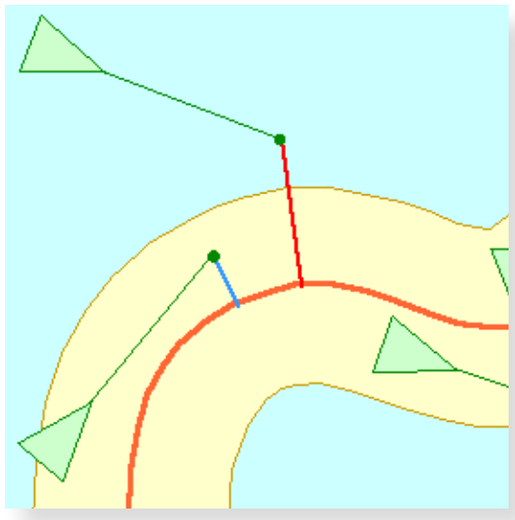
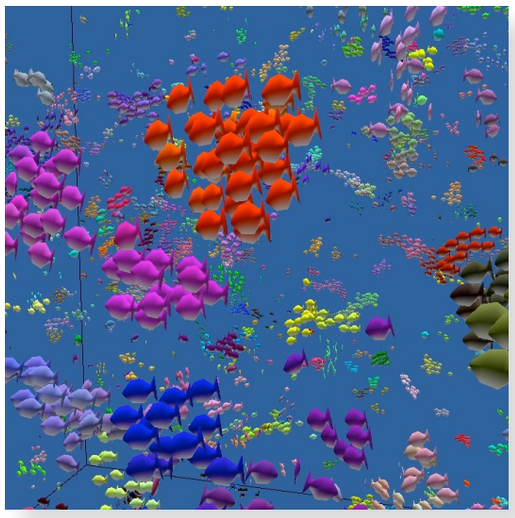


Steering Behaviors



Craig Reynolds

presented at:

UCSC CMPM146 Game AI
February 26, 2016

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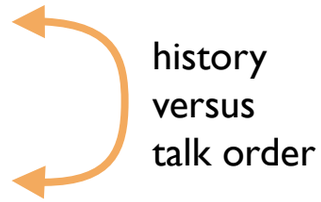
these slides: http://www.red3d.com/cwr/presentations/2016_UCSC_Steering_Behaviors.pdf

In this talk

- History (mine and steering behaviors)
- Flocking boids (self-organization, emergence)
- Generalizing steering behaviors
- OpenSteer (open source library)
- Other collective behavior models (stigmergy)
- Learning/optimization applied to steering behaviors



History

- Childhood interest in bird flocks and "model worlds"
- College work on multi-agent simulations in 3d worlds
- SIGGRAPH 1986: first boids motion tests
- SIGGRAPH 1987: boids paper, *Breaking the Ice*
- GDC 1999: paper on generalized steering behaviors
- GDC 2000: real time interactive boids
- 2003 OpenSteer (C++ lib, ports to other languages)
- 2006: high performance multicore/GPU versions

What are steering behaviors?

- Help autonomous characters navigate their world
- Get from here to there, without bumping into things
- Important in modeling *embodied* multi-agent systems
- Simulation model of human crowds and animal groups
- Applications in games, VR, and films (crowd scenes)

Steering behaviors: assumptions

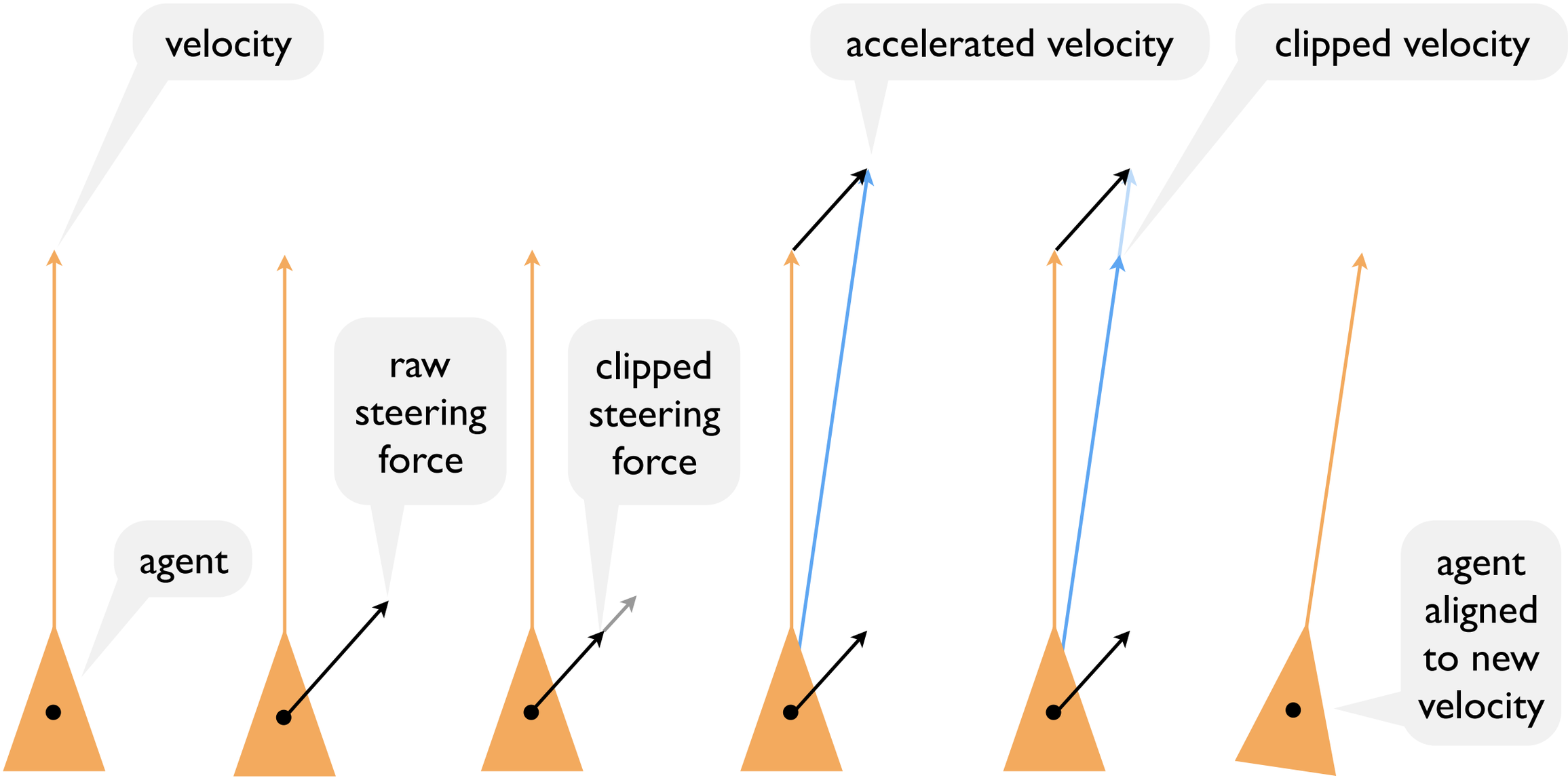
- Position and orientation have continuous values
- Speed high enough that momentum matters
- Each agent runs their own behaviors
- Behaviors based on perception of local environment
- Environment is world geometry plus nearby agents
- Typically reactive behavior, not long term planning

Typical steering behaviors

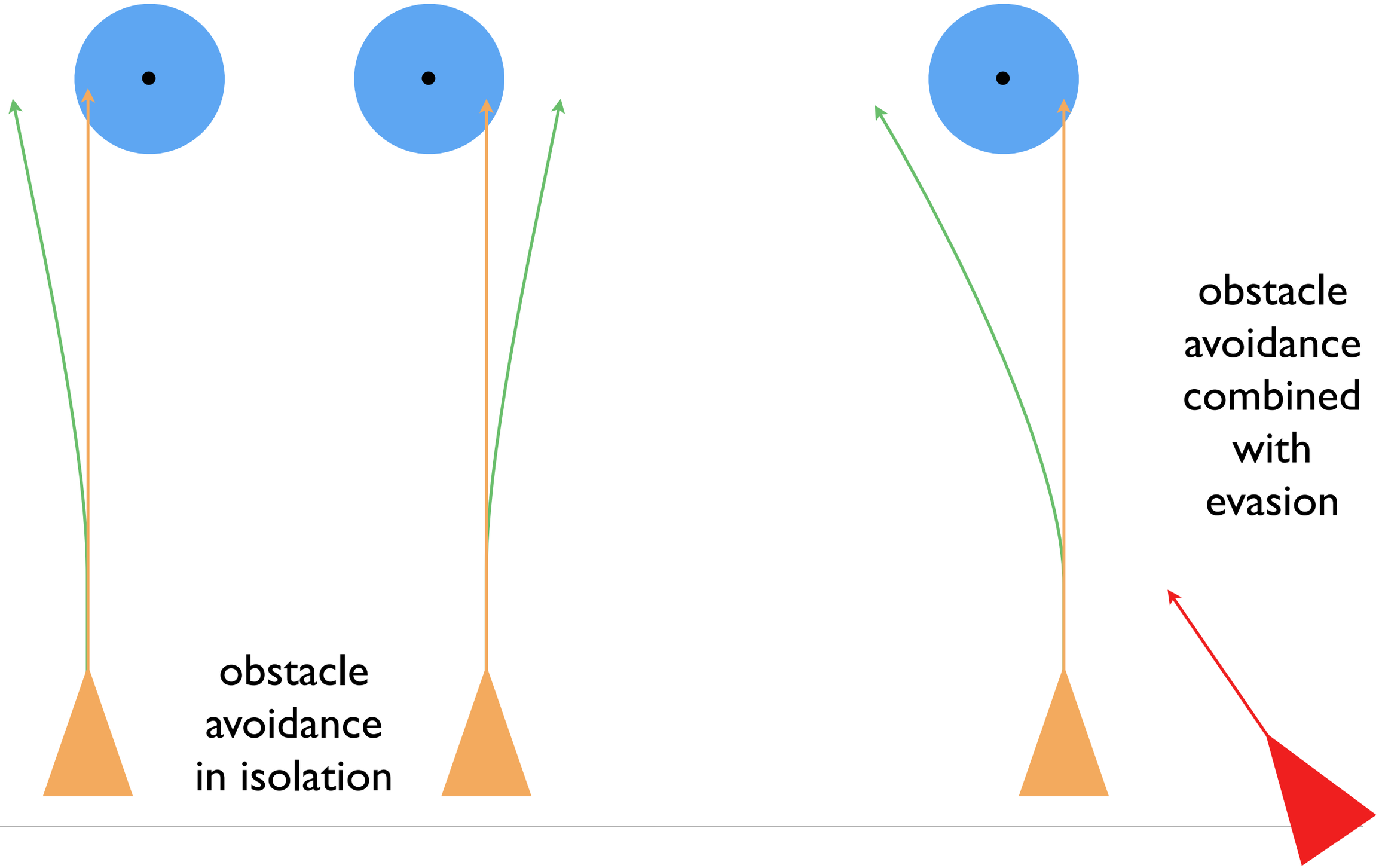
- seek / flee
- pursue / evade
- wander
- arrival
- avoid obstacle
- containment
- path following
- wall following
- flow field following
- flocking
- separation
- alignment
- cohesion

Steering Behaviors

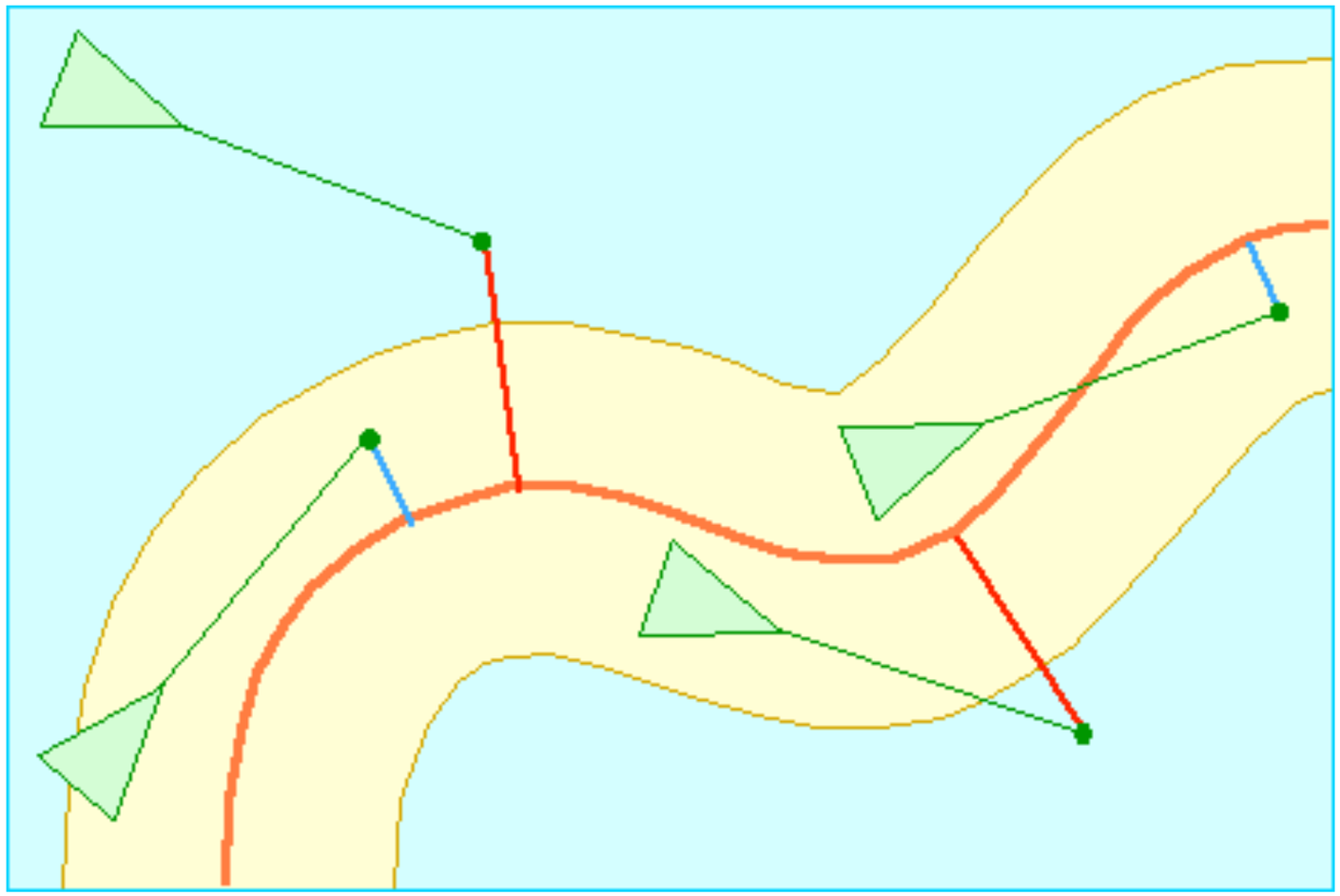
applying steering forces to velocity-aligned point mass "vehicles"

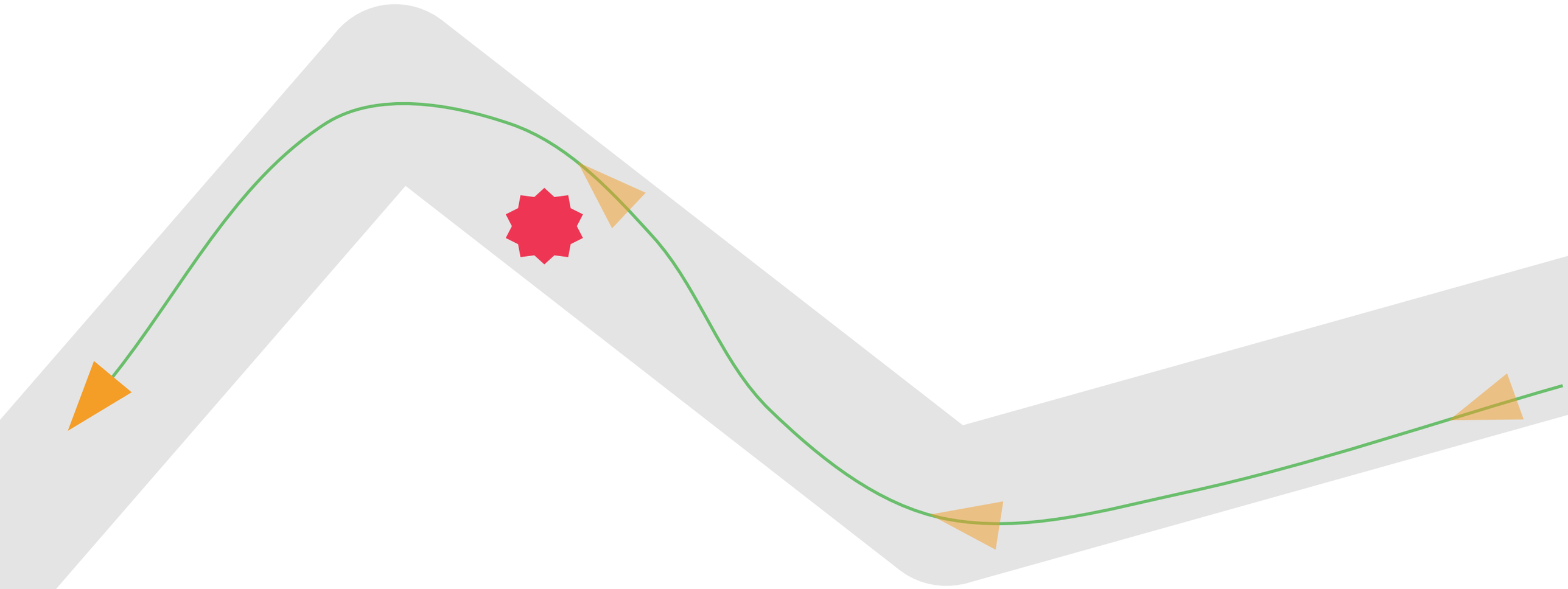


Combining steering behaviors

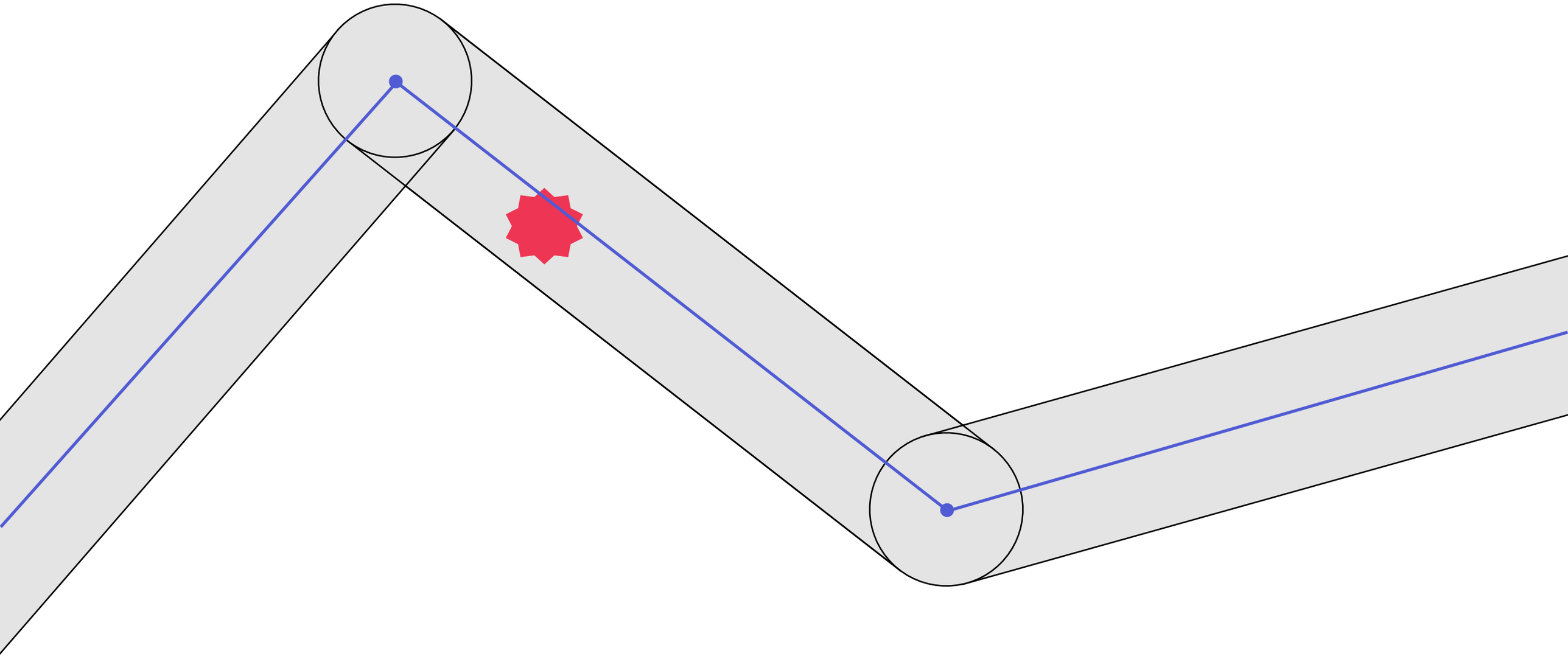


Steering behavior example: path following

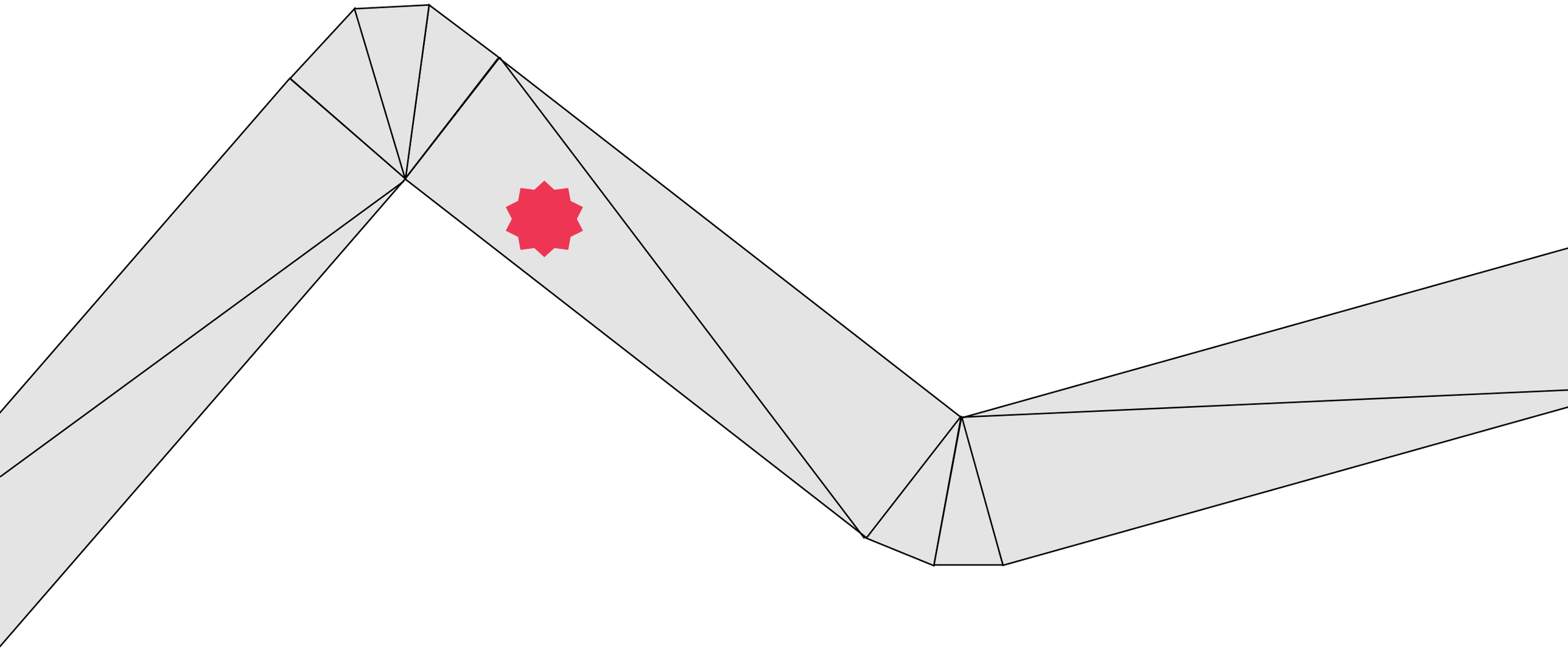




composed steering behaviors: follow path and avoid obstacle

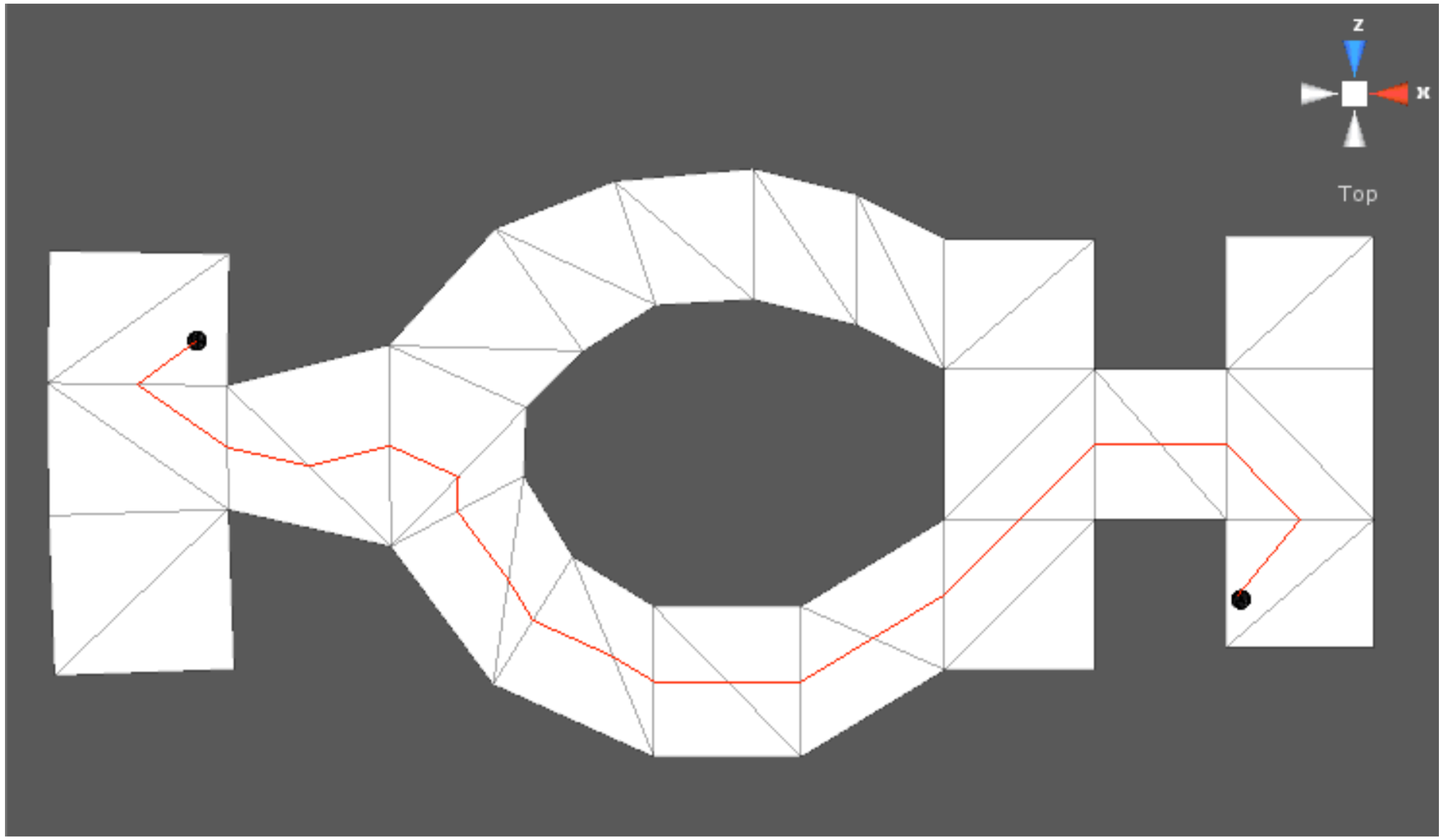


sphere swept along polyline



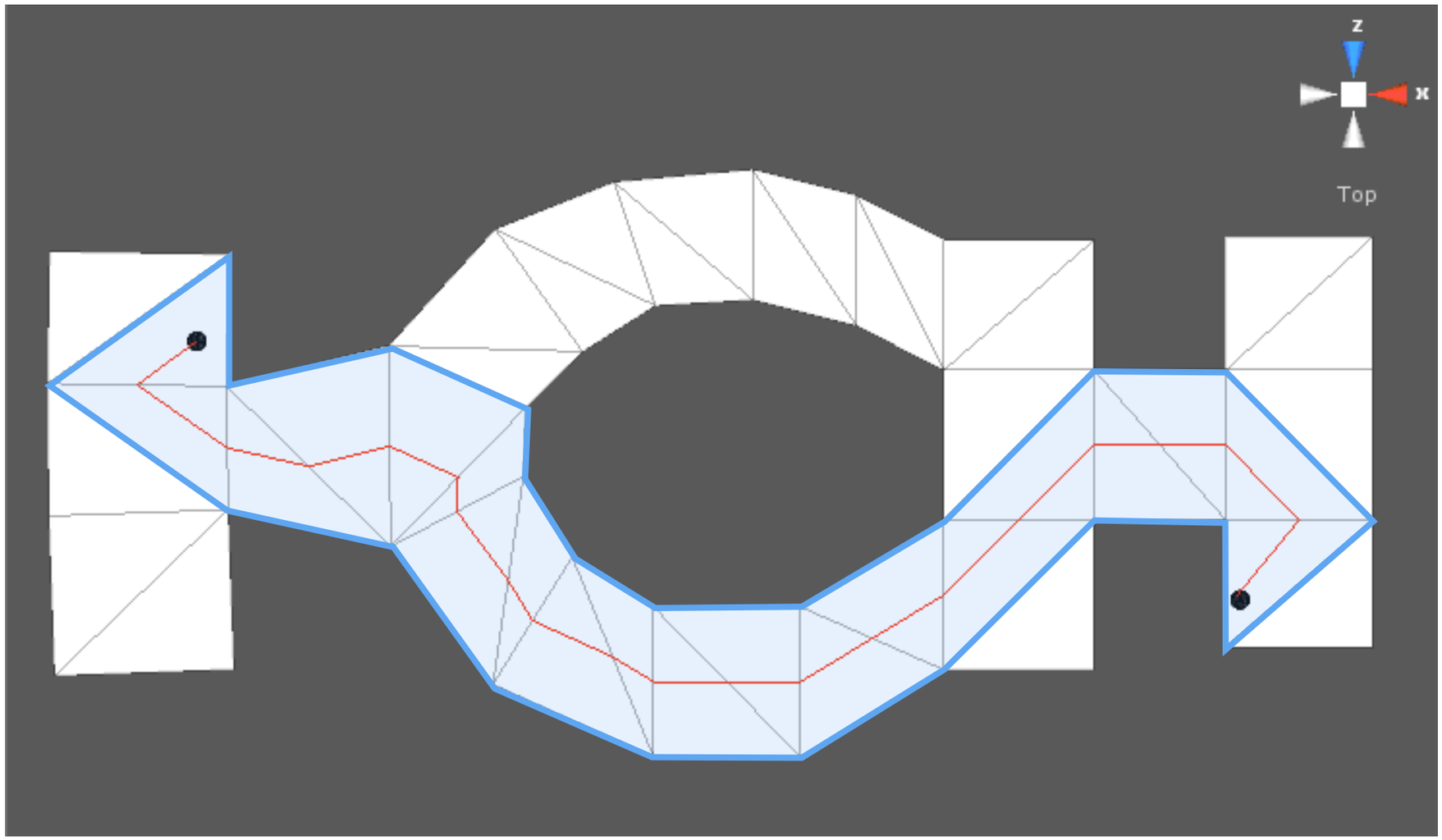
navigation mesh

navmesh: a parenthetical aside



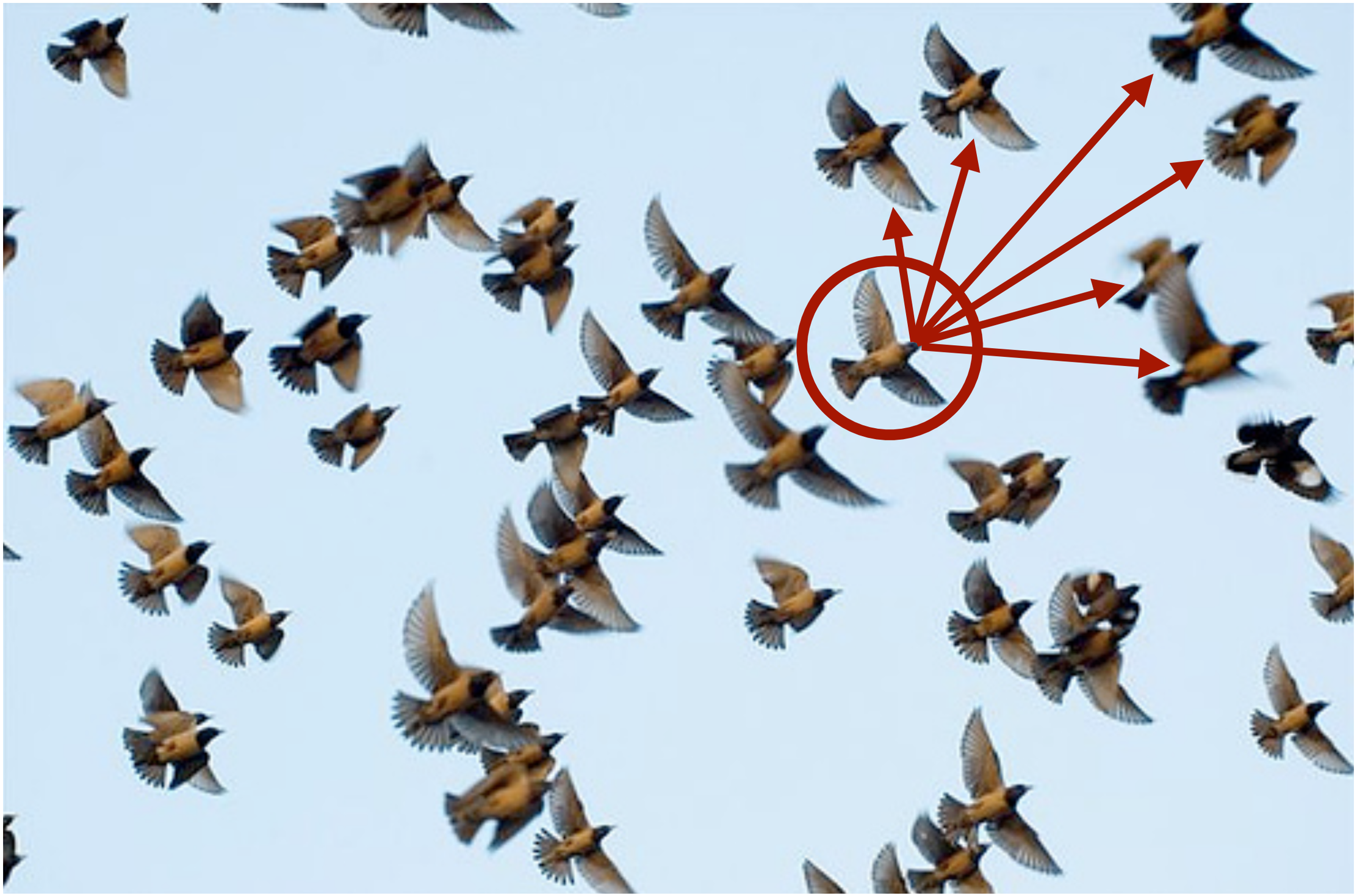
Michael Grenier (2011) http://mgrenier.me/2011/04/pathfinding-102-ish/

navmesh: a parenthetical aside

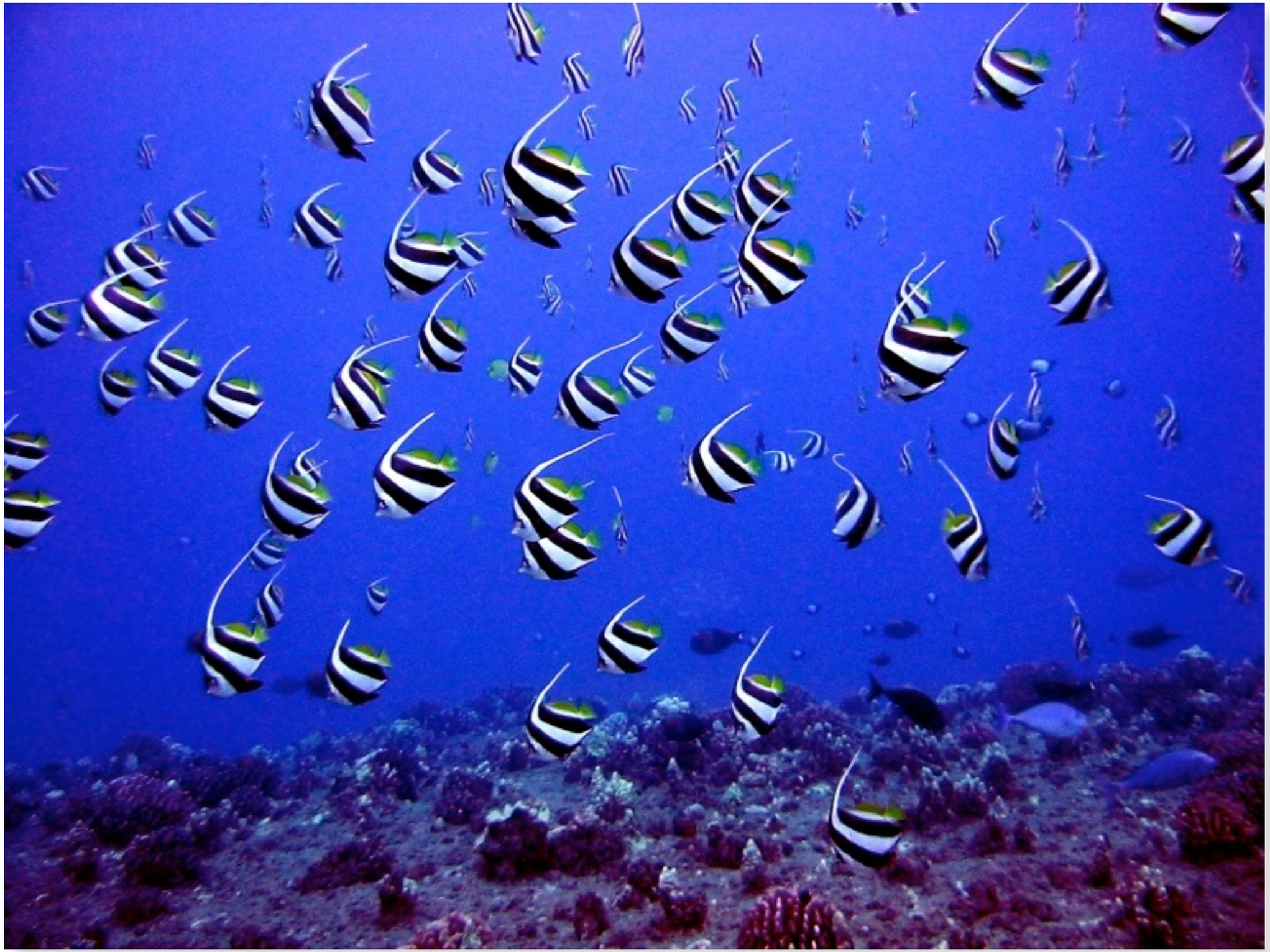


Michael Grenier (2011) http://mgrenier.me/2011/04/pathfinding-102-ish/

Boids



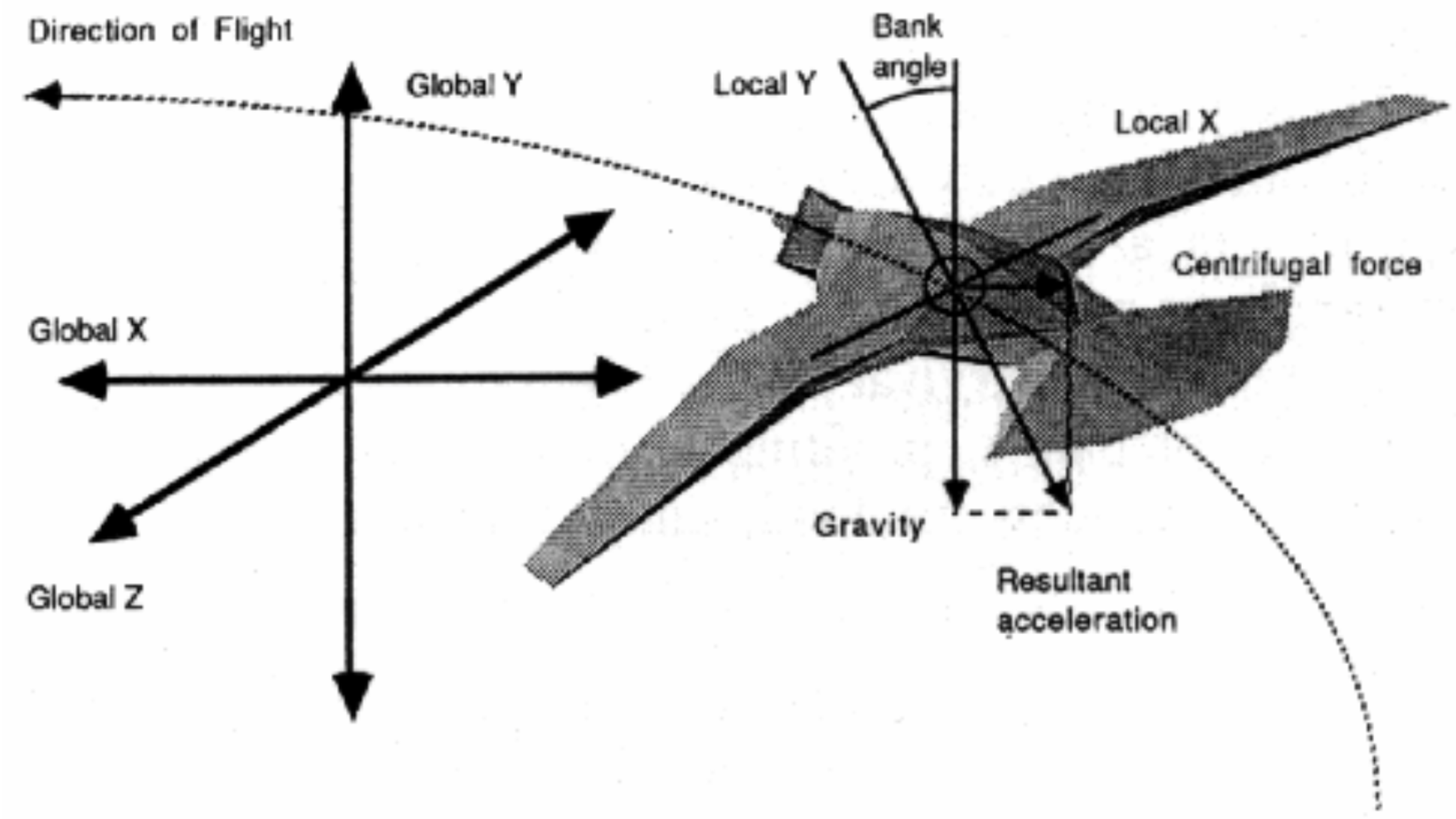
iStockPhoto



iStockPhoto

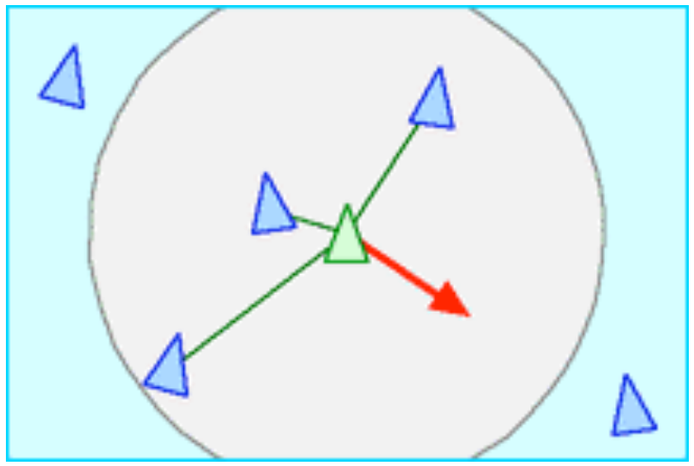
Self-organization

- many autonomous agents ("multi-agent simulation")
- local interaction between neighboring agents
- emergence of global behavior or structure

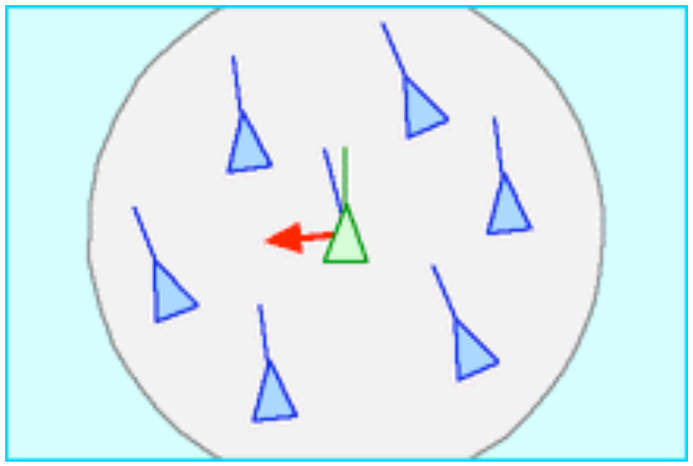


boid's local coordinate system and *banking*

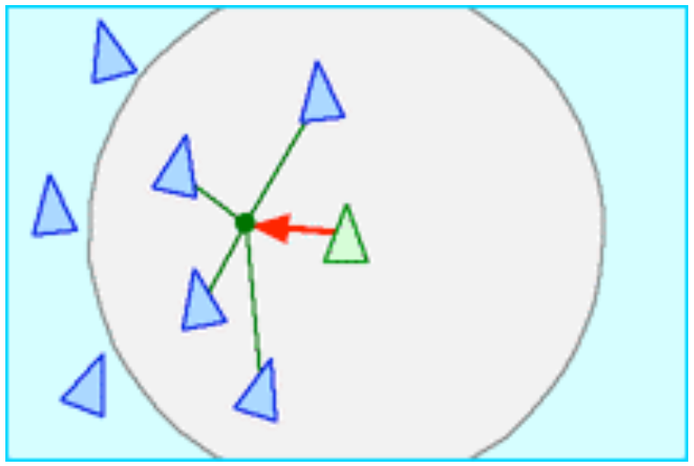
Three component steering behaviors of flocking:



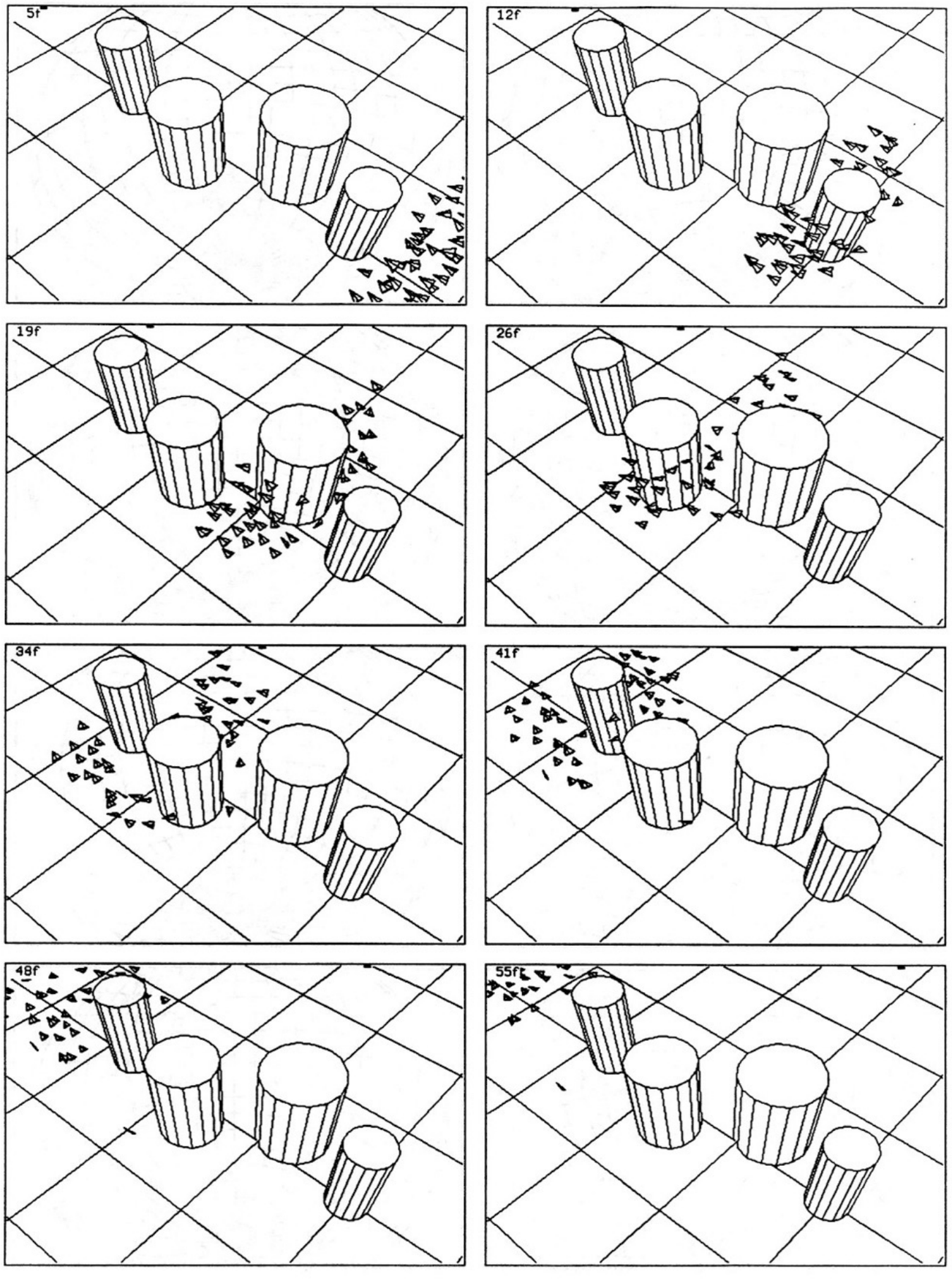
Separation



Alignment



Cohesion



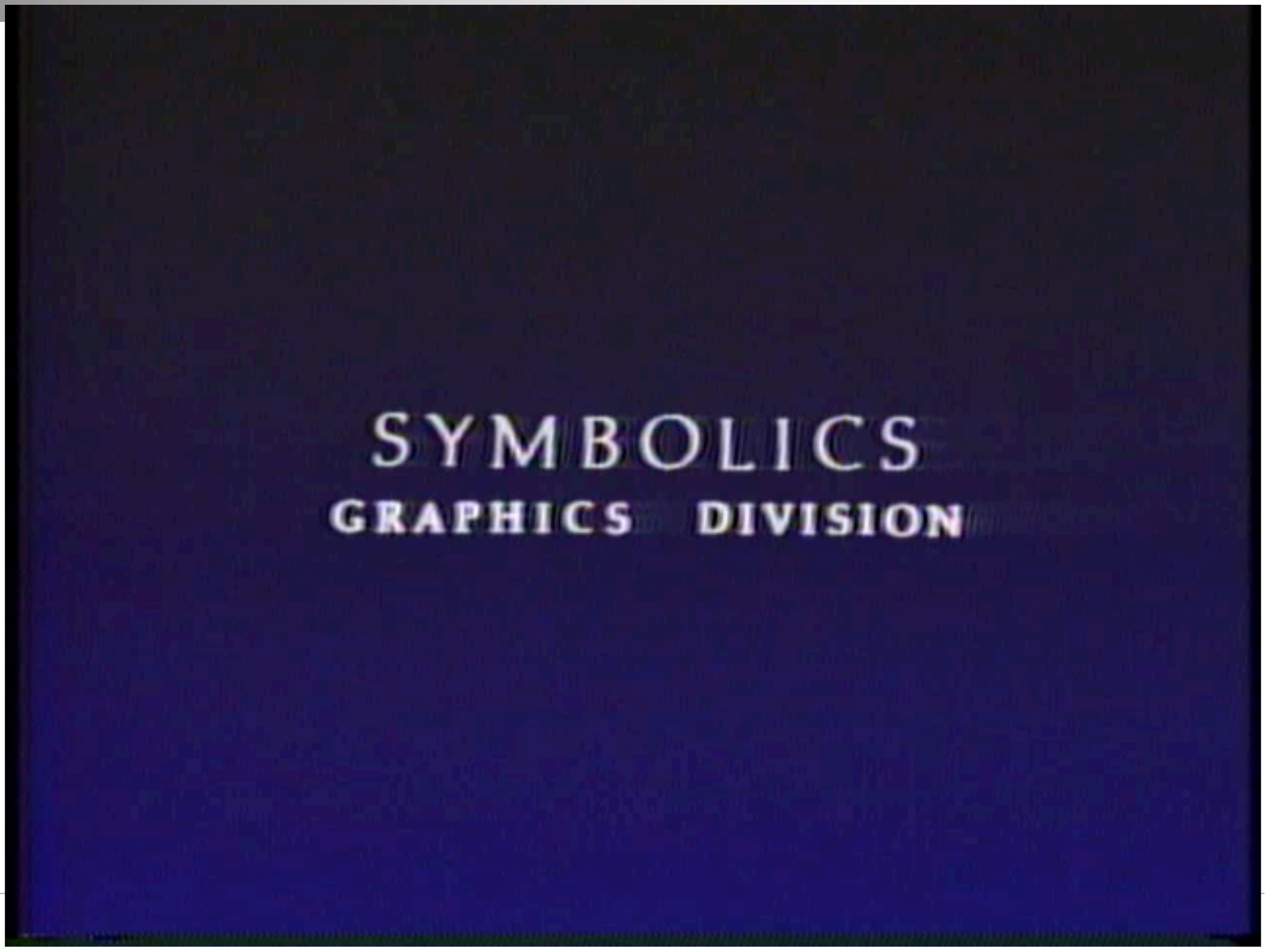
Early boids motion test:

- flocking
  - separation
  - alignment
  - cohesion
- seek
- obstacle avoidance

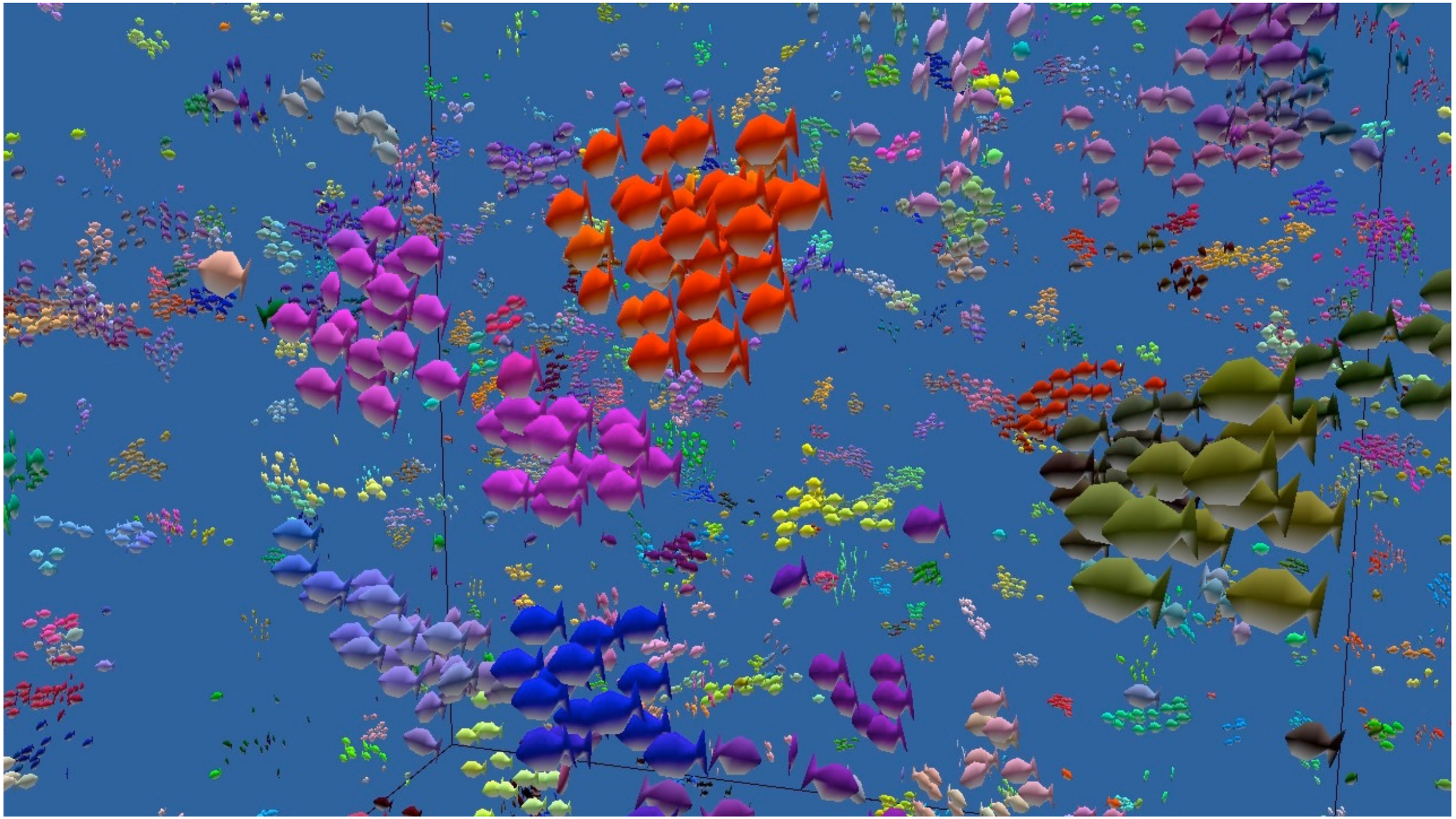
1986 screen grabs from Symbolics Lisp Machine

Boids B on YouTube

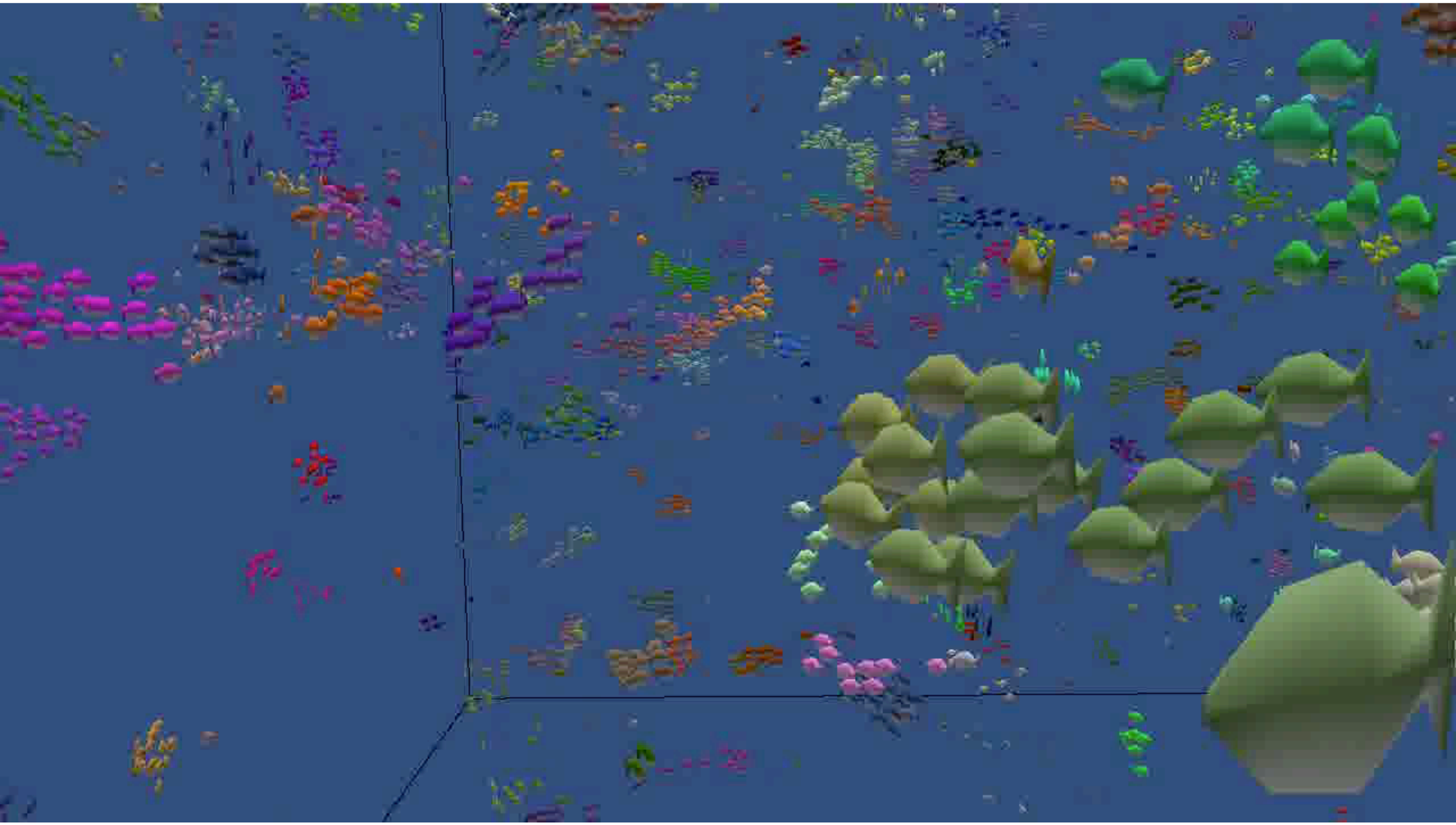
(Stanley and Stella in) Breaking the Ice
1987



BtI on YouTube



Real time boids on PS3 — about 10,000 at 60Hz — PSCrowd, 2006



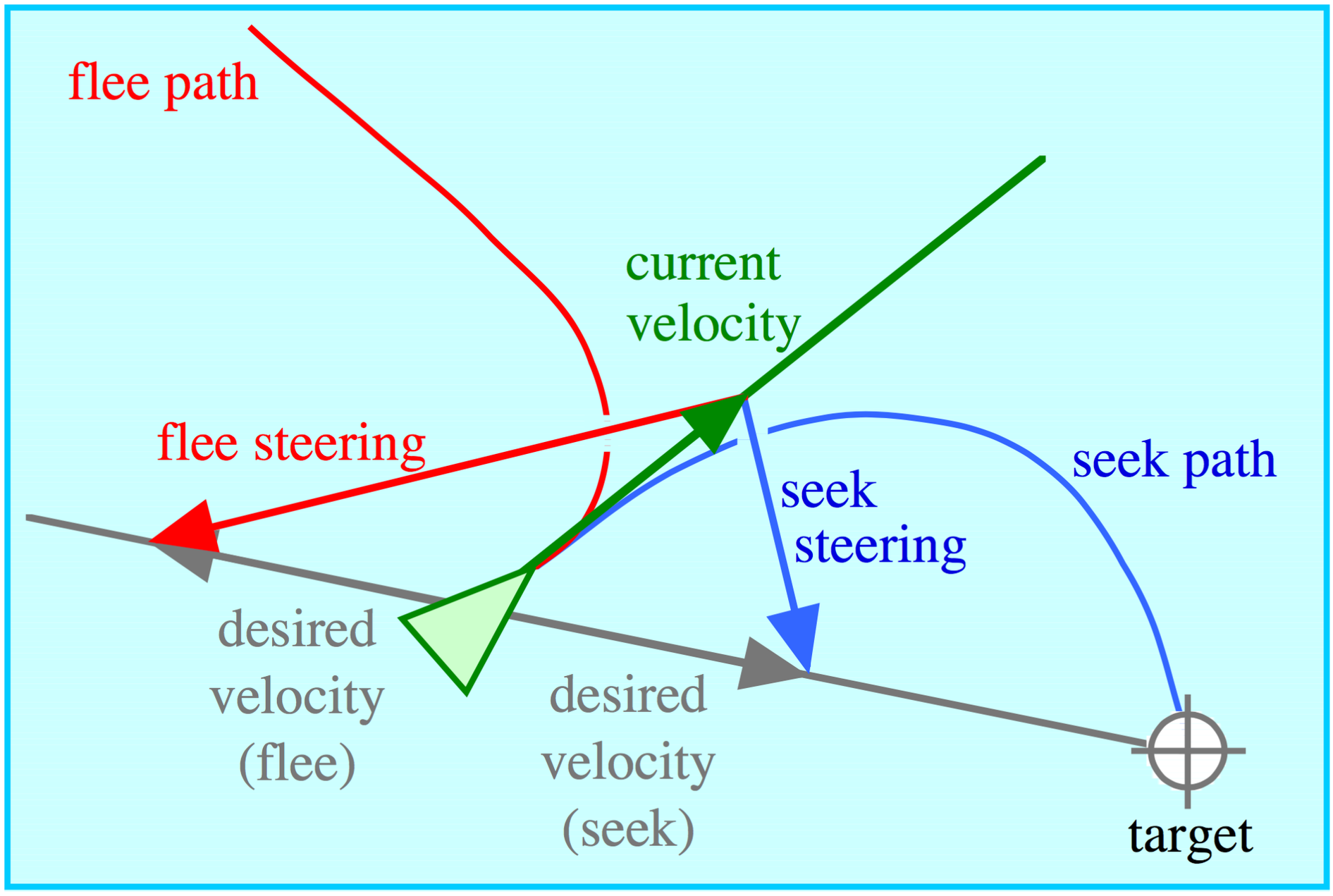
chameleon test on youtube

final 12k fish on youtube

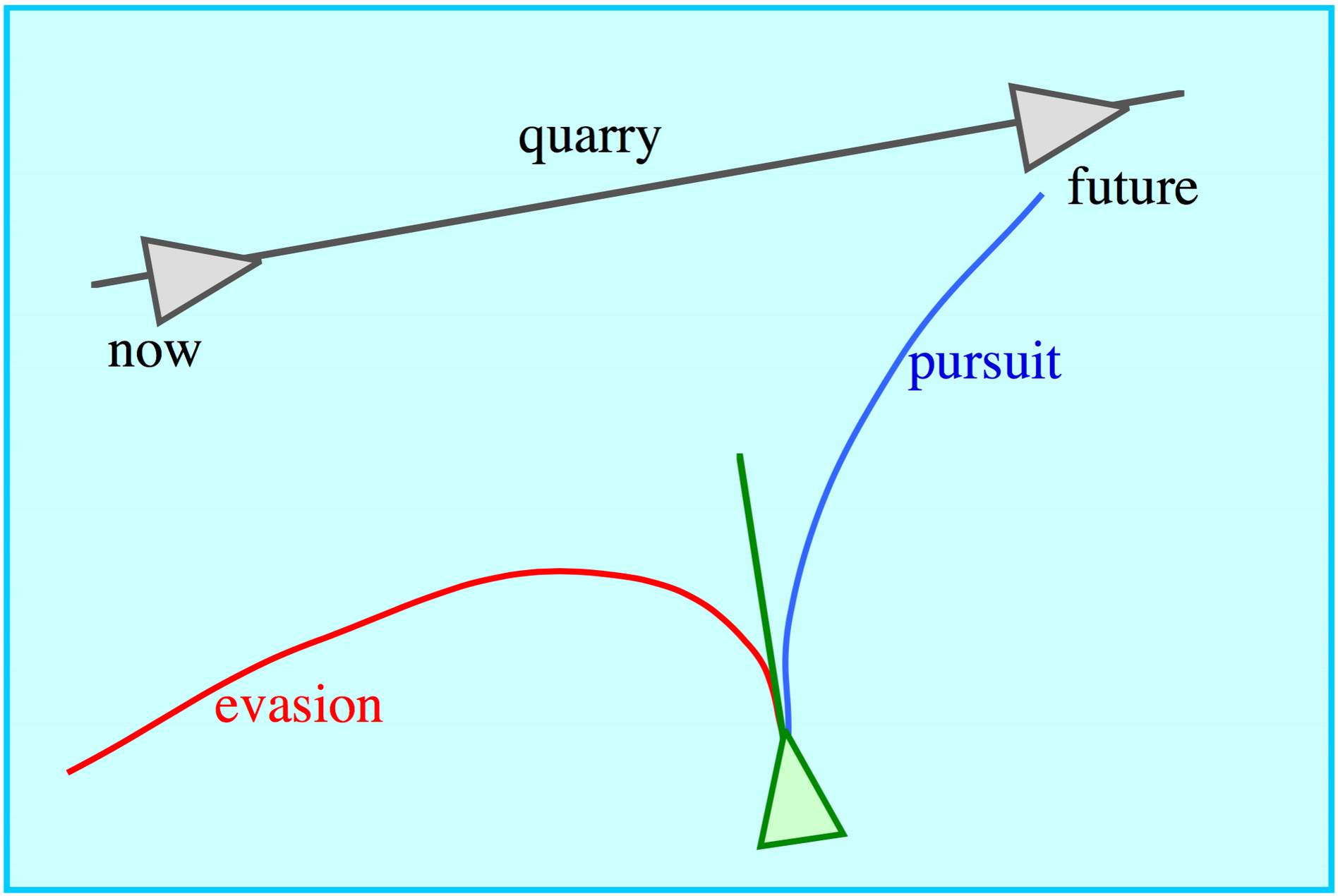
Steering Behaviors

Steering behaviors

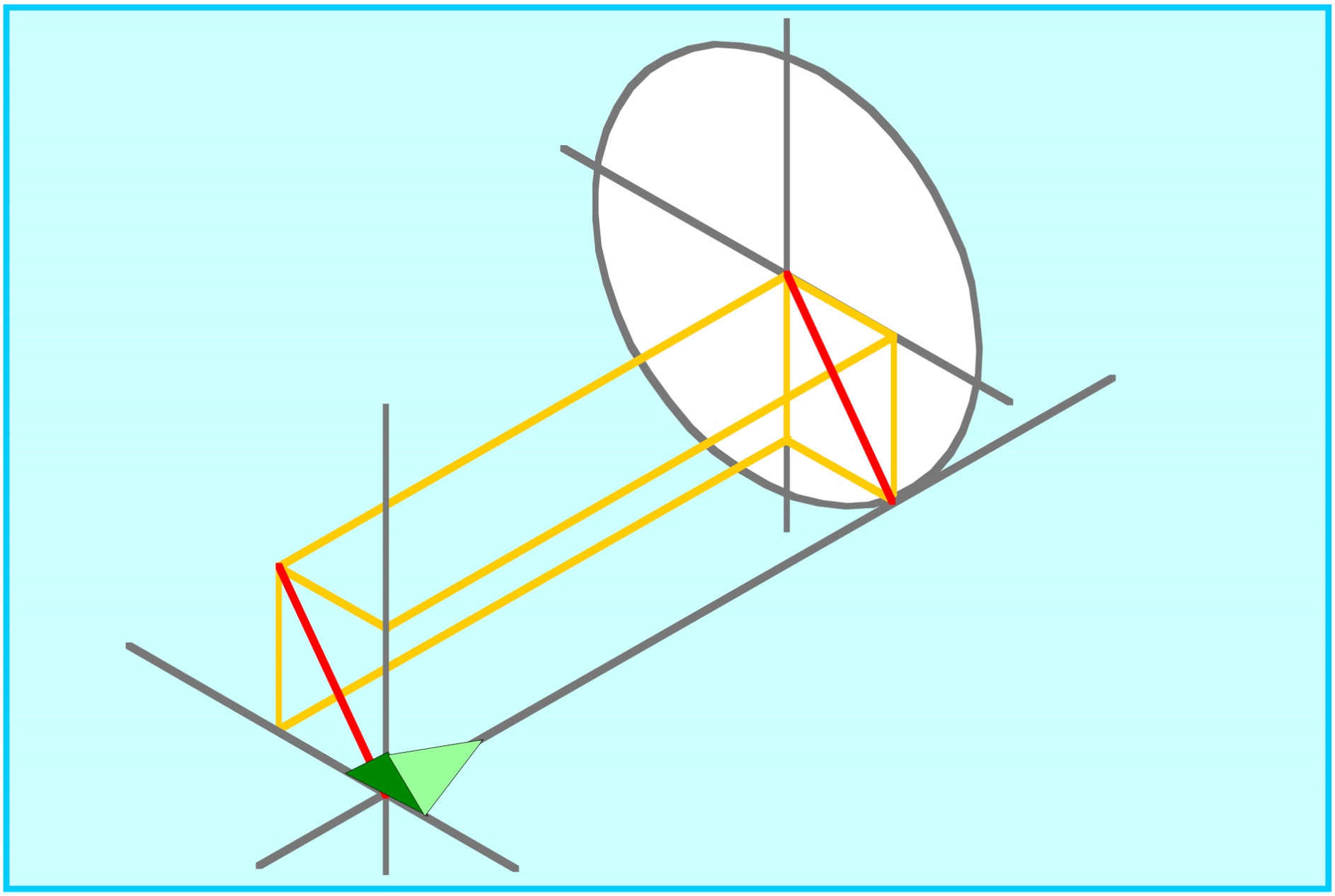
- Generalization of the three components of boids
- Toolkit of behaviors for autonomous characters
- Goal-oriented motion controllers
- To model animals, humans or vehicles



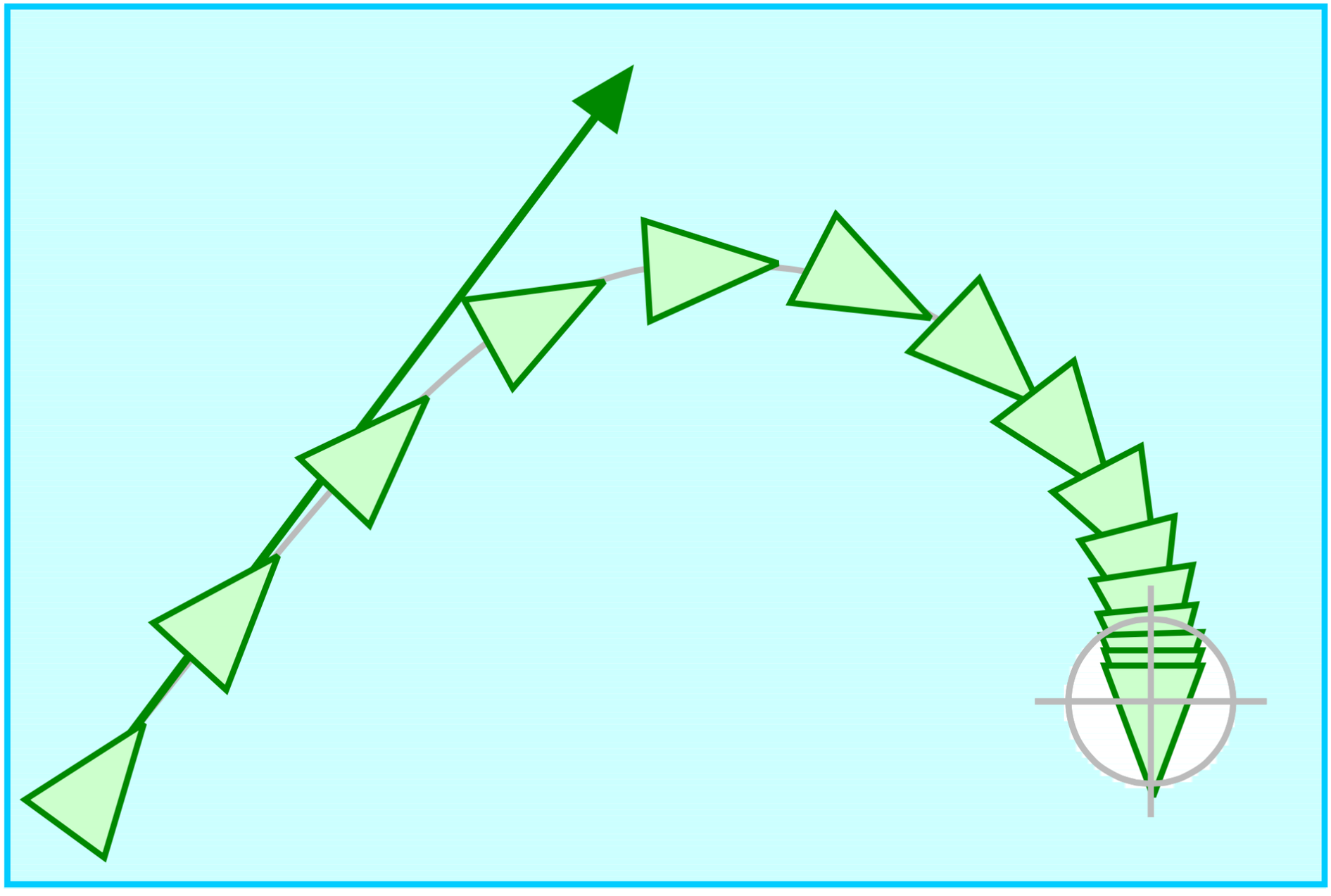
seek and flee steering behaviors



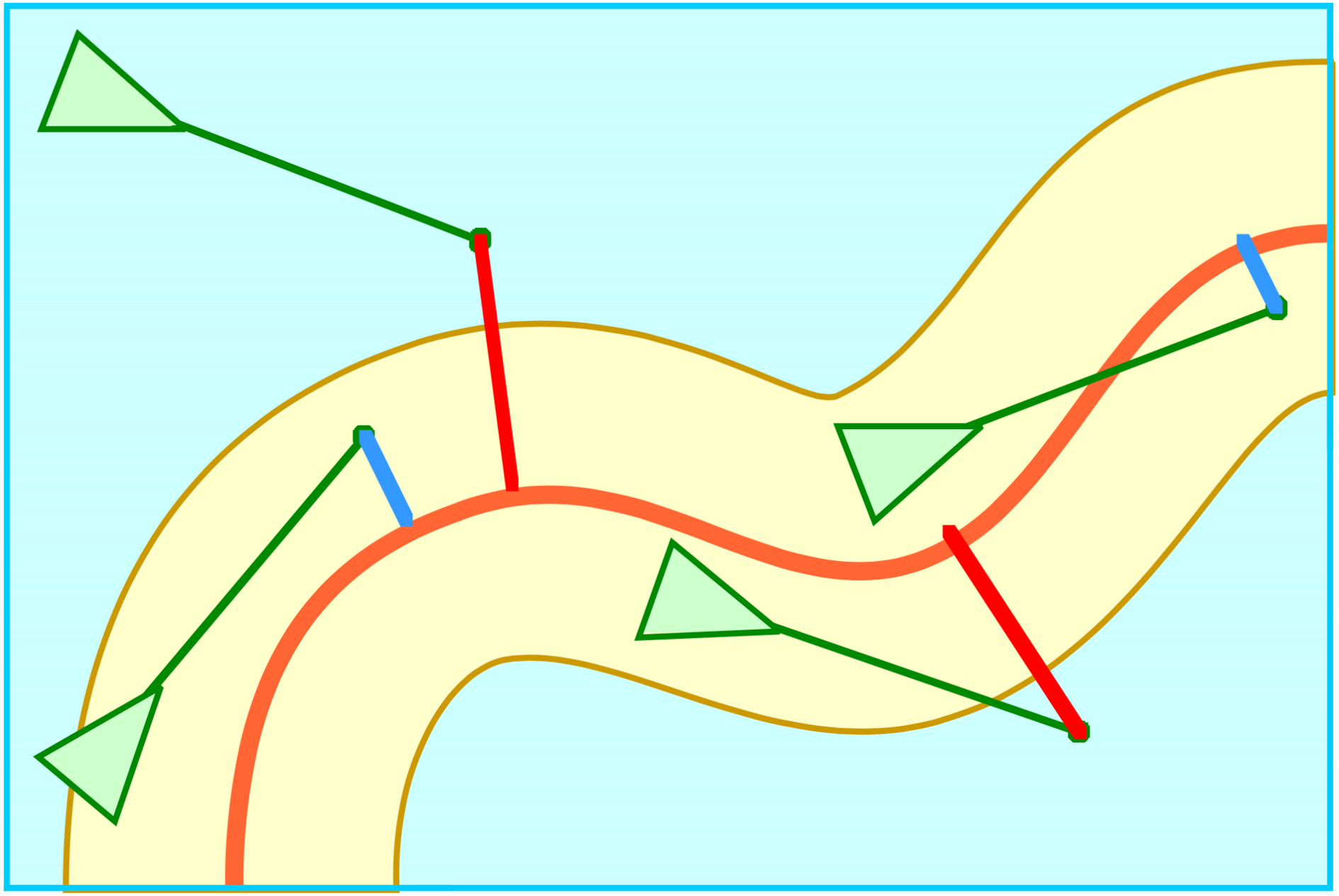
pursuit and evasion



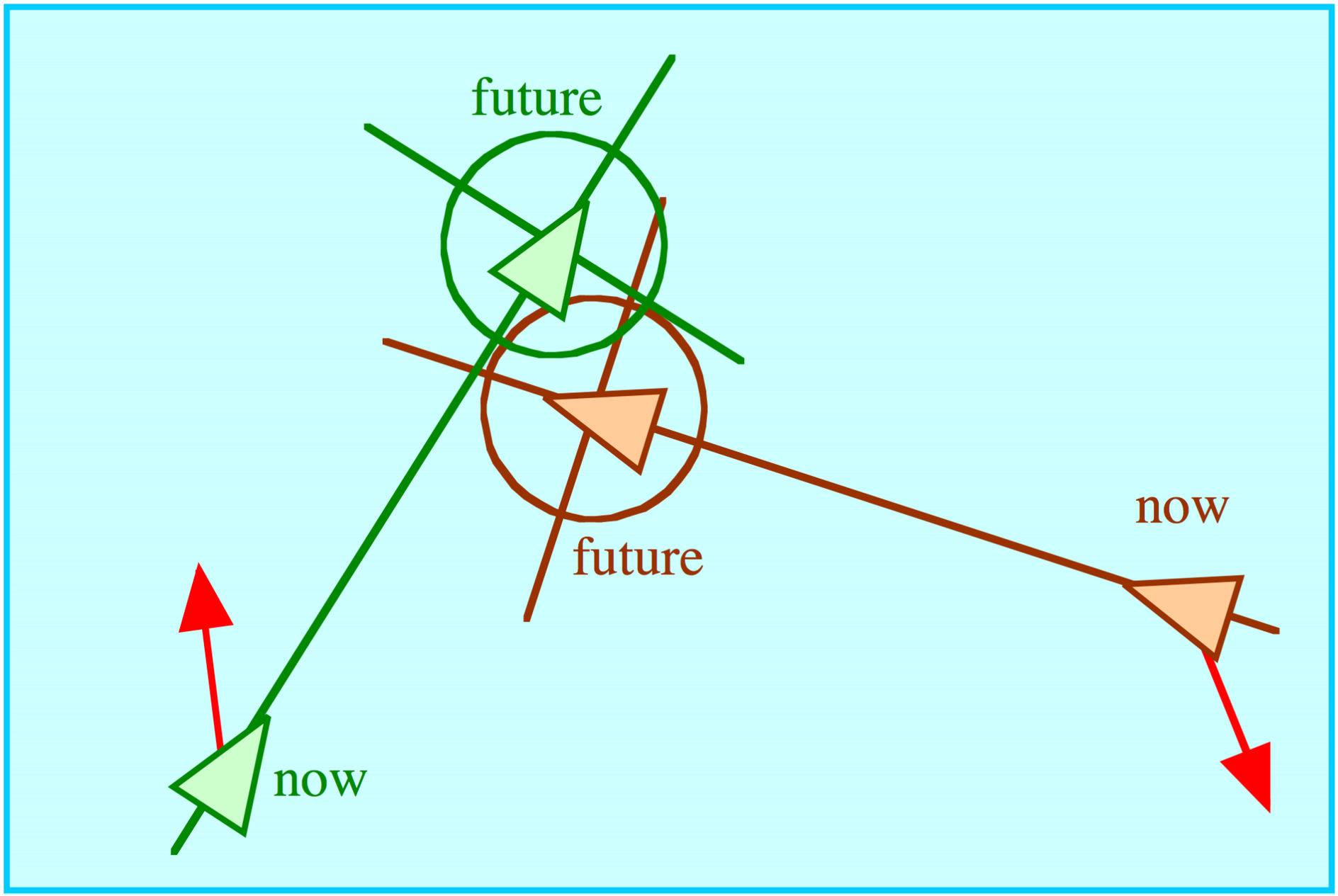
offset pursuit



arrival steering behavior



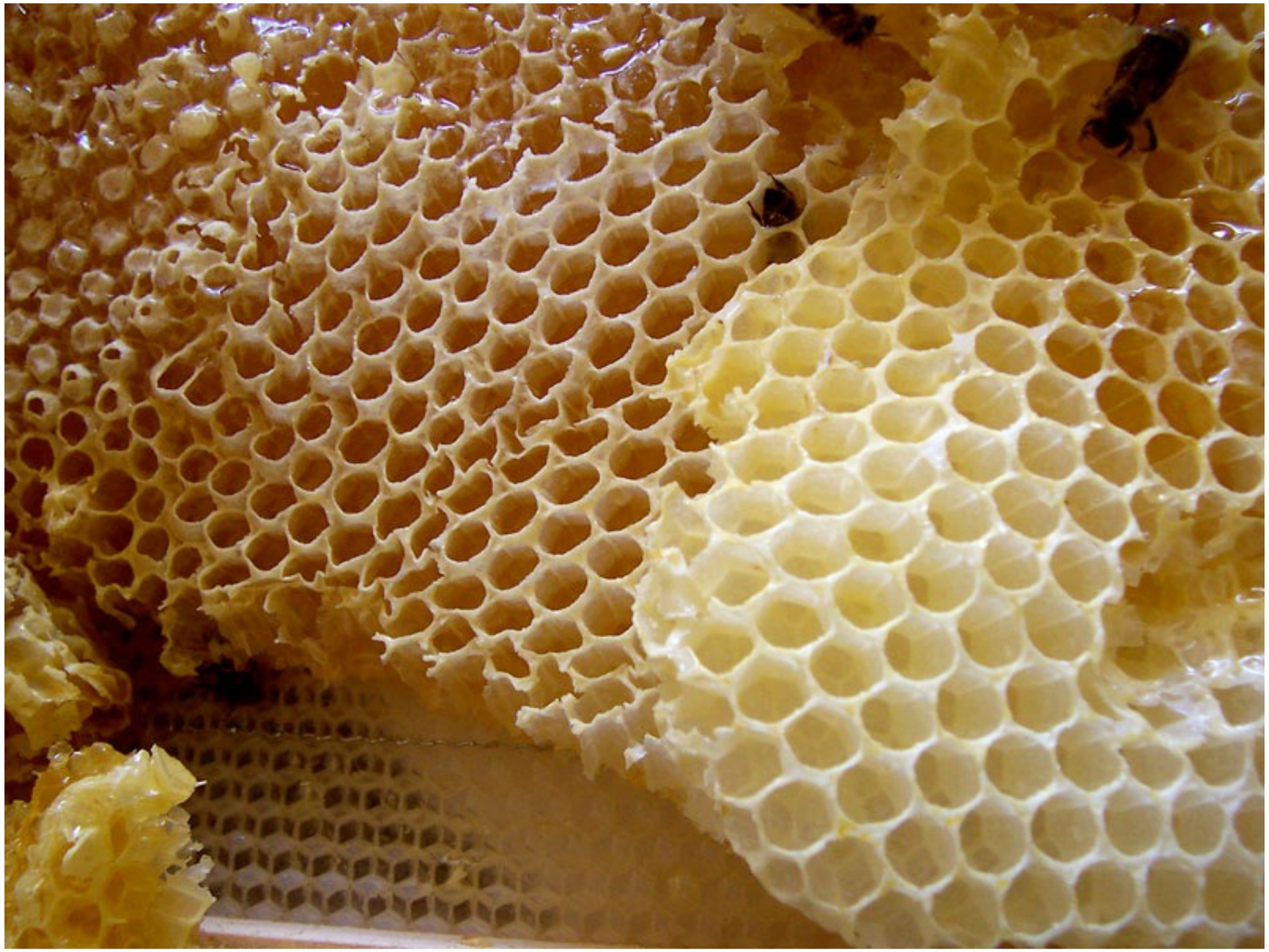
path following



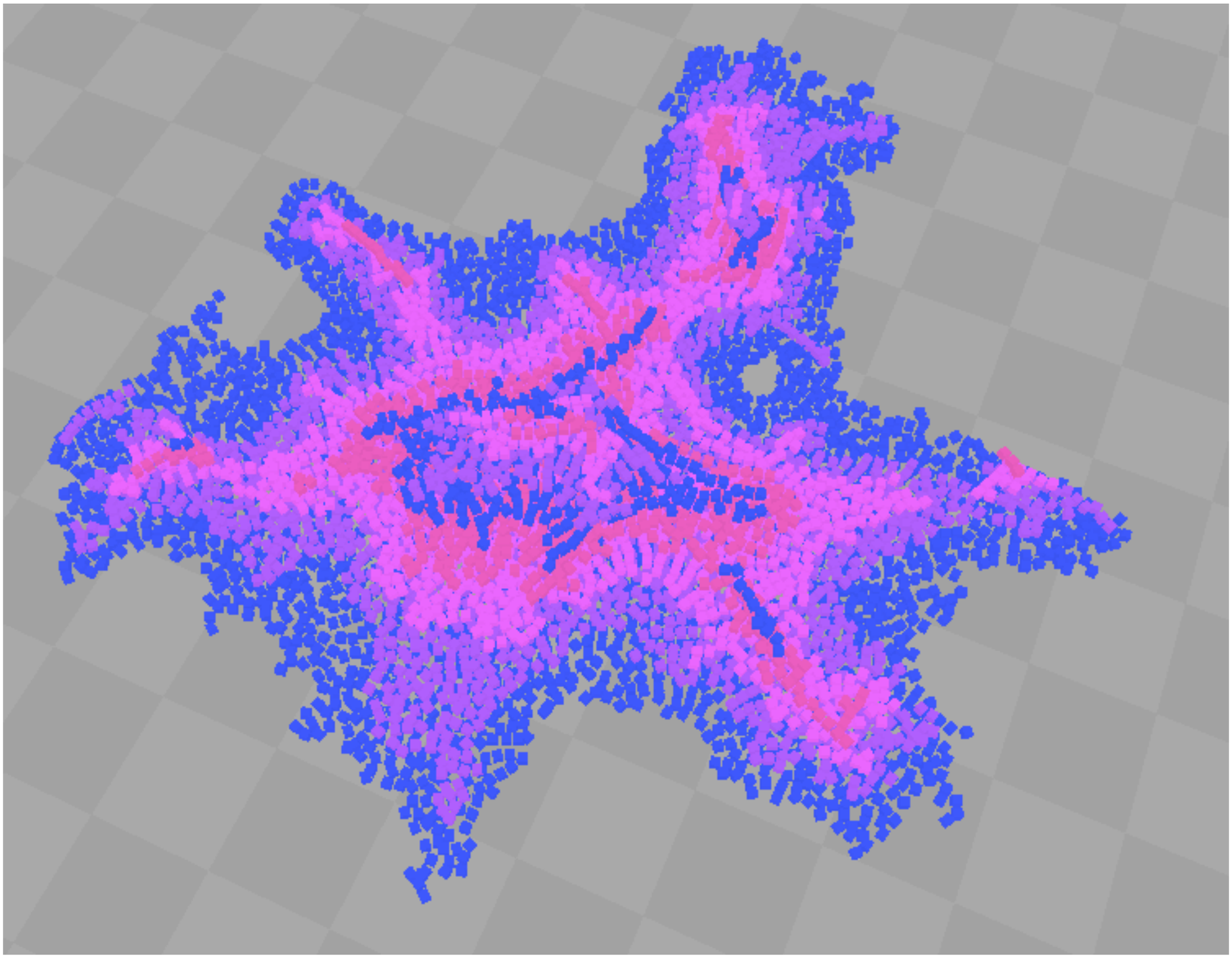
unaligned collision avoidance

Stigmergy and collective construction

Collective construction: bees building honeycomb

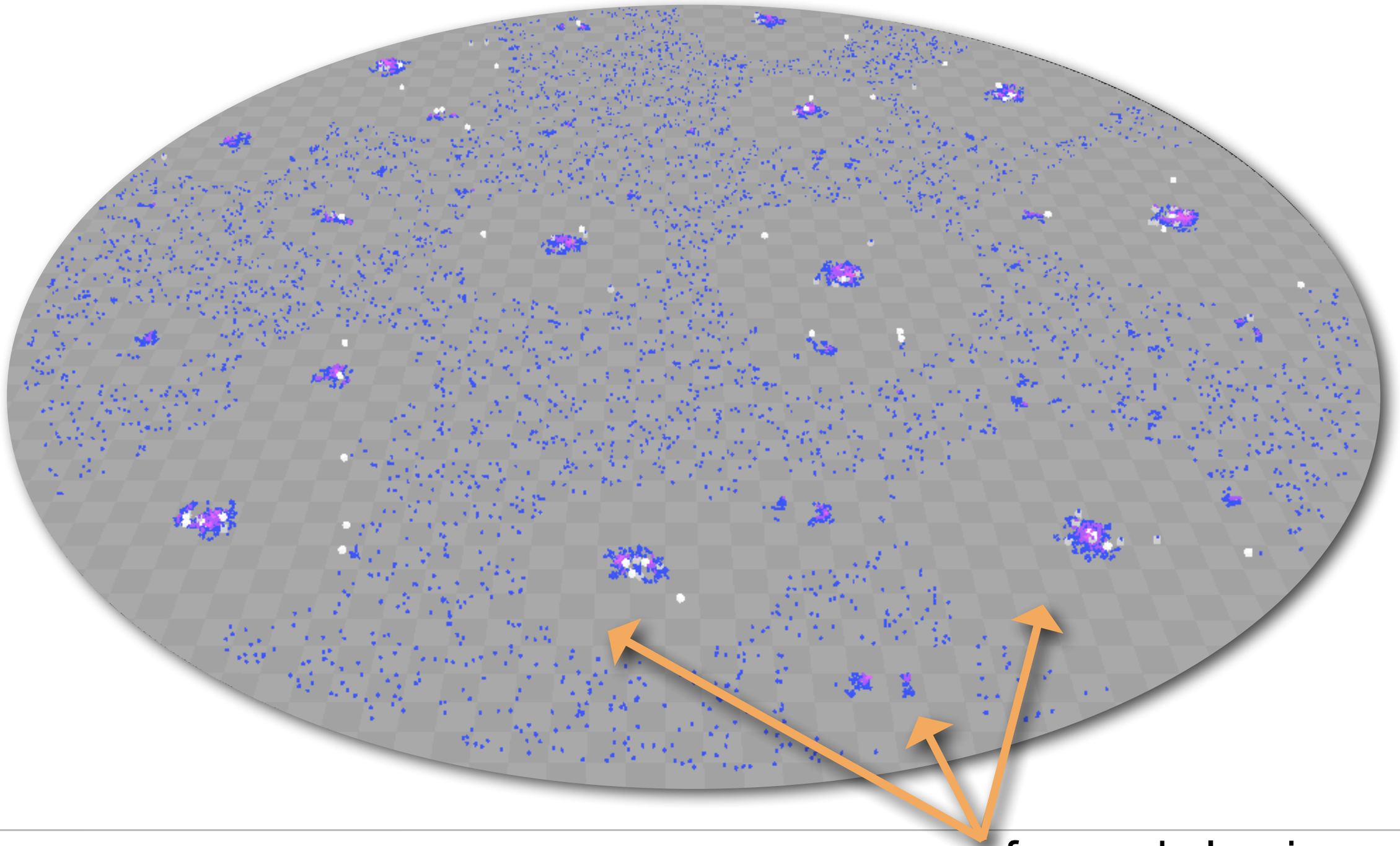


Collective construction: termite mound size



8000 bricks

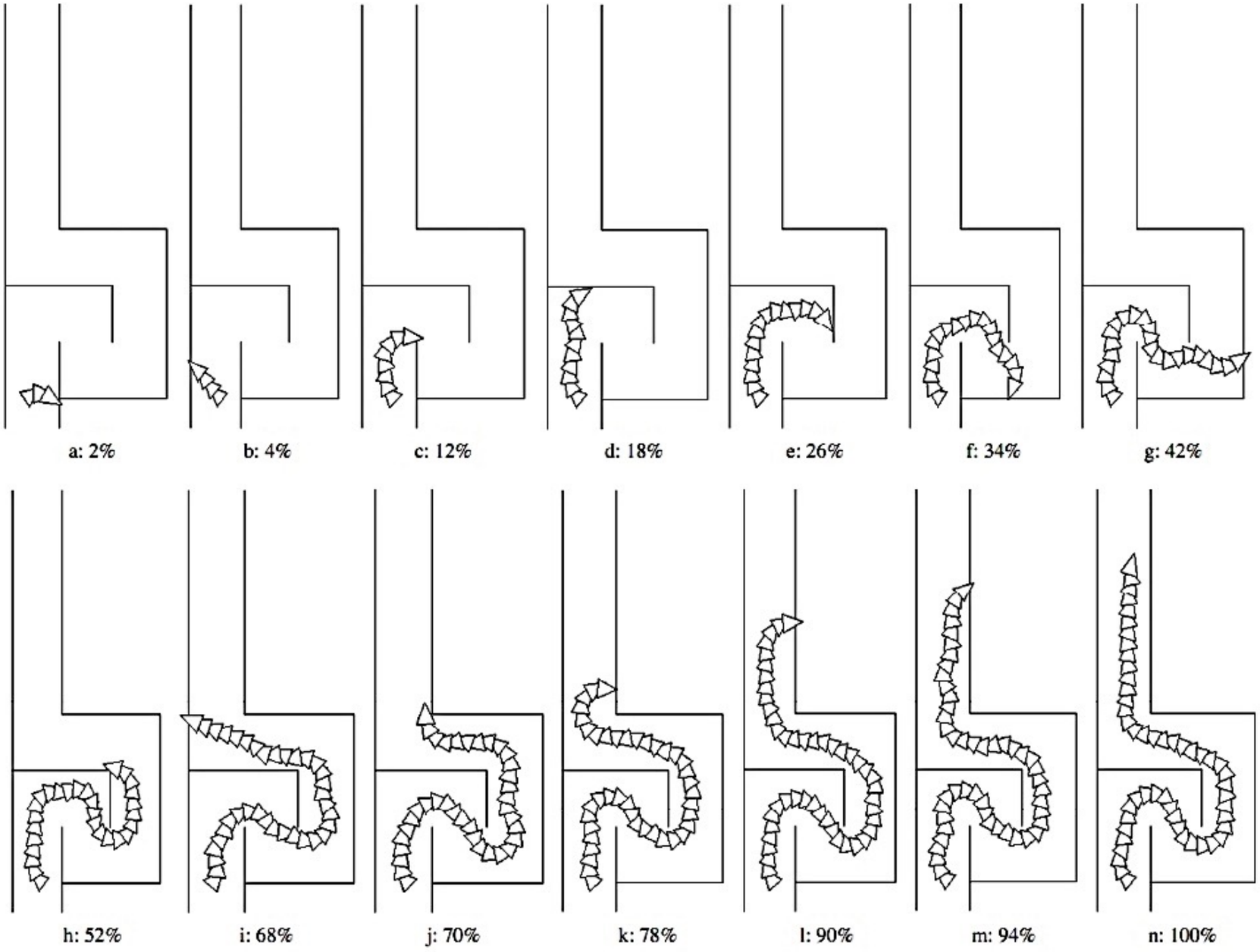
Stigmergy: emergent team construction



demo: OpenSteer

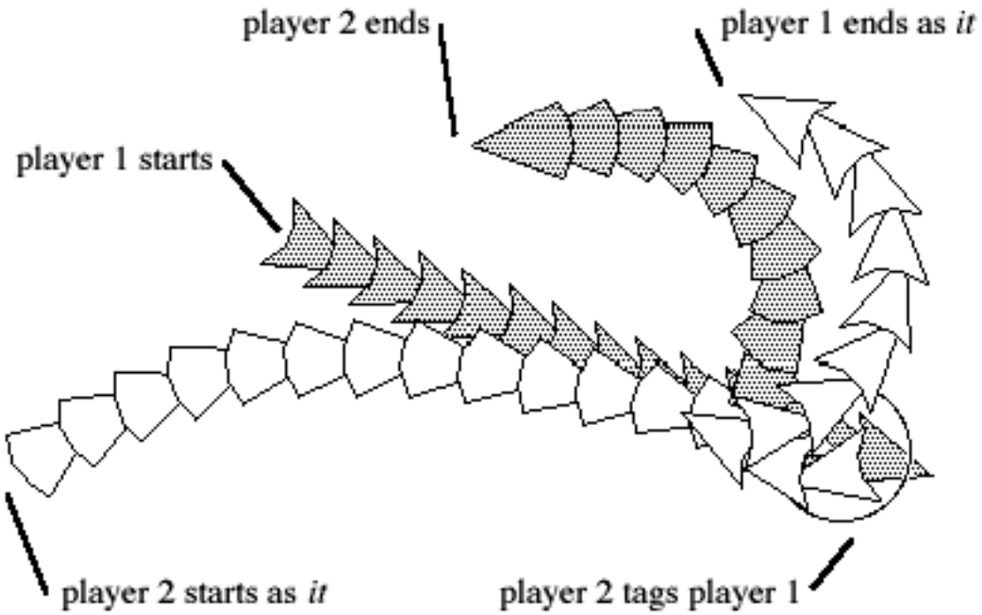
Evolutionary optimization of steering behaviors

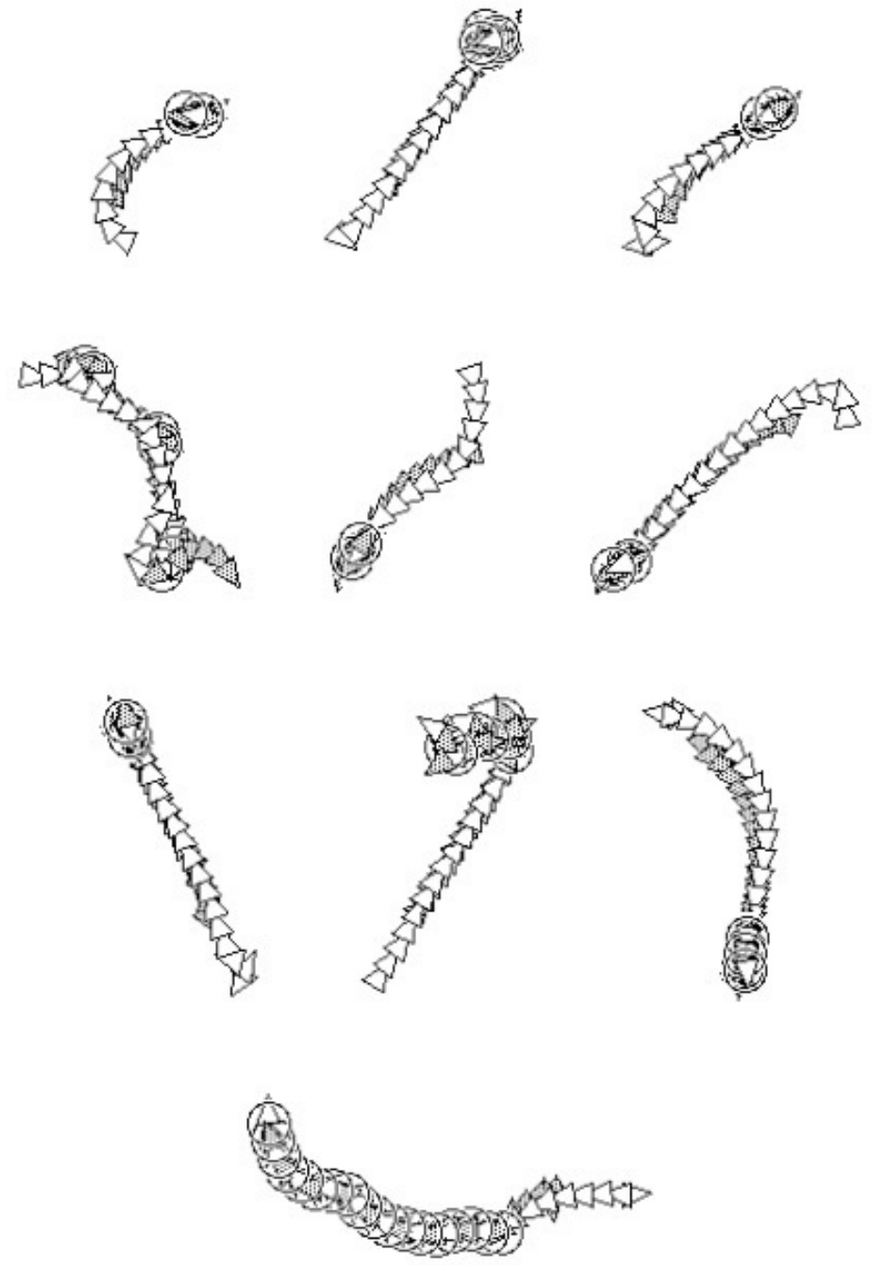
Evolutionary Steering



Evolution of Corridor Following Behavior in a Noisy World — SAB 1994

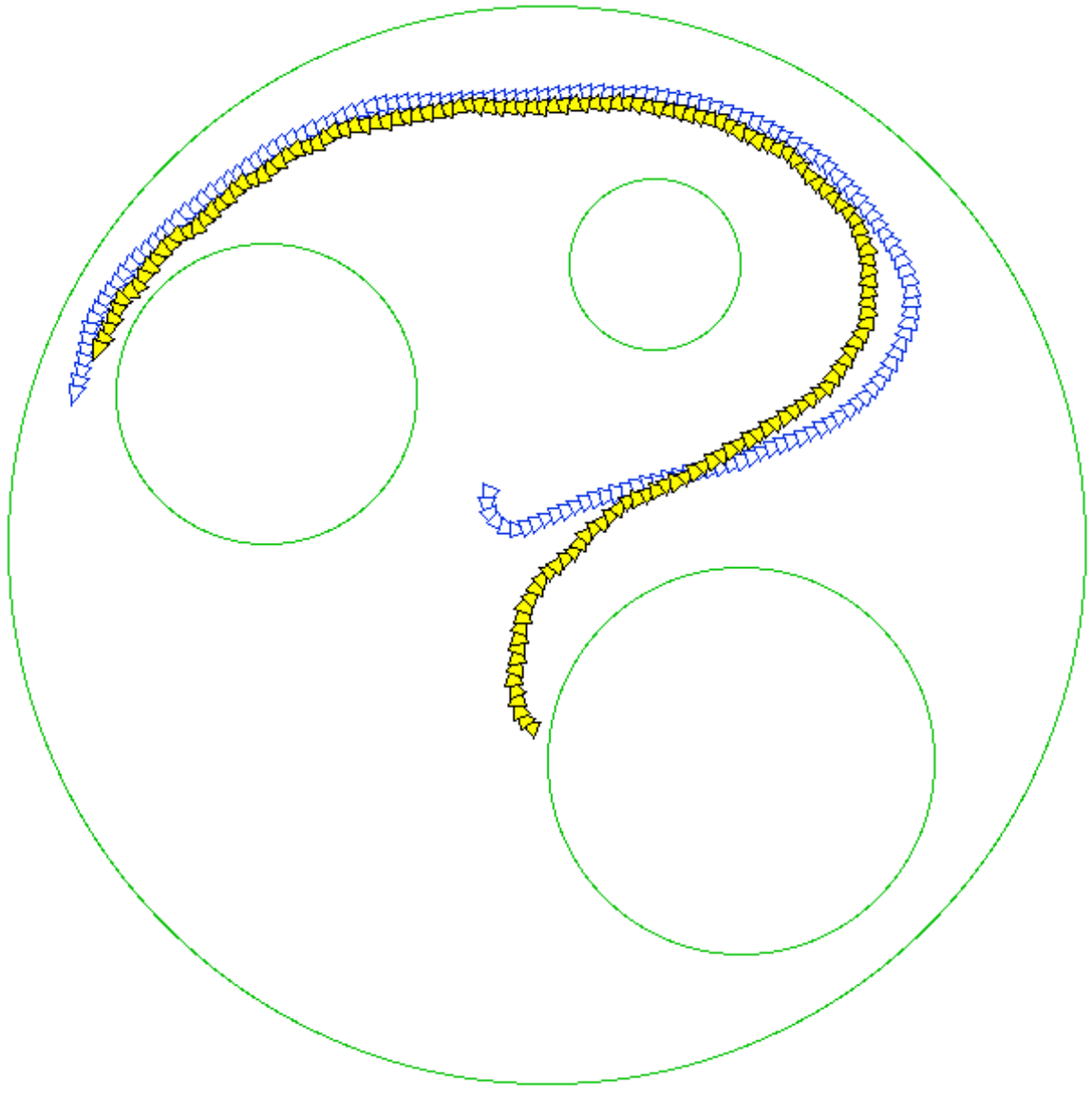
Evolutionary Steering

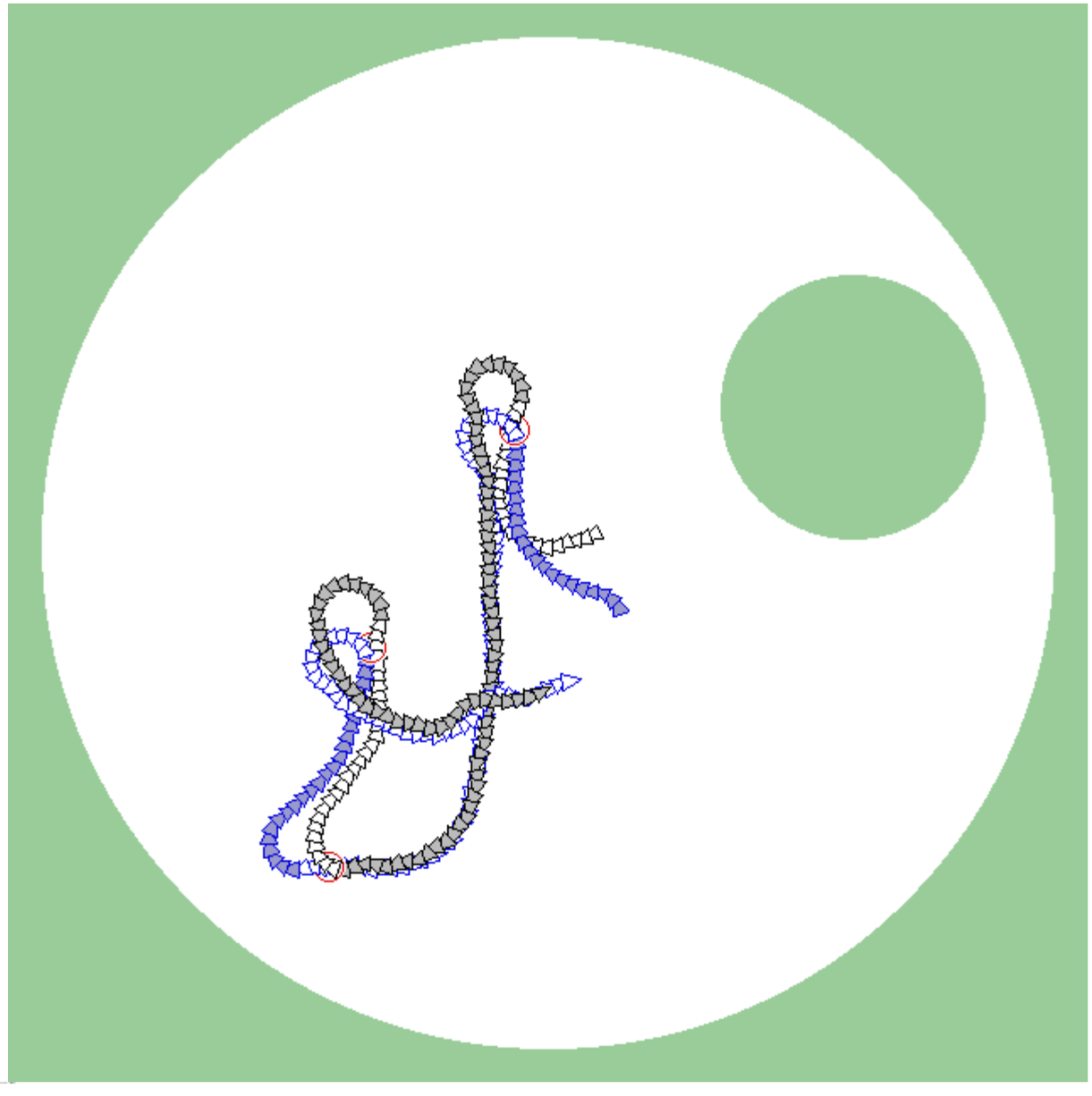




Competition, Coevolution and the Game of Tag — ALife 1994

Evolutionary Steering





subsequent work on “tag” with obstacles — unpublished

Steering behaviors on the web

In addition to your textbook, some other resources:

- 1999 paper, Java demos: http://www.red3d.com/cwr/steer/ (Google "steering behaviors")
- OpenSteer: http://opensteer.sourceforge.net/
- *Understanding Steering Behaviors* by Fernando Bevilacqua http://gamedev.tutsplus.com/author/fernando-bevilacqua/
- These slides: http://www.red3d.com/cwr/temp/2013_Steering_Behaviors.pdf

these slides: http://www.red3d.com/cwr/presentations/2016_UCSC_Steering_Behaviors.pdf

Thank you!

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