Control of industrial robots

Introduction to the course

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General information (1/3)

- Programs offering this course:
  - MSc in Automation and Control Engineering
  - MSc in Computer Science and Engineering
  - MSc in Electronics Engineering
  - MSc in Engineering Physics

- Schedule:
  - Monday 08:15-10:15 (room 3.03, formerly S.0.2)
  - Wednesday 08:15-10:15 (room 2.1.2, formerly N.1.2)

- Course organization:
  - 32 hours of lectures
  - 6 hours of practice sessions
  - 12 hours of computer lab (teaching assistant: Costanza Messeri)
  - 5 credits
General information (2/3)

- **Single or integrated course?**

  This course can be taken in two ways:

  - As a standalone 5 credits course:
    090914 CONTROL OF INDUSTRIAL ROBOTS

  - As a module of an integrated 10 credits course:
    052368 CONTROL OF INDUSTRIAL AND MOBILE ROBOTS

- **What is the difference?**

  - Nothing in terms of contents and teaching activities
  - For the integrated course, a single integrated exam test will be offered
General information (3/3)

- **Prerequisites:**
  - Basics in Automatic Control
  - Basics in Mechanics
  - Essential elements in robot kinematics will be reviewed in the course

- **Aims:**
  - Current and advanced methodologies for the control of robotic manipulators
  - Tools for robot programming
  - Understand how the robot interacts with the environment

- **Course web page:**
  - [http://home.deib.polimi.it/rocco/cir](http://home.deib.polimi.it/rocco/cir)
  - Program, lecture notes, lab material, texts of previous exams...

- **Exams:**
  - Written examination (text in English, solutions preferably in English)
  - Oral integration at the instructor’s discretion
Textbooks

B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo: 
*Robotics: Modelling, Planning and Control, 3rd Ed.*
Springer, 2009 (In English)

https://www.springer.com/it/book/9781846286414

B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo:
*Robotica: modellistica, pianificazione e controllo, 3a Ed.*
McGraw-Hill Italia, 2008 (In Italian)

https://www.mheducation.it/9788838663222-italy-robotica-3ed

G. Magnani, G. Ferretti, P. Rocco:
*Tecnologie dei sistemi di controllo, 2a Ed.*
McGraw-Hill Italia, 2007 (In Italian)

Program (1/3)

- **Industrial robotics:**
  - Robots, applications, trends.

- **Robot kinematics:**
  - Quick review of direct, inverse and differential kinematics.
  - Kinematics of redundant manipulators
  - Inverse differential kinematics.

- **Robot dynamics:**
  - Dynamic models of robot manipulators
  - Euler-Lagrange and Newton-Euler formulations: main properties
  - Identification of dynamic parameters
  - Direct and inverse dynamics
Program (2/3)

- **Motion planning:**
  - Path planning and trajectory planning
  - Joint space trajectories: point to point motion and interpolation of points (splines)
  - Kinematic and dynamic scaling of trajectories
  - Cartesian space trajectories: position and orientation trajectories
  - Path planning with obstacle avoidance
  - Robot programming: examples

- **Control of robot manipulators:**
  - Review of independent joint control methods
  - Advanced schemes for joint control
  - Computed torque feedforward control
  - PD control with gravity compensation
  - Inverse dynamics control
  - Robust and adaptive control
  - Operational space control
Program (3/3)

- Interaction with the environment:
  - Force sensors
  - Impedance and admittance control
  - Hybrid position/force control

- Control with vision sensors:
  - Components of a visual system
  - Image processing
  - Image-based and position-based visual servoing
Contacts

➤ **Office hours:**
  - Tuesday 10:00 – 12:00 at DEIB, Building 20, 2nd floor. Check the official web page before.
  - By e-mail

➤ **E-mail:**
  - paolo.rocco@polimi.it

➤ **Personal web pages:**
  - http://home.deib.polimi.it/rocco
  - Other teaching material, old courses, ...

➤ **MERLIN Lab page:**
  - http://merlin.elet.polimi.it

➤ **Theses:**
  - You are welcome: see my personal web page