UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Robotics and Automation

2223-3-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 and discrete time)
- Linear Control Theory (continuous and discrete 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 the elements of 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
- System definition
- Linear, time-invariant systems: time domain approach
- Natural modes of a linear, time-invariant system
- Linear, time-invariant systems: frequency domain approach, Laplace transform, Zeta transform. Bode diagrams
- Equilibrium points and stability
- Stability for linear, time-invariant feedback systems in continuous time: Nyquist theorem
- Single input/single output Feedback control systems: design specifications, rejection of the disturbances, step response, PID, digital control
- Design of a Linear Feedback Control for a DC Motor
- DC Motor modeling (Lorentz and Faraday-Henry Laws)

- Linear Feedback Control for a DC Motor

Prerequisites

Suggested prerequisites

- least squares estimation, linear regression;
- non-linear unconstrained optimization;
- basics of matrix calculus and matrix properties;
- systems of first order linear differential equations (what they are, not resolution methods);

Teaching form

The teaching activities will take place in italian.

The teaching activities will include:

- interactive classes and practice during classes;
- pre-recorded classes, consisting in audio, and tablet screen used as blackboard, of classes of previous years;
- 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);

- A. Ruberti, A. Isidori, "Teoria dei SIstemi", Boringhieri, 1985 (in Italian)

- A. Isidori, "Sistemi di Controllo", Siderea, 1979 (in Italian)

- P. Palumbo, Appunti delle lezioni di Automatica (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;
- Automatic Control
- oral questions (or exercises to be solved in front of the teacher)

Unless the (unlikely) case of the teachers to decide a change, the weights for the different parts are the following:

mark = 0.5 * mark_robotics + 0.5 * mark_automation

mark_automation
a single mark

mark_robotics
weghted average of the diffeent marks, with the following weights:
motion control for a manipulator (question in the final written test) 0.10
direct and inverse kinematics (question in the final written test) 0.15
sensing (exercise in the final written test) 0.15
sensing (questyion in the final written test) 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

Office hours

Send email to arrange an appointment

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY