Generating Natural Human Motion

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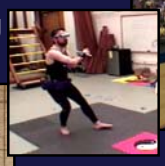
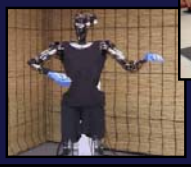
Why Human Motion?

- Computer animation

- Interactive environments
- Physical training
- Robotics

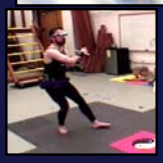




Why Natural?

- Computer animation

- Interactive environments
- Physical training
- Humanoid Robots



Examples

- Motion Capture
- Simulation
- Optimization
- Robot Control

Motion Capture -> Natural?

Motion Capture

Motion Analysis

House of Moves

House of Moves

Human Motion Data

Vicon MX-40 camera system, 12 cameras

120fps at 4Mpixel resolution

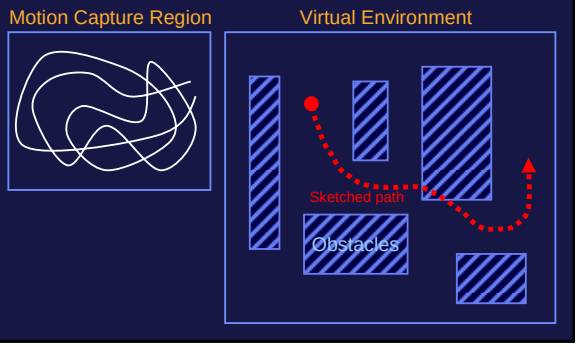
4-9mm markers, 40-100+ ⟹ joint angles

http://mocap.cs.cmu.edu

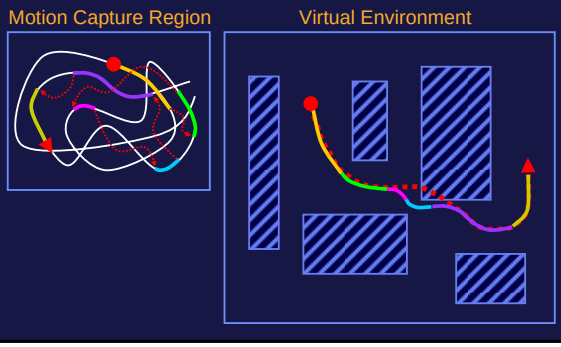
But does it remain natural through modifications?

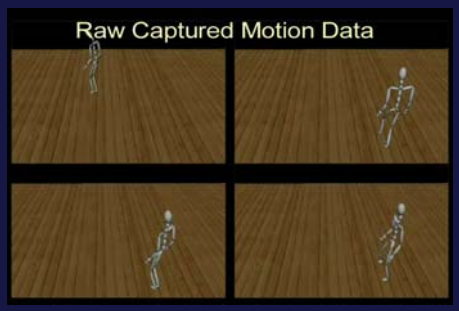
Motion Graphs

Re-sequence



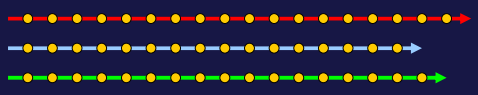
Re-sequence



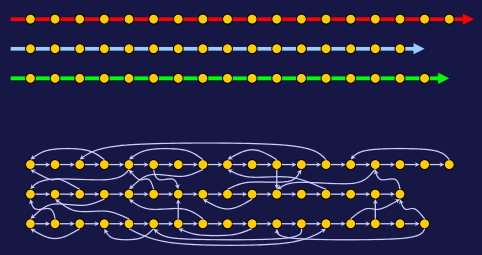


with Jehee Lee

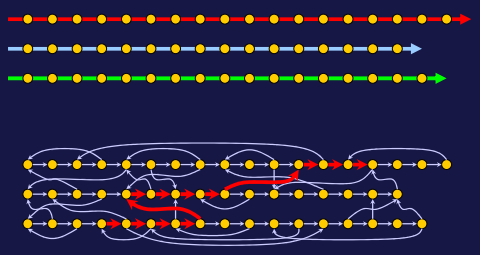
Unstructured Input Data



Connecting Transitions

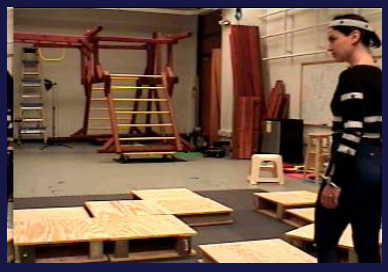


Search (local) to Find Path

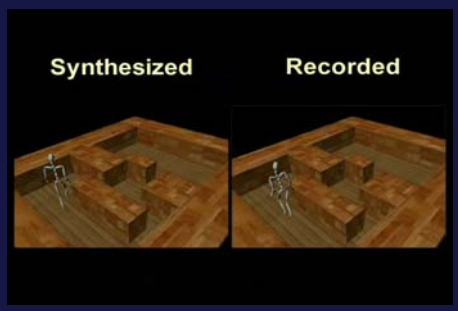


Motion Data for Rough Terrain

Comparison to Real Motion

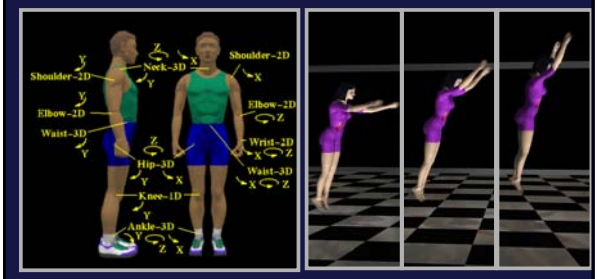


Comparison to Real Motion



Physically Correct != Natural

Simulation of Human Motion



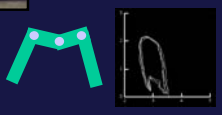
Simulation of Human Motion

All motion in this animation was generated using dynamic simulation.

Where do control laws come from?

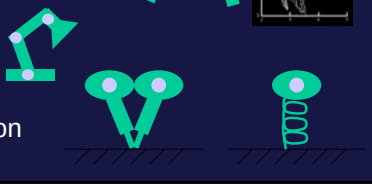
observation

biomechanical literature



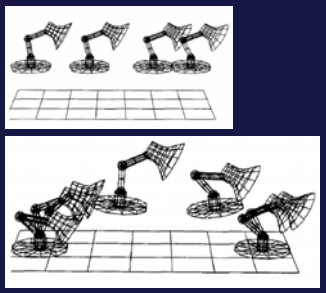
optimization

physical intuition



Optimization != Natural

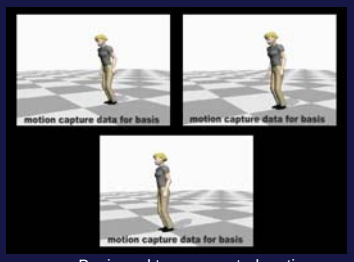
Witkin and Kass SIGGRAPH 1988



But what happens with human characters?

50 to 60 dimensions

- Pick few motions with similar behavior
- Use principal component analysis to compute low-dimensional space
- Optimize in low-dimensional space



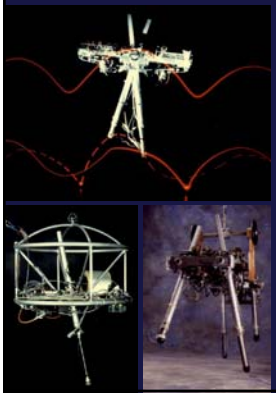
Basis and two generated motions

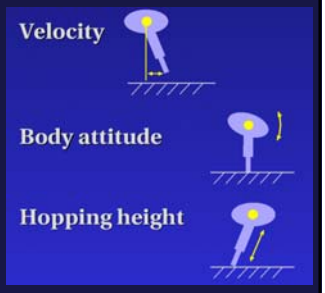
with Alla Safonova and Nancy Pollard

Controlling Robots to be Natural?

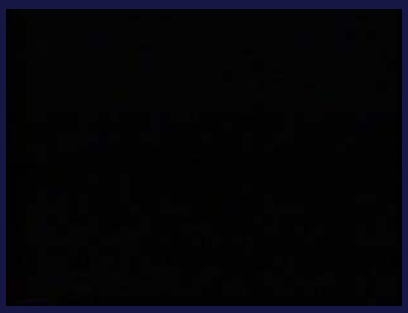
with Jeff Koechling and Marc Raibert

with Marc Raibert





with Marc Raibert



with Marc Raibert

Mimicking people

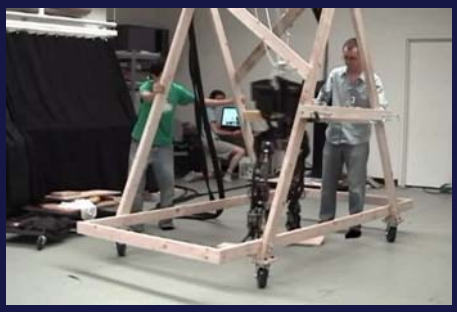
with Alla Safonova and Nancy Pollard

ASIMO

Humanoid Robot: Lower Body

Sarcos

Sarcos Humanoid



with Stuart Anderson and others