COMPUTER ENGINEERING (LM55)

(Lecce - Università degli Studi)

Teaching ROBOTICS

GenCod A003152

Owner professor GIOVANNI INDIVERI

Teaching in italian ROBOTICS

Teaching ROBOTICS

SSD code ING-INF/04

Reference course COMPUTER ENGINEERING

Course type Laurea Magistrale

Credits 9.0

Teaching hours Front activity hours: 81.0

For enrolled in 2017/2018

Taught in 2018/2019

Course year 2

Language ENGLISH

Curriculum PERCORSO COMUNE

Location Lecce

Semester First Semester

Exam type Oral

Assessment Final grade

Course timetable https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION

The main objectives of the course are to acquire skills and competencies in the analysis, modeling, navigation, guidance and motion control system design for autonomous robots.

REQUIREMENTS

Although there are no strict course prerequisites in terms of previous positive course proficiency tests, students are expected to have a solid knowledge and understanding of basic control theory (linear and nonlinear), vector algebra and classical mechanics.

COURSE AIMS

Knowledge and understanding

After the course the student should understand the following aspects of Robotics

* basic kinematics and dynamics models of articulated robots and vehicles;
* the role and interplay of the Navigation, Guidance and Control systems for a mobile robot;
* the role and interplay of kinematics versus dynamics model based motion control systems.

Applying knowledge and understanding

After the course the student should be able to

* properly model and simulate basic motion control tasks for articulated robots and vehicles;
* define the specs for Navigation, Guidance and Control systems of simple models of articulated robots and vehicles;
* evaluate the performances of Navigation, Guidance and Control systems of articulated robots and vehicles;
* design basic Navigation, Guidance and Control systems for articulated robots and vehicles.

Making judgements

Students should acquire the ability to compare pros and cons of different approaches to the solution of a specific problem through examples and problems.

Communication

The ability to communicate on technical topics should be acquired by discussing in a rigorous way not only concepts and tools of robot motion control tasks and Navigation, Guidance and Control systems, but also the adopted solution to a specific problem.

Learning skills

Selected problems will be proposed that require elaborating on introduced concepts and methods, also with the help of selected readings suggested by the instructor (from the list of references). Identifying solutions to non trivial problems will be important to be ready for autonomous lifelong learning.

TEACHING METHODOLOGY

Lectures and exercises including numerical simulation sessions.

ASSESSMENT TYPE

The final exam consists of two parts: the first is basically written in nature the deliverable being either a brief report, or a set of slides or a computer simulation program. The topic of this piece of work is selected to complement one of the topics addressed within the course. The candidates are expected to autonomously apply their course related knowledge, understanding, and problem solving abilities to a new, but related, topic within a broader context. The second part of the exam consists in an oral discussion about the program of the course; this part of the exam aims at evaluating the knowledge and understanding of the contents of the programs that were not specifically addressed by the first test. Moreover, with reference to the course program, the second part of the exam aims at assessing the ability of the candidates to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information. The candidates ability to properly communicate their ideas, knowledge and conclusions are evaluated through both the first and second parts of the exam.

OTHER USEFUL INFORMATION

All course material is available at https://drive.google.com/drive/folders/1XRQtCzN276rSFtlD8FsmLihtyzFMU79i?usp=sharing

The previous course web site at:
https://intranet.unisalento.it/
is not being updated since early October 2018. Please refer to the Drive site linked above for the up-to-date course material.

FULL SYLLABUS

Theory

- Modeling of Robotic Systems

An Introduction to Robot Mechanical Structure: industrial robotics and advanced robotics. Preliminaries on Robot Modelling, Planning and Control. Introduction to the main motion control problems: path following, trajectory tracking and pose regulation. Geometric modeling of a robot system. On the pose of a rigid body. Introduction to the modeling of the orientation of a rigid body: on the geometry of rotations and rotation matrices. Rotations, SO(3) and its possible parameterization. SO(3) properties and the angular velocity vector. Homogeneous transformations. The problem of attitude estimation. Direct Kinematics: open and closed frame chains. Denavit - Hartenberg convention.

On the geometry of typical manipulator structures: the three-link planar arm, parallelogram arm, spherical arm, anthropomorphic arm, spherical wrist, Stanford manipulator, anthropomorphic arm with spherical wrist. Joint space and operational space, workspace, kinematic redundancy and introduction to the kinematic singularities. The geometrical inverse problem. Solution of inverse geometrical problem for typical arm models.

- Direct and Inverse Kinematics

The robot Jacobian and its role in the solution of the direct and inverse kinematic problems. Introduction to the kinematic inversion problem for fully actuated, underactuated and redundant robot systems. Geometrical tools to solve the inverse kinematics problem. The SVD and its role in the computation of the jacobian pseudo-inverse. Geometrical interpretation of inverse kinematic solutions. Introduction to the concept of prioritized task control: examples and discussion.

- Controllo architectures for autonomous vehicles and industrial robots

Introduction to the dynamics modeling of robot manipulators and vehicles. Dynamic equations and their main properties. Dynamics of marine vehicles. The control problem: introduction to joint space and operational space approaches to solve the motion control problem. Decentralized control in joint space. Independent joint control and decentralized feedforward compensation. Computed torque feedforward control. Centralized control. PD Control with gravity compensation. Inverse dynamics control. Operational space control: general schemes and basic properties. PD Control with gravity compensation. Inverse dynamics control for manipulators and autonomous vehicles.

- Introduction to Marine and Mobile Robotics

Specific issues related to the modeling and control in marine robots. Introduction to the dynamic modeling of marine vehicles. Major sensing, communication and motion control issues related to the marine environment.

Navigation, guidance and control issues for marine robots. Attitude estimation, localization and navigation issues for marine vehicles.

Exercises

- Kinematics inversion

On the design, coding and testing of pseudo-inverse task based motion control algorithms using SVD and regularized least squares based approaches.

- Path following for a mobile robot

On the design, coding and testing of a path following algorithm for the unicycle model.

REFERENCE TEXT BOOKS	▪ Siciliano, B., Sciavicco, L., Villani, L. and Oriolo, G., Robotics Modelling, Planning and Control, Springer 2009, ISBN 978-1-84628-641-4 ▪ Lecture notes from Giovanni Indiveri ▪ T. I. Fossen, Handbook of Marine Craft Hydrodynamics and Motion Control, Wiley, 2011