EvALife

Autonomous Characters
for Games and Animation

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Autonomous Characters for Games and Animation

EvALife

- *Self-directing* characters which operate autonomously

  ("puppets that pull their own strings" -Ann Marion)

- Applications in:
  - games and other interactive venues
  - animation for television and feature films
- History:
  - first used experimentally in 1987
  - in wide commercial use today

Autonomous Characters

EvALife

- Autonomous agents for simulated 3D worlds
  - situated
  - embodied
- Intersection of several fields
  - ethology
  - artificial life
  - autonomous robotics
  - dramatic characters
- Adjunct to physically-based modeling
  - dynamics versus volition
  - bouncing ball versus pursuing puppy

Reactive Behavior

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- Behavior driven by reaction to environment
  - both passive scenery and active characters
- Simplifies complex animation
  - many characters can be animated by a single behavior
- Allows user interaction
  - improvisational style permits unscripted action

Applications of Autonomous Characters

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- Behavioral animation (film and television)
  - coordinated group motion
  - extras / background action
- Interactive multimedia (games / virtual reality)
  - opponents and allies
  - background characters
- Autonomous robotics
  - search / exploration / mapping
  - prototyping for evolutionary robotics
- Theoretical biology
  - testing theories of emergent natural behavior

Creating Character Behaviors

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- By design
  - programming
  - authoring

    (example: Motion Factory)
- Through self-organization
  - evolution
  - and other forms of *machine learning*:

    neural nets
    decision trees
    classifier systems
    simulated annealing

Ad hoc Behavioral Hierarchy

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- Action selection
  - goals and strategies
- Path selection / steering
  - global motion
- Pose selection / locomotion
  - local motion (animation)

Combining Simultaneous Behaviors

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- Combination
  - discrete selection
  - behavioral blending
- Low priority behavior should not be:
  - completely locked out
  - allowed to contradict (and perhaps cancel out) a higher priority behavior

Behavioral Blending

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- Summation / averaging
- Prioritized sequential selection
  - first active
  - stochastic (dithered) decision tree

Behavioral Animation

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Behavioral Animation

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- Background action
- Autonomous characters
  - behavioral model
  - graphical model
- Improvised action

Behavioral Animation: Group Motion

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- Individual
  - simple local behavior
  - interaction with:
    - nearby individuals
    - local environment
- Group:
  - complex global behavior

Behavioral Animation: Examples of Group Motion

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- People
  - crowds, mobs, passersby
- Animal
  - flocks, schools, herds
- Vehicle
  - traffic

Applications of Behavioral Animations

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- 1987: *Stanley and Stella in: Breaking the Ice,* (short)
  Director: Larry Malone, Producer: Symbolics, Inc.
- 1988: *Behave*, (short)
  Produced and directed by Rebecca Allen
- 1989: *The Little Death,* (short)
  Director: Matt Elson, Producer: Symbolics, Inc.
- 1992: *Batman Returns,* (feature)
  Director: Tim Burton, Producer: Warner Brothers
- 1993: *Cliffhanger,* (feature)
  Director: Renny Harlin, Producer: Carolco.
- 1994: *The Lion King,* (feature)
  Director: Allers / Minkoff, Producer: Disney.

Applications of Behavioral Animations

EvALife

- 1996: *From Dusk Till Dawn,* (feature)
  Director: Robert Rodriguez, Producer: Miramax
- 1996: *The Hunchback of Notre Dame,* (feature)
  Director: Trousdale / Wise, Producer: Disney.
- 1997: *Hercules,* (feature)
  Director: Clements / Musker, Producer: Disney.
- 1997: *Spawn,* (feature)
  Director: Dippé, Producer: Disney.
- 1997: *Starship Troopers,* (feature)
  Director: Verhoeven, Producer: Tristar Pictures.
- 1998: *Mulan,* (feature)
  Director: Bancroft/Cook, Producer: Disney.

Applications of Behavioral Animations

- 1998: *Antz,* (feature)
  Director: Darnell/Guterman/Johnson, Producer: DreamWorks/PDI.
- 1998: *A Bugs Life,* (feature)
  Director: Lasseter/Stanton, Producer: Disney/Pixar.
- 1998: *The Prince of Egypt,* (feature)
  Director: Chapman/Hickner/Wells, Producer: DreamWorks.
- 1999: *Star Wars: Episode I--The Phantom Menace,* (feature)
  Director: Lucas, Producer: Lucasfilm.

Autonomous Character Case Studies

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- Hand programmed
  - steering behavior library
  - boids
  - hockey players
- Evolution
  - corridor following
  - tag players

Steering Behaviors

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- seek or flee from a location
- pursuit and evasion
- arrival (position / velocity / time constraints)
- obstacle avoidance / containment
- path / wall / flow field following
- group behaviors
  - unaligned collision avoidance
  - Leader following
  - flocking (three components)

Steering Behaviors

EvALife

…steering behavior demos…

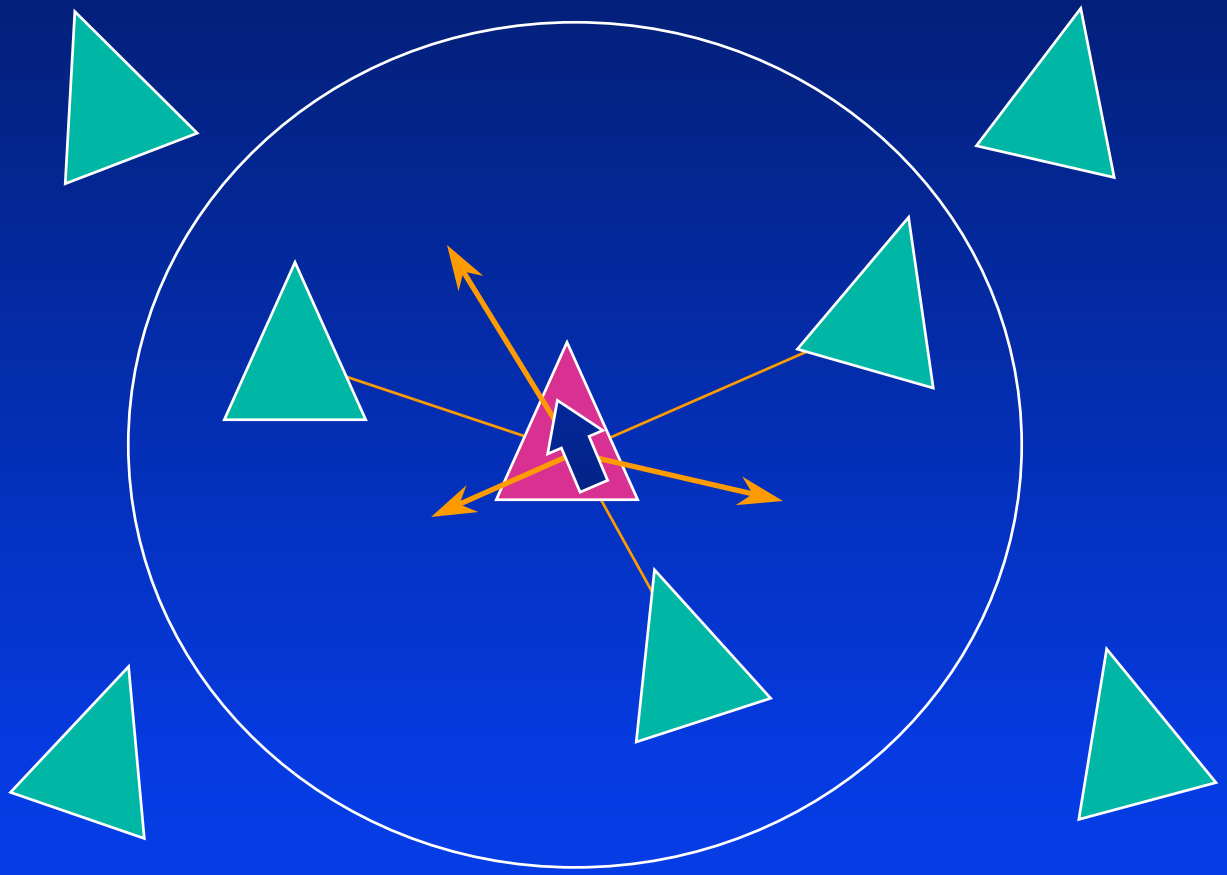
Boid Flocking
(three component steering behaviors)

EvALife

- Separation
  - steer to move away from nearby flockmates
- Alignment
  - steer toward average heading of nearby flockmates (accelerate to match average velocity of nearby flockmates)
- Cohesion
  - steer towards average position of nearby flockmates

Boids:
Separation

EvALife



Boids:
Alignment

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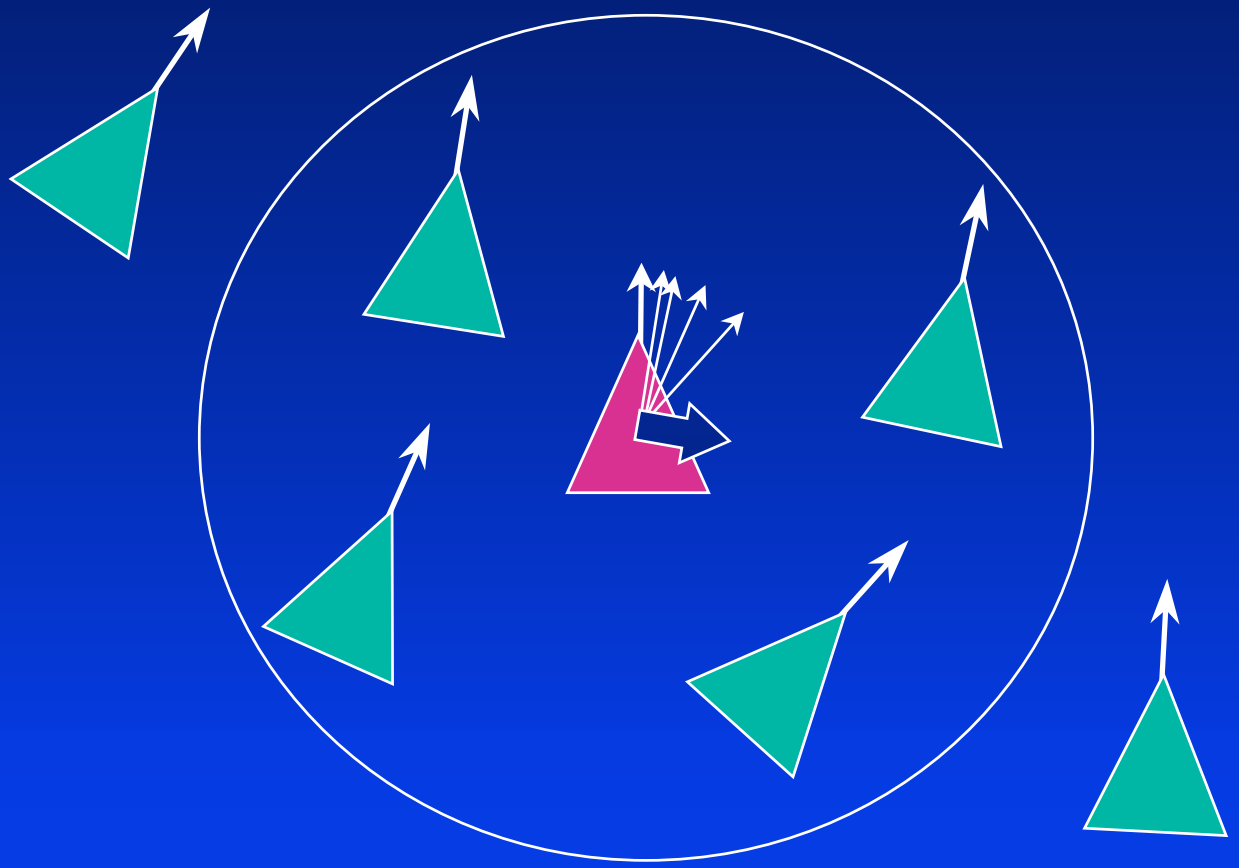

Boids: Aggregation

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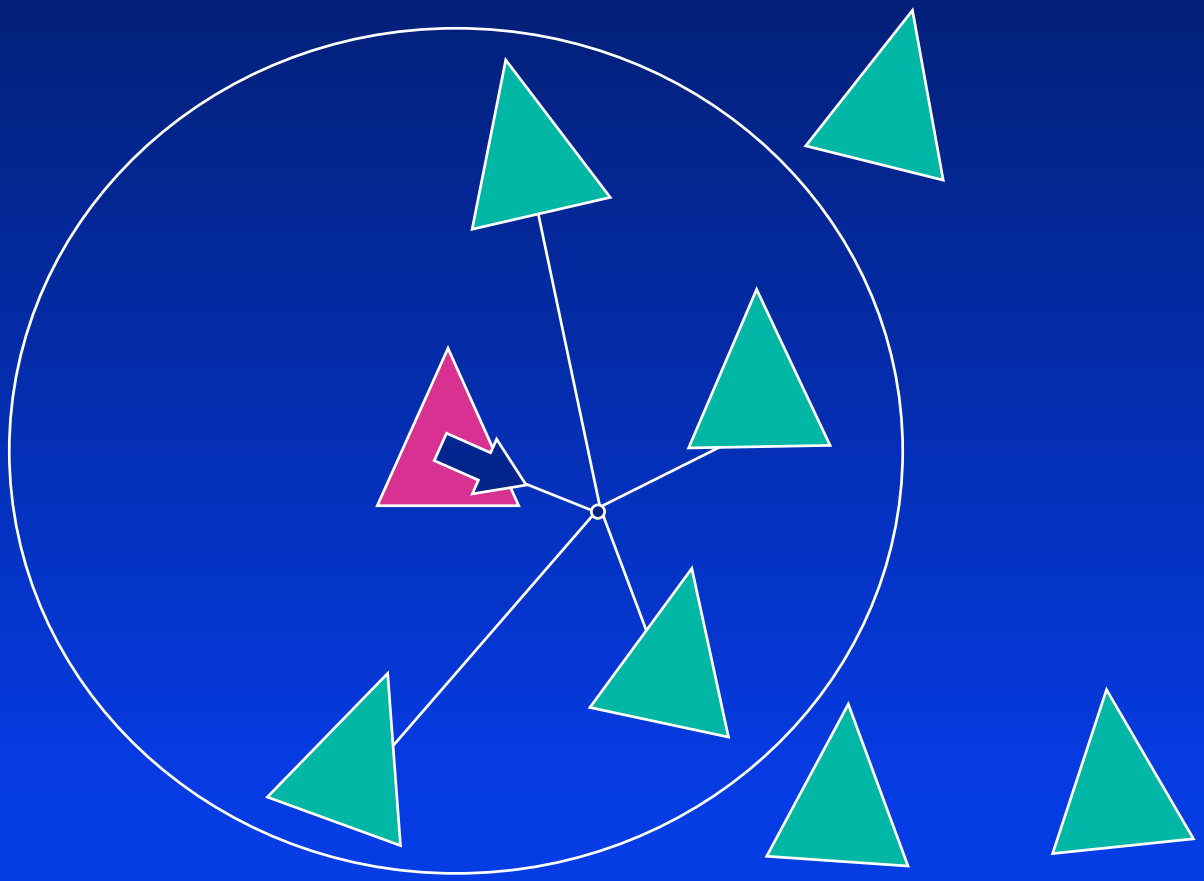

Boids
(full behavioral model)

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- Obstacle avoidance
- Flocking
  - separation
  - alignment
  - cohesion
- Migratory (attraction / repulsion)

Boids Web Page

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http://www.red.com/cwr/boids.html

Boids Video

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…boids video...

Basic Hockey Player

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- Physical model
  - point mass
  - limited force and velocity
  - collision modeling (as cylinder)
- Awareness of
  - position and velocity of players and puck
  - position of rink and markings
- Behaviors:
  - avoid rink walls and goal nets
  - chase loose puck, skate towards location…
- Assigned role

  (forward, wing, defenseman, goalie)

Hockey *Role* Model

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- Defenseman
  - if you have the puck…
  - if your teammate has the puck...
  - if puck is within your zone:
    - discourage shot on goal
    - discourage pass to opponent
    - don't crowd goalie
  - do basic hockey play stuff

Hockey Demo

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…hockey demo…

Evolution of Behavior

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- Agent in simulated world
- Evolution of
  - behavioral controller
  - agent morphology (see Sims SIGGRAPH 94)
- Fitness based on agent's performance
  - objective fitness metric
  - competitive fitness

Evolution of Corridor Following Behavior in a Noisy World

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- Evolve controller for abstract vehicle
- Task: corridor following
  - noisy range sensors
  - noisy steering mechanism
- Evolution of sensor morphology

Corridor Following: goal

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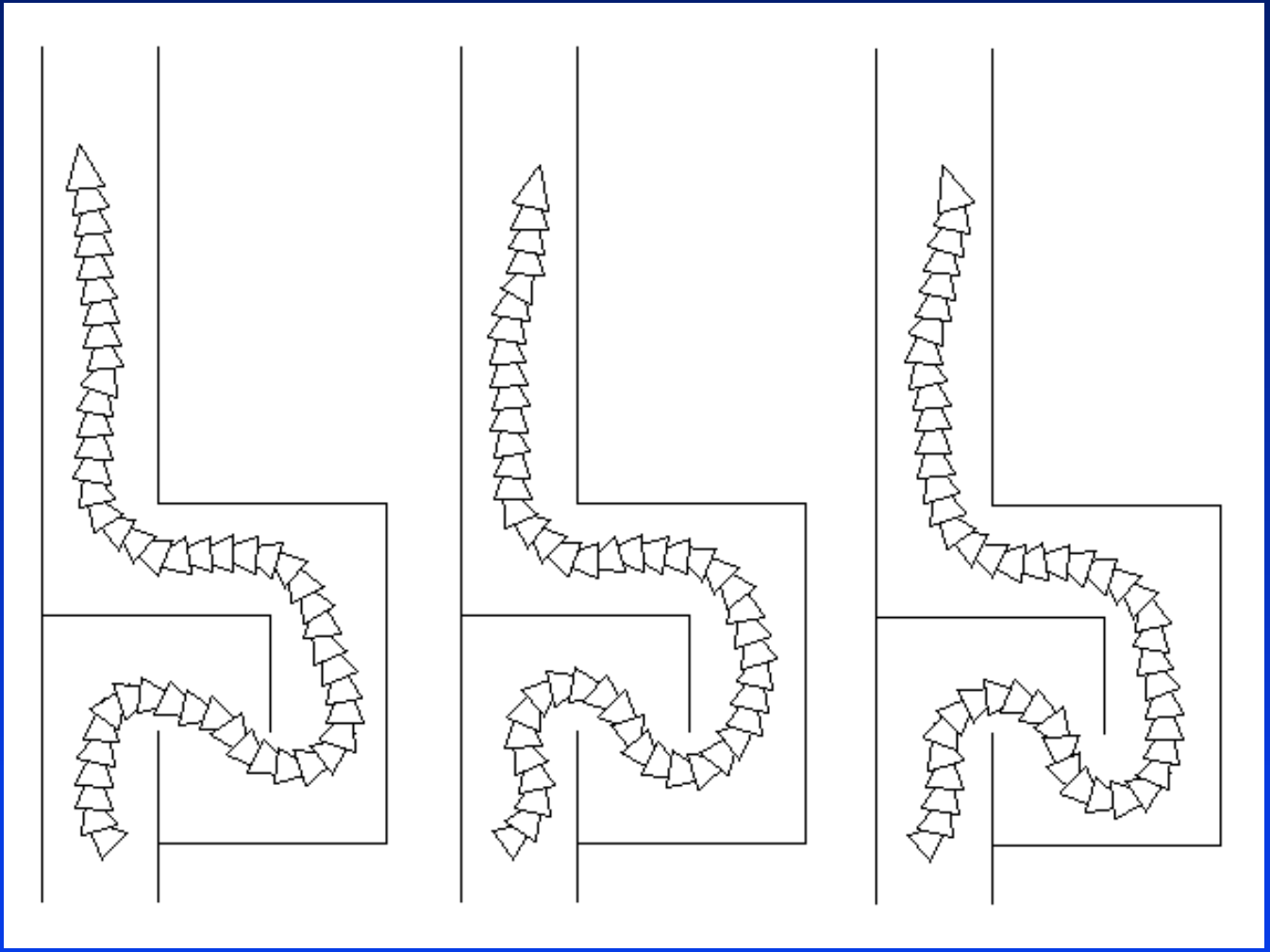

Corridor following: fitness

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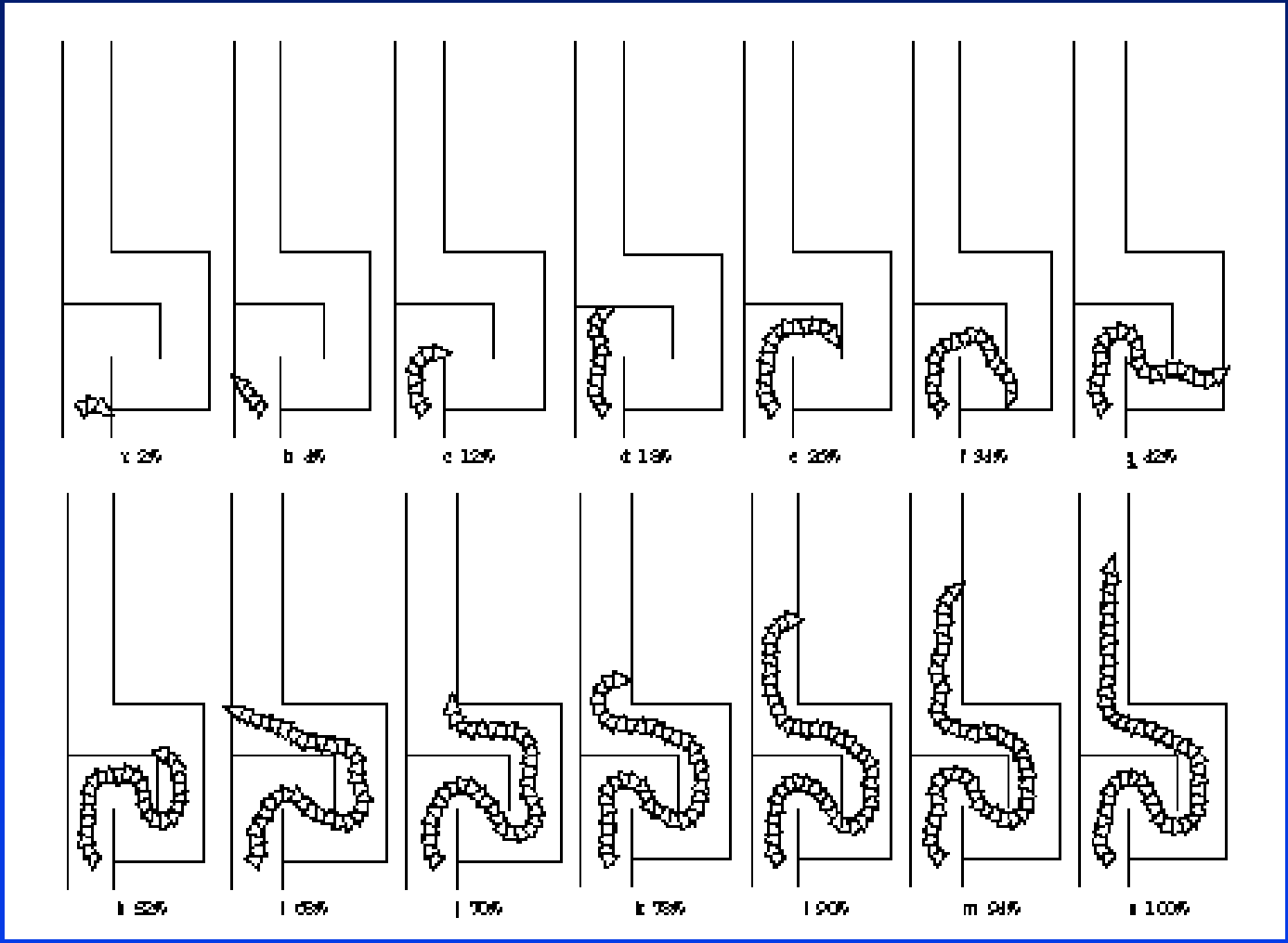

Corridor Following: Results

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- Works well
- Difficulty strongly related to the representation used
- “Competent” controllers easy to find
- Reliability of controllers is difficult to measure

Corridor Following: Experimental Design

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- Vehicle model
  - constant speed
  - limited steering angle
  - noisy sensors (arbitrary number & direction)
  - noisy steering mechanism
- Genetic Programming
  - hybrid steady-state model
  - worst of four noisy trials
  - population: 2000
  - size limit for evolved programs: 50

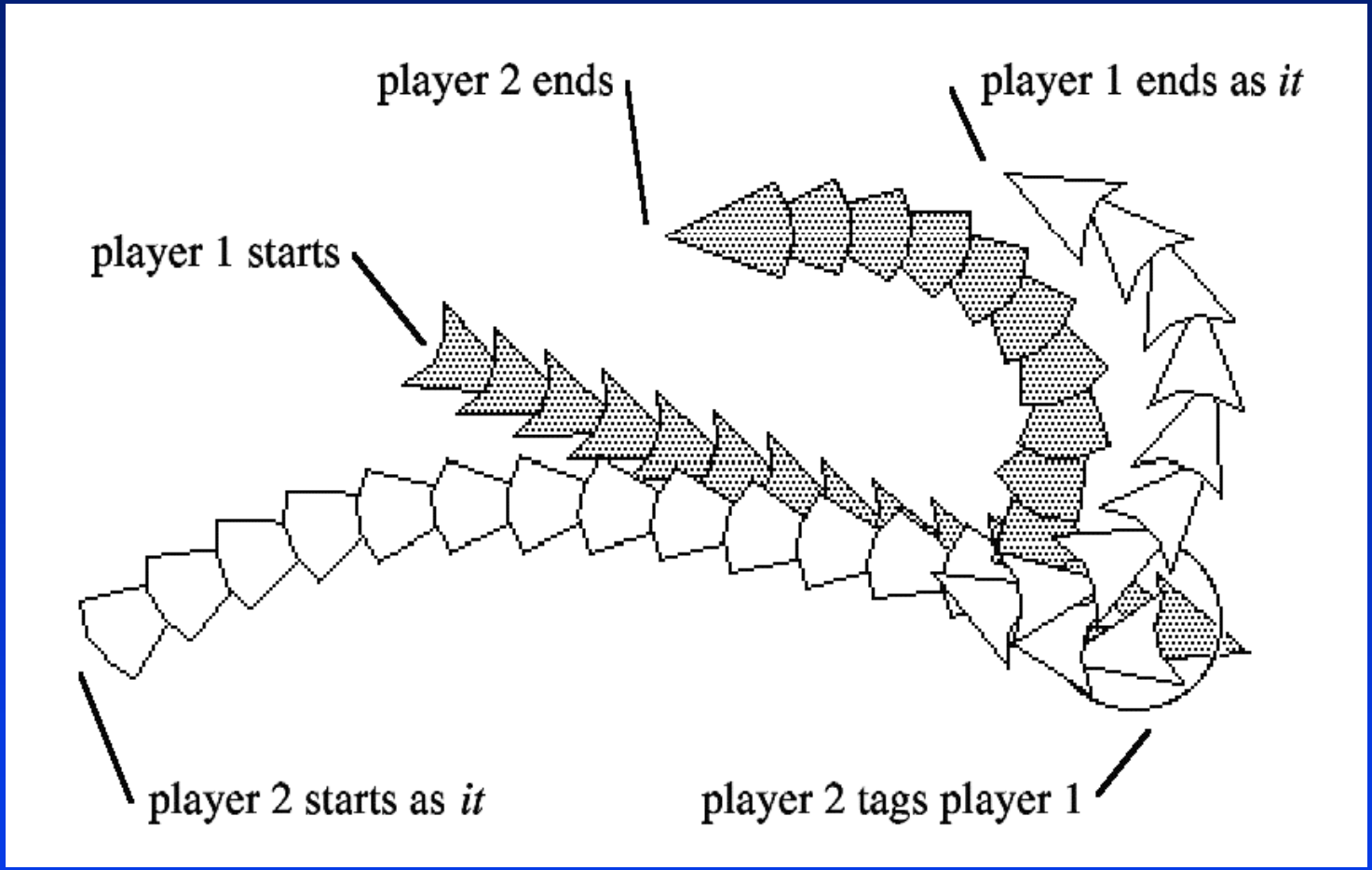
Competition, Coevolution and the Game of Tag

EvALife

- The game of tag
  - symmetrical pursuit and evasion
  - role reversal
- Goal: discover steering behavior for tag
- Method: emergence of behavior
  - evolution
  - competitive fitness
- Self-organization: no expert knowledge required

Competition, Coevolution and the Game of Tag -- Examples 1

EvALife



Competition, Coevolution and the Game of Tag -- Examples 2

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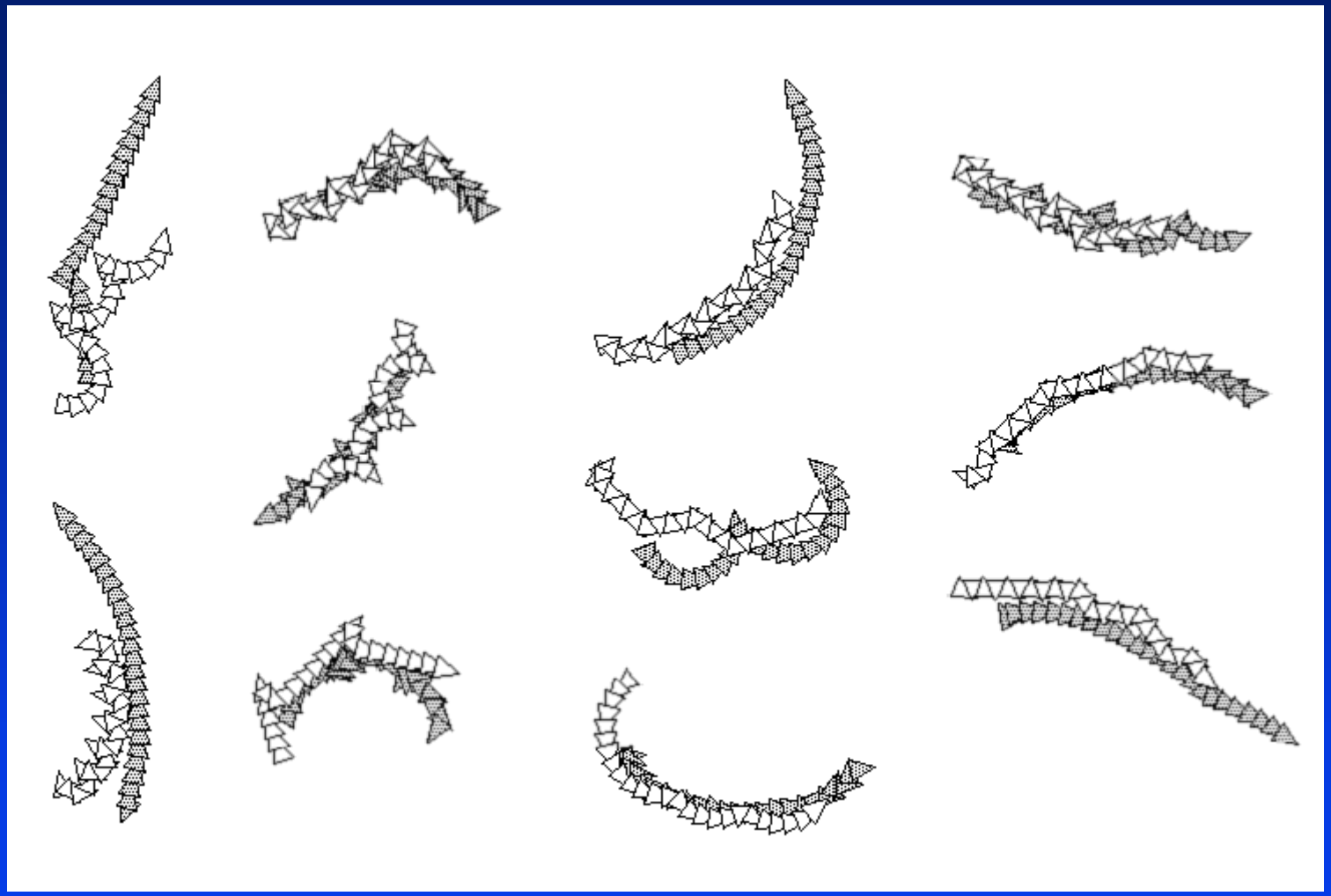
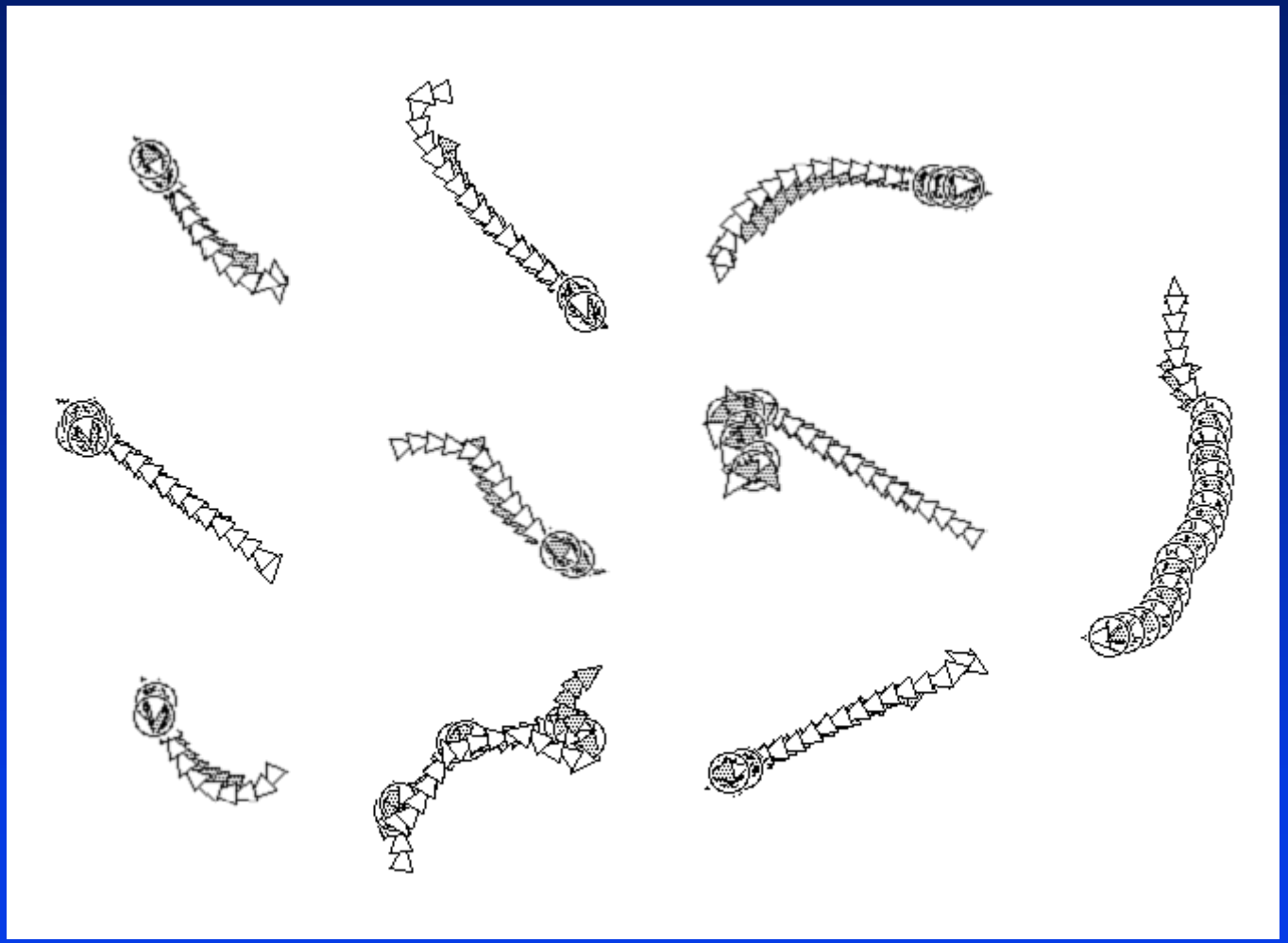


Competition, Coevolution and the Game of Tag -- Examples 3

EvALife



Competition, Coevolution and the Game of Tag -- The Results

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- It works (more or less)
- An ecology of competing behaviors will arise
- All evolved behaviors were sub-optimal

  (perhaps do to *collusion*: “live and let live”)

Conclusion

EvALife

- Autonomous characters:
  - add richness and complexity to virtual worlds
  - automate creation of groups and crowd scenes
  - allow life-like improvisational action
  - can react to unanticipated situations, like user input
- Games and animation provide many applications of, testbeds for, and problems to be solved by research in:
  - artificial life
  - artificial intelligence
  - evolutionary computation
  - and other biologically-inspired methods

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