



Active Dynamics

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Computer Animation

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



Pixar

Simulation

- Predict how objects change over time according to physical laws



University of Illinois



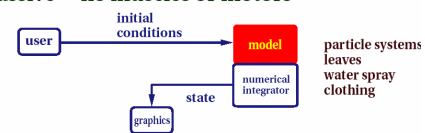
Simulation

- Dynamics
 - Considers underlying forces
 - Compute motion from initial conditions and physics
- Kinematics
 - Considers only motion
 - Determined by positions, velocities, accelerations

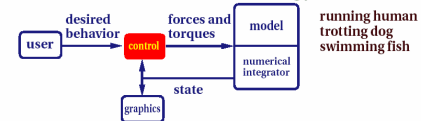


Passive vs. Active Dynamics

Passive--no muscles or motors



Active--internal source of energy

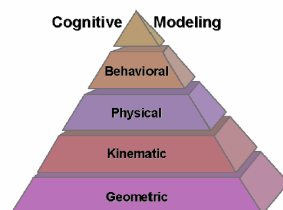


Hodgins



Active Dynamics

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

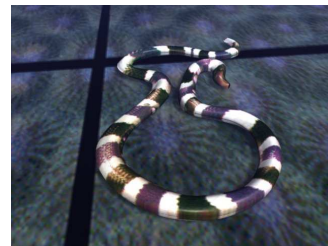


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Motion

- Example 1: how do worms move?



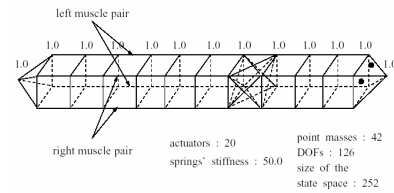
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Snake Motion



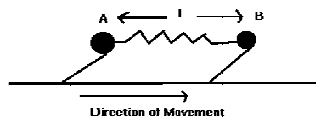
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Worm Biomechanical Model



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Worm Physics



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

$$a = f / m$$

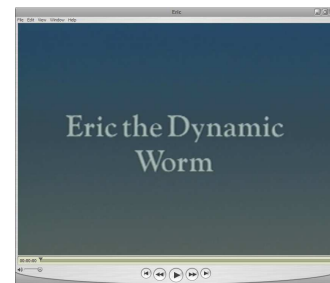
$$X = \frac{1}{m} \iint f dt dt$$

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

Her Majesty's Secret Serpent



Miller89

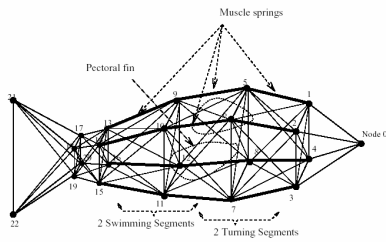
Fish Motion



- Example 2: how do fish move?

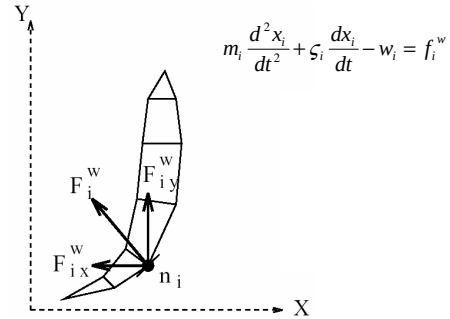


Spring-Mass Model for Fish



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Hydrodynamic Locomotion



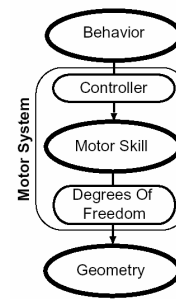
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Swimming



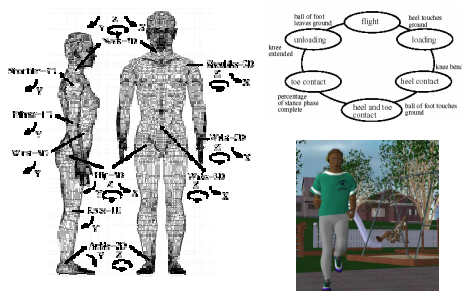
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Motor System



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Animating Human Athletics



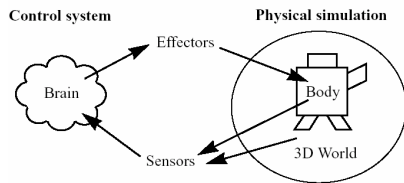
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Animating Human Athletics



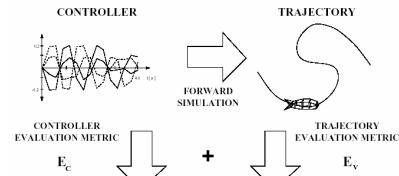
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Learning Motions



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Learning Muscle Controllers



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

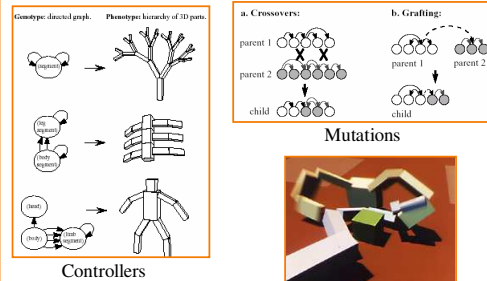
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Learning to Swim



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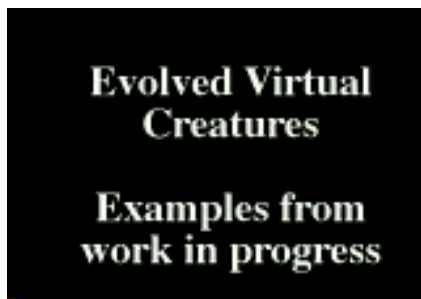
Evolved Virtual Creatures



Physics & Objective

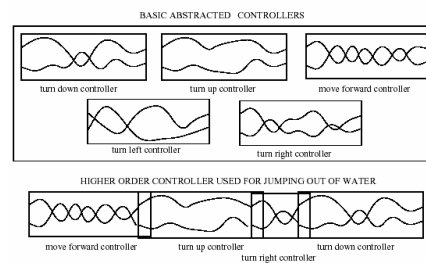
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Evolved Virtual Creatures



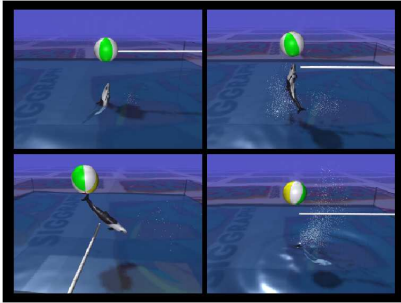
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Multi-Level Controllers



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Learning Complex Motions

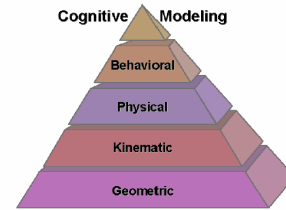


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Active Dynamics

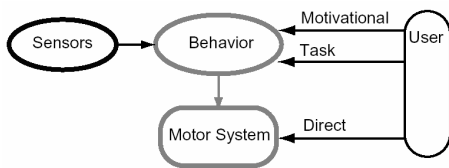


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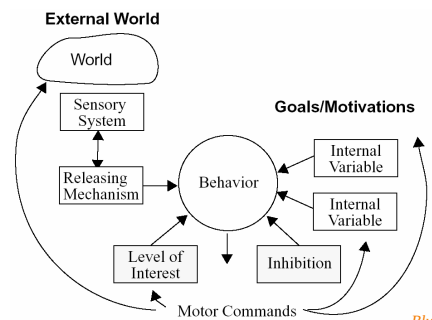
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Behavior



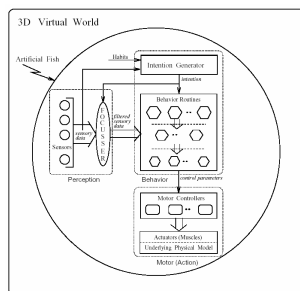
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Behavior



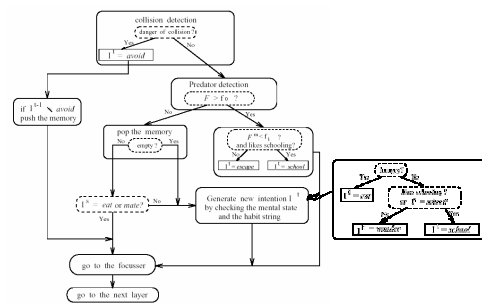
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Fish Behavior Controller



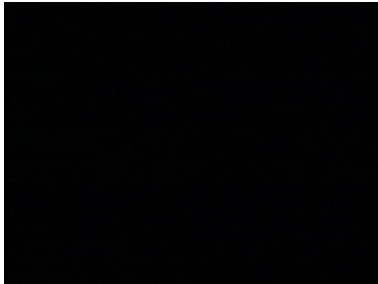
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Intention Generator



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Go Fish!



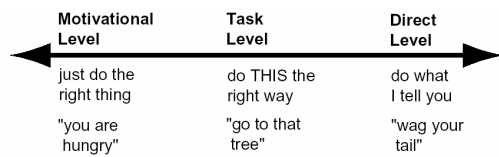
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Underwater World of JC



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Multi-Level Control

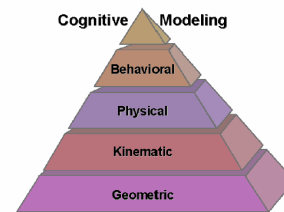


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Active Dynamics

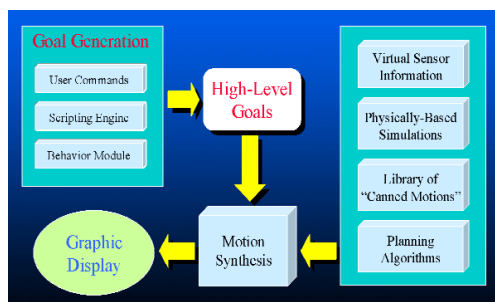


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 - Planning



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Planning



Kuffner

Motion Planning



Kuffner

Duffy the Merman

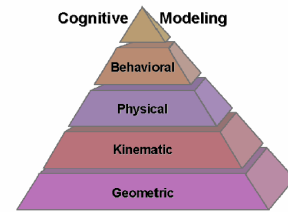


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Summary



- Motions
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