Robotics and Animatronics in Disney

Lecture 1: Overview

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About Myself

2002	Ph.D. in Mechanical Engineering, University of Tokyo (Department of Mechano-Informatics)
2002-03	Postdoctoral Fellow, Carnegie Mellon University (Prof. Jessica Hodgins)
2003-08	Assistant/Associate Professor, Department of Mechano-Informatics, University of Tokyo
2008-	Senior Research Scientist, Disney Research, Pittsburgh

Research Interests

Synthesizing natural motions for humanoid robots and characters

- Tools: dynamics simulation, humanoid robot modeling, inverse kinematics, geometry-based algorithms
- Analysis: motion capture, musculoskeletal human model
- Synthesis: humanoid robot control, using motion capture data, motion planning

The Walt Disney Company

- Studio Entertainment: *Walt Disney Animation Studios, Pixar, Walt Disney Studios Motion Pictures, Marvel, (Lucasfilm), etc.*
- Parks and Resorts: *Walt Disney Imagineering, Walt Disney World, Disney Cruise Line, etc.*
- Media Networks: *ABC, ESPN, ABC Family, etc.*
- Disney Consumer Products: *Disney Consumer Products, Disney Publishing Worldwide, Disney Store*
- Disney Interactive: *Disney Interactive Games, Disney Interactive Media*

Disney Research

- A part of Walt Disney Imagineering
- But works with all business units
- Locations
  - Disney Research, LA (DRLA): Glendale, CA
  - Disney Research, Pittsburgh (DRP): Pittsburgh, PA
  - Disney Research Boston (DRB): Boston, MA
  - Disney Research, Zurich (DRZ): Zurich, Switzerland
  - Pixar Research Group: Emeryville, CA
  - Walt Disney Animation Studios Research: Burbank, CA

DRP

- Director: Jessica Hodgins (also LA)
- 4 [Senior] Research Scientists (1 in robotics)
- 8 postdocs (3 in robotics)
- 5 research staffs
- 4 administrative staffs
- Consultants
- Many interns

DRP Research Areas

- Computer vision
- Human-computer interaction
- Robotics
- Machine learning
- Wireless communication
- Speech recognition

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Robotics @ Disney

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Robotics @ Disney

- Walt Disney Imagineering
  - Mostly development of robots for deployment
  - Advanced development: semi-long-term projects
- Disney Research
  - Pittsburgh: 1 SRS, 3 postdocs, 4-6 lab associates (interns)
  - LA: 2 SRS, 1 postdoc
  - Zurich: 2 robotics-related projects

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Robotics @ Disney

- Just accomplishing a task is not enough: style and plausibility (and cost) are also important.
- We have existing hardware systems.
- Most "customers" don't care technology.
  - Artists
  - Engineers
  - Guests
  - Consumers
- We can usually control the environment.
  - We may even cheat to some extent.

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Robotics @ Disney



Human-Robot Interaction

Natural and Stylized Motions

Humanoid Modeling and Control

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Natural and Stylized Motions

- Animation
  - Highly labor-intensive task
  - Experienced animators
  - Physical robot for fine-tuning
- Maintenance
  - Manual adjustments
  - Limited time/resource

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Humanoid Modeling and Control

- Disney robots (Audio-Animatronic Figures)
  - No real contacts with environment / objects


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Human-Robot Interaction

- Some prior attempts in Disney
- Operator + supervisor: not scalable


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Challenges

Safe physical interaction

New hardware

Leverage existing hardware

Animation: interfaces that are simple but allows full control

Maintenance: maintain original animation quality

Robust force control

Modeling and sensing

Simple and inherently robust robots

Human-Robot Interaction

Natural and Stylized Motions

Humanoid Modeling and Control

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DRP Projects

Human-Robot Interaction

Soft robots

Physical human-robot interaction

Mocap to non-humanoids

A100 modeling & control

Locomotion on dynamic objects

Programming interfaces for animators

Contact force optimization

Mocap to humanoids

Simplified models

Identification & calibration

Natural and Stylized Motions

Humanoid Modeling and Control

Robot Platforms



"Sky" (A100 figure) @ DRP

"The Sarcos Robot" @ CMU

"Miley" @ DRLA

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"Sky"

- Typical Disney figure (A100)
- Hydraulic (600PSI)
- 4DOF body, 3DOF torso, 2 shoulder shrugs (linear), 7DOF arms, 3DOF neck, mouth, 10 fingers
- Disney proprietary low-level position controller
- Linux interface to update position commands and obtain position / pressure data @ 120Hz

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The Sarcos Robot

- Floating-base humanoid robot
- Hydraulic (3000PSI)
- 7DOF legs, 7DOF arms, 3DOF torso, 3DOF neck
- Sensors: joint angles (potentiometer), joint torque, IMU, 6-axis force/torque sensors in feet
- On-board low-level position/force controller @ 5kHz
- Xenomai-based external PC for high-level control @ 1kHz

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"Miley"

- Planar bipedal robot developed by Rick Cory (DRLA)
- 2 joints per leg
- Series elastic actuators

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Lecture Overview

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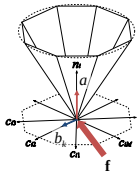
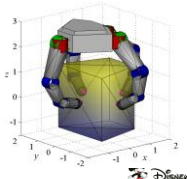
Pittsburgh

Day 1

- Introduction
- Computation
  - Inverse and Forward Dynamics
  - Geometric Algorithms for Robotics





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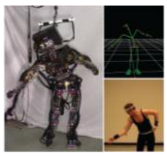
Day 2

- Motion Synthesis
  - Review of physics-based techniques in animation
  - Using motion capture to control humanoid robots
  - Using motion capture to control non-humanoid robots



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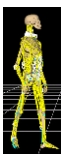
Day 3

- Modeling and Control
  - Humanoid robot modeling and control
  - Human modeling and control
- Physical human-robot interaction



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Evaluation

- Attendance
- Report: an essay on the discussion points presented at one of the 8 lectures (details to follow)