



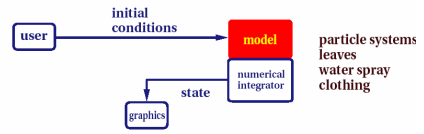
Active Dynamics

Thomas Funkhouser
Princeton University
COS 426, Spring 2006

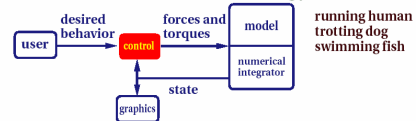
Passive vs. Active Dynamics



Passive--no muscles or motors



Active--internal source of energy

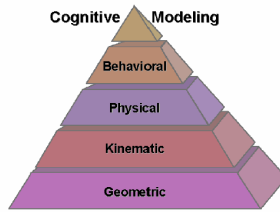


Hodgins

Active Dynamics



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



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Motion



- Example 1: how do worms move?



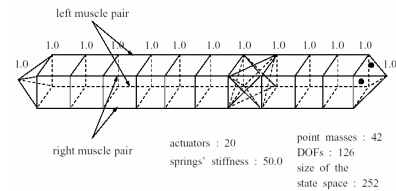
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Snake Motion



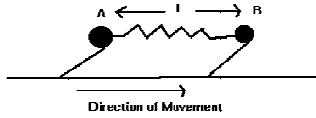
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Worm Biomechanical Model



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Worm Physics



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

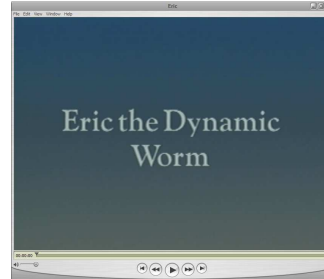
f = force along spring direction
 k = spring force constant
 D = damping force
 l = current spring length
 L = minimum energy spring length

$$a = f/m$$

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

... plus forces due to friction with ground. Miller88

Eric the Dynamic Worm



Miller88

Her Majesty's Secret Serpent



Miller89

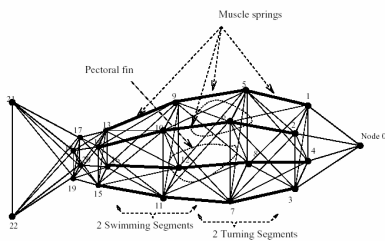
Fish Motion



- Example 2: how do fish move?

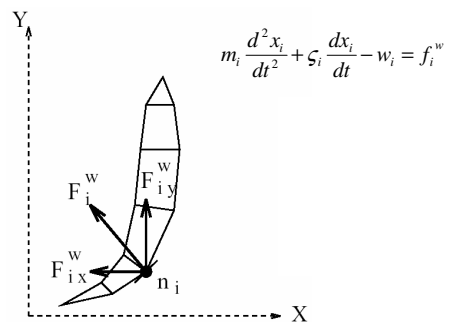


Spring-Mass Model for Fish



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Hydrodynamic Locomotion



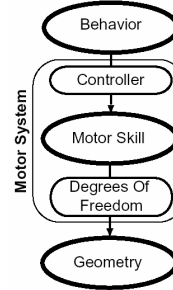
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Swimming



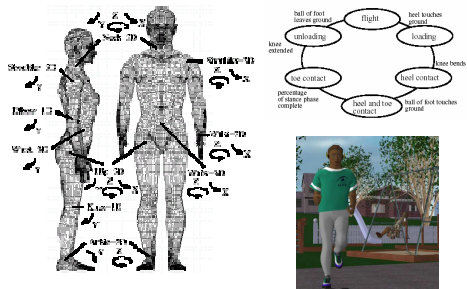
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Motor System



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Animating Human Athletics



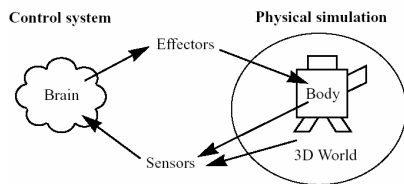
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Animating Human Athletics



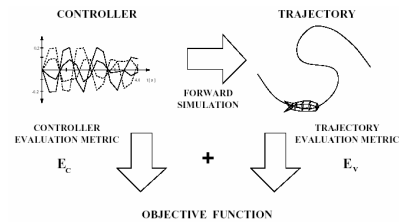
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Learning Motions



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Learning Muscle Controllers



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

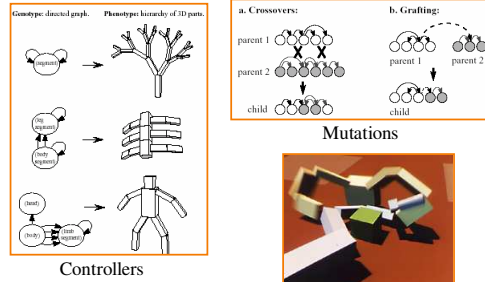
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Learning to Swim



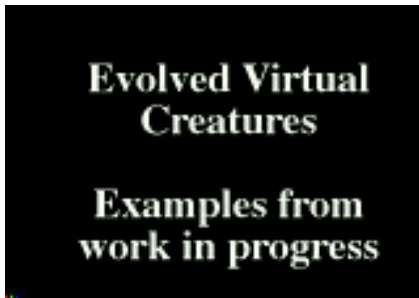
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Evolved Virtual Creatures



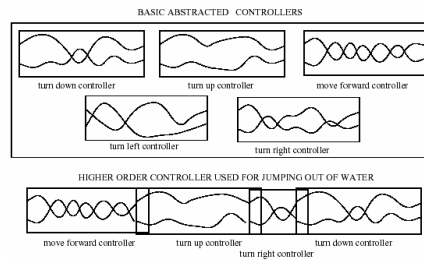
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Evolved Virtual Creatures



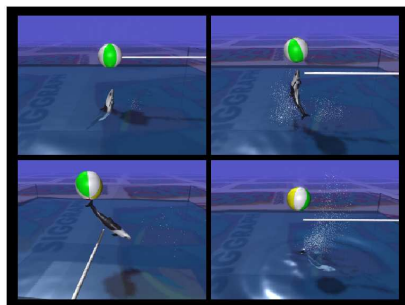
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Multi-Level Controllers



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Learning Complex Motions

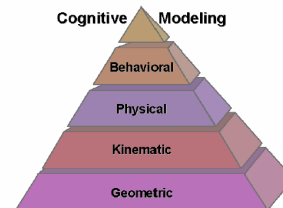


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Active Dynamics

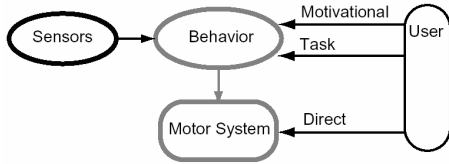


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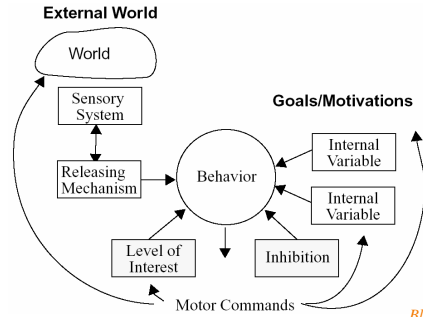
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Behavior



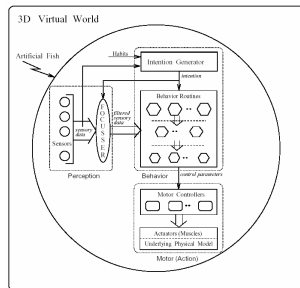
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Behavior



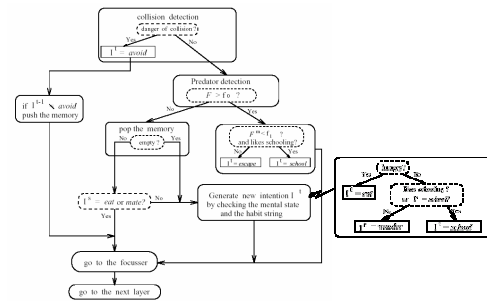
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Fish Behavior Controller



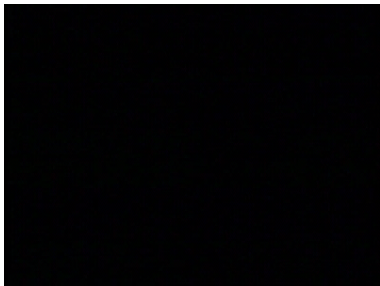
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Intention Generator



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Go Fish!



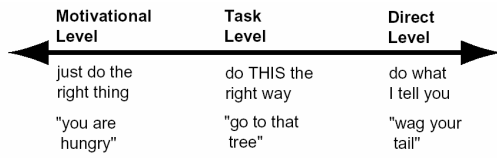
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Underwater World of JC



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Multi-Level Control

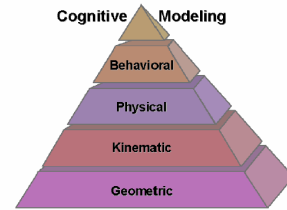


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Active Dynamics

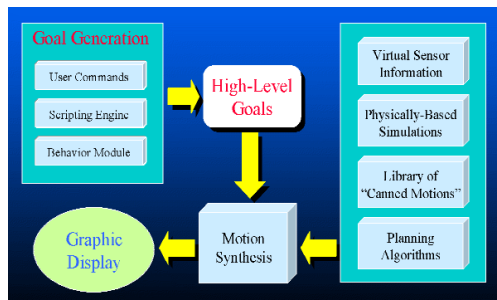


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Planning



Kuffner

Motion Planning



Kuffner

Duffy the Merman

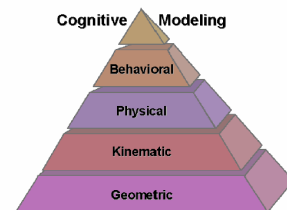


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Summary



- Motions
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