Motion generation for complex robots

Nicolas Mansard
LAAS-CNRS, Toulouse
Motivation
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Mathematical tools for describing the movement
Mathematical tools for describing the movement

Biomechanics: Model of human body and action
Motivation

Mathematical tools for describing the movement

Biomechanics: Model of human body and action

Gaming, computer animation
Outline of the class

1. Inverse geometry

   Find a configuration …
How to construct this motion?
Outline of the class

1. Inverse geometry
   *Find a configuration …*

2. Inverse kinematics
   *Find a velocity …*
How to construct this motion?
Outline of the class

1. Inverse geometry
   Find a configuration …

2. Inverse kinematics
   Find a velocity …

3. Inverse dynamics
   Find a force …
How to construct this motion?
Outline of the class

1. Inverse geometry
   Find a configuration …

2. Inverse kinematics
   Find a velocity …

3. Inverse dynamics
   Find a force …

4. Optimal control
   Find a trajectory …
How to construct this motion?
Outline of the class

1. Inverse geometry
   *Find a configuration …*

2. Inverse kinematics
   *Find a velocity …*

3. Inverse dynamics
   *Find a force …*

4. Optimal control
   *Find a trajectory …*

5. Reinforcement learning
   *Find a policy …*
Flexible Muscle-Based Locomotion for Bipedal Creatures

SIGGRAPH ASIA 2013

Thomas Geijtenbeek
Michiel van de Panne
Frank van der Stappen
Outline of the class

1. Inverse geometry
   Find a configuration …  Static optimization

2. Inverse kinematics
   Find a velocity …  Quadratic optimization

3. Inverse dynamics
   Find a force …  Constrained optimization

4. Optimal control
   Find a trajectory …  Linear-quadratic regulator

5. Reinforcement learning
   Find a policy …  Machine learning
Practical work
In-house robotics

- Presentation of a real humanoid robot
- Demonstration at LAAS
- Visit of the laboratory

Objectives of this part:
- Connection with a research facility
- Opportunity to see one of the two full-size humanoid robot in France (the only one working today)
Industrial conference

Francesco Ferro
PAL Robotics, Barcelona

Matthieu Masselin
Wandercraft, Paris

Sebastien Borriat
Airbus Manufacturing Research, Toulouse
Other concerns

For each three-hour session:

- “Cinema” introduction, about a lab or an experiments
  10 minutes – motivate the daily class
  Often by a LAAS (junior) researcher

- Overview of the class with powerpoint
  15 minutes – main ideas, outline, take-away message

- Black board developments
  Occasional use of video projector
  Typical media: robot movements, algorithm outputs, plots …

- Daily use of computer support
  Practical work with the software of the lab
  Based on Ubuntu 12.04/14.04 …. or a VirtualBox
Text books

- My own textbook is yet a draft
  http://homepage.laas.fr/nmansard/textbook_draft.pdf
- Featherstone 2009: rigid body dynamics
- Nocedal&Wright 2006: optimization
- Liberzon 2012: optimal control
- Muray 1990: fundamentals of robotics
- Siciliano 2010: generic robotics
Questions ?