UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Robotics and Automation

2425-3-E3101Q114

Aims

This course gives an introduction to robotics and automation systems. Concerning robotics, both industrial and mobile robotics will be introduced, concerning automation both systems theory, i.e., analytical modeling of systems, and the control of linear systems, will be introduced.

Contents

Robotics

- Representation of roto-traslations
- Industrial manipulators
- Mobile bases
- Review of sensors

Automation

- Introduction to Dynamic 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;
- control of single joints;
- review of kinematics of mobile bases;
- taxonomies of sensors;
- proprioceptive sensors (rotation, end-of-range, etc);
- range sensing based on triangulation (photo-emitter - photo-diode, structured light with simple and pseudo-casual pattern, stereo vision, etc.);
- 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

- Definition of dynamic system;
- 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:

- erogative classes
- interactive practice on development of software (C language) on small didactic robots;
- pre-recorded classes, consisting in audio and video of a tablet screen used as blackboard, of classes of previous years;
- interactive meetings with programming practicals (in 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 average of the mark obtained in Robotics and the mark obtained in Automation systems.

Robotics mark

- development of matlab programs during the semester (on demand it is possible to arrange this part in another period) on some of the following topics:
- Roto-translations of rigid bodies in the plane;
- Roto-translations of rigid bodies in the space;
- Movimentation of open kinematics chains defined with the conventions of Denavit - Hartemberg / movimentation of a small didactic robot;
- Written verification on topics not covered by the small matlab / C 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.

Automation systems

- oral questions (or exercises to be solved in front of the teacher) about the topics of the course.

Unless the (unlikely) case of minor changes, 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 (question in the final written test) 0.10
lab1 roto-traslations 2D (fisrt mlab) 0.15
differeces between the 2 way to use patch3D (file pdf) .. 0.05
lab2 rototraslation 3D (second mlab) 0.15
lab3 ..... 0.15
convenzioni DH (third mlab) or software for controlling the motion of a Coderbot

Office hours

Send email to arrange an appointment

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY