Active Dynamics

COS 426, Spring 2014

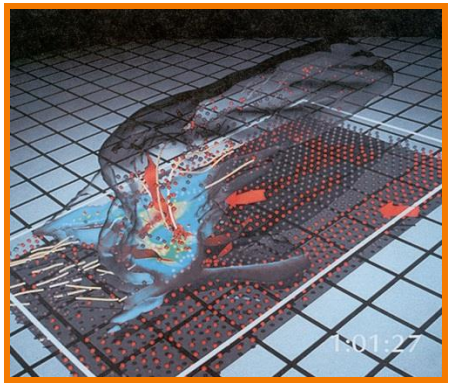
Princeton University

Computer Animation

- Animation
  - Make objects change over time according to scripted actions

Pixar

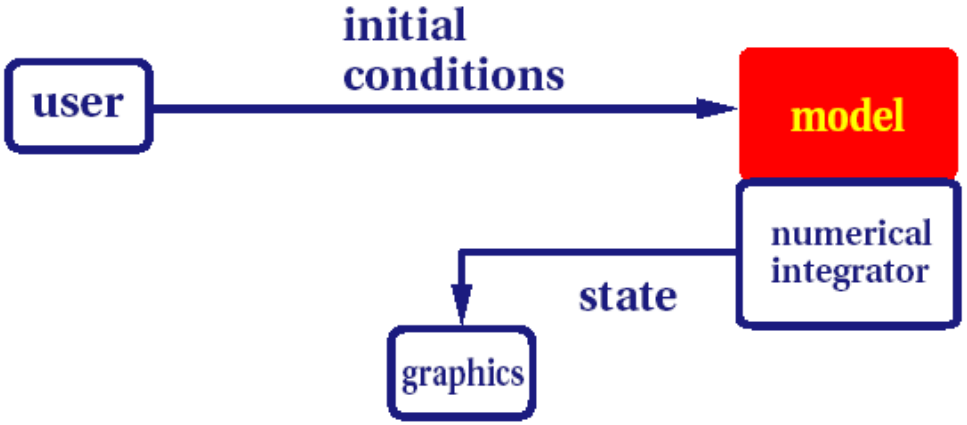
- Simulation / dynamics
  - Predict how objects change over time according to physical laws



University of Illinois

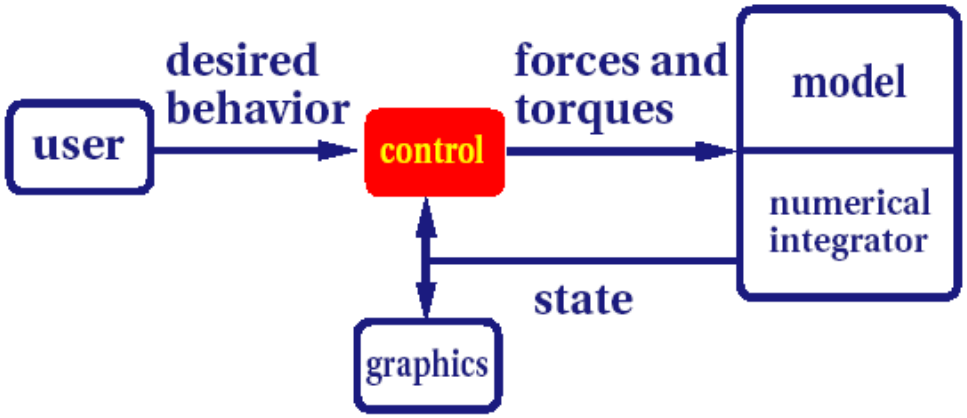
Passive vs. Active Dynamics

Passive--no muscles or motors



particle systems
leaves
water spray
clothing

Active--internal source of energy

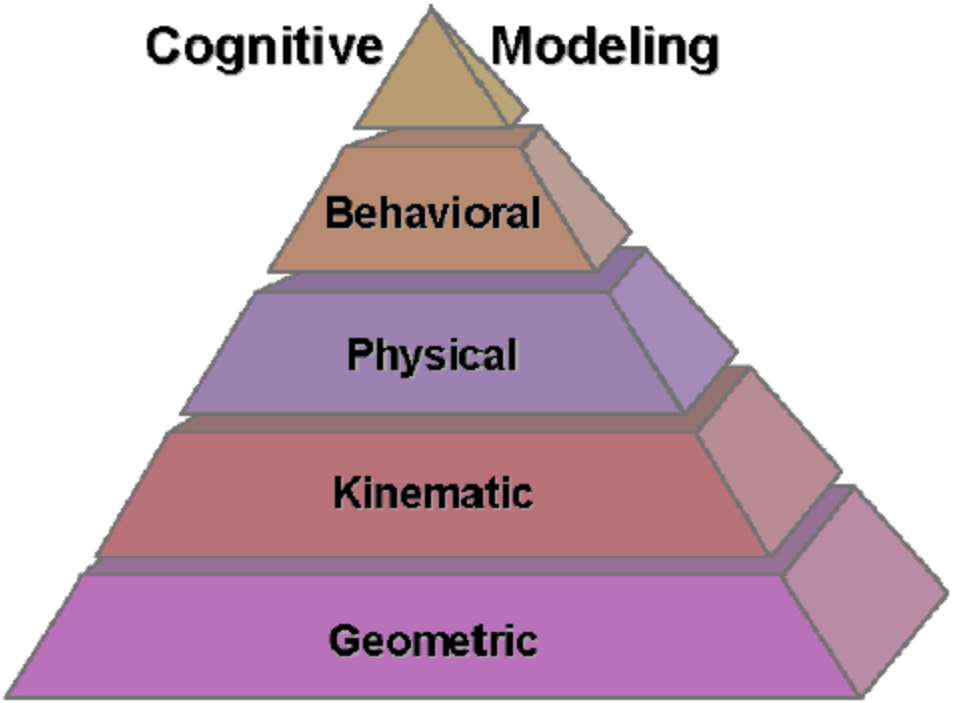


running human
trotting dog
swimming fish

Hodgins

Active Dynamics

- Motions
  - Physics
  - Controllers
  - Learning
- Behaviors
  - States
- Cognition
  - Planning



Funge99

Motion

- Example 1: how do worms move?

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Snake Motion

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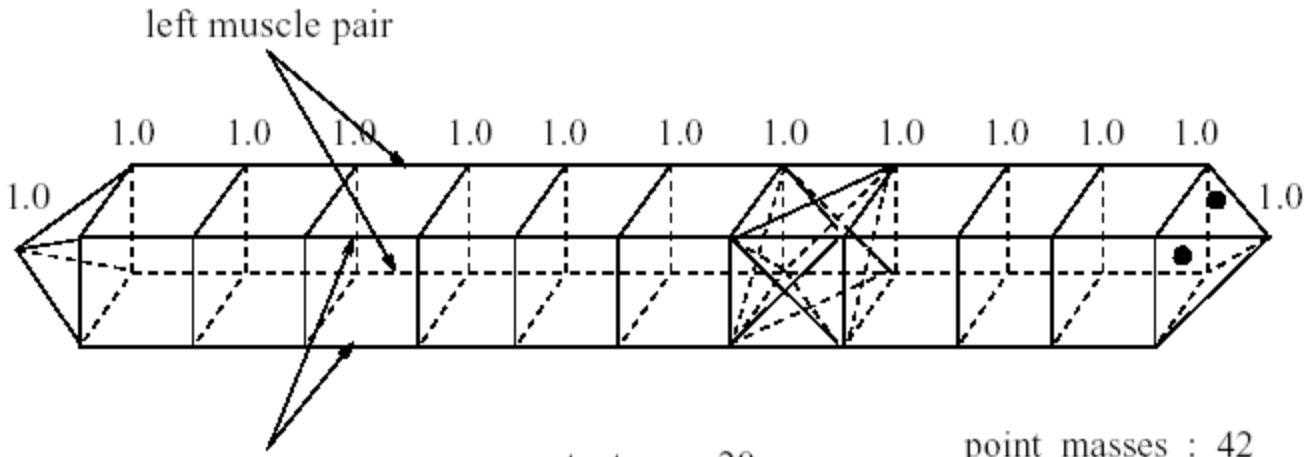
Worm Biomechanical Model



actuators : 20

springs' stiffness : 50.0

point masses : 42

DOFs : 126

size of the state space : 252

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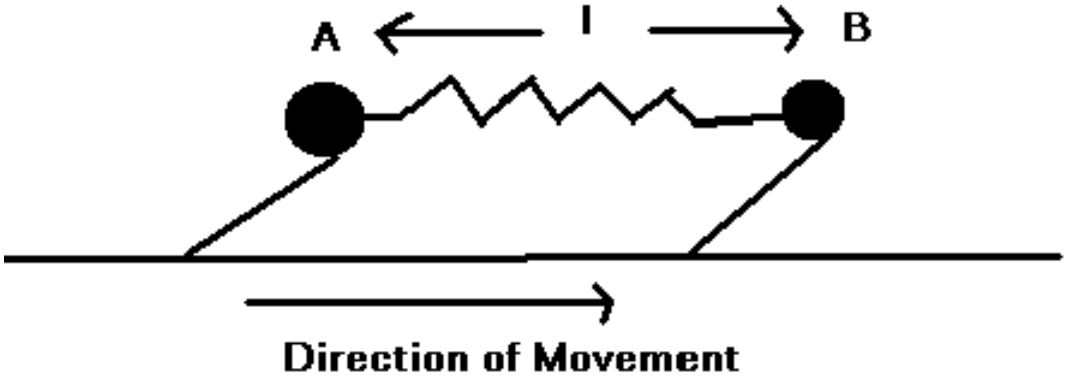
Worm Physics



$$f = k(L - I) - D\frac{dl}{dt}$$

$$a = f / m$$

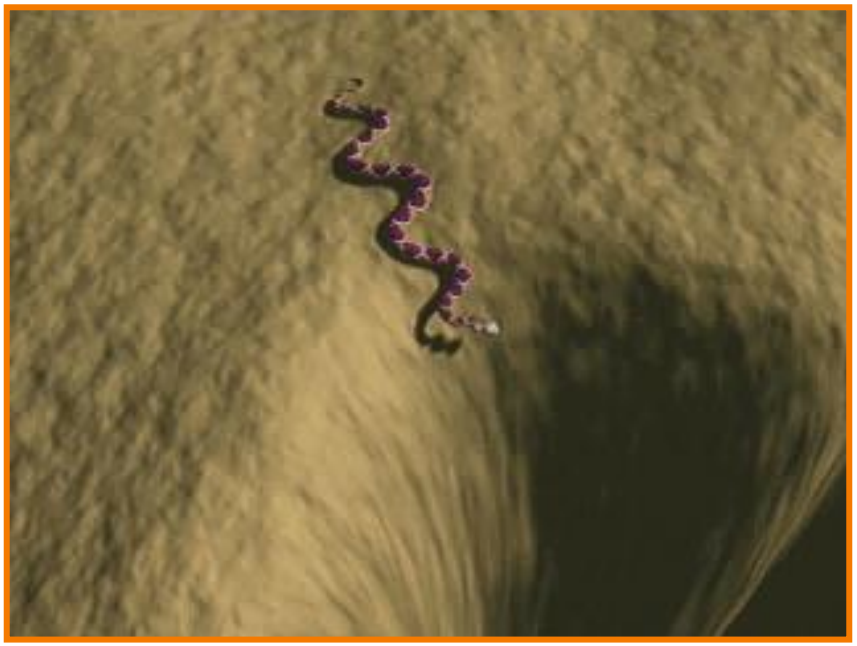
$$x = \iint (f / m)\, dt$$

f = force along spring direction
k = spring force constant
D = damping force
I = current spring length
L = minimum energy spring length

... plus forces due to friction with ground.

Miller88

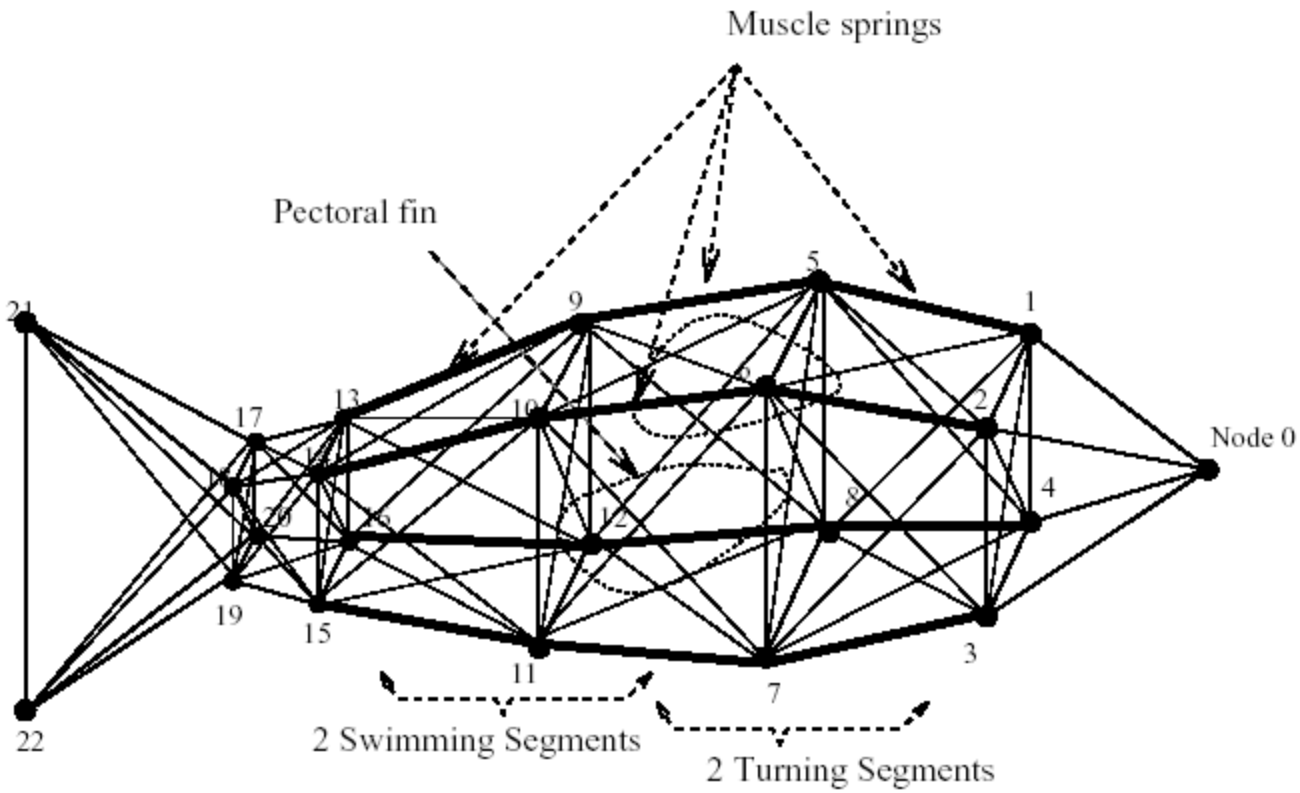
Her Majesty's Secret Serpent



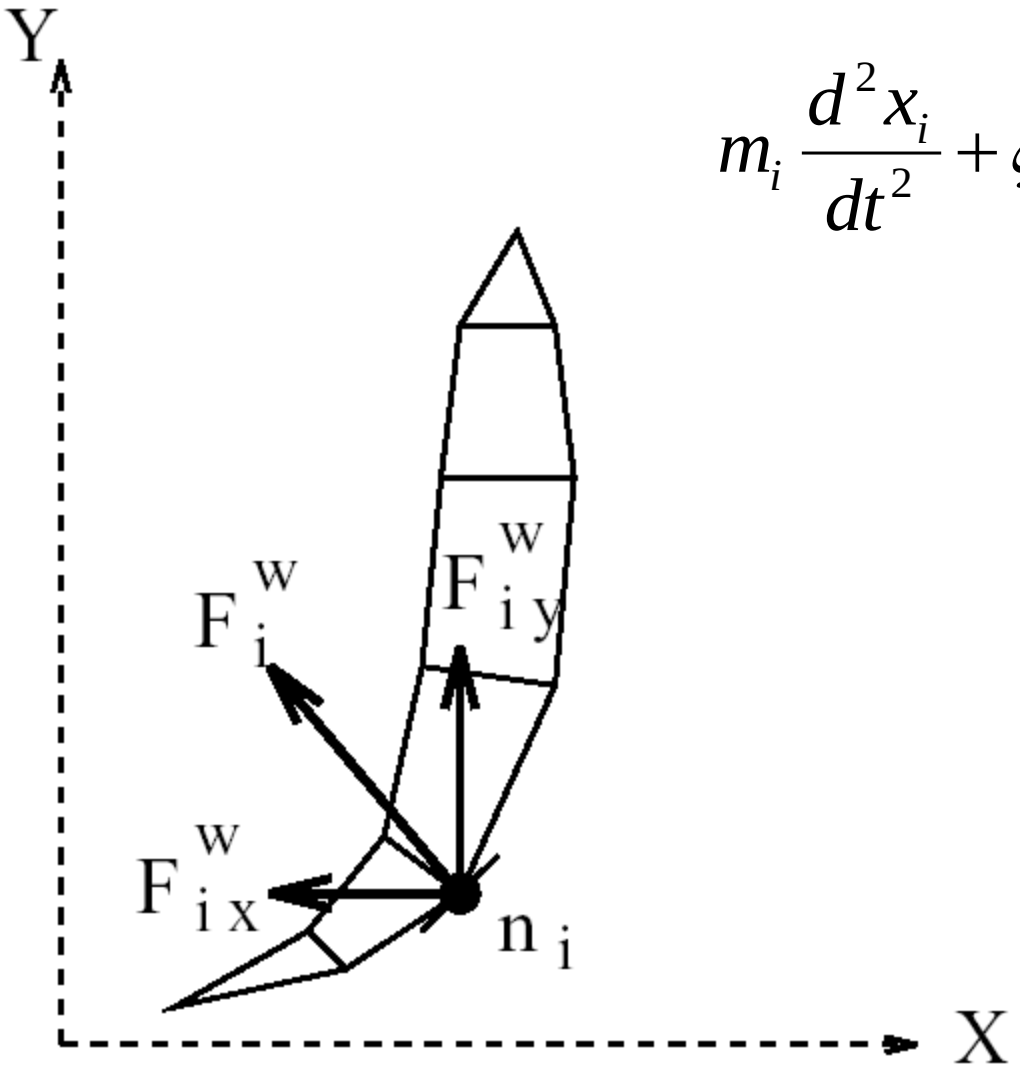
Fish Motion

- Example 2: how do fish move?

Spring-Mass Model for Fish

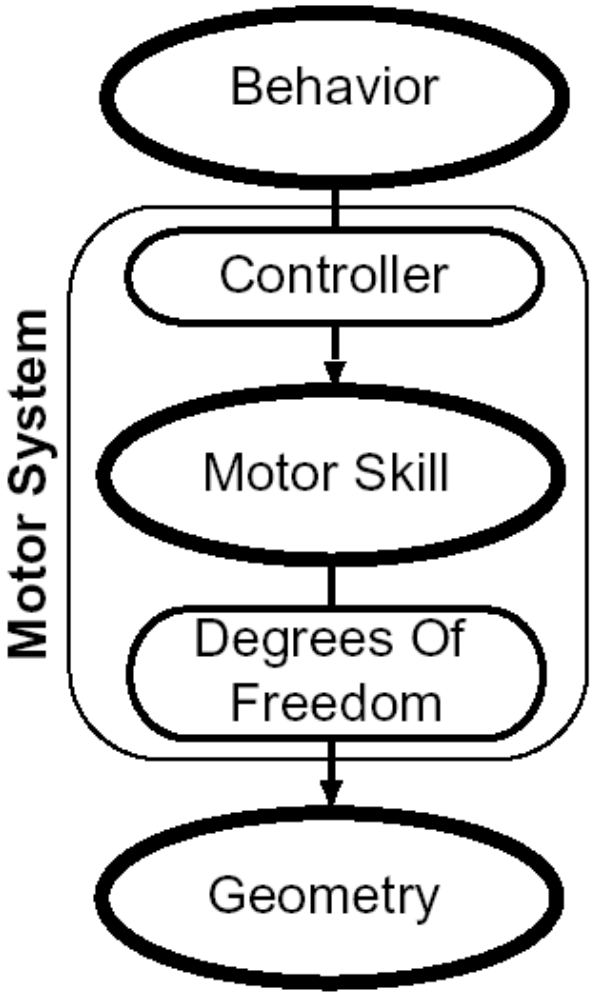


Hydrodynamic Locomotion



$$m_i \frac{d^2 x_i}{dt^2} + \varsigma_i \frac{dx_i}{dt} - w_i = f_i^w$$

Motor System



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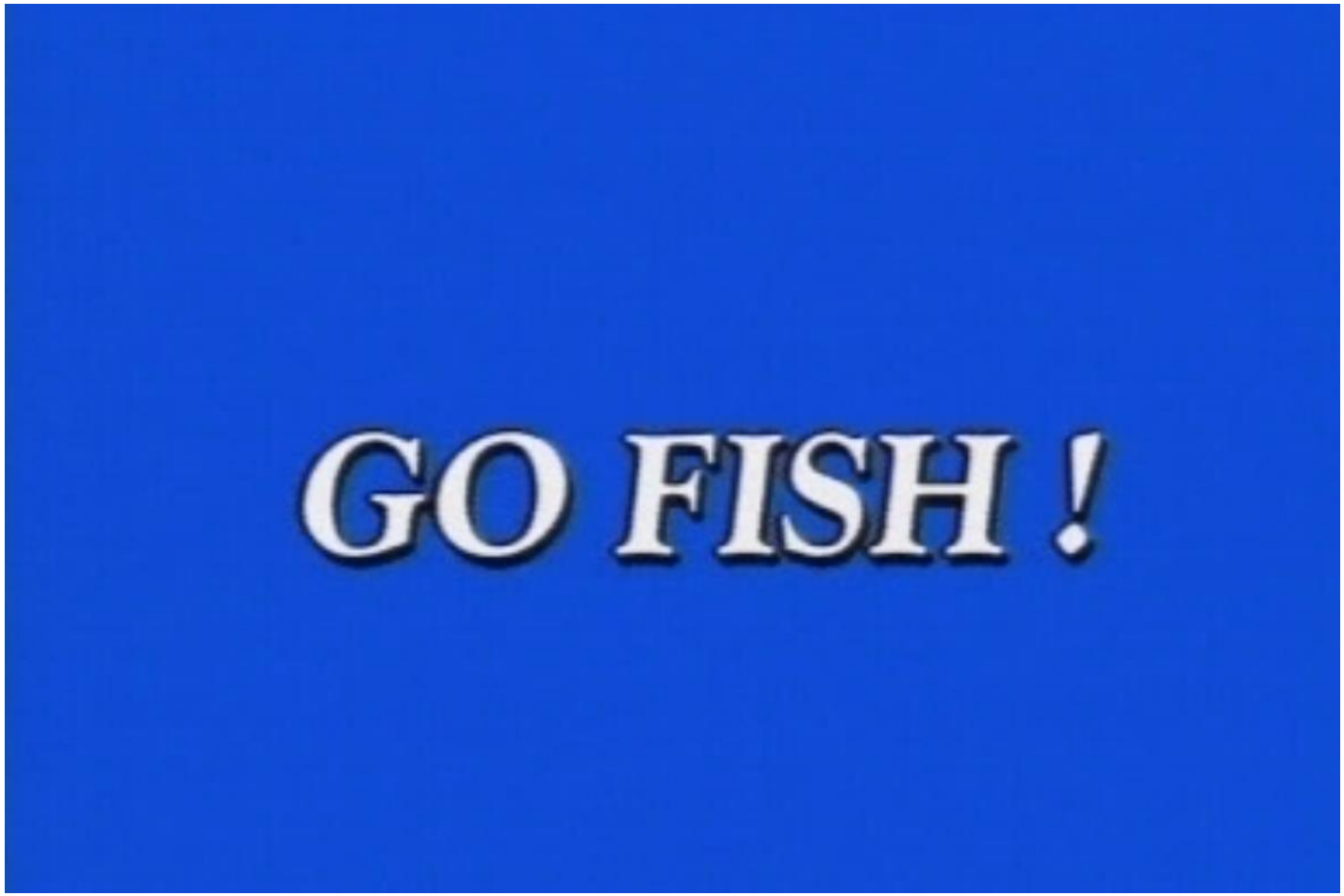
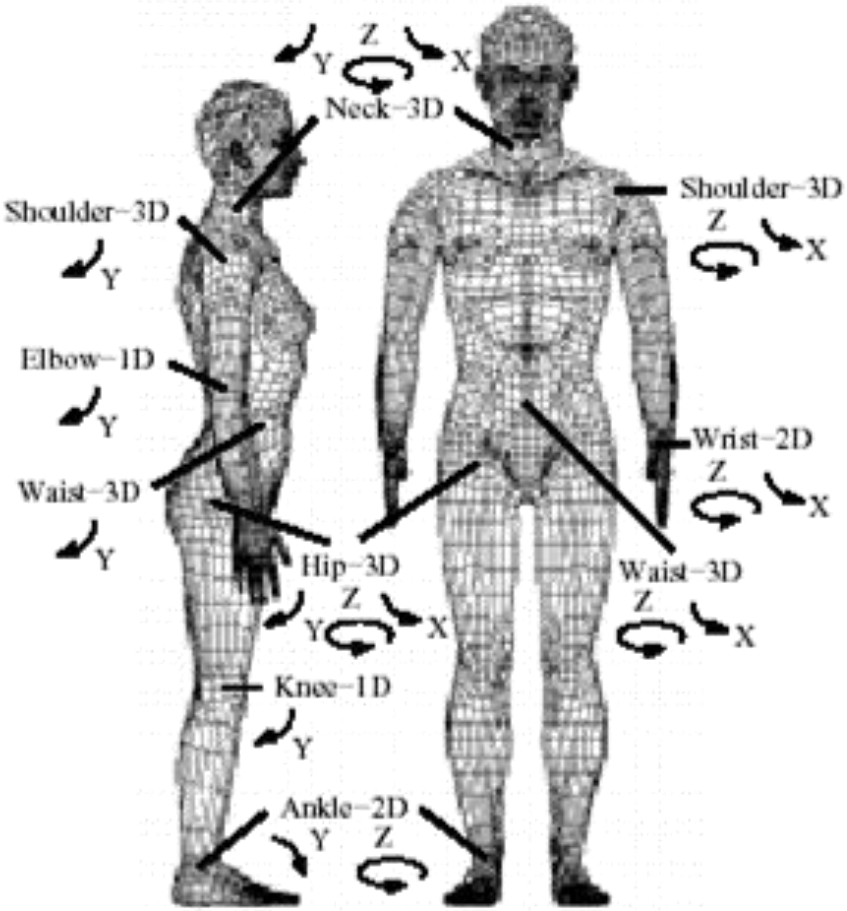
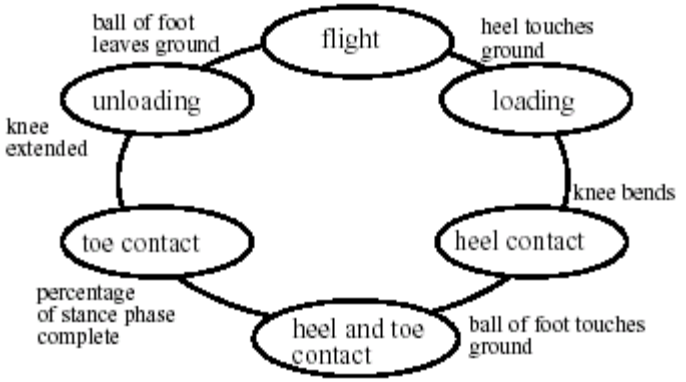
Swimming



Human Motion





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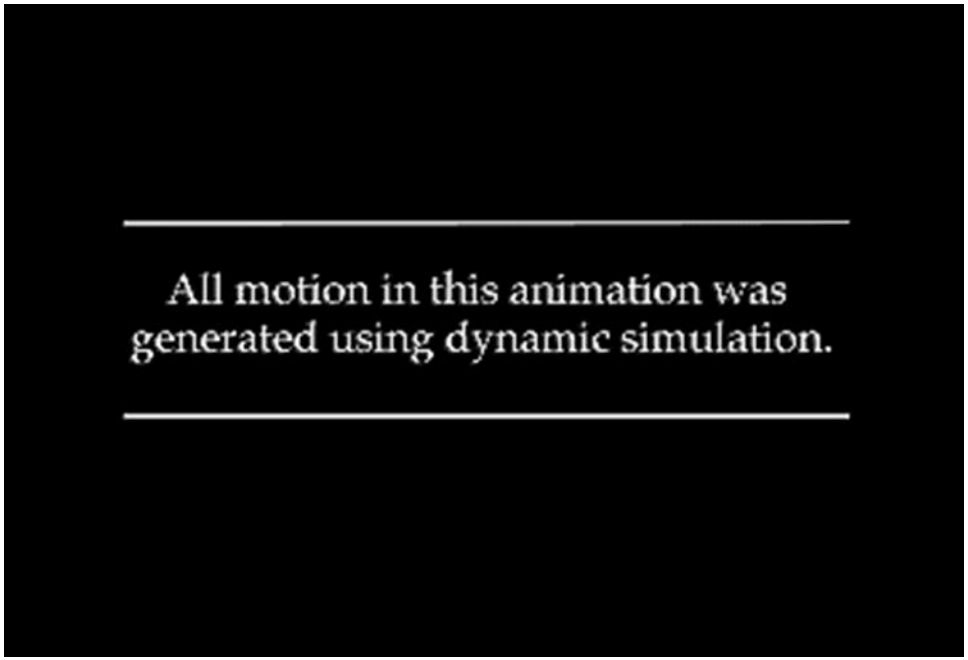
Animating Human Athletics



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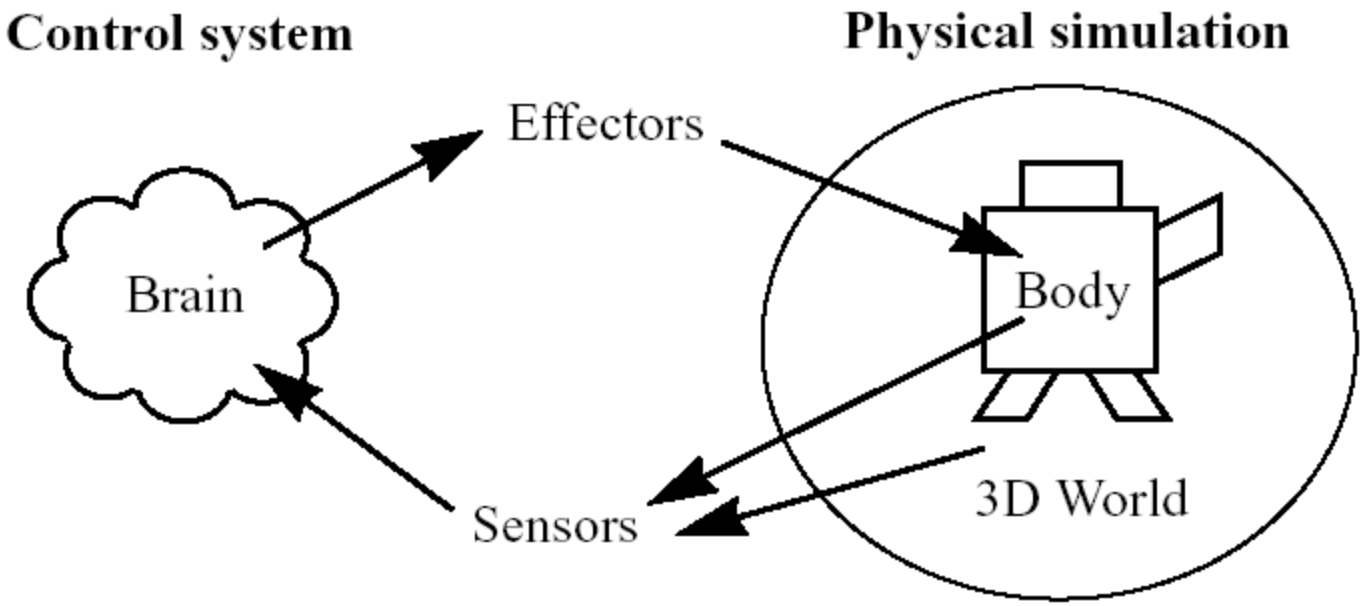
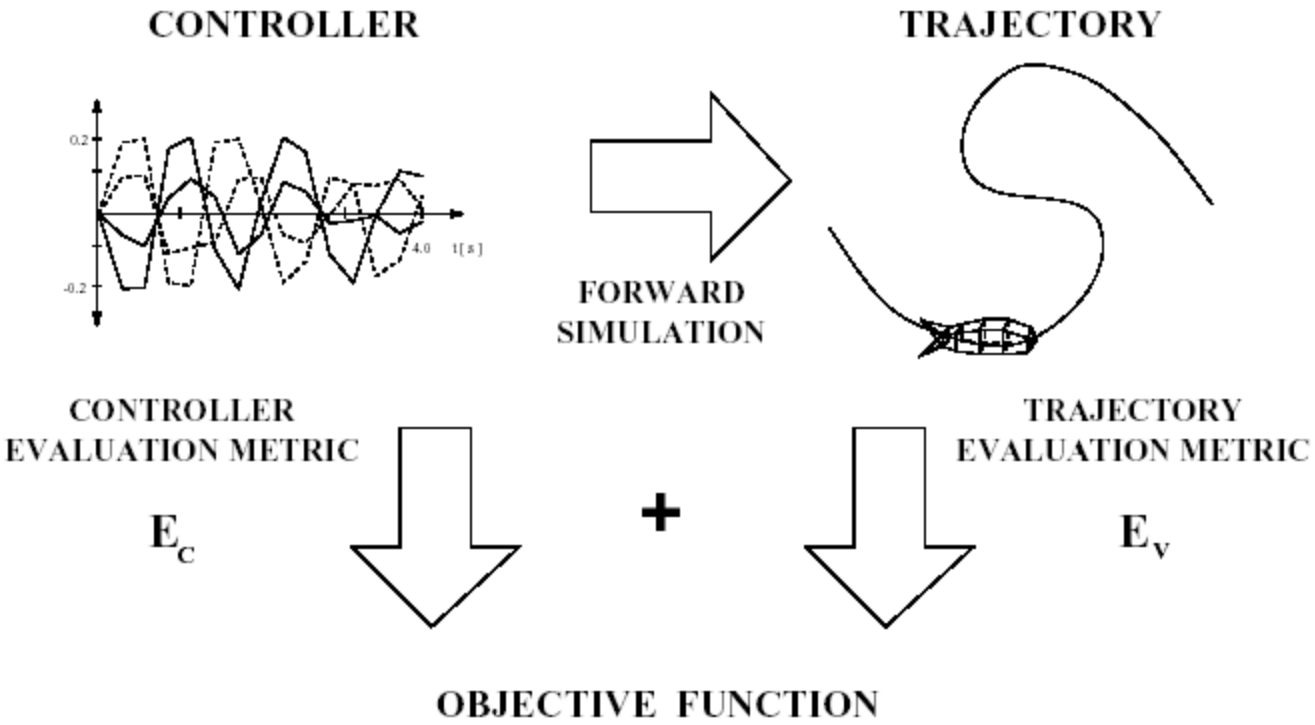
Learning Motions



Sims94

Learning Muscle Controllers



OBJECTIVE FUNCTION

$$E(\mathbf{u}(t)) = \int_{t_0}^{t_1} \left(\mu_1 E_u(\mathbf{u}(t)) + \mu_2 E_v(\mathbf{v}(t))\right)\, dt;$$

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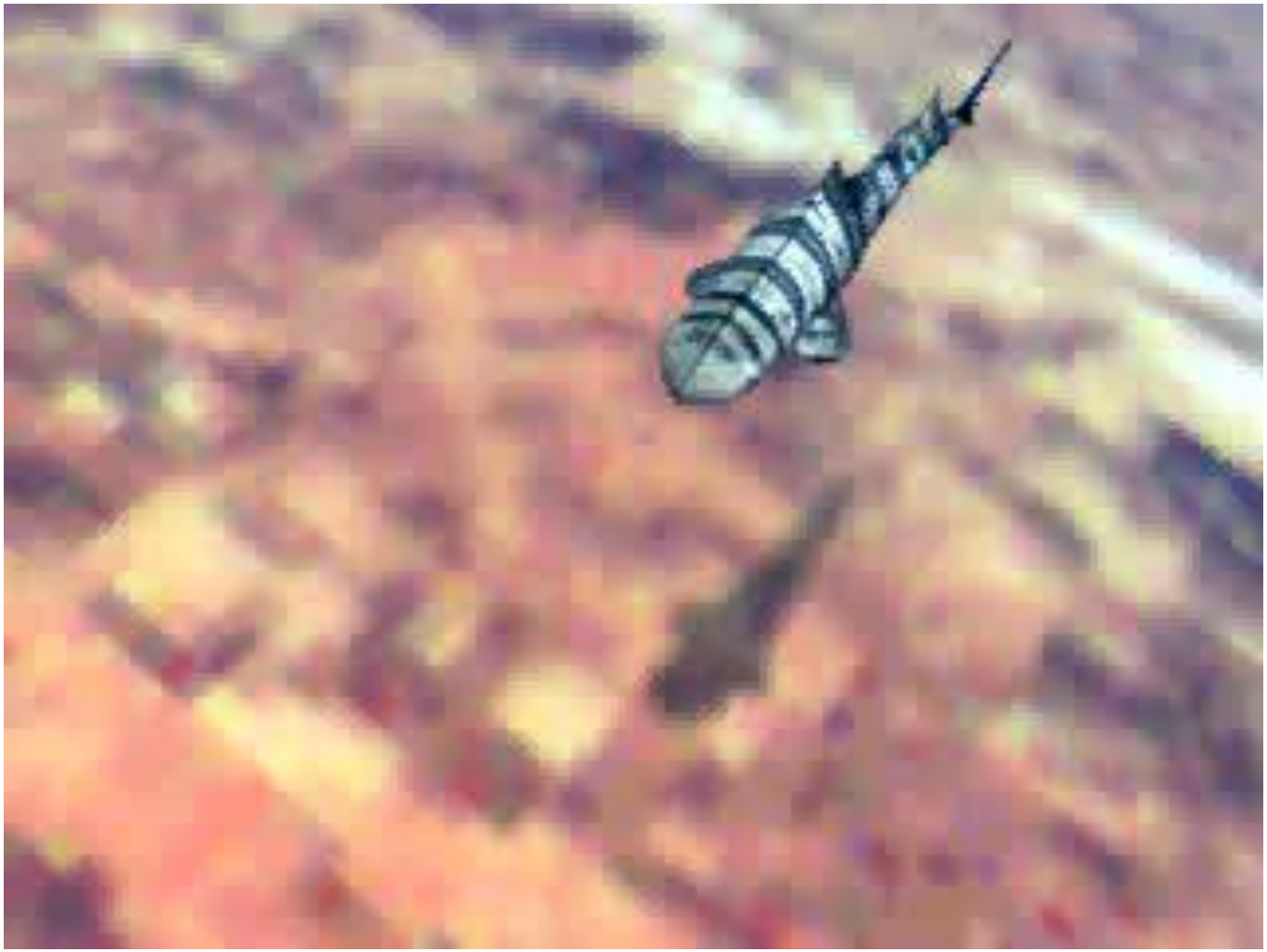
Learning to Swim



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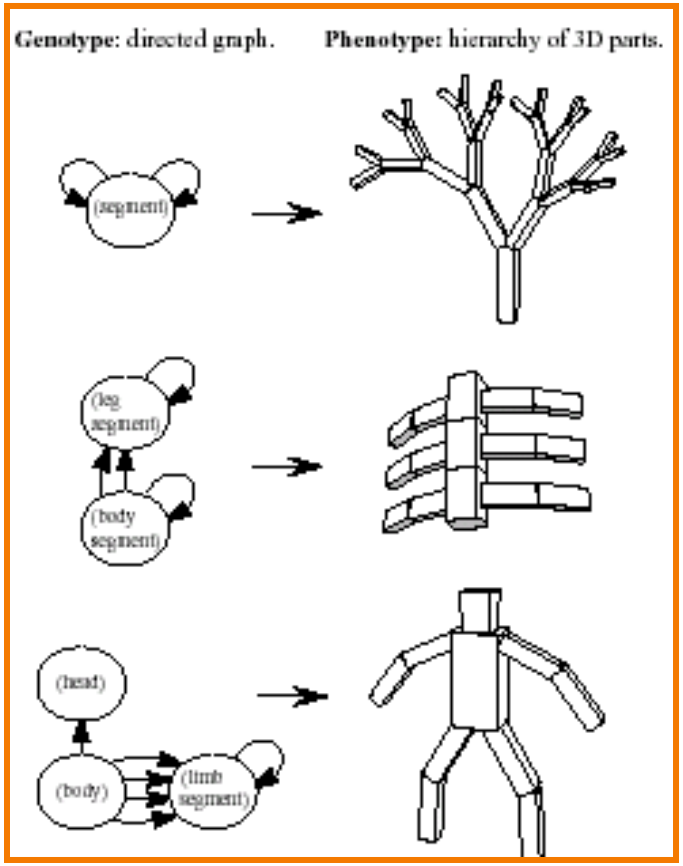
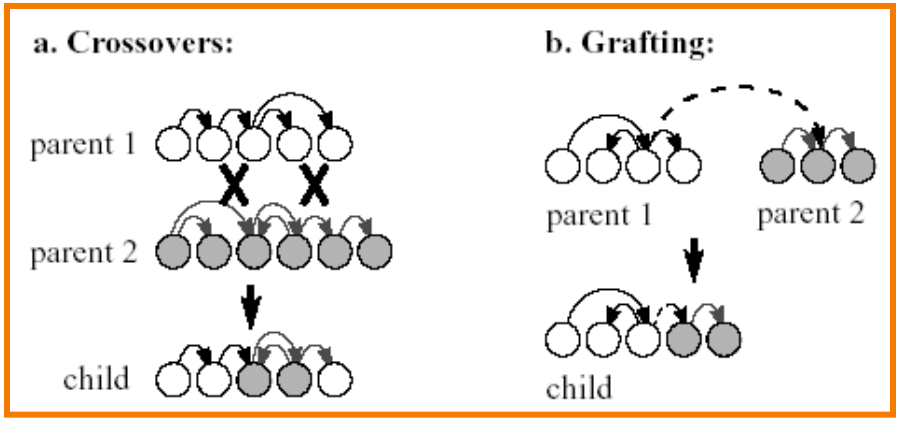
Evolved Virtual Creatures



Controllers



Mutations

Physics & Objective

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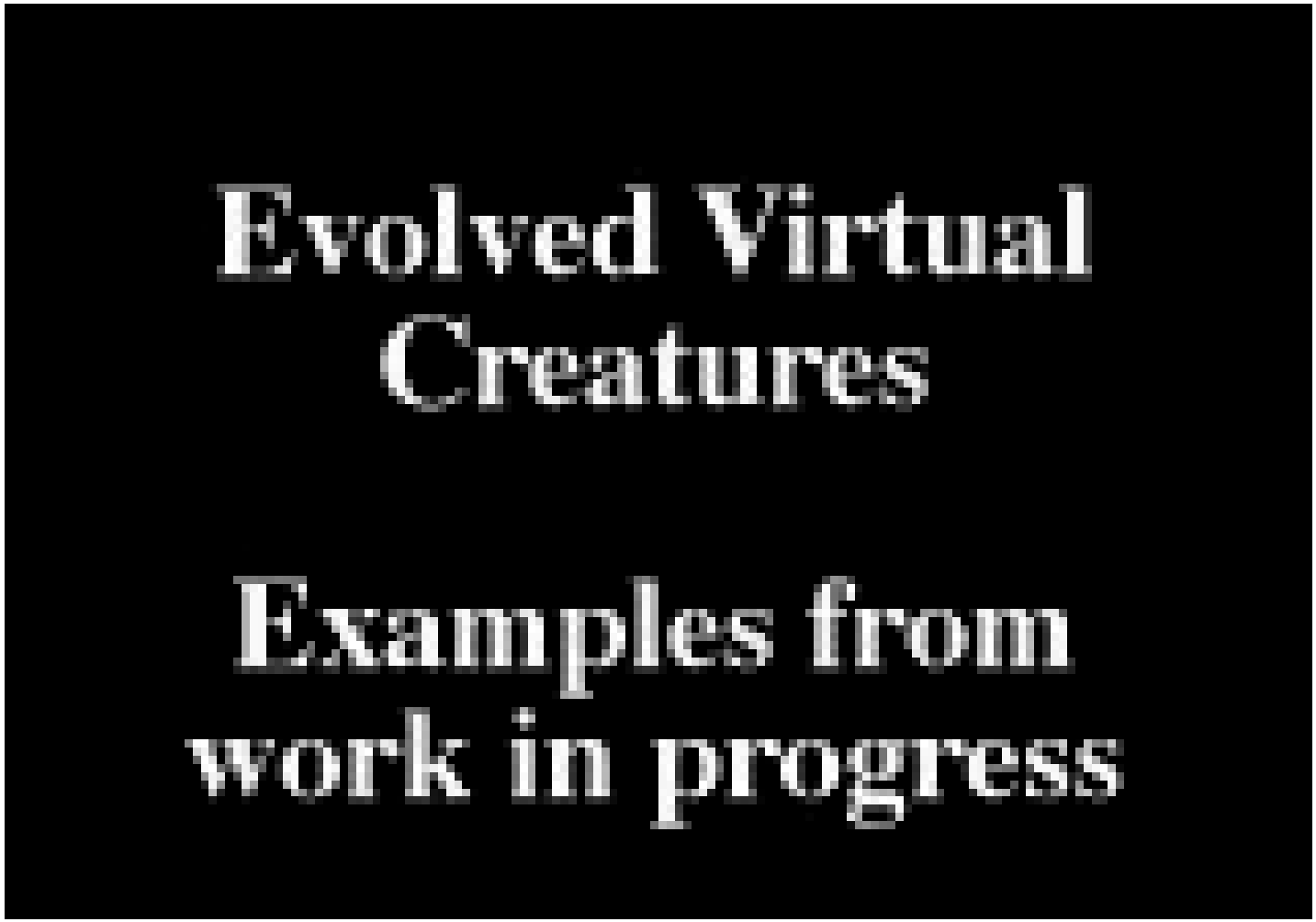
Evolved Virtual Creatures



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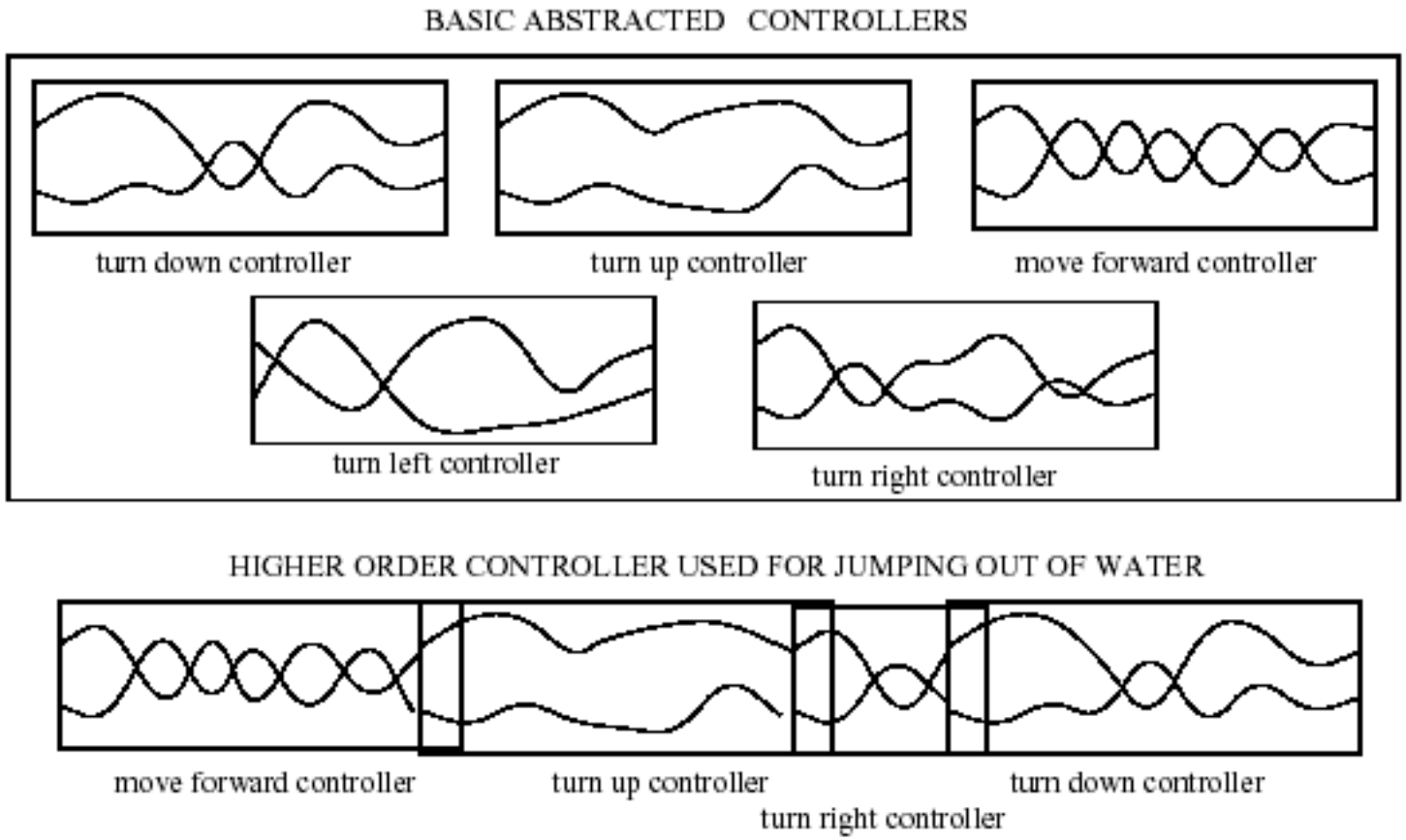
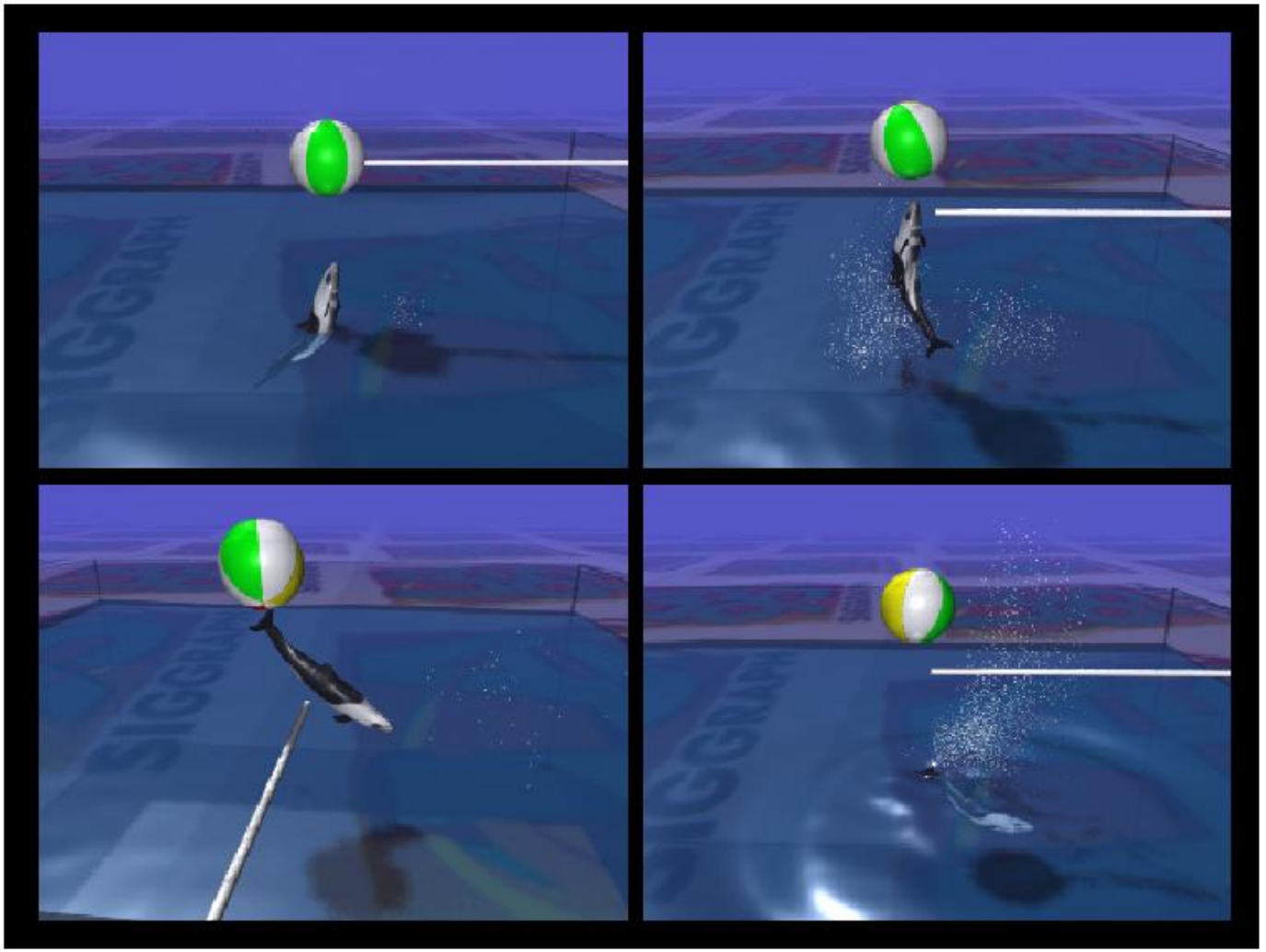
Multi-Level Controllers



Learning Complex Motions



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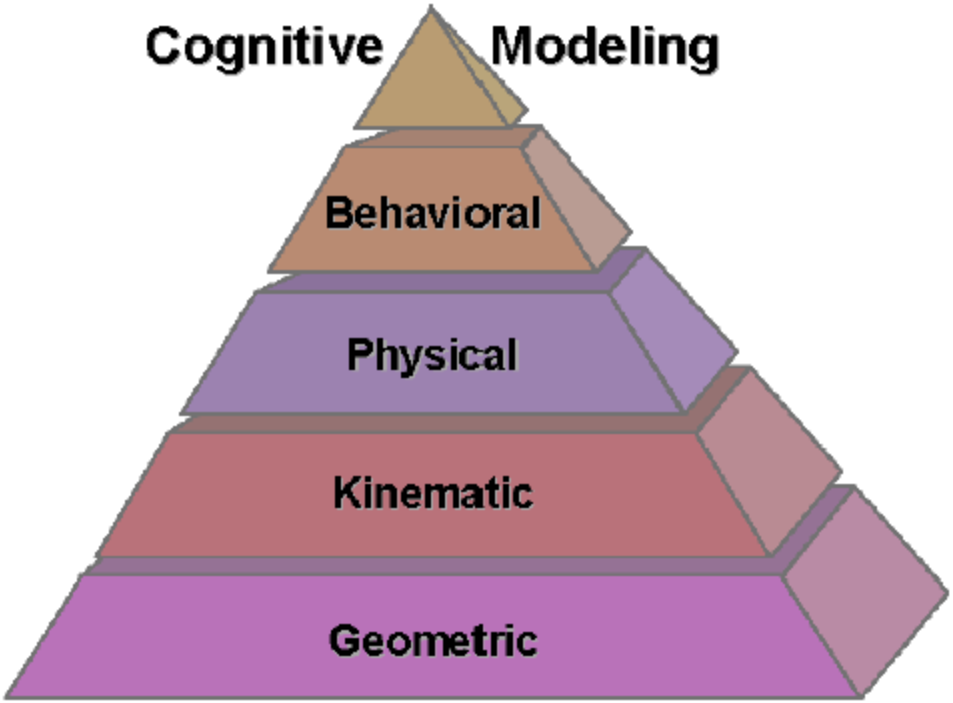

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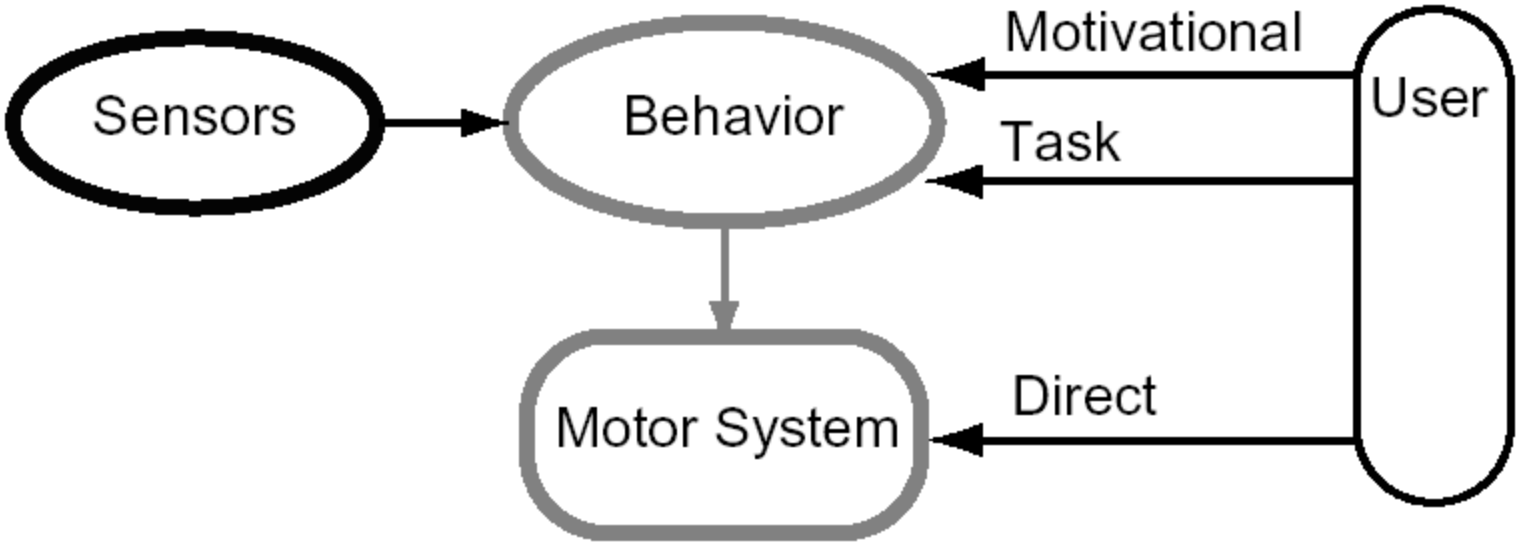
Behavior



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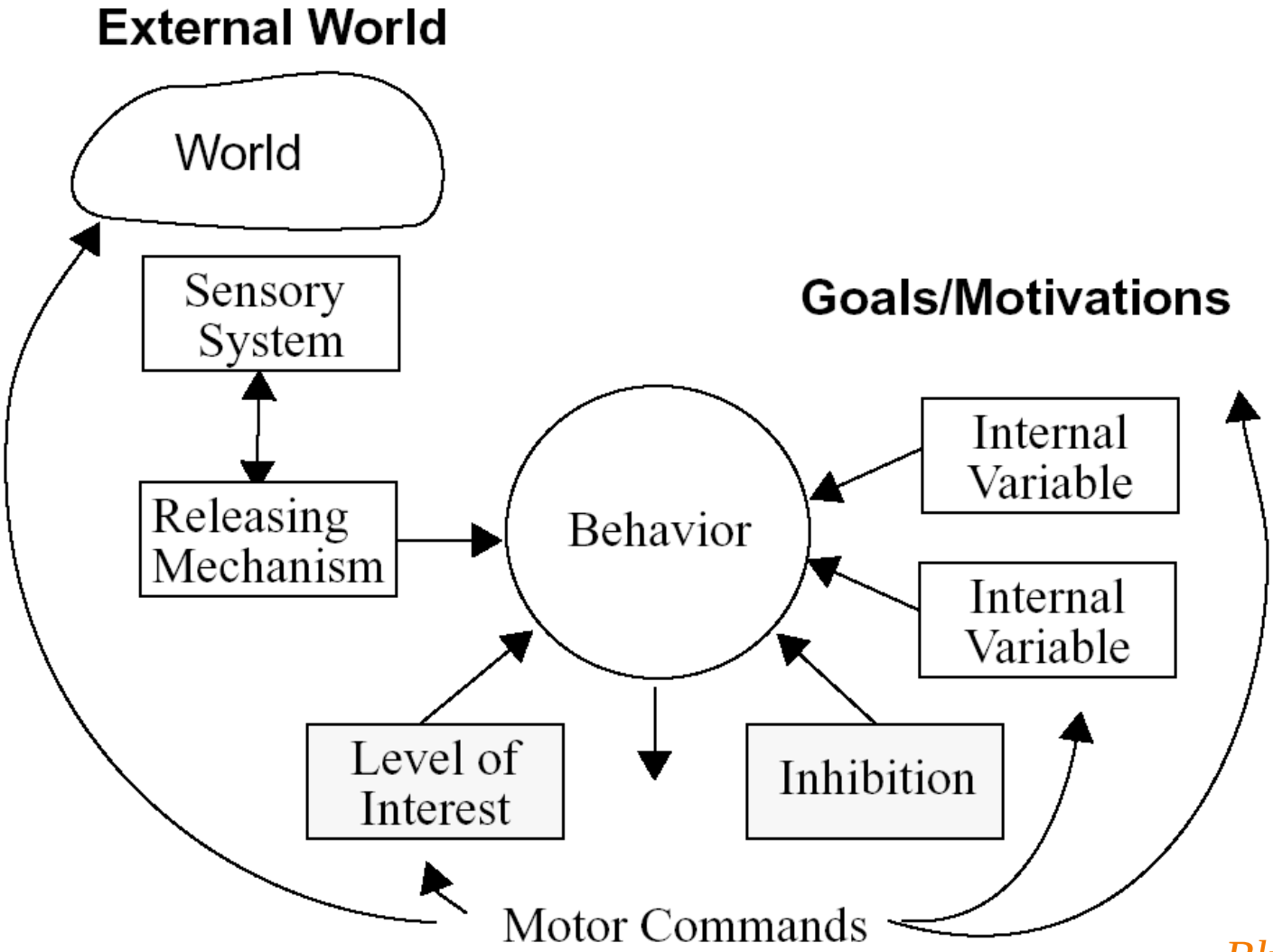
Behavior



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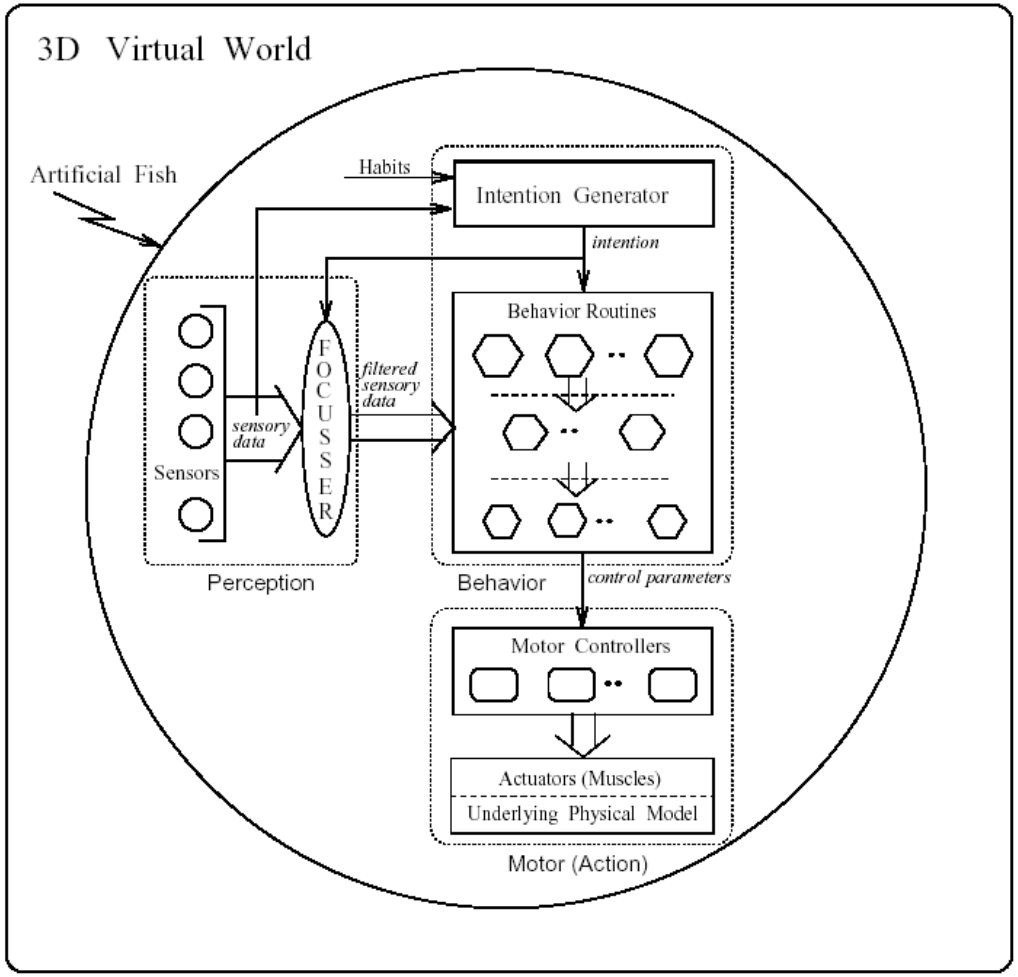
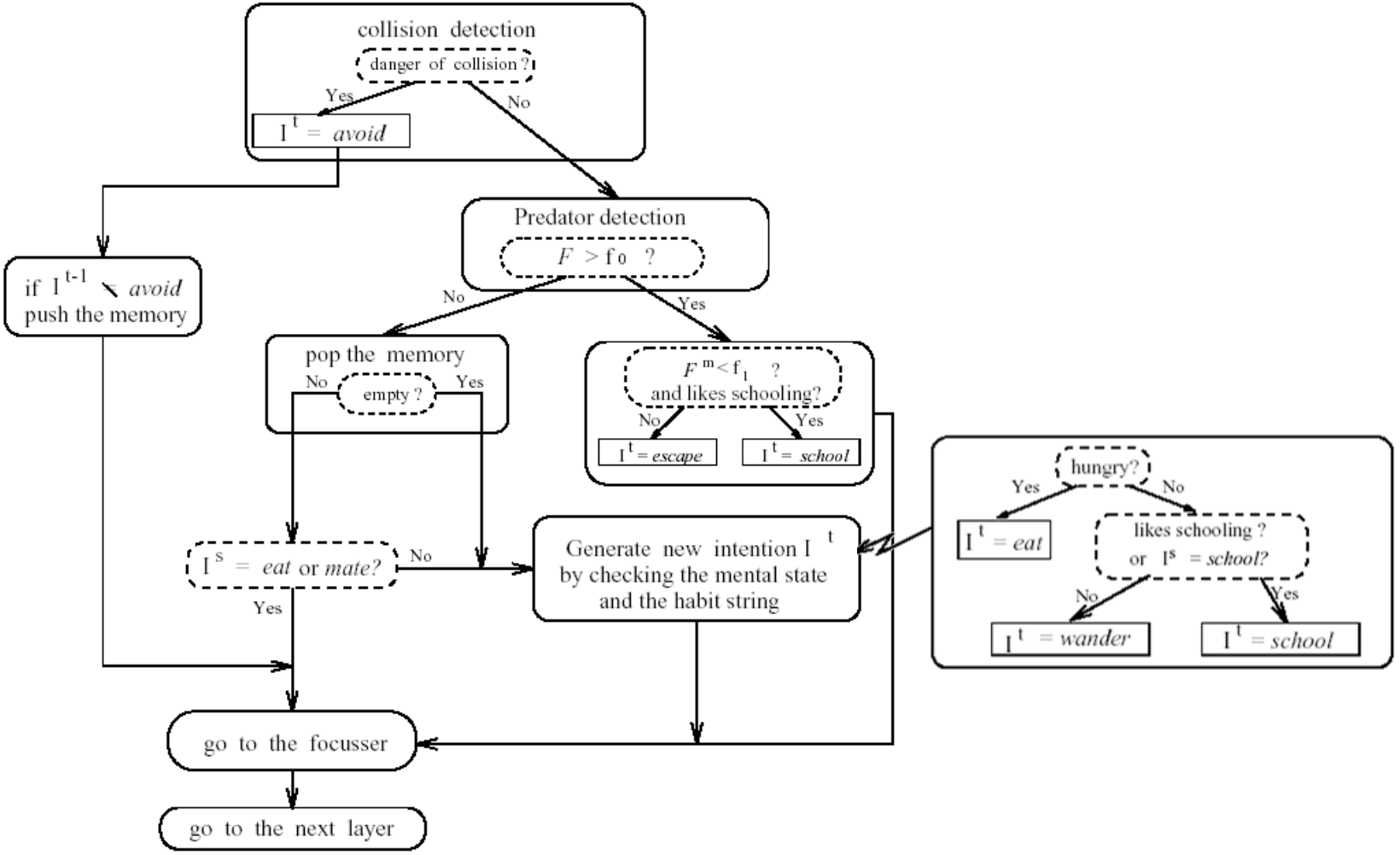
Fish Behavior Controller



Intention Generator



Undersea World of JC

Active Dynamics

- Motions
  - Physics
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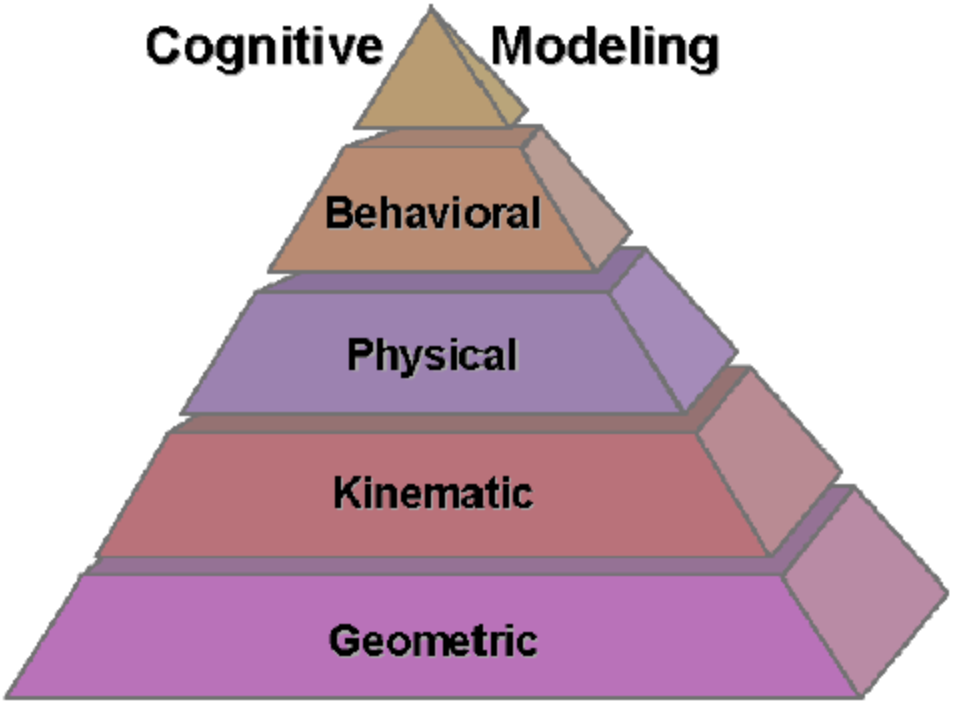
  - Planning



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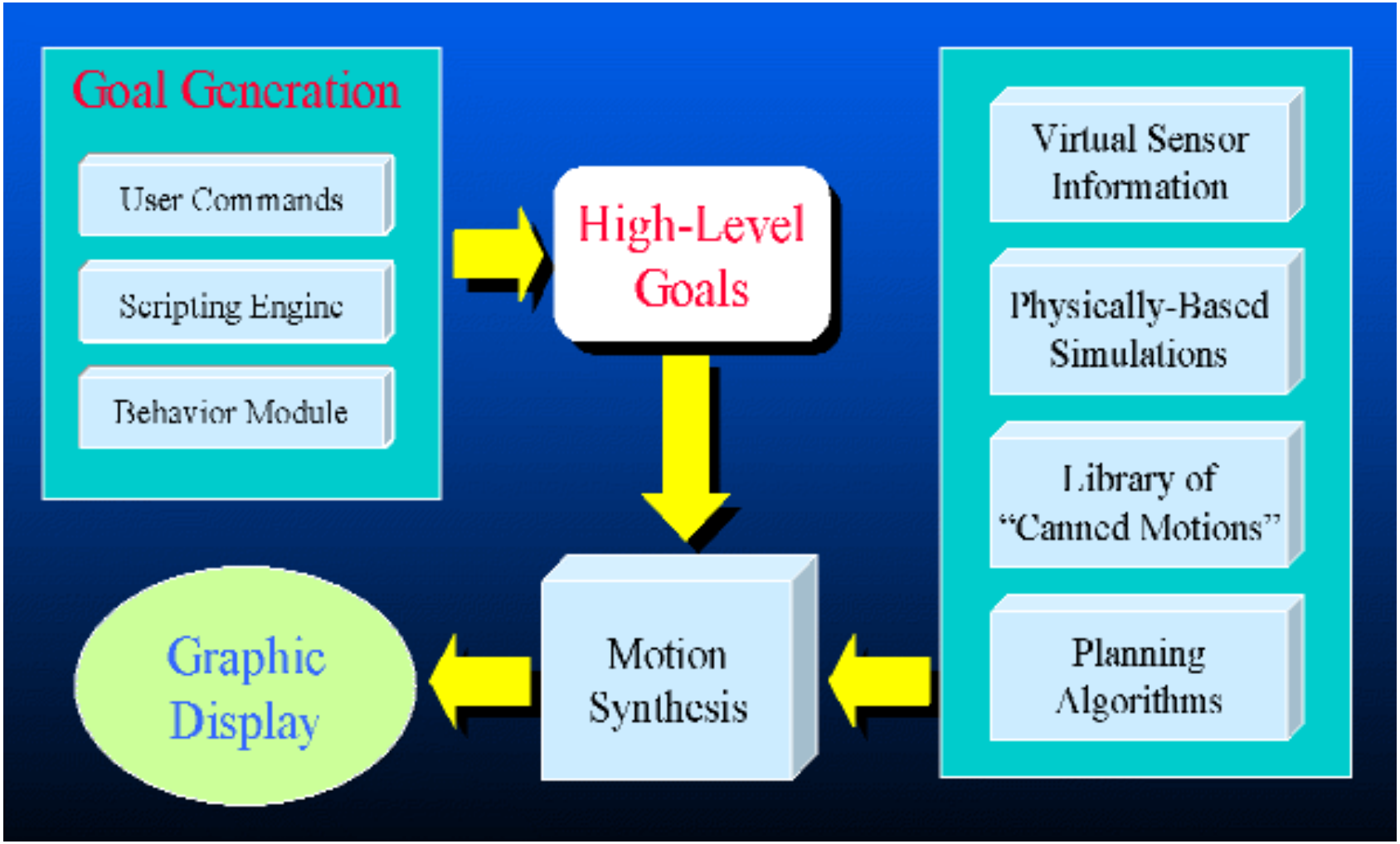
Planning



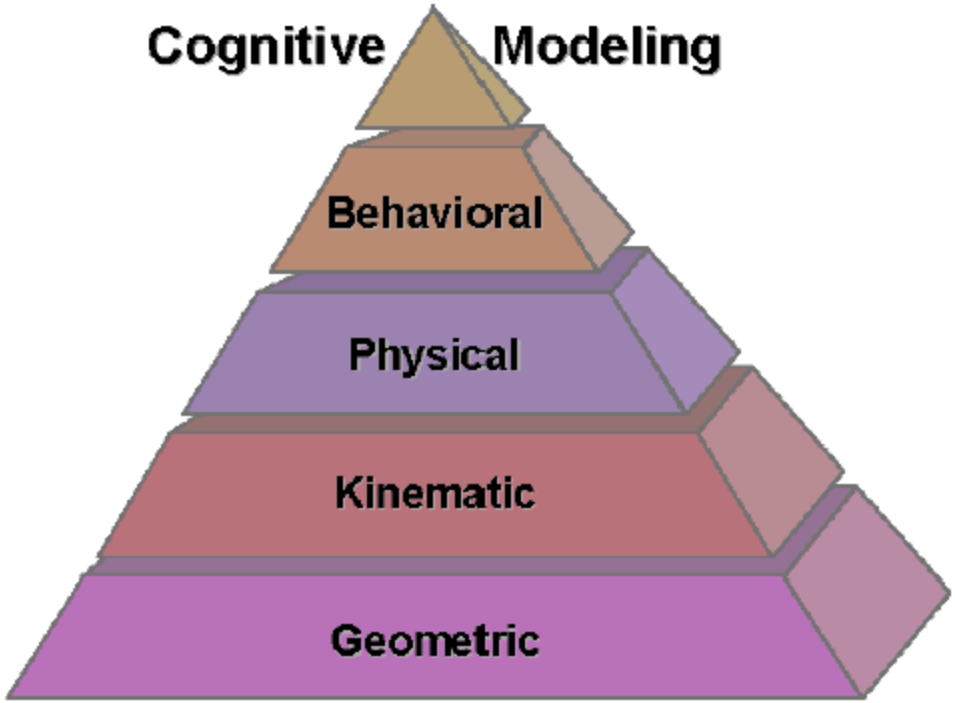
Kuffner

Motion Planning

Kuffner

Summary

- Motions
  - Physics
  - Controllers
- Behaviors
  - Learning
- Cognition
  - Planning



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