UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Robotics and Automation

2122-3-E3101Q114

Aims

This course gives an introduction to robotics and automation systems. For robotics both industrial and service robotics will be considered, for automation both systems theory, i.e., analytical modeling of systems, and the control of linear systems.

Contents

- Robotics
    - Roto-traslations;
    - Industrial manipulators
    - Mobile bases
    - Review of sensors
- Automation
    - Introduction to Dynamical Systems (continuous time)
    - Linear Control Theory (continuous time)
    - Design of a Linear Feedback Control for a DC Motor

Detailed program

- Robotics
    - review of applications of robotics
    - representation of rotations in cartesian coordinates;
    - representation of translations in cartesian coordinates;
    - representation of roto-translations in homogeneous coordinates;
    - introduction to kinematics of industrial manipulators;
    - Denavit - Hartemberg conventions for modeling open kinematic chains;
    - trajectory interpolation by means of trapezoidal speed profiles for manipulators with independent

    joint control;
    - review of kinematics of mobile bases;
    - taxonomies of sensors;
    - range sensors: range sensing based on triangulation (photo-emitter - photo-diode, structured light with simple and pseudo-casual pattern, stereo vision, etc.);
    - range sensors: range sensing based on time of flight (ultrasound, laser range finder, laser scanner with 1 and many scanning planes, scanning: mechanical, mems micro-mirrors, phased arrays, flash lidars, etc.);
    - proximity detection (induction, condenser, Hall effect, photo-cells, etc.);
    - robot programming;
- Automation
    - Introduction to Dynamical Systems (continuous time)
        1. Definitions (movement, trajectory, steady states, stability)
        2. Stability Criteria, Controllability, Observability
        3. Transfer Functions, Laplace Transform
        4. Frequency Response (Bode Diagrams)
        5. Dynamic Resonance Systems
    - Linear Control Theory (continuous time)
        1. Introduction to Control Theory – Control Systems Architectures
        2. Linear Time-invariant Control Systems
        3. Feedback Systems Analisys (stability, static and dynamic performance)
        4. Nyquist Diagram - Robust Stability Analisys
        5. Design of Feedback Control Systems - Pole Assignment Technique
    - Design of a Linear Feedback Control for a DC Motor
        1. DC Motor modeling (Lorentz and Faraday-Henry Laws)
        2. Linear Feedback Control for a DC Motor

Prerequisites

Teaching form

The teaching activities will take place in italian.

The teaching activities will include:

- interactive classes and practice during classes;
- interactive meetings about the programming practicals (matlab).

Textbook and teaching resource

- Textbooks
    - P. Bolzern, R. Scatolini, N. Schiavoni, "Fondamenti di Controlli Automatici", 2 Ed., McGraw-Hill, 2004 (in italian);
    - (supplementary): R. C. Dorf, R. H. Bishop, "Moder control systems", Prentice Hall;
    - textbook on DC motors: G. Ferretti, G. Magnani, "Modellistica e controllo dei servomeccanismi di posizione con motori a magneti permanenti", Pitagora Editrice, Bologna, 2002 (in italian);
    - Siciliano, B., Sciavicco, L., Villani, L., Oriolo, G., "Robotics: Modelling, Planning and Control", Advanced Textbooks in Control and Signal Processing, Springer, 2009;
    - (out of print) K. S. Fu, R. C. Gonzalez, C. S. G. Lee, "Robotics: Control, Sensing, Vision, and Intelligence", McGraw-Hill, 1987;
    - J. J. Craig, "Introduction to Robotics, Mechanics and Control", 3rd ed, Pearson Ed. Int., 2005

    - R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd ed., MIT Press, 2011
- Other material
    - Other material, available of the elearning platform

Semester

Second semester

Assessment method

The final mark is the averege of the mark obtained in Robotics and Automation systems.

- Robotics
    - development of 3 small matlab programs during the semester (on demand it is possible to arrange this part in another period) on the following issues:
        - Roto-translations of a rigid body in the plane;
        - Roto-translations of a rigid body in the space;
        - Conventions of Denavit - Hartemberg;
    - written verification on issues not covered by the small matlab programs:
        - direct and inverse kinematics of manipulators;
        - motion control of a industrial manipulator: technological infrastructure (motor, transmission, power driver, etc.)and trajectory interpolation by means of trapezoidal speed profiles;
        - sensors, mainly range sensing;
    - one question on robot programming;
- Automation systems
    - development of a simulink / matlab program assigned by the teacher; it is required to complete this assignment in one month, otherwise another program will be assigned to the student.

Disregarding the unlikely case of a change, the weights for the different parts are the following:

```
mark = 0.5 * mark_robotics + 0.5 * mark_automation

mark_automation
a mark on the matlab / simulink project,

mark_robotics
weghted average of the diffeent marks, with the following weights:
motion control (final written test) ..................... 0.10
sensing (final written test) ............................ 0.15
robot programming (oral question) ....................... 0.10
lab1 roto-traslations 2D (fist mlab) .................... 0.15
differeces between the 2 way to use patch3D (file pdf) .. 0.05
lab2 rototraslazioni 3D (second mlab) ................... 0.15
lab3 convenzioni DH (third mlab) ........................ 0.15
cinematica diretta ed inversa ((final written test) ..... 0.15
```

Office hours

Send email to arrange an appointment