Interactive Character Animation using Simulated Physics

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Given by Derek Basehore

Why use Physics?

- Responses to Actions in the simulated environment do not rely on existing data (kinematics)
- Can create unique reactions depending on the stimulus

How?

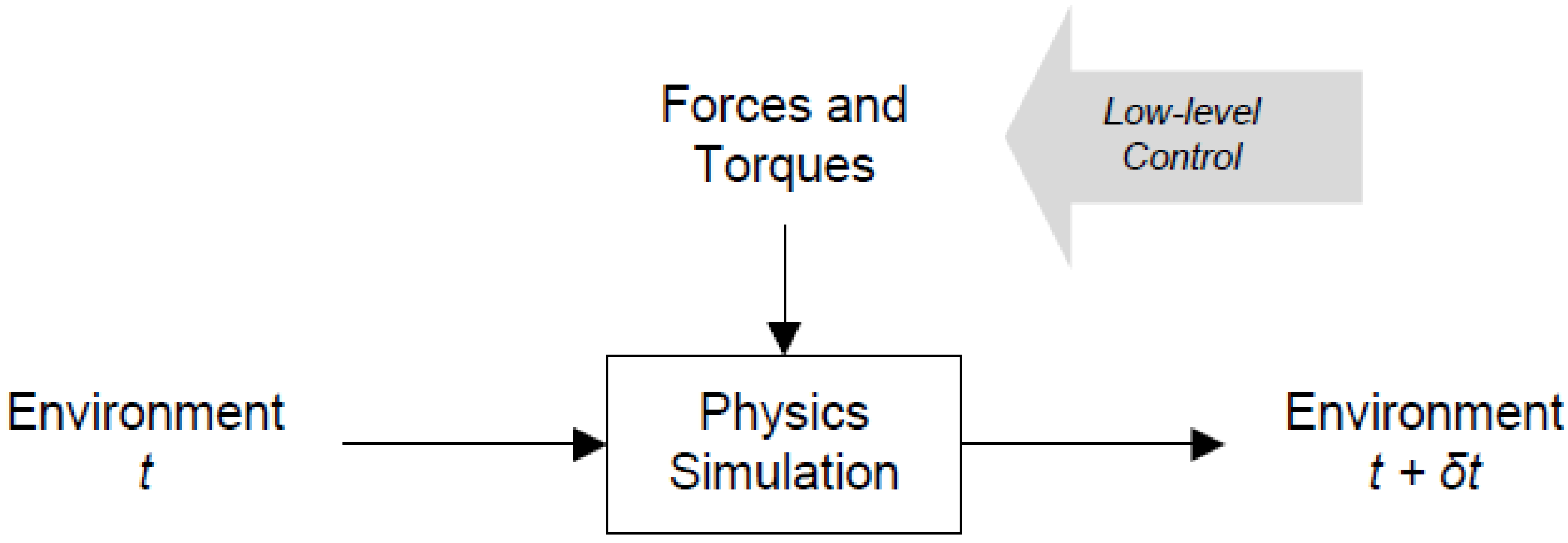

Figure 2: *Animation using physics simulation.*

Overview

- Forward Dynamics vs. Inverse Dynamics
- Actuation Modeling
- Motion Controllers
- Optimization

Forward Dynamics

- Compute the accelerations of simulated objects
- Based directly off of simple physics equations

$$L = mv$$

$$H = Iw$$

$$q'' = M(q)^{-1}\left(c(q, q') + T(q)\tau + e(q)\right)$$

Inverse Dynamics

- Opposite of forward dynamics
- Instead of taking accelerations, you take a motion and find the acceleration needed to perform that motion.
- Motion data is analyzed to determine which motions to use

$$\tau = T(q)^{-1}\left(M(q)q'' + c(q, q') + e(q)\right)$$

Different Actuation Models

- Muscle-Based Actuation
- Servo-Based Actuation
- Virtual Forces

Muscle-Based Actuation

- Computationally expensive, so real time simulations typically do not use it
- Need at least 2 muscles for every degree of freedom since muscles can only pull (hence more computationally intensive)

Servo-Based Actuation

- Every joint is controlled by a servo motor
- Can lead to more unnatural looking animation when optimization is used (as opposed to muscle-based actuation)

Motion Controllers

- Use sensor data to control the motion of the character
- Joint State, Contact Information, Center of Mass, Target Position, etc.

Joint-Space Motion Control

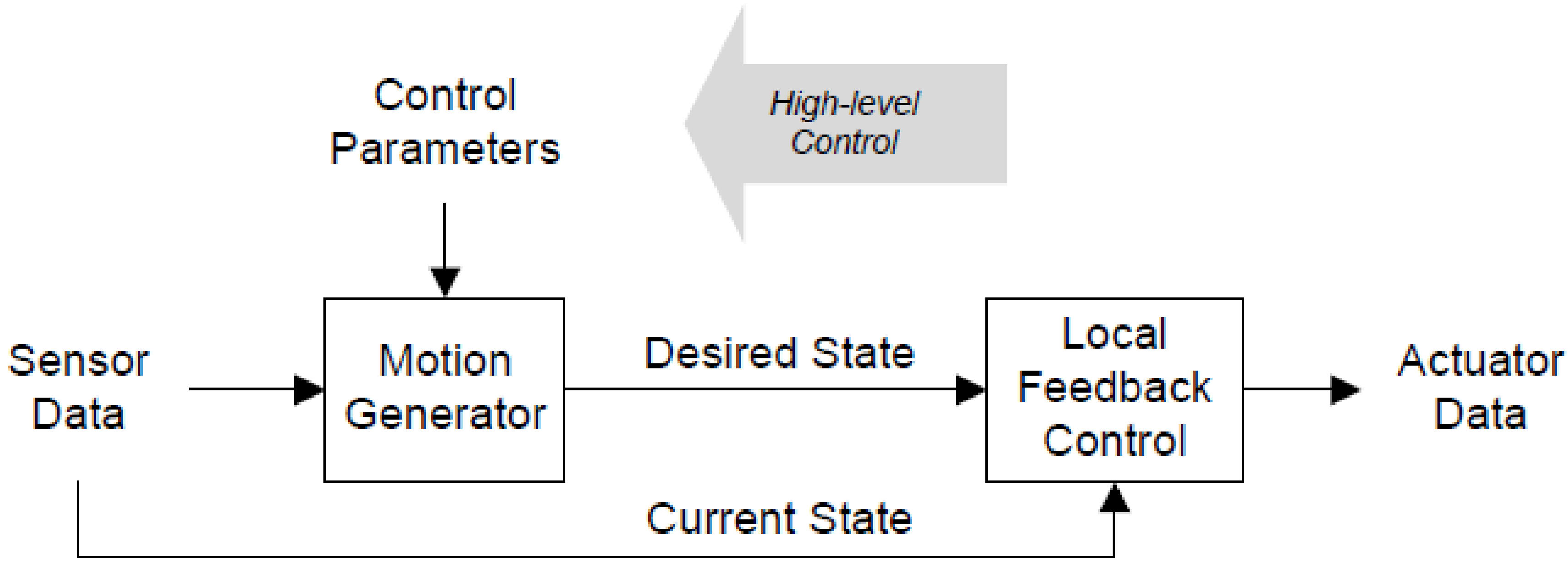

Figure 6: *Joint-space motion control*

Stimulus-Response Network Control

- Creates strict relations between sensors and actuators
- Relies heavily on optimization
  - often uses evolutionary algorithms for offline optimization and reinforcement learning for online optimization

Videos of Research Projects

- http://www.youtube.com/watch?v=JBgG_VSP7f8
- http://people.csail.mit.edu/jovan/assets/movies/abe-2007-mcf.mp4