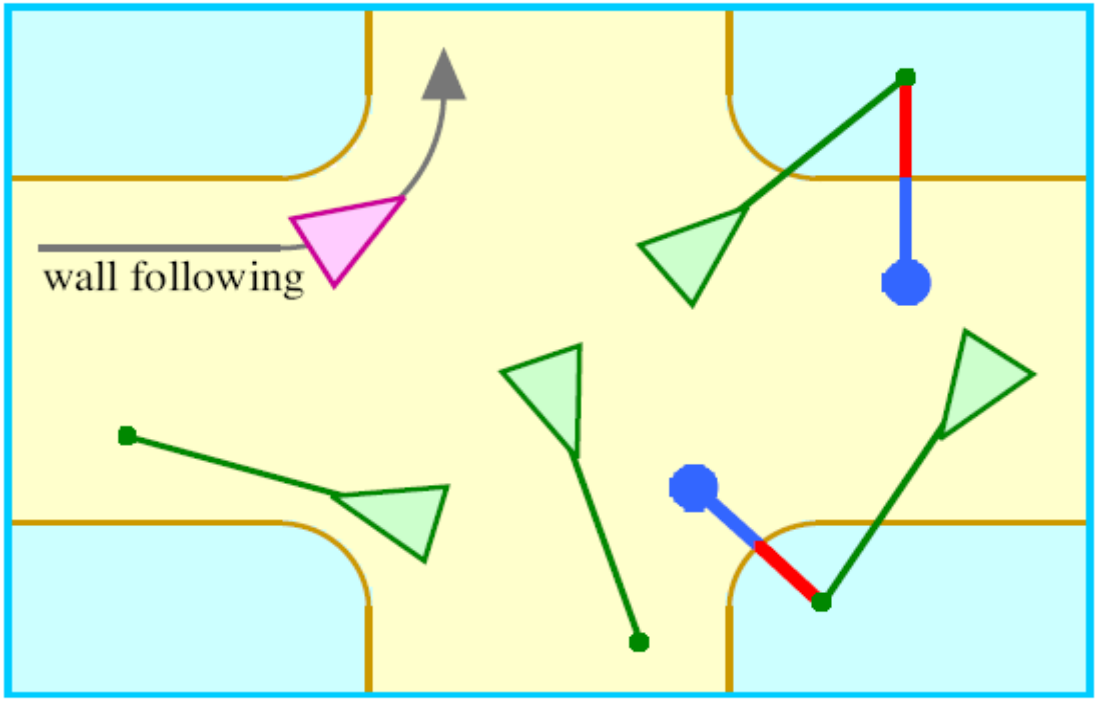

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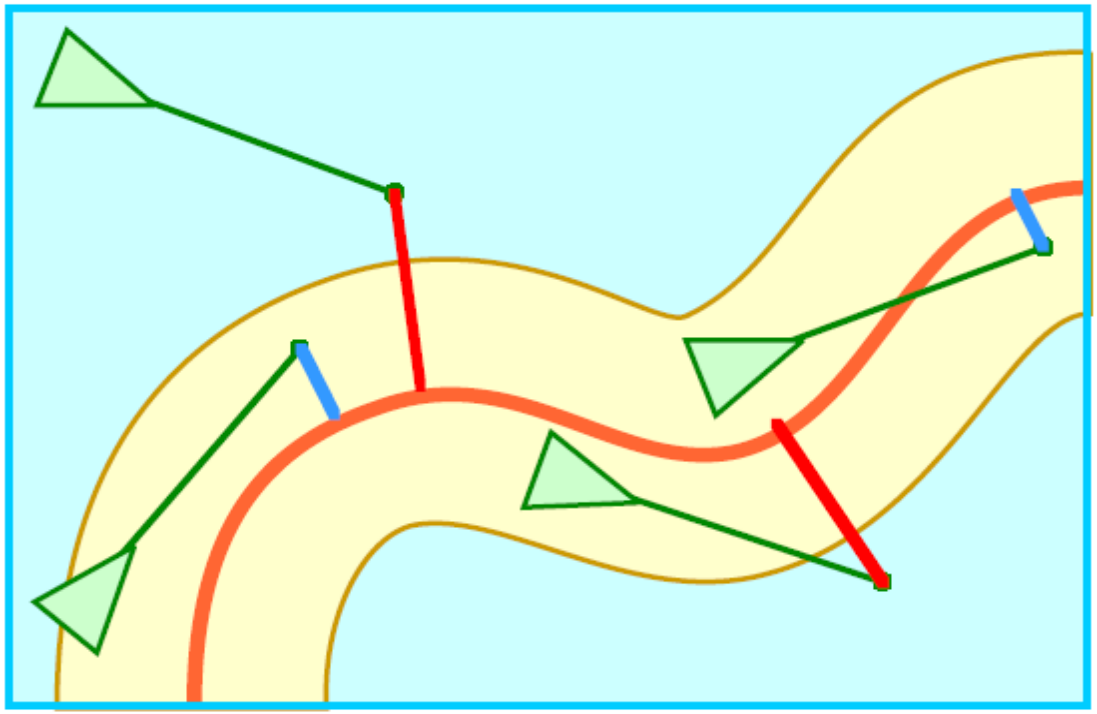

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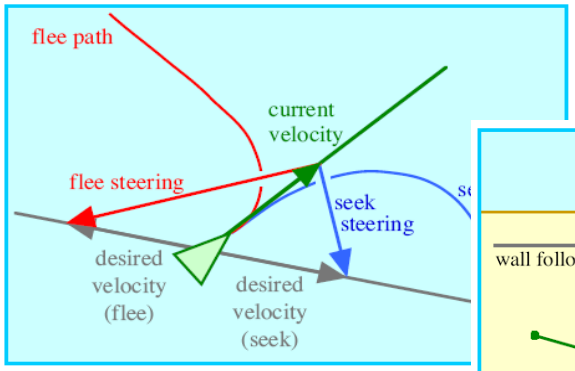
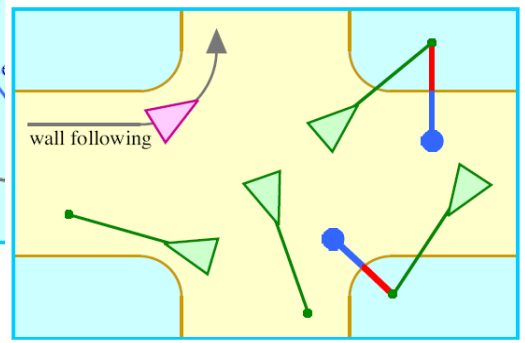
Other Examples (combined behaviors)

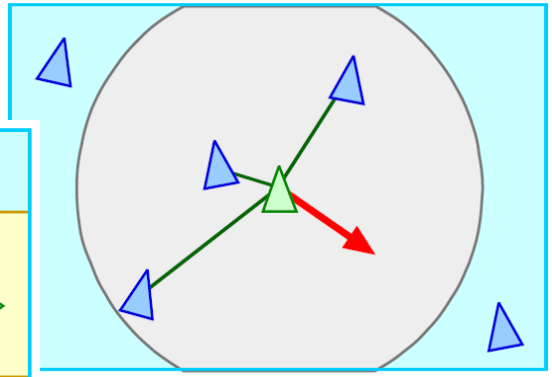
- Combined behaviors
  - Queuing = seek, containment, & separation
  - Flocking = alignment, cohesion, & separation



Seek



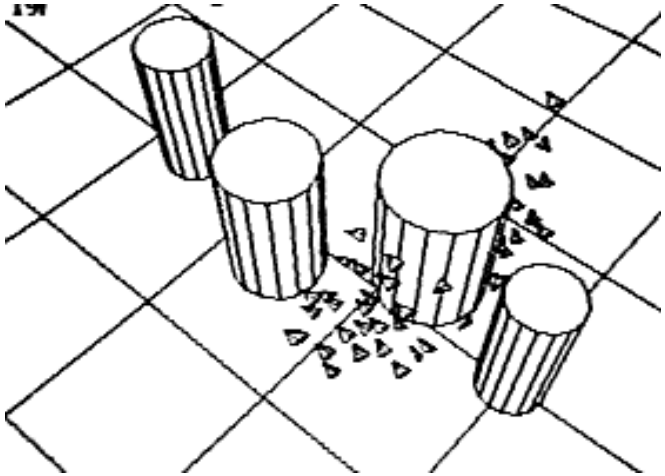
Containment



Separation

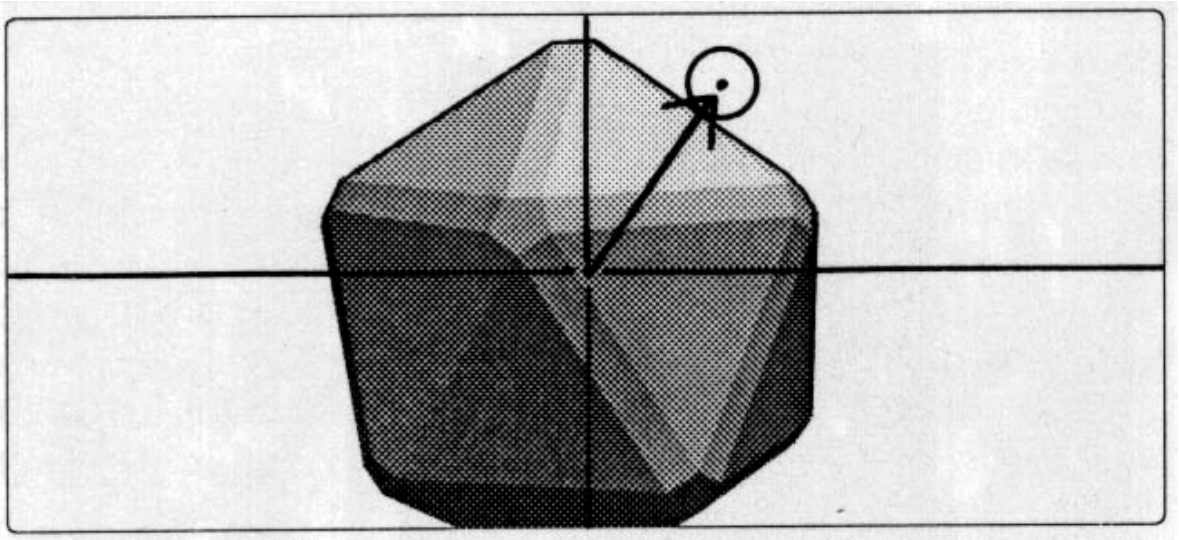
Obstacle Avoidance (1)

- Force field approach
  - Obstacles have a field of repulsion
  - Boids increasingly repulsed as they approach obstacle
- Drawbacks:
  - Approaching a force in exactly the opposite direction
  - Flying alongside a wall



Obstacle Avoidance (2)

- Steer-to-avoid approach
  - Boid only considers obstacles directly in front of it
  - Finds silhouette edge of obstacle closest to point of eventual impact
  - A vector is computed that will aim the boid at a point one body length beyond the silhouette edge



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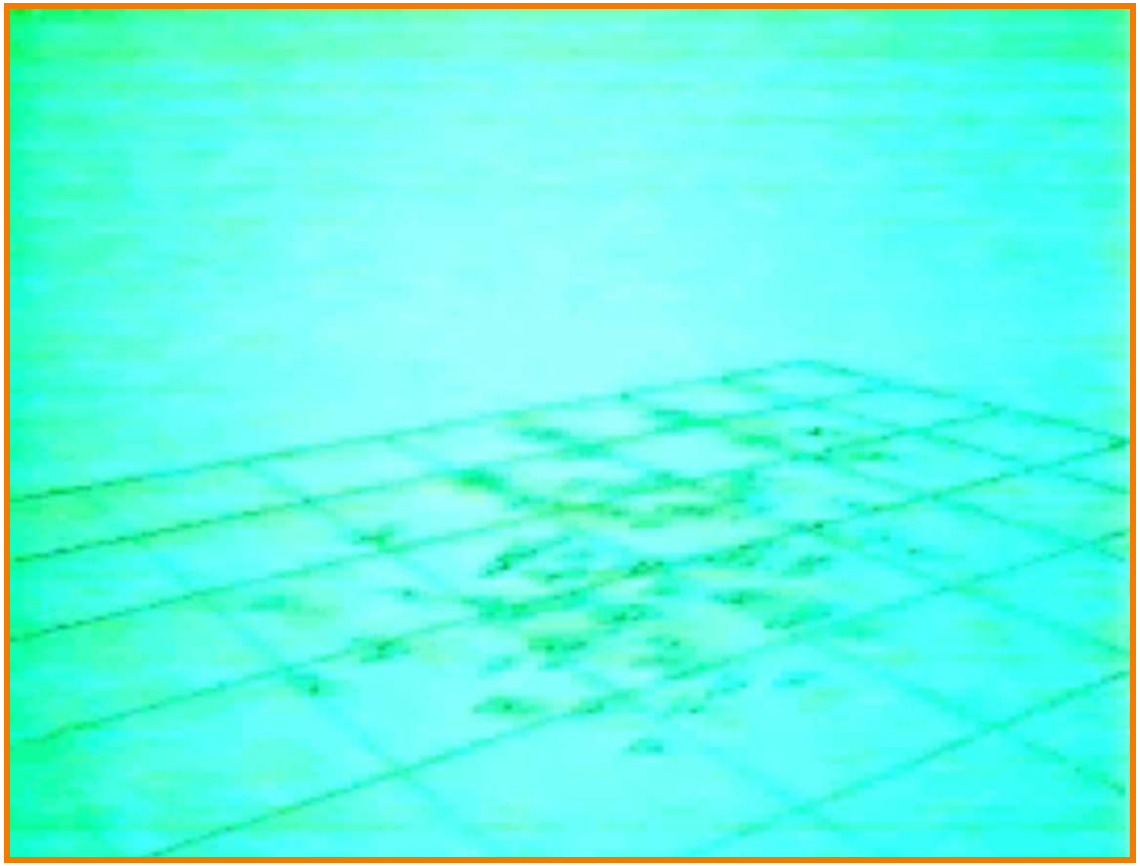
Arbitrating Independent Behaviors

- Navigation module of boid brain to collect relevant acceleration requests and then determine single behaviorally desired acceleration
  - Weighted average according to priority
- Emergency acceleration allocated to satisfy pressing needs first
  - Example: Centering ignored in order to maneuver around obstacles

Boid Example



Reynolds

Boid Example

http://www.kfish.org/~conrad/java/Boids/example2.html