Active Dynamics

COS 426, Spring 2015

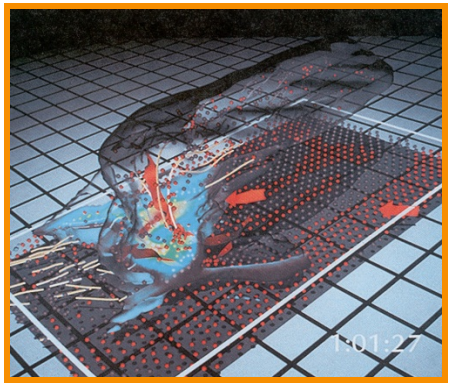
Princeton University

Computer Animation

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

Pixar

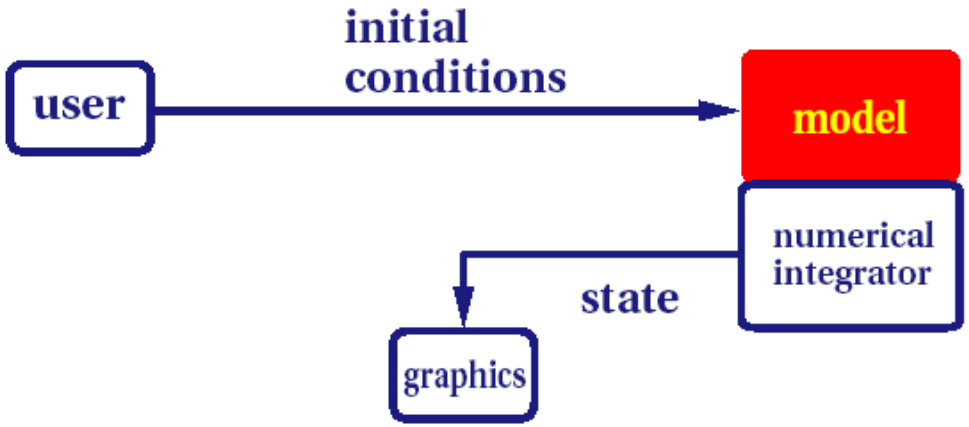
- Simulation / dynamics
  - Predict how objects change over time according to physical laws



University of Illinois

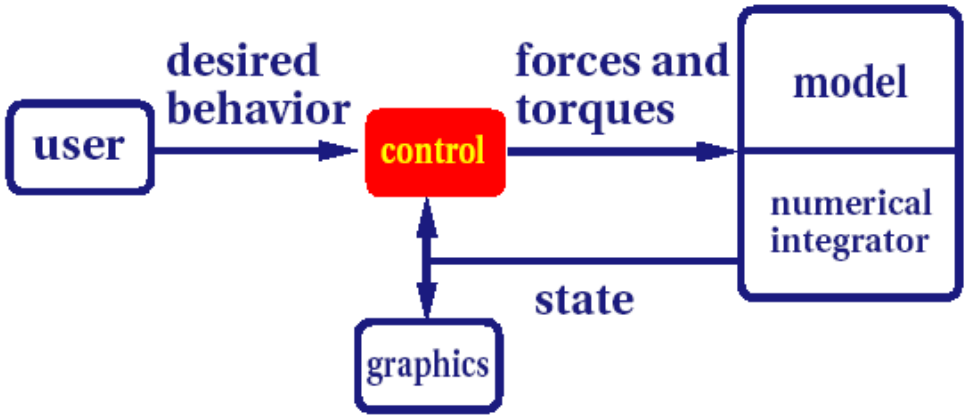
Passive vs. Active Dynamics

Passive--no muscles or motors



particle systems
leaves
water spray
clothing

Active--internal source of energy

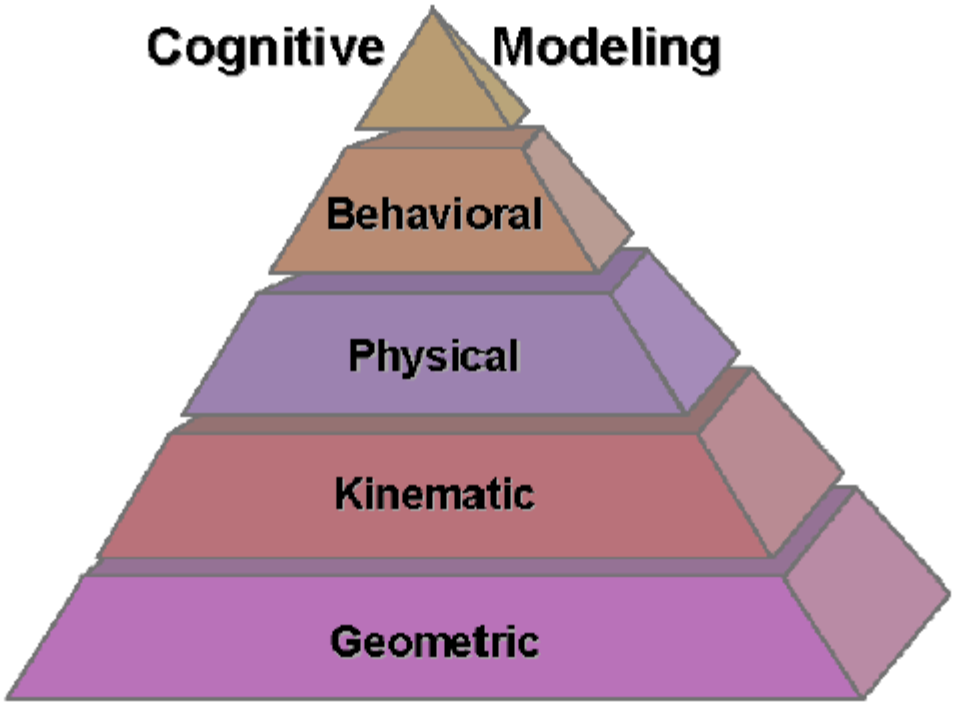


running human
trotting dog
swimming fish

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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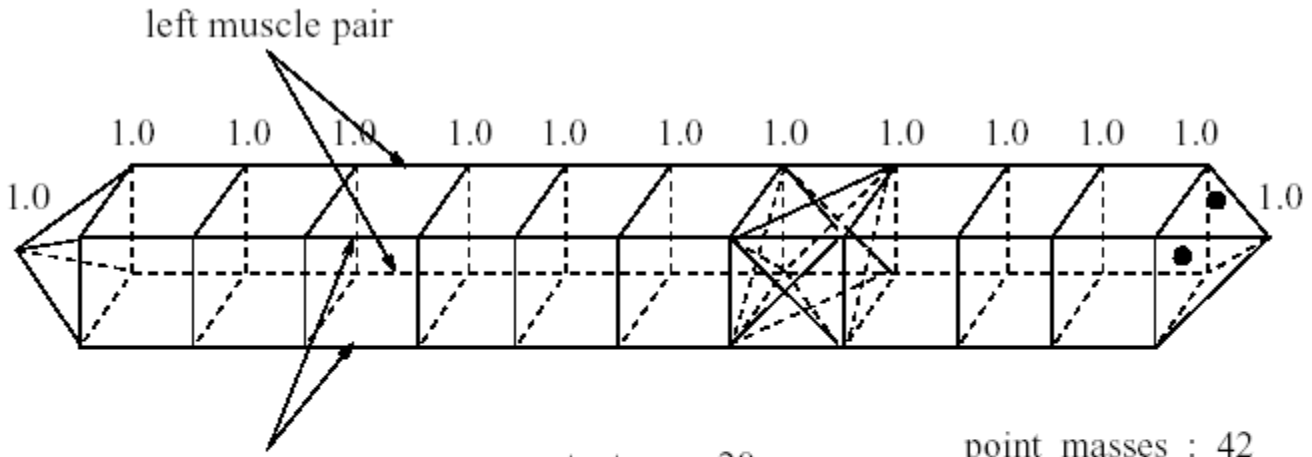
Worm Biomechanical Model



actuators : 20

springs' stiffness : 50.0

point masses : 42

DOFs : 126

size of the state space : 252

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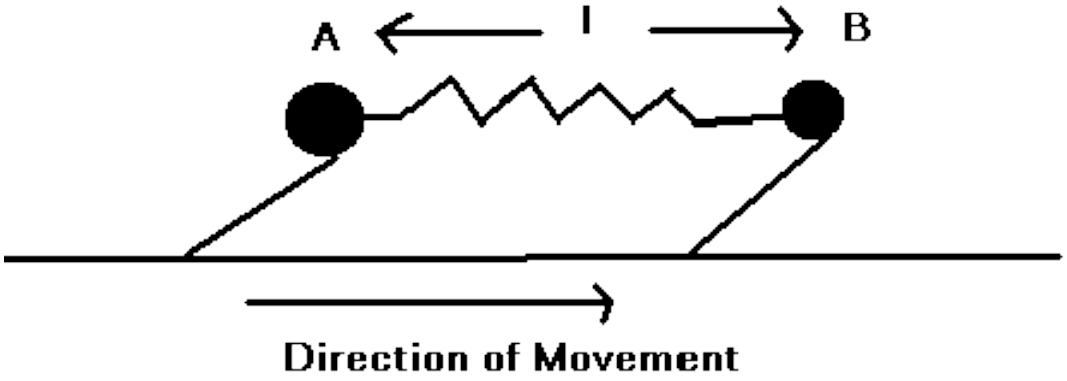
Worm Physics



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

$$a = f / m$$

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

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

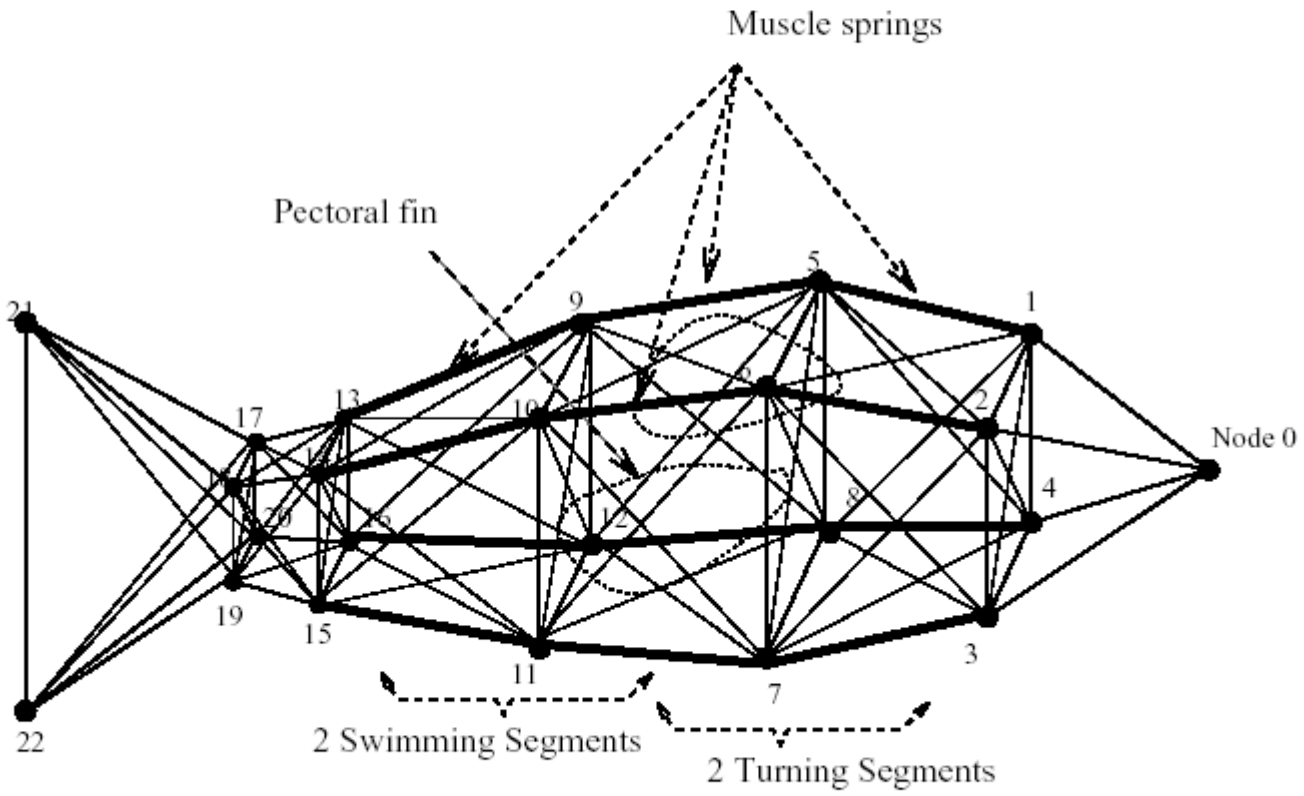
Her Majesty's Secret Serpent

Miller89

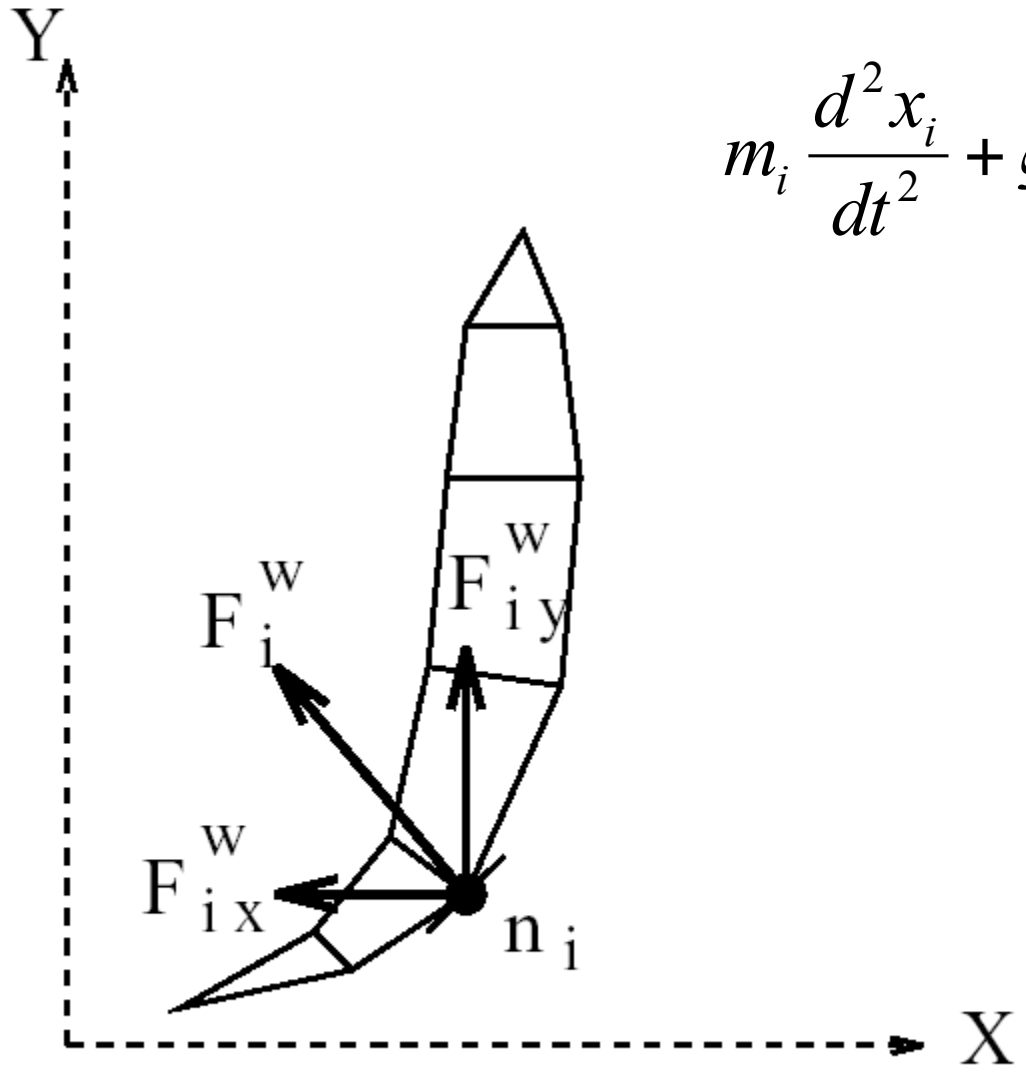
Fish Motion

- Example 2: how do fish move?

Spring-Mass Model for Fish

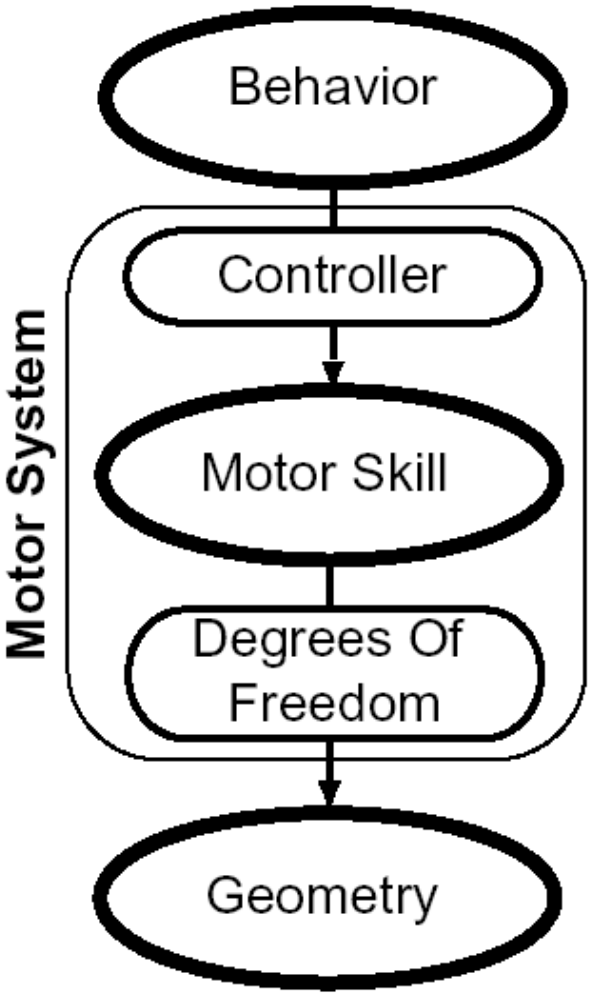


Hydrodynamic Locomotion



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

Motor System



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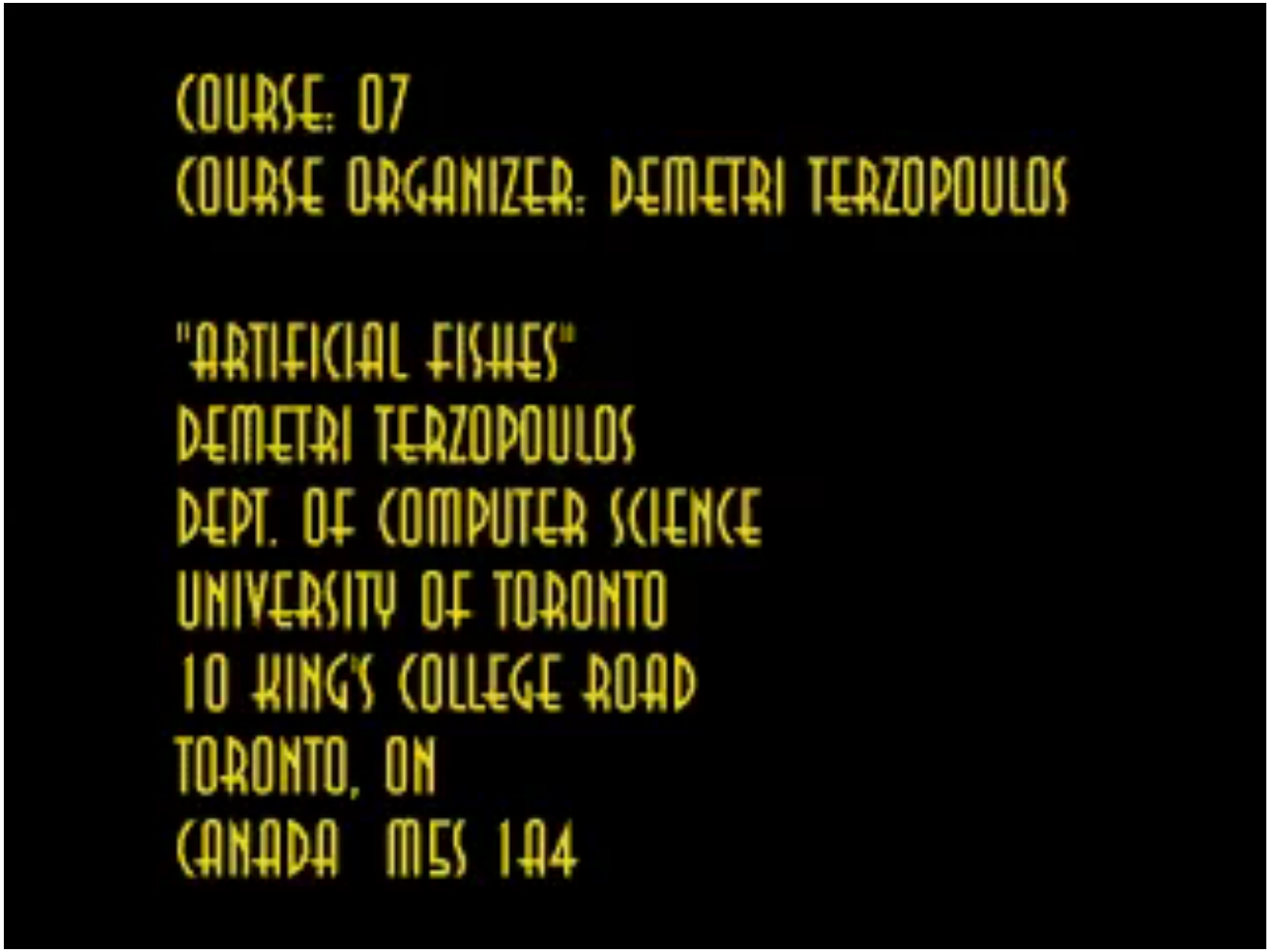
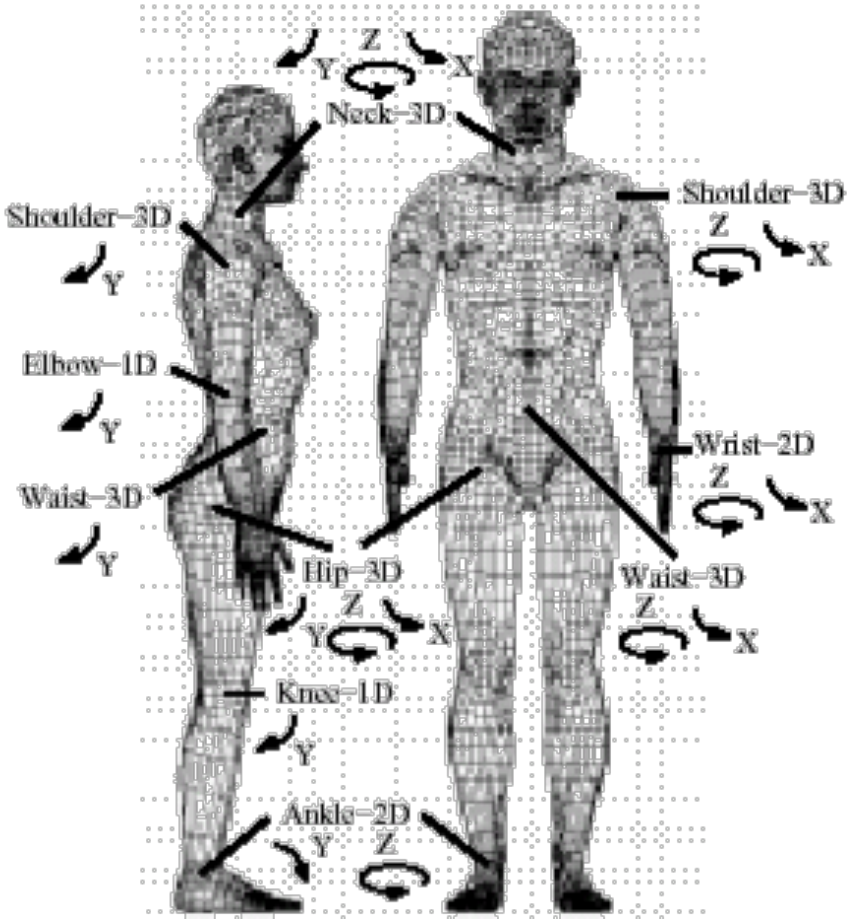
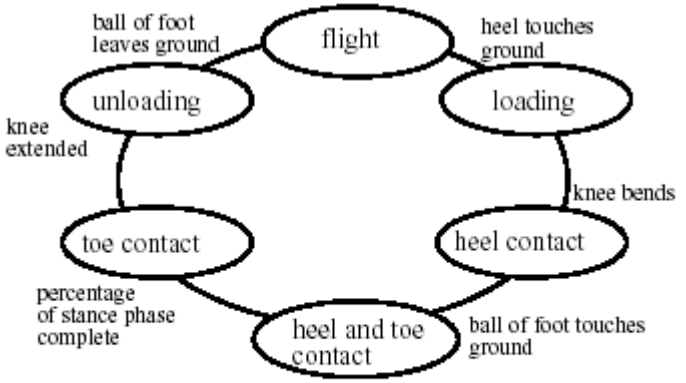
Swimming


COURSE: 07
COURSE ORGANIZER: DEMETRI TERZOPOULOS
"ARTIFICIAL FISHES"
DEMETRI TERZOPOULOS
DEPT. OF COMPUTER SCIENCE
UNIVERSITY OF TORONTO
10 KING'S COLLEGE ROAD
TORONTO, ON
CANADA M5S 1A4

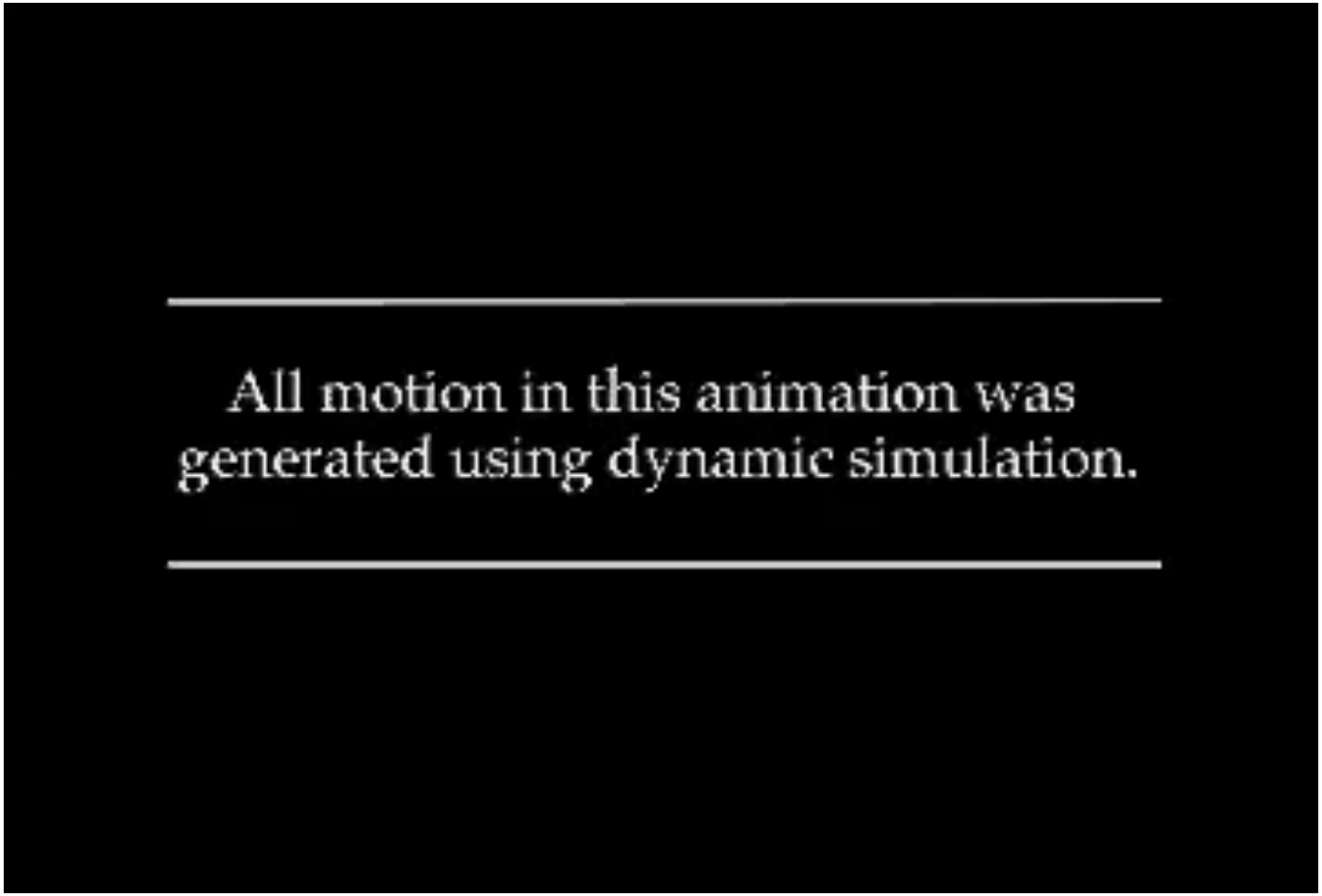
Human Motion





Hodgins

Animating Human Athletics



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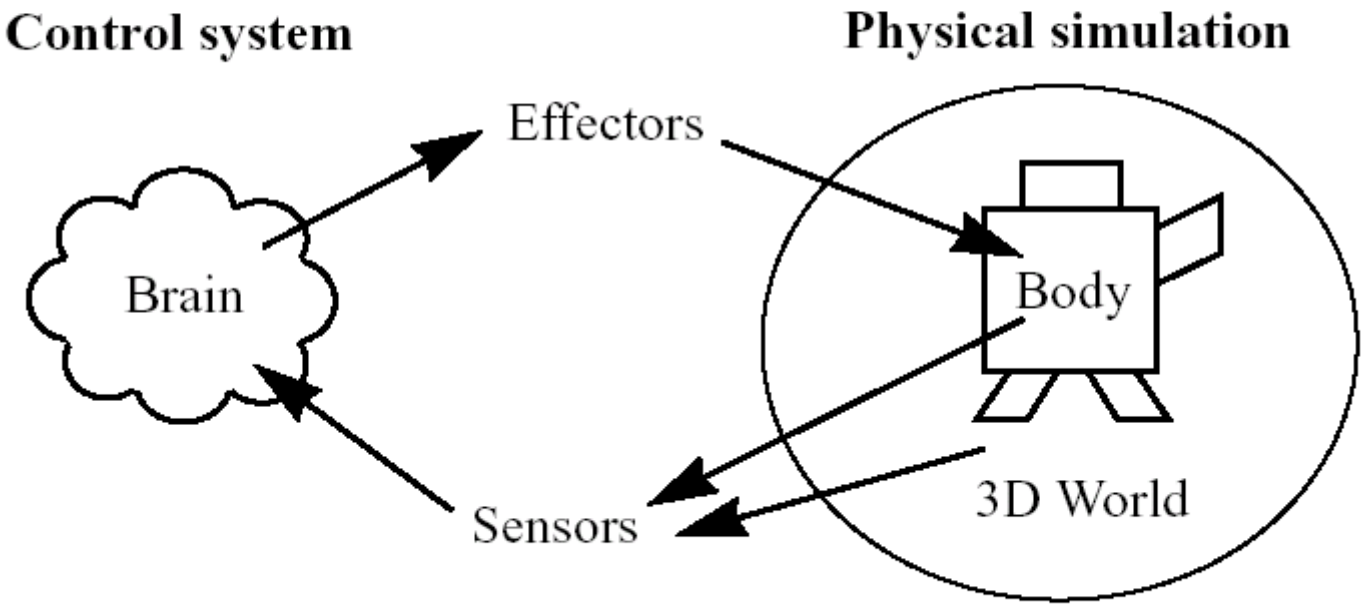
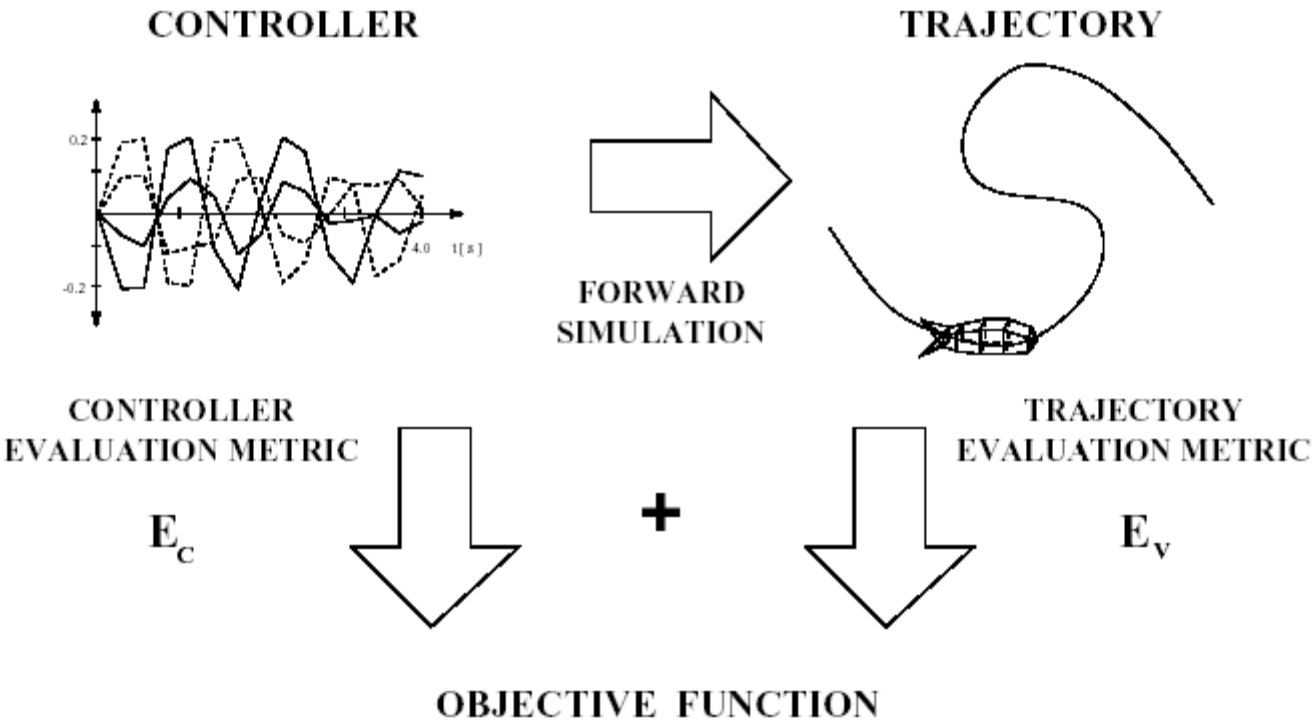
Learning Motions



Sims94

Learning Muscle Controllers



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

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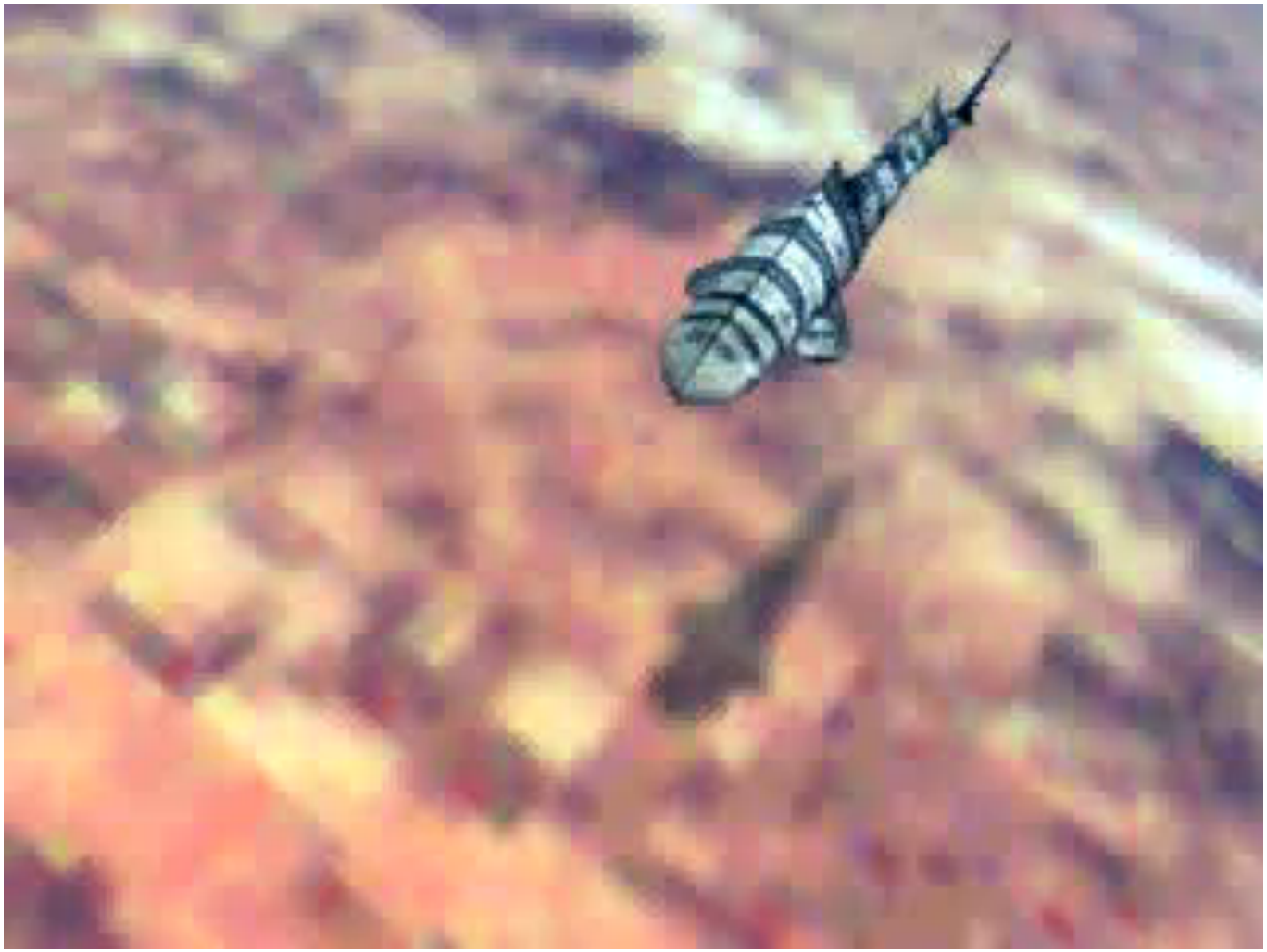
Learning to Swim



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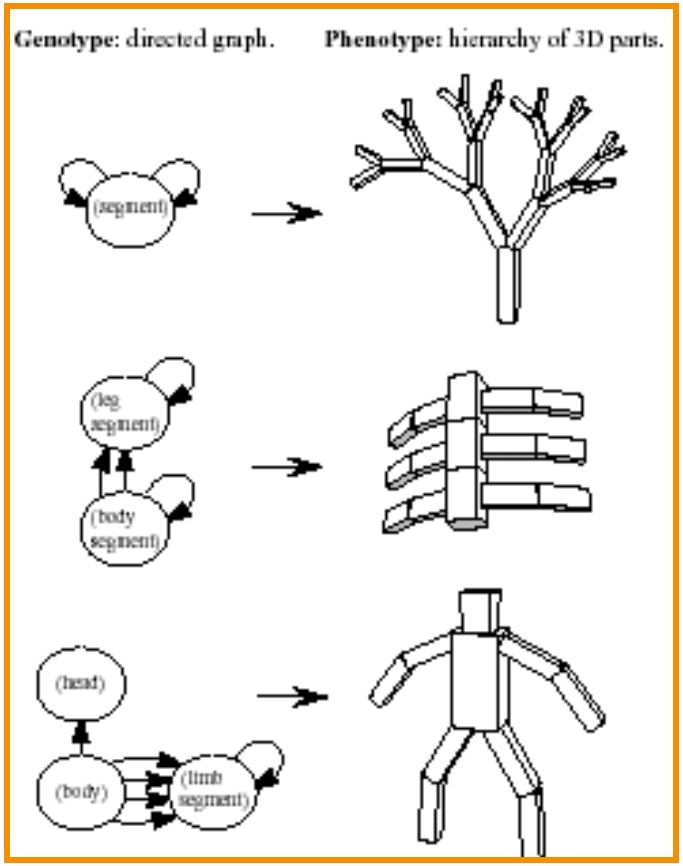
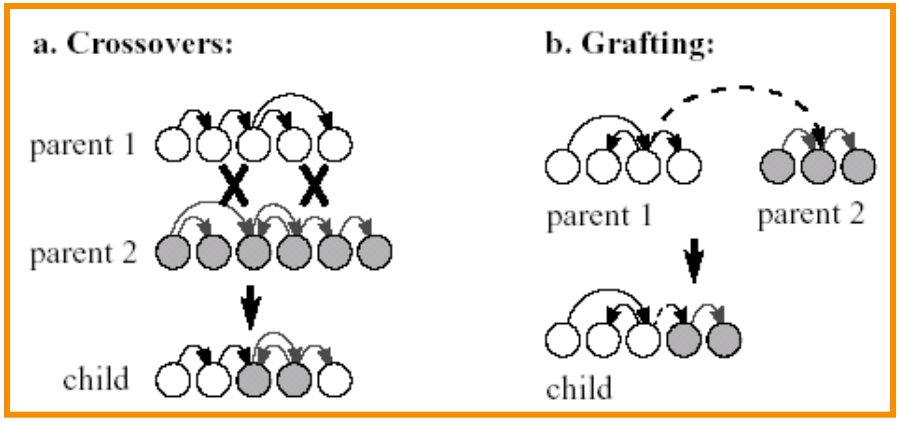
Evolved Virtual Creatures



Controllers



Mutations

Physics & Objective

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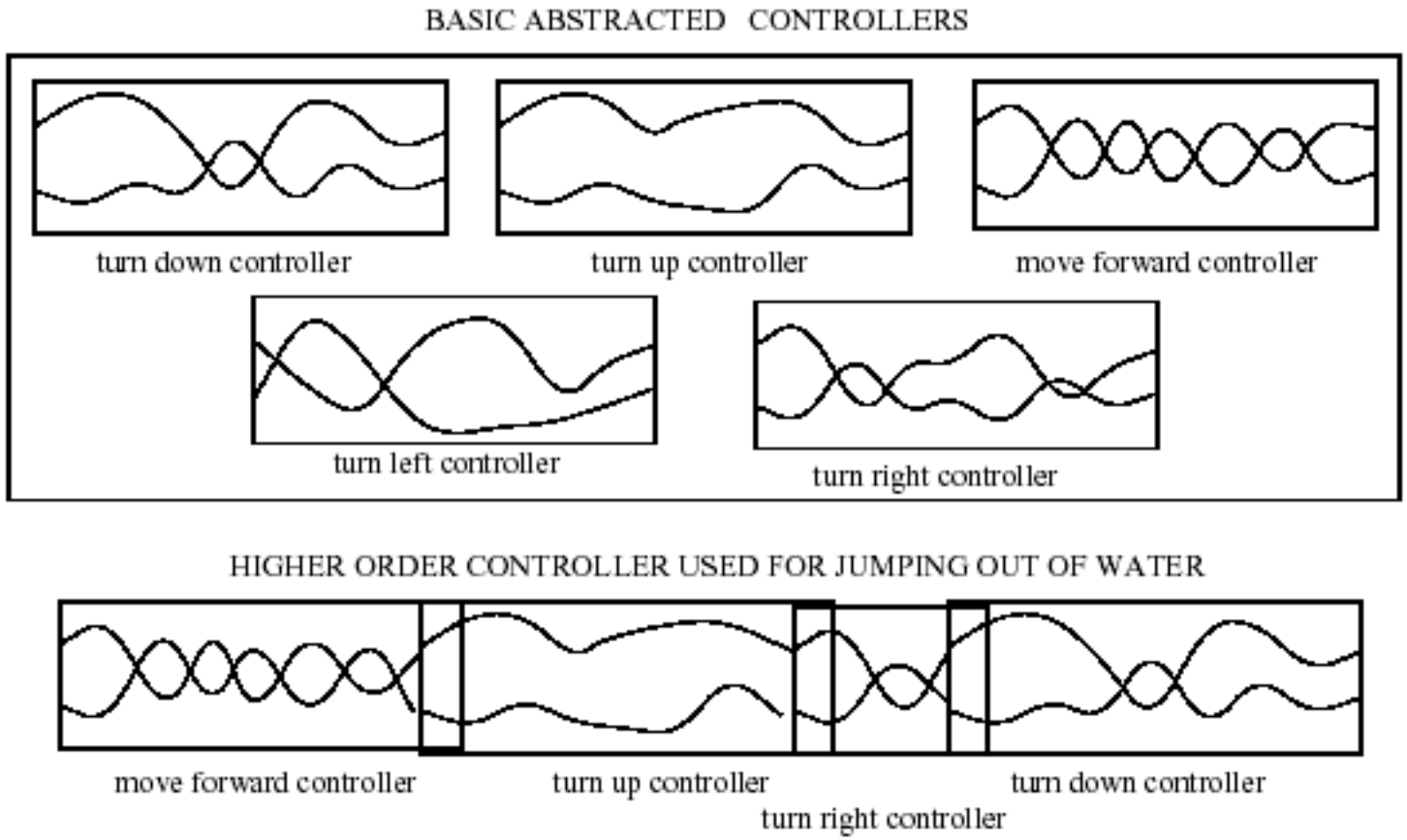
Evolved Virtual Creatures

Sims94

Multi-Level Controllers



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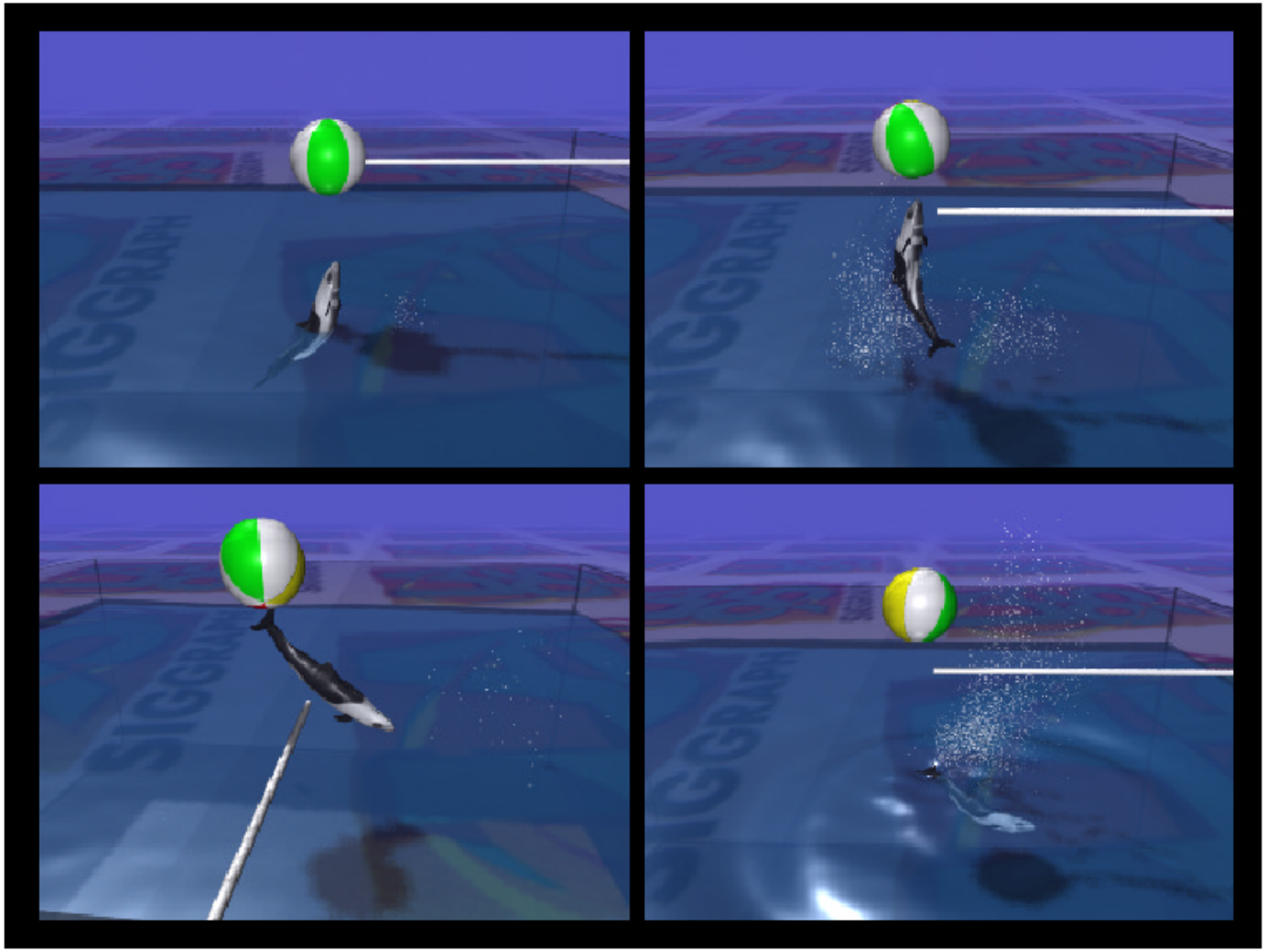
Learning Complex Motions



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- ➢ Behaviors
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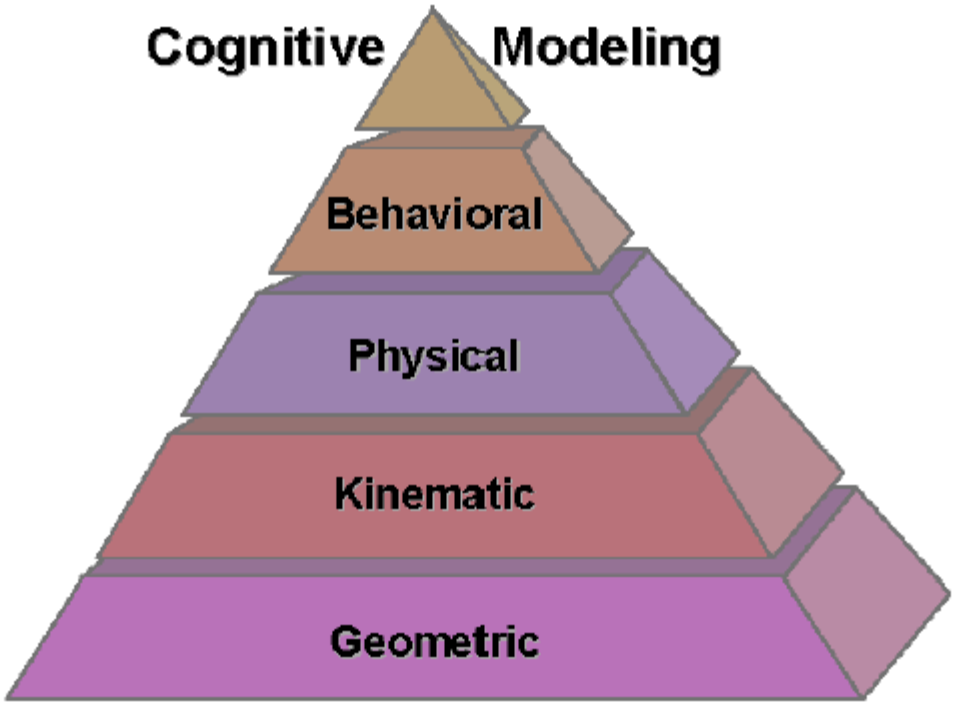

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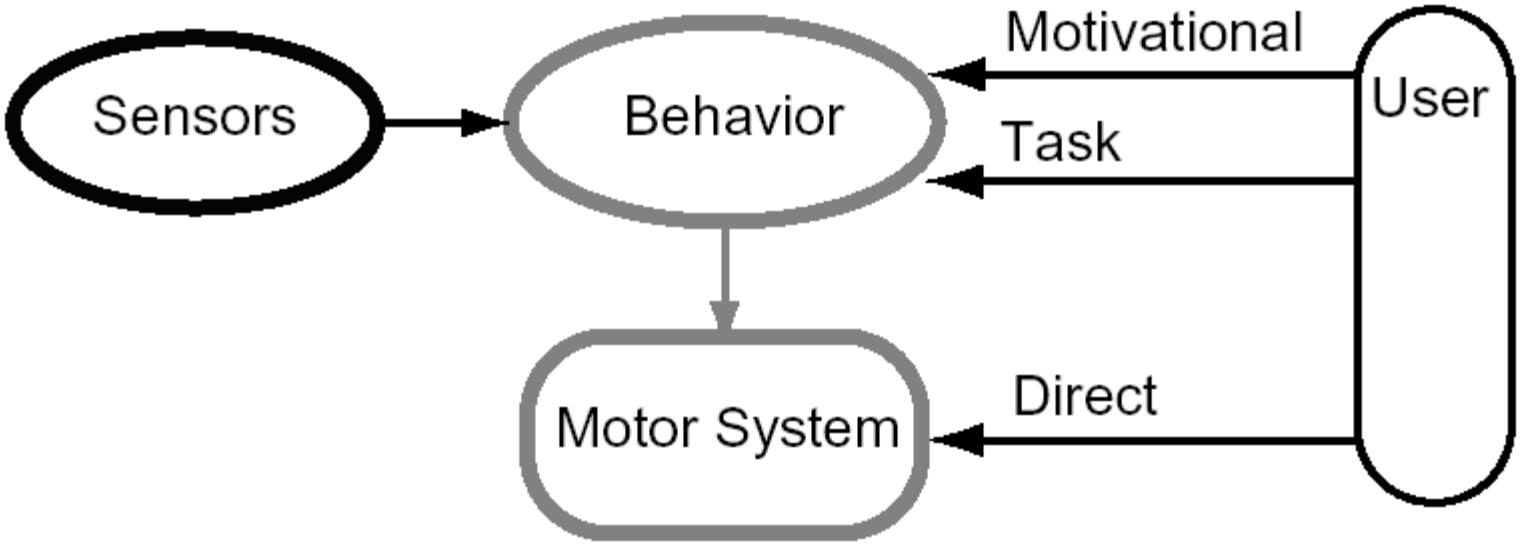
Behavior



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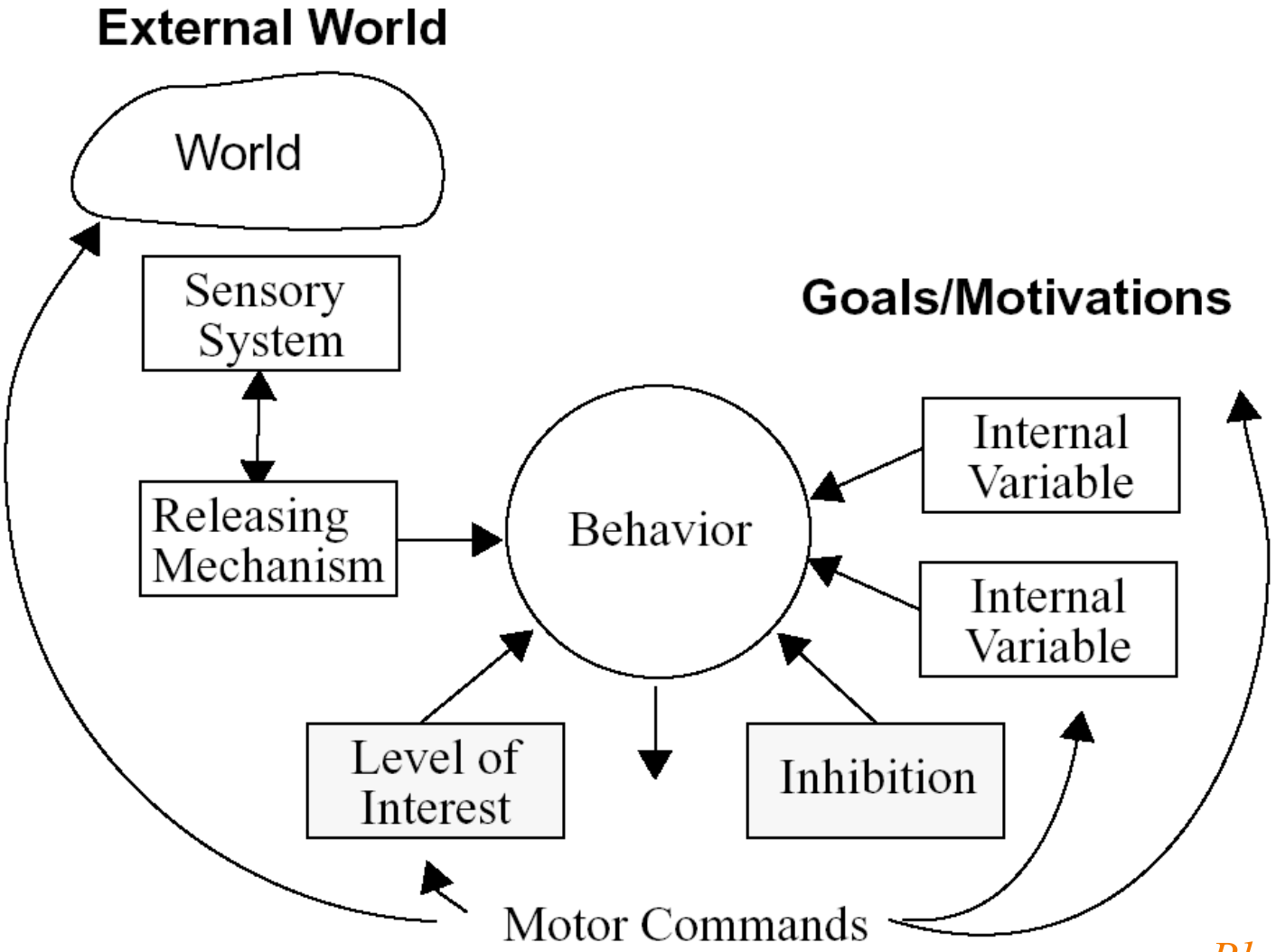
Behavior



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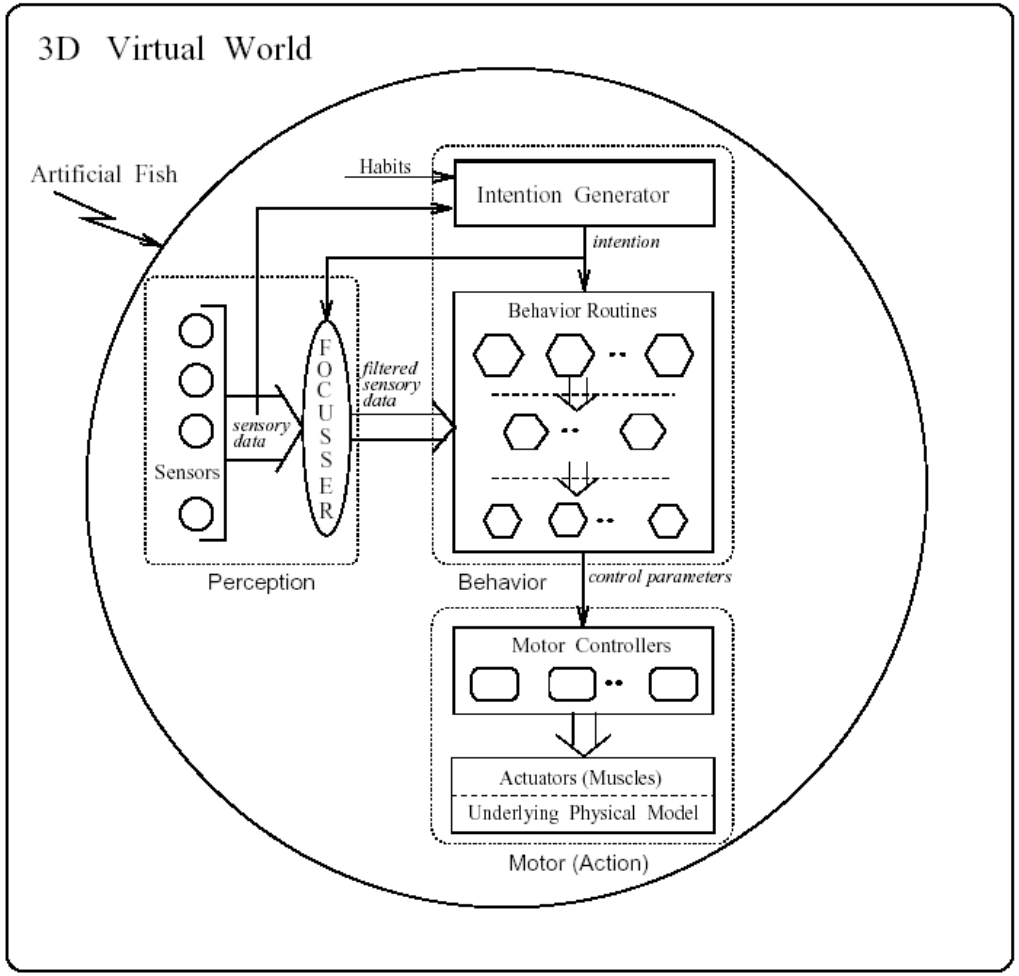
Fish Behavior Controller



Motion Planning

Show merman clip

Active Dynamics

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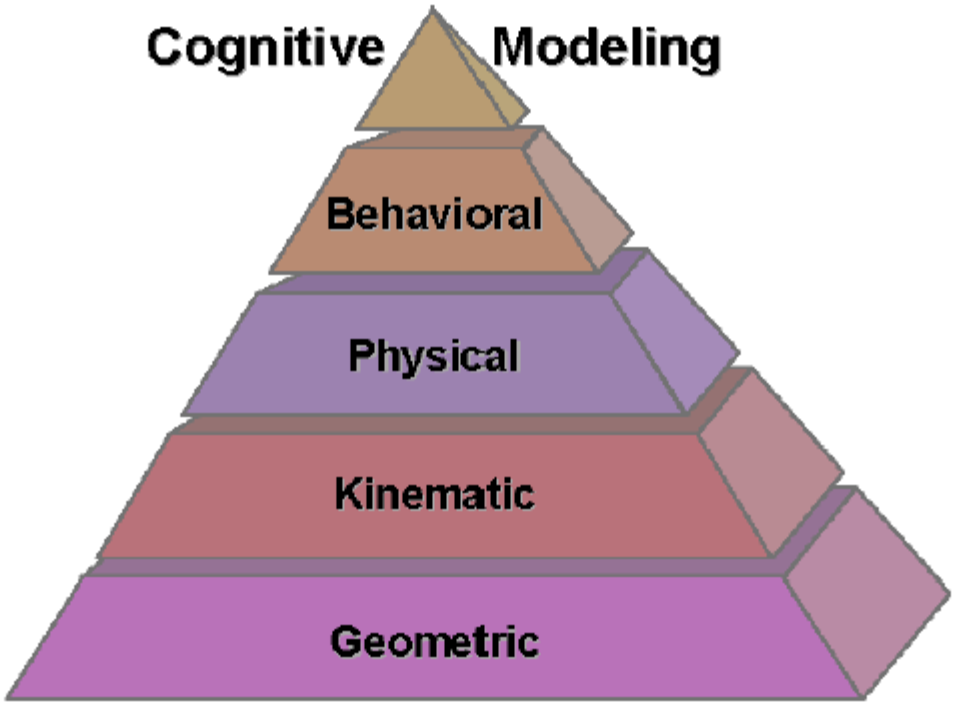

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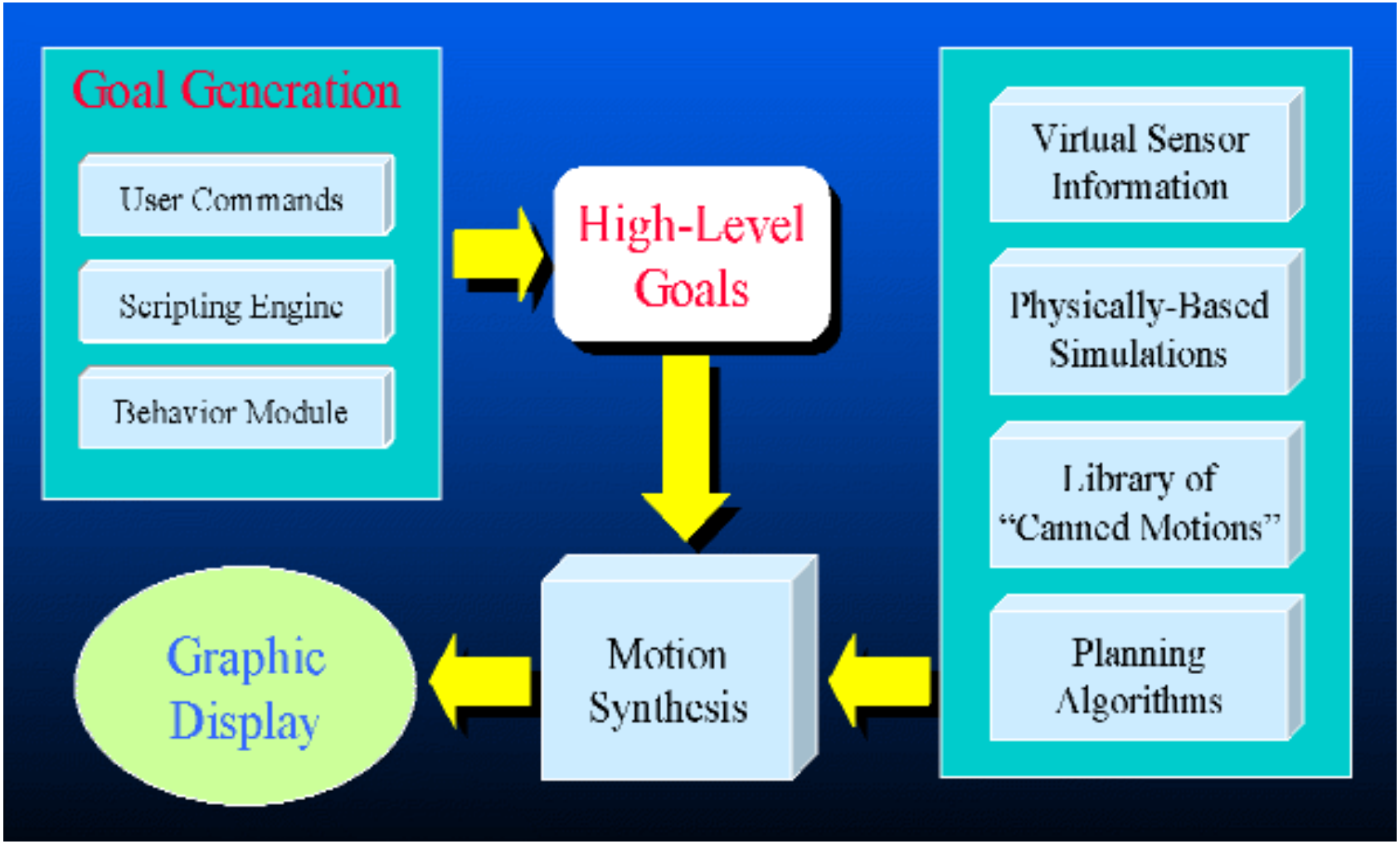
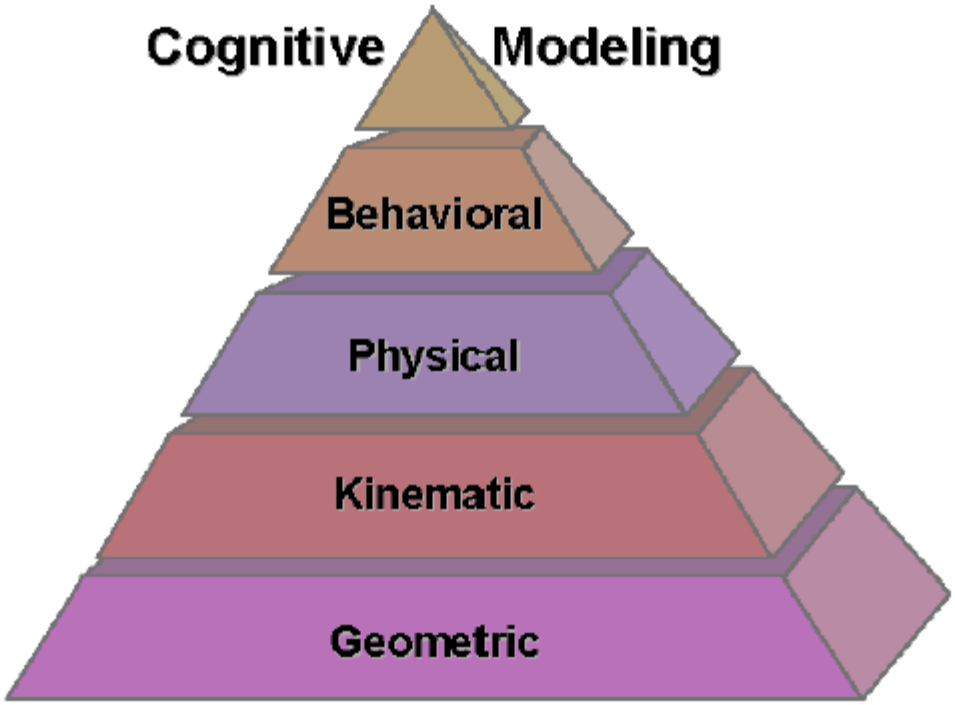
Planning


Goal Generation
User Commands
Scripting Engine
Behavior Module
High-Level Goals
Virtual Sensor Information
Physically-Based Simulations
Library of "Canned Motions"
Planning Algorithms
Motion Synthesis
Graphic Display

Motion Planning

Summary

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



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