# Physics-based control of dynamic characters

Tutorial II, CASA 2003

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## 1 CONTENT

Dynamically simulated characters provide pointed advantages over their non-physical counterparts for many computer animation applications but the approach raises many challenging questions in regards to their control. Physically based characters perform actions that are tied to the real world through the realistic constraints placed on their motion. This affords viewers' intuition about natural movement, especially for humanoid figures as a useful and important component of understanding synthetic action and interaction of such characters. In addition, while sophisticated behaviors do require controllers to be performed realistically, dynamic characters always move in a consistent, physically plausible manner even under completely unknown and novel conditions because of their persistent dynamic constraints. Of course, the challenge in realizing dynamic characters lies in formulating and building reasonable control routines that will provide coordination and the appearance of intelligence, in addition to the basic physical aspects of motion. The wide scope of control problems for such characters include: low-level muscle-like actuation as well as joint limits and interdependencies; adaptible behavior-level control; and high-level cognitive and multi-character actions.

This tutorial will provide an overview to control for dynamic characters as well as a focused progression from base-level to high-level control. After a brief introduction of dynamic systems, consecutive layers for a general control hierarchy are to be presented. For each layer, the fundamental issues will be introduced along with a framework that places each within the context of a larger control infrastructure. Approaches will be discussed along with limitations and results. In this fashion, participants in this tutorial will be exposed to a full spectrum of control ideologies and their application to a scope of low- and high-level problems.

We propose to present a half-day length for the tutorial.

## 2 OUTLINE

- **Introduction.**
- **Models and Dynamics of Articulated Characters.**
  - Rigid body dynamics.
  - Articulated figure dynamics.
  - Biomechanics considerations.
  - Available tools. (Commercial and free)
- **Motor Control.**
  - Low-level control.
  - Controller design.
  - Automatic methods for controller design.
  - Adapting controllers to new characters.
  - Motion Capture driven control.

- **Higher level control**
  - Composite controllers.
  - Multi-tasking.
  - Behaviors.
  - Cognition.
- **Conclusion-Discussion**
  - Summary.
  - Resources (Tools, Biomechanics and robotics literature).
  - Future trends.

# 3 SCOPE AND AUDIENCE

## 3.1 INTENDED AUDIENCE

This tutorial is targeted for researchers, students and professionals that want to obtain a comprehensive overview of the state of the art about the dynamic animation and control of animated characters. The tutorial covers a wide range of topics with the intent to give a condensed yet comprehensive picture. The tutorial is particularly useful for students who are just starting to work in the area of controling dynamic characters as they will see

- a summary of the state of the art in a wide range of relevenat topics,
- the different levels of control abstraction,
- the available tools and resources.

## 3.2 PREREQUISITES

Basic understanding of physics and control.

# 4 SPEAKERS IN ALPHABETICAL ORDER

- Petros Faloutsos, Assistant Professor, University of California at Los Angeles (co-organizer).
- Nancy Pollard, Assistant Professor, Brown University.
- Demetri Terzopoulos, Professor, New York University.
- Victor Zordan, Assistant Professor, University of California at Riverside (co-organizer).