



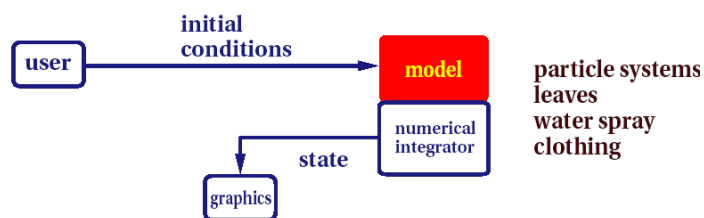
Active Dynamics

Thomas Funkhouser
Princeton University
COS 526, Fall 2002

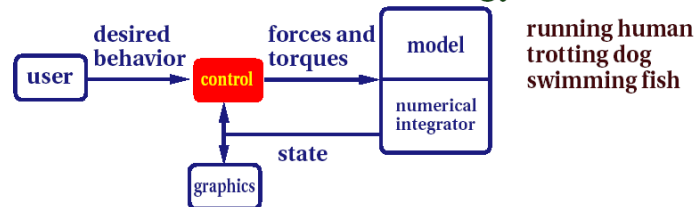
Passive vs. Active Dynamics



Passive--no muscles or motors



Active--internal source of energy

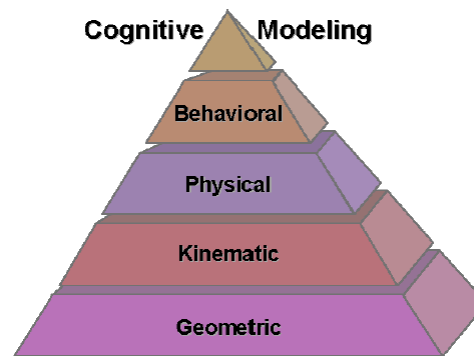


Hodgins

Active Dynamics



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



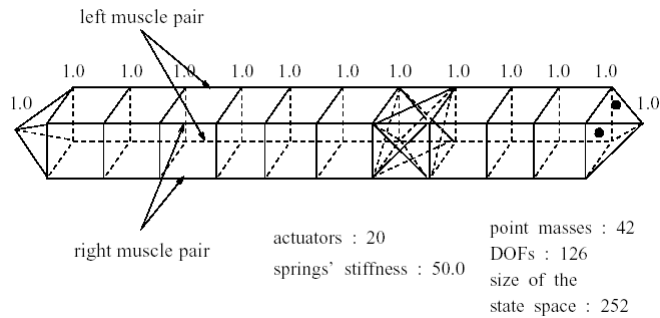
Funge99

How Do Worms/Snakes Move?



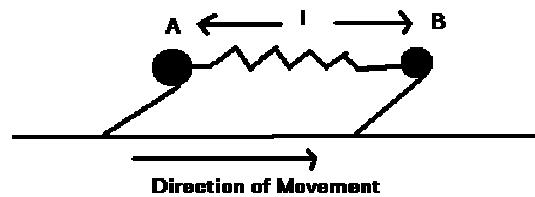
Grzeszczuk95

Worm Biomechanical Model



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Worm Physics



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

$$a = f / m$$

$$X = \frac{1}{m} \iint f dt dt$$

f = force along spring direction

k = spring force constant

D = damping force

l = current spring length

L = minimum energy spring length

... plus forces due to friction with ground.

Miller88

Eric the Dynamic Worm



Miller88

Snake Motion



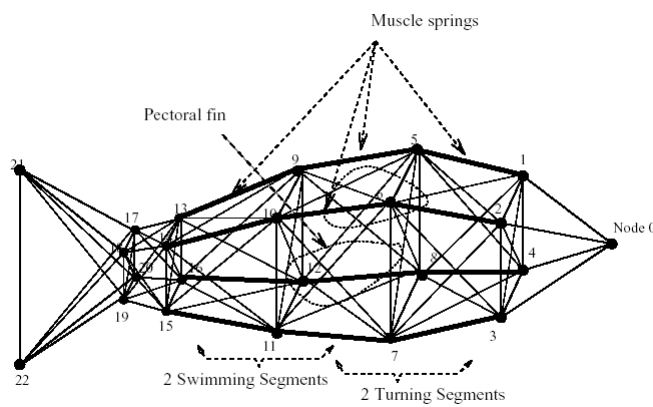
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Her Majesty's Secret Serpent



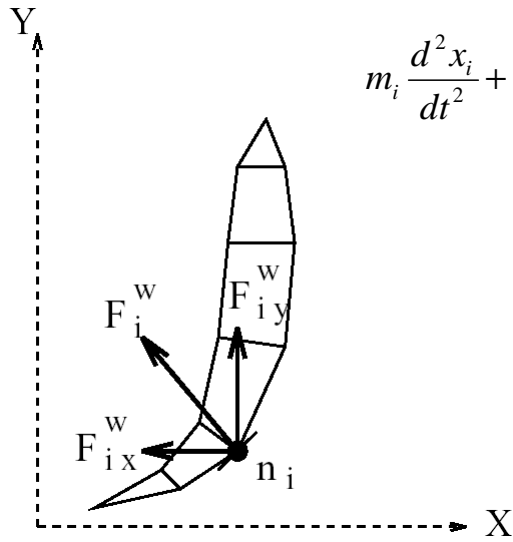
Miller89

Spring-Mass Model for Fish



Tu94

Hydrodynamic Locomotion



Tu94

Swimming



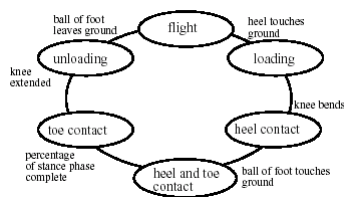
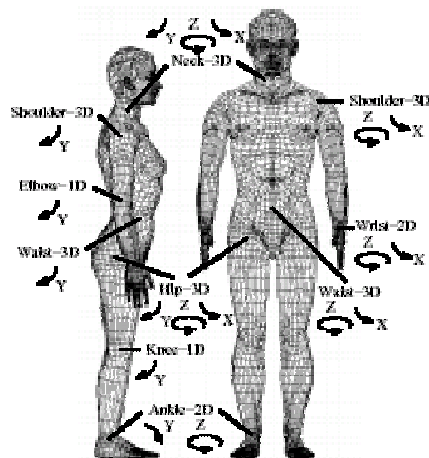
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“On the Run”



Raibert

Animating Human Athletics



Hodgins

Animating Human Athletics



—
All motion in this animation was
generated using dynamic simulation.
—

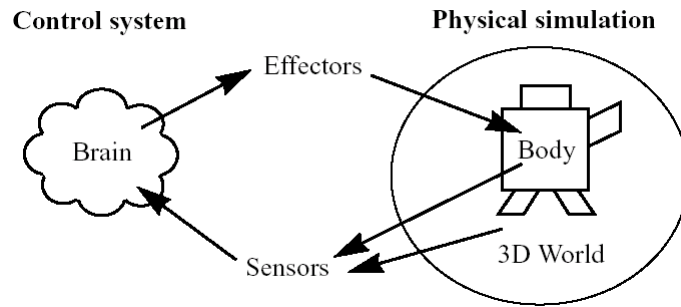
Hodgins

Alien Occurrence



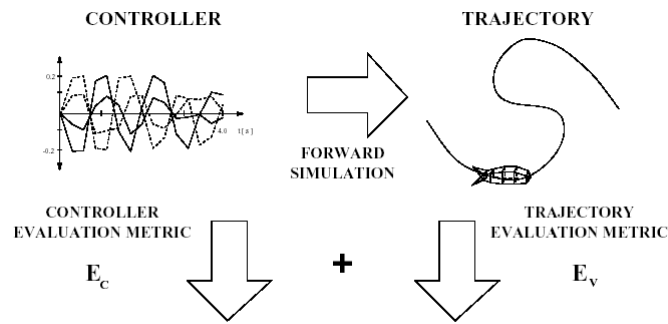
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Learning Motions



Sims94

Learning Muscle Controllers



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

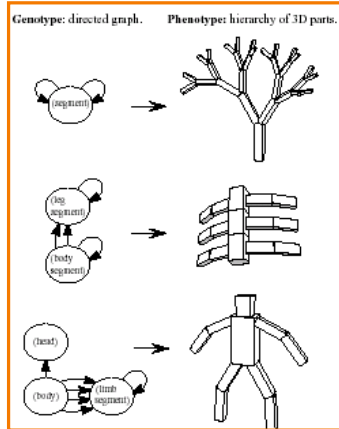
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Learning to Swim

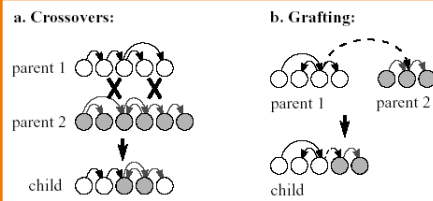


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Evolved Virtual Creatures



Controllers



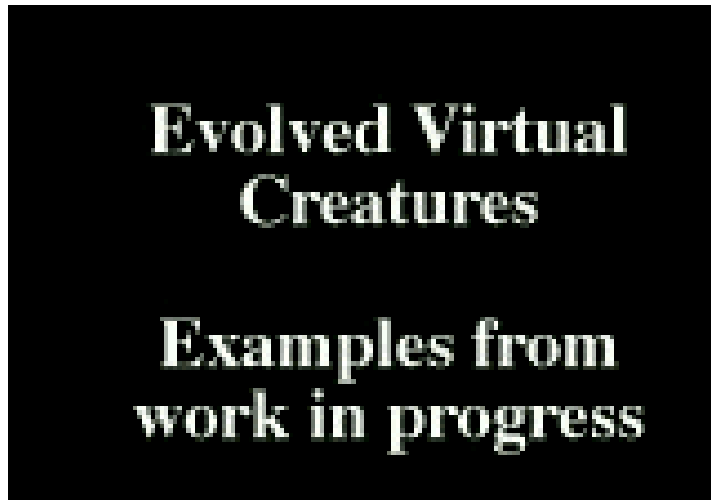
Mutations



Physics & Objective

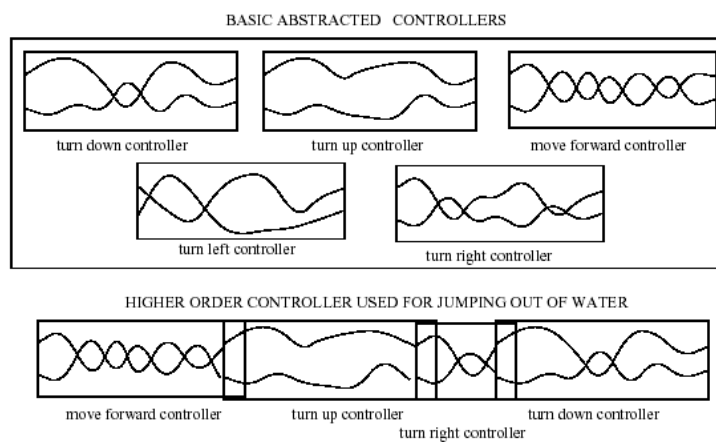
Sims94

Evolved Virtual Creatures



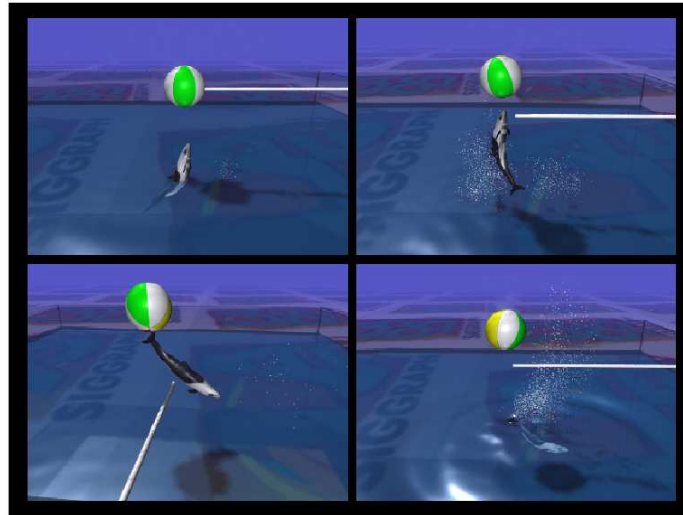
Sims94

Multi-Level Controllers



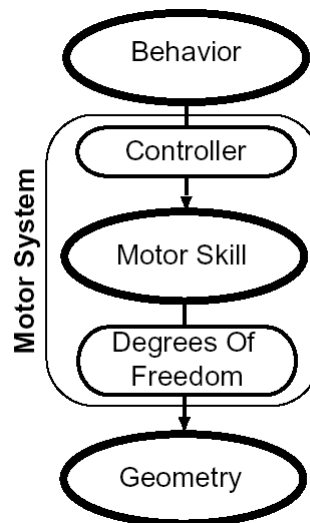
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Learning Complex Motions



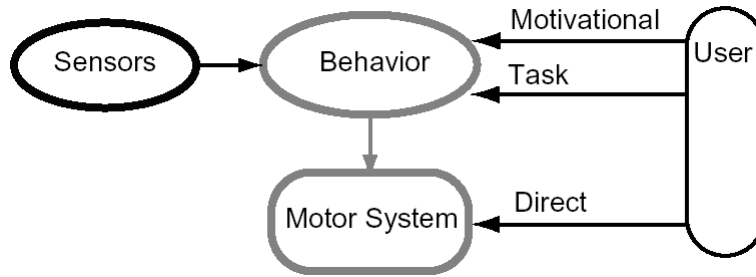
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Behavior



Blumberg95

Behavior



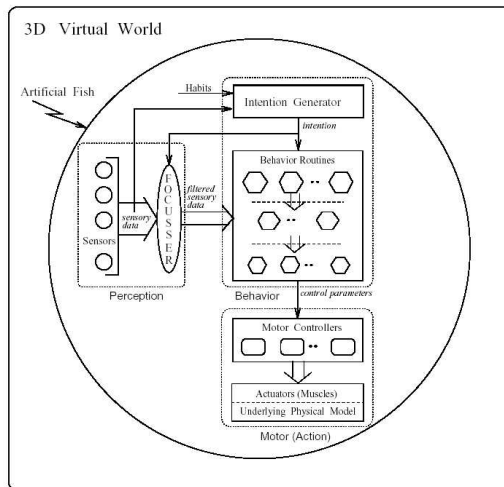
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Fish Behavior



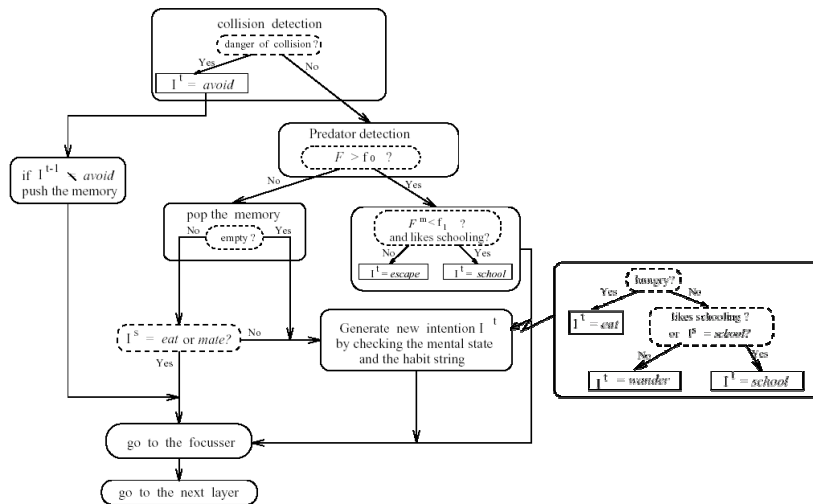
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Fish Behavior Controller



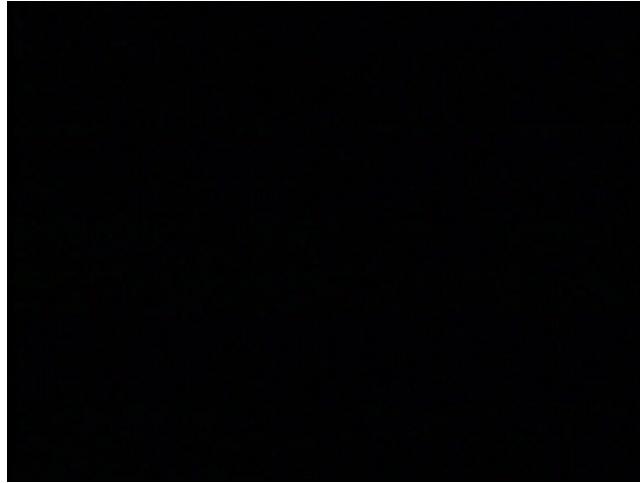
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Intention Generator



Tu94

Go Fish!



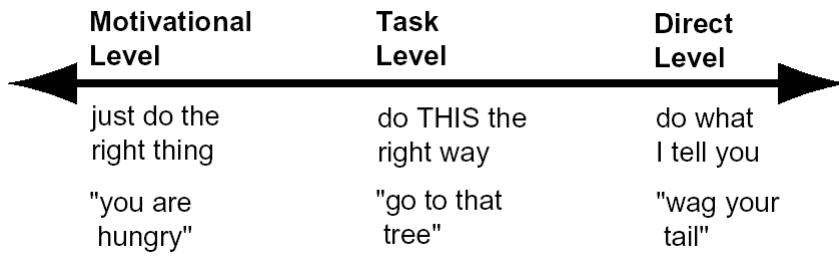
Tu94

Underwater World of JC



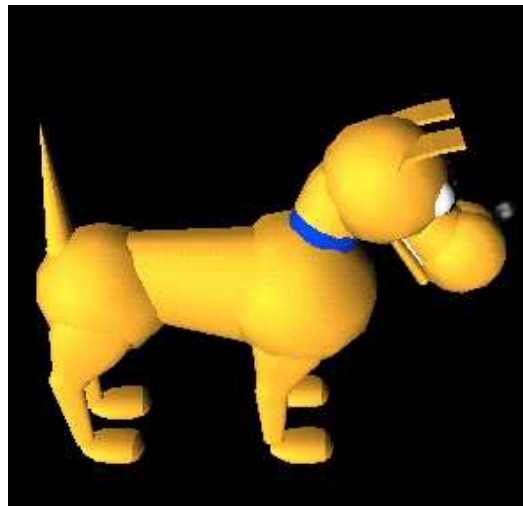
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Multi-Level Control



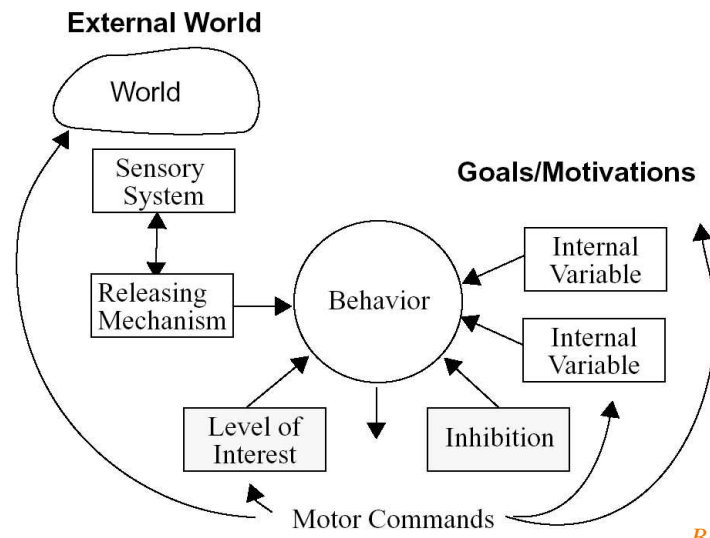
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Silas T. Dog



Blumberg

Silas T. Dog



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Duffy the Merman

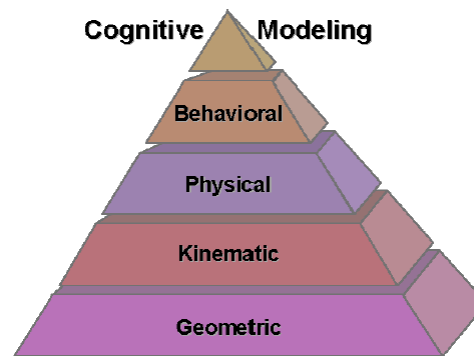


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Summary



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



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