INTRODUCTION TO ROBOTICS

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About Myself

- Mail: andrea.calanca@univr.it
- Affiliation: Altair Robotics Lab, University of Verona

- Previous Experience
  - Academic Researcher (Univ. Verona)
  - Software Engineer (Replay, Sole24)
  - Automation engineer (Tetrapack Group)
  - Audio DSP engineer (Overloud)
  - Control Engineer (Electrolux Group)

Course Prerequisites

- Linear Algebra
  - Matrices, linear operators, vector spaces
- Newton Mechanics
  - Motion equations, linear and rotational
- Classic (Linear) Control Theory (Continuous systems)
  - Laplace transform, root locus, Bode and Nyquist diagrams
- Matlab
  - Basic programming skills

Course Material

- Books
  - “Robotica. Modellistica, pianificazione e controllo” di Siciliano, Sciavicco, Villani, Oriolo
  - “Robotica industriale. Modellistica e controllo di manipolatori” di Lorenzo Sciavicco e Bruno Siciliano
- Slides and Notes provided by the teacher.
- Lessons hand notes!
- Others:
  - “Appunti ed esercizi di Meccanica Razionale” Luciano Battaia

Course Program

- Kinematics
- Differential kinematics
- Dynamics (of rigid robots)
- Control (of rigid robots)
  - Position control
  - Force Control
  - Impedance Control

Course Program

- Kinematics - Siciliano
- Differential kinematics - ~Siciliano
- Dynamics (of rigid robots) - Calanca+Siciliano
- Sensors and Actuators - Siciliano
- Control (of rigid robots)
  - Position control - Siciliano+Notes
  - Force Control - Notes
  - Impedance Control - Siciliano

Course General Information

- Receiving hours: Wednesday 16.00 – 17.30
- Exam: written + project

What is Robotics?

A very multidisciplinary subject

- Mechanic engineering
- Electronic engineering
- Control engineering
- Computer Science
- Artificial Intelligence

What is Robotics?

Mechanics

- Rigid body kinematics
- Rigid body dynamics

- Lagrangian Mechanics
- Hamiltonian Mechanics
- Deformable body kinematics and dynamics

What is Robotics?

Electronics & Electrotechnics

- Digital electronics (e.g. encoders, hall sensors, stepper motors, inverters)
- Analog electronics (e.g. potentiometers, resolvers, filters, linear amplifiers)
- Sensors & sensor conditioning
- Actuators & power units
- Processors & interfaces
- Communication

What is Robotics?

Control Theory

- Classical Control
  - Linear controllers, loop shaping, root locus, Nyquist and Bode stability criterions, robustness indexes
- Non-Linear Control
  - Feedback linearization, passivity based control, sliding-mode control, adaptive control, back-stepping control and more!
- Modern Control
  - Control as an optimization problem. Not so many examples for the moment due to computational burden (model predictive control)
- System Identification & Optimal Filtering
  - Parametric identification, state observers

What is Robotics?

Computer Engineering

- Operating systems, distributed and networked systems, real-time scheduling and resource allocations
- Software architectures & design patterns
- Modern (not obsolete) programming paradigms: object oriented, component oriented.
- Computer Vision: 3D reconstruction, classification, recognition, etc.
- Machine learning: learning by demonstration, reinforcement learning, etc.

What is Robotics?

Artificial Intelligence

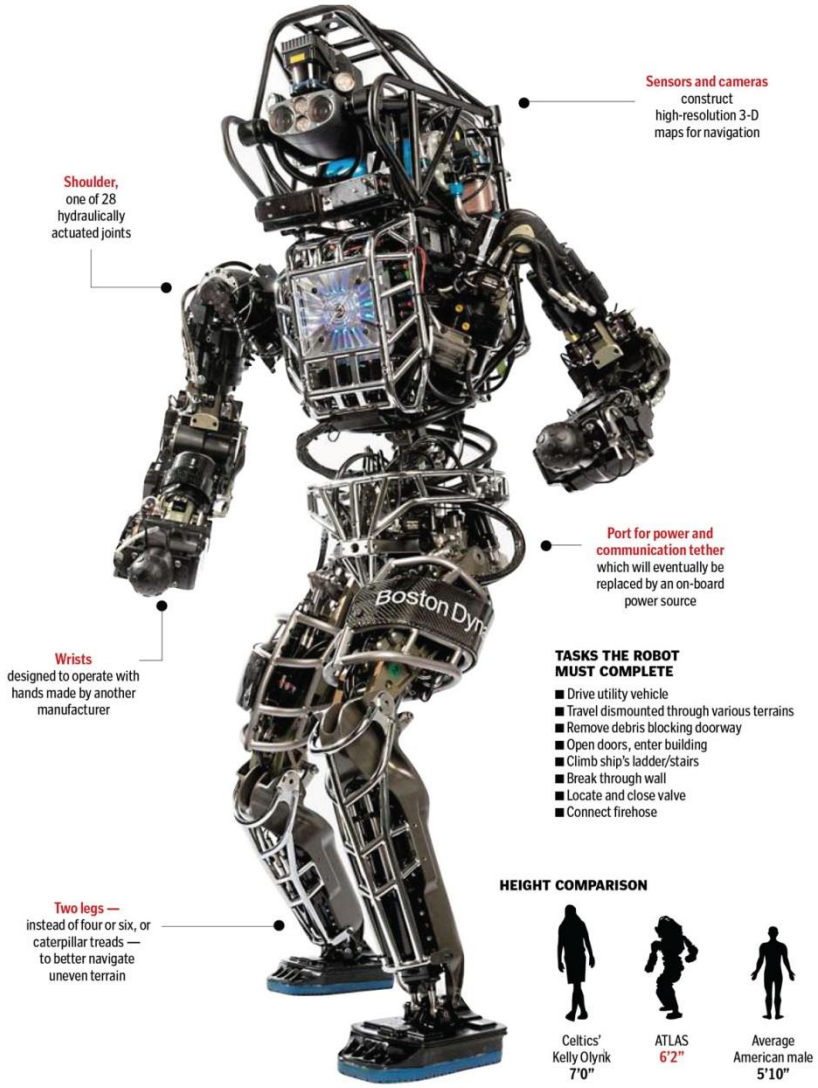
- Reasoning: Solving Problems by Searching, Classical Search, Adversarial Search, Constraint Satisfaction Problems, Logical Agents, First-Order Logic, Planning, Knowledge Representation

- Uncertain reasoning: Probabilistic Reasoning (Bayes, e.g. Bayesian networks), Statistical Inference, Decision Support Systems, Fuzzy Logic.

What is a Robot?

DARPA

Atlas



What is a Robot?

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What is a Robot?

This is not a Robot!

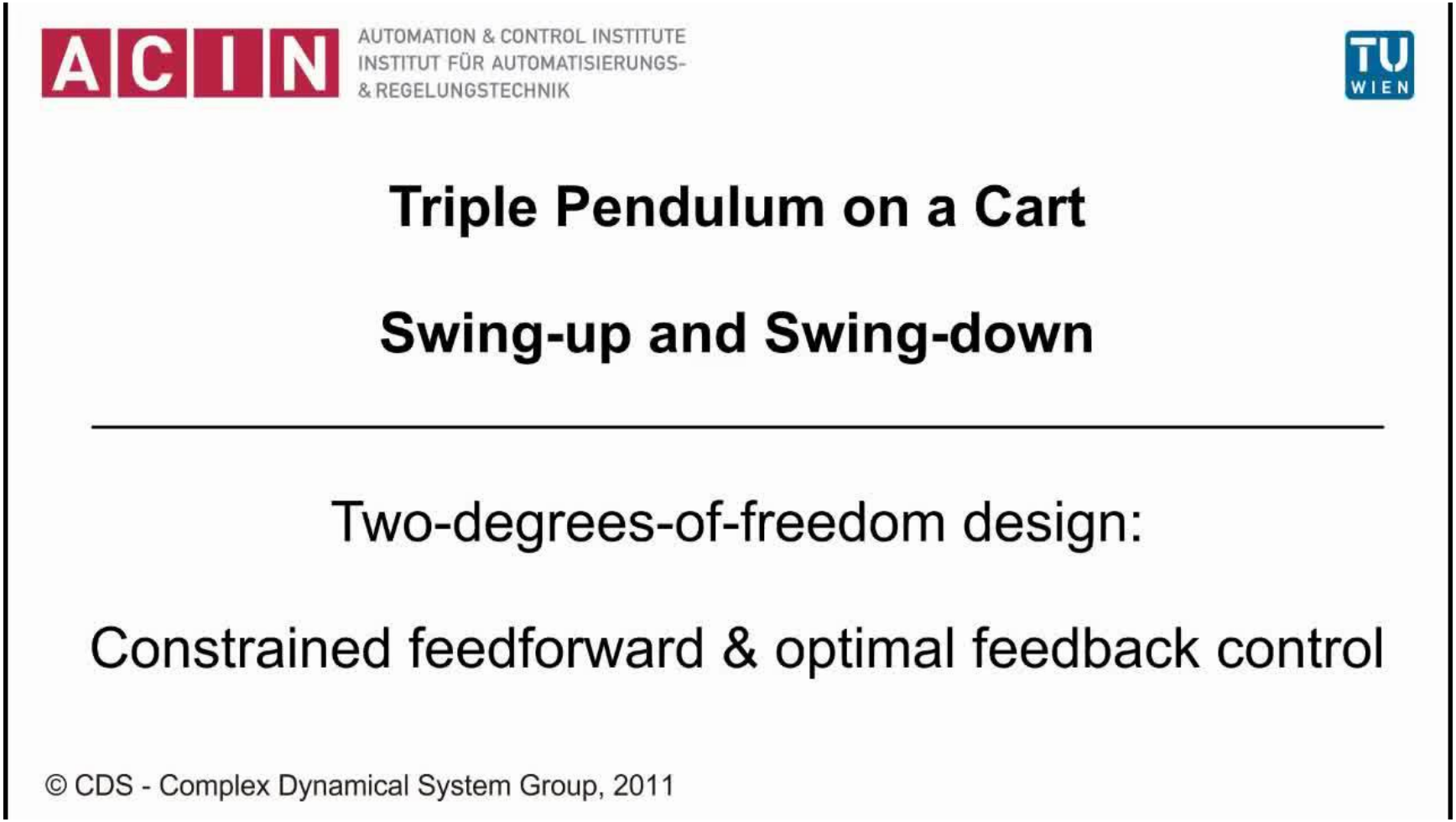
About this Course

- We will focus on Mechatronic Systems, mainly on mechanics and control topics aiming at understanding robot control design principles

- Base Topics
  - Kinematics
  - Differential Kinematics
  - Dynamics
  - Control Theory

The Importance of Mechanics

The Importance of Control



The Importance of Control