인간 동작데이터를 이용한 물리기반 캐릭터 시뮬레이션*

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Simulating Biped Behaviors From Human Motion Data

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Abstract

Physically based simulation of human motions is an important issue in the context of computer animation, robotics and biomechanics. We present a new technique for allowing our physically-simulated planar biped characters to imitate human behaviors. Our contribution is twofold. We developed an optimization method that transforms any (either motion-captured or kinematically synthesized) biped motion into a physically-feasible, balance-maintaining simulated motion. Our optimization method allows us to collect a rich set of training data that contains stylistic, personality-rich human behaviors. Our controller learning algorithm facilitates the creation and composition of robust dynamic controllers that are learned from training data. We demonstrate a planar articulated character that is dynamically simulated in real time, equipped with an integrated repertoire of motor skills, and controlled interactively to perform desired motions.

Keywords: Human Motion, Physically Based Simulation, Biped Walk and Balance, Motion Capture, Controller Learning

1 Introduction

Animating biped characters in a physically-simulated virtual world has been an important issue in the context of computer animation, robotics and biomechanics. A number of techniques from control theory and machine learning have been adopted for designing physically-simulated controllers for each individual human behavior such as walking and balancing. One appealing approach to controller design is learning the control strategies from human performers. A rich set of motion data can be acquired from a live actor performing a specific behavior in a variety of situations. The data set can then be used to inform how animated characters should respond for any given situation. This imitation-based learning approach has demonstrated its potential capability of transferring stylistic human motion to simulated characters and humanoid robots.

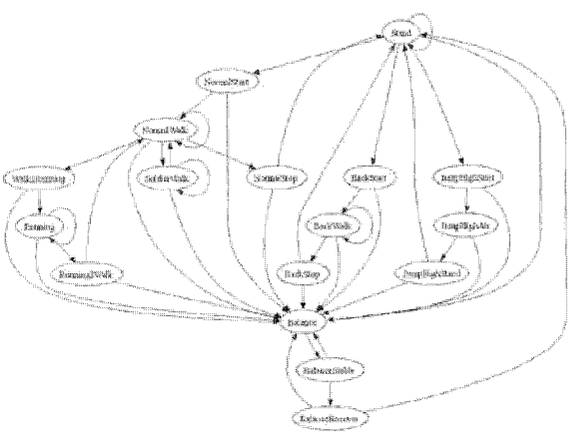

Figure1. An example of finite state machines that govern transitioning between motor controllers. The nodes correspond to motor controllers and the edges show the transition possibilities between controllers.

Despite much research progress, learning a biped behavior from motion capture data is still challenging when the behavior requires subtle control for maintaining its balance, which is difficult to capture from recorded motion data. Another difficulty is the physical imprecision of the captured motion data. Since the dynamic character model is drastically simplified from the live actor, any biped character that exactly follows the captured joint angle trajectories would lose its balance and fall over in a few steps

*Extended abstract; The full paper is accepted to SIGGRAPH 2007.

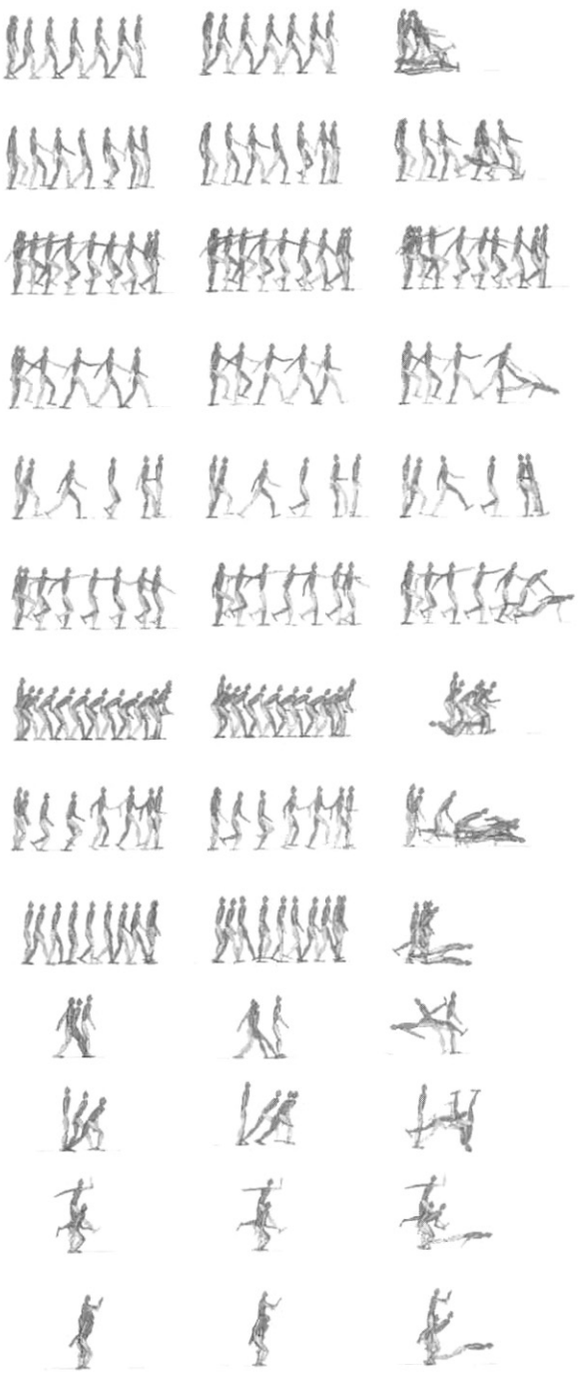

Figure2. The results of motion optimization. (Left column) Original motion capture data. (Center column) Rectified motions are simulated by PD controllers. (Right column) Original motions are simulated by PD controllers. Most of the data result in falling down.

We present a new technique for allowing our physically-simulated planar biped characters to imitate human behaviors. We start with a set of motions that were recorded from a live actor performing actions repeatedly. The motion set is rectified via optimization in such a way that the simplified dynamic model can approximately reproduce the recorded motion trajectories by actuating its joints while maintaining its balance. The control policy of the character's behavior is learned from the rectified motion set. This control policy allows our characters to imitate biped behaviors robustly.

We also propose a method of composing learned dynamic controllers into an integrated framework that allows the character to transition between different behaviors. Robust transitioning from one motor controller to the other is achieved by learning a designated transition controller. The training data for the transition controller are either motion-captured or synthesized by blending existing data kinematically. Once all the controllers are learned, our character can be dynamically simulated in real time and controlled interactively to perform desired motions.

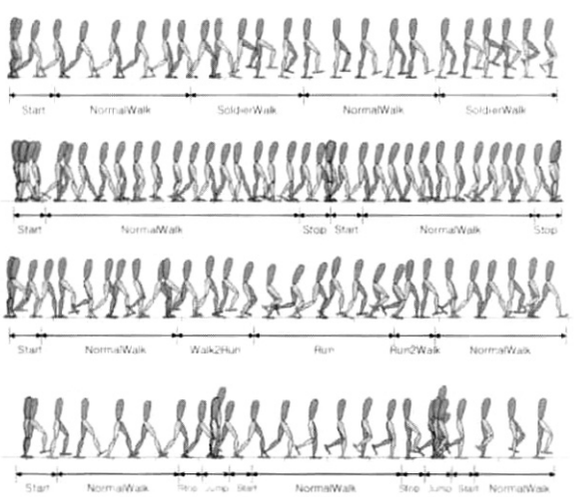

Figure3. Transitioning between controllers

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