COURSE DESCRIPTION CARD - SYLLABUS

Course name

Modeling and control of robots [S1AiR2>MiSR]

Course

Field of study

Automatic Control and Robotics

Year/Semester

2/4

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

Polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

30

Laboratory classes

30

Other

0

Tutorials

15

Projects/seminars

0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

The student starting this subject should have a basic knowledge of the subject Foundations of robotics, mathematical analysis and general mechanics. In particular, he should have knowledge in mathematics necessary to: analyze the properties of dynamic systems and their numerical simulation in the time domain [K1_W1]. She/he should have knowledge of selected branches of physics necessary to understand the basic physical phenomena occurring in elements and systems of automation and robotics and in their surroundings [K1_W2].

Course objective

The aim of the course is: Prodviding students with the basic knowledge necessary to understand the issues of robot control. This includes the transfer of knowledge related to wheeled and handling robots in the scope of modeling their dynamics for control purposes. Developing students' skills in solving problems related to the mathematical description of restrictions imposed on the movement of a mobile robot, manipulation robot control along a given trajectory, taking into account its dynamics model.

Course-related learning outcomes

Knowledge:

Student
1. has ordered and theoretically founded general knowledge in the field of general mechanics: statics, kinematics and dynamics, including the knowledge necessary to understand the principles of modeling and construction of simple mechanical systems [K1_W3];
2. is familiar with the current state and the latest development trends of robotics [K1_W21];
3. knows the basic methods used to solve simple engineering tasks in the field of manipulation robot kinematics [K1_W23].

Skills:
The student can:
1. read and understand the design technical documentation and simple technological diagrams of automation and robotics systems [K1_U2];
2. determine the mathematical models of the manipulator kinematics and also use them to solve basic tasks related to robot programming [K1_U11];
3. has basic operational skills of industrial manipulation robots; can create, test and run a simple motion program for an industrial manipulator; can solve basic tasks related to robot kinematics [K1_U17].

Social competences:
The student is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which devices and their components can function [K1_K5].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The learning outcomes presented above are verified as follows:
Formative assessment:
a) in the scope of lectures:
based on answers to questions about the material discussed in previous lectures,
b) in the field of laboratories:
based on an assessment of the current progress of task implementation,
Summative rating:
a) in the scope of lectures, verification of assumed learning outcomes is carried out by:
i. assessment of knowledge and skills demonstrated during the written lecture exam (may be provided in the form of an e-course test)
ii. assessment of knowledge and skills based on individual discussion of the results of the written exam (additional control questions),
b) in the scope of exercises, verification of assumed learning outcomes is carried out by:
i. assessment of student's preparation for individual auditorium exercises and assessment of skills related to the implementation of laboratory exercises (a given series of laboratory exercises is preceded by a test, i.e. the so-called entrance ticket),
ii. continuous assessment, during each class (oral answers), rewarding the increase in the ability to use known principles and methods,
iii. assessment of knowledge and skills related to the implementation of learning outcomes through two written tests.
Getting extra points for activity during classes, especially for:
i. discuss additional aspects of the issue,
ii. effectiveness of applying the acquired knowledge while solving a given problem,
iii. comments related to the improvement of teaching materials,
iv. indicating students' perceptive difficulties enabling ongoing improvement of the didactic process.

Programme content

The course programme covers the most important issues related to the modelling of the dynamics and control of a robot: direct and inverse dynamics of manipulator; manipulator statics; simple algorithms for positional and force control of a manipulator; constraints on the velocity in the Pfaff form of a wheeled robot in plane motion for basic kinematic structures; derivation of the dynamics model of a wheeled robot; stabilisation task for a mobile robot.

Course topics

The lecture program includes the following topics:
1. The manipulator dynamics model: Simple and inverse task of the manipulator dynamics.
2. Robot manipulator statics.
3. Robot control systems:
independent node control; point-to-point control; continuous control; inverse dynamics control algorithm; robot force interactions with the environment: compliance control, force control with internal position loop, force control with
internal speed loop;. hybrid force and position control; impedance control.
4. Definition of speed limits (non-holonomic restrictions) ofwheeled robot motion on a plane in the form of Pfaff.
i. description of non-holonomic restrictions for a two-wheeled robot with differential drive,
ii. description of non-holonomic restrictions for a kinematic car robot,
iii. simple kinematics for a two-wheeled robot and a kinematic car type robot,
iv. definition of zero space for speed limits.
5. Construction of a dynamics model for a wheeled robot.
i. dynamics model for a two-wheeled robot with differential drive,
ii. dynamics model for a kinematic car robot.
6. Stabilization for a two-wheeled robot with differential drive based on a kinematic model.
7. Analysis of the contact force of the mobile robot with the differential drive with the ground
i. slip modeling for a two-wheeled robot with differential drive.

Tutorial exercises are conducted in the form of 2-hour classes, during which students solve accounting tasks covering the content provided in the lecture. The kinematic structures of robots are considered in detail during the exercises, together with constraints on the speed of the robot. In addition, robot dynamics modelling tasks are solved in the exercises.

Laboratory:
Laboratory exercises conducted in the form of fifteen 2-hour classes during which students become familiar with the programming systems of industrial robots, carry out tasks related to mobile robots and measurements. Each three cycle is preceded by their discussion. In addition, they will be introduced to simulation environments that support the engineer's work. The lab is divided into 2 cycles, each cycle is preceded by a tutorial. The topics of the laboratory exercises are as follows:
1. Basics of operation and programming of the Fanuc LR Mate 200iD/7L robot.
2. Basics of operation and programming of the Staubli TX60L robot.
3. Programming the Staubli TX60L robot - palletizing task.
4. Fundamentals of operation and programming of the KUKA KR6 robot.
5. Programming the KUKA KR6robot - a manipulation task.
6. Kinematics and location of the two-wheeled mobile robot.
7. Mobile robot control system.
8. 3D rotations, homogeneous transformations and kinematics of manipulators.
9. Building a local environment map - scanner with an infrared sensor.
The organization of the laboratory includes:
i. OHS training,
ii. training on the use of KUKA, Staubli and Fanuc robots,
iii. completing all the above exercises by the student (the group performing the exercise consists of two/ three people),
iv. special classes for doing homework are provided for people who, due to absence or unpreparedness,could not do the exercise.

Teaching methods

Teaching methods:
1. Lecture: traditional presentation illustrated with numerous examples solved on the board.
2. Tutorial exercises: solving tasks, case studies.
3. Laboratory exercises: discussion of exercises and joint implementation of laboratory tasks (this is particularly important because manipulation robots are dangerous devices and work with them can only be under the control of the person conducting the classes).

Bibliography

Basic:
1. Wprowadzenie do robotyki. Mechanika i sterowanie, J.J. Craig, WNT Warszawa, 1993
2. Dynamika i sterowanie robotów, M.W. Spong, M. Vidyasagar, WNT, Warszawa 1997
3. Manipulatory i roboty mobilne. Modele, planowanie ruchu, sterowanie, K. Tchoń, A. Mazur, I. Dulęba, R. Hossa, R. Muszyński, Akademicka Oficyna Wydawnicza, Warszawa, 2000
4. Modelowanie I sterowanie robotów, K. Kozłowski, P. Dutkiewicz, W. Wróblewski, Wydawnictwo Naukowe PWN, Warszawa, 2003.
5. Zdanowicz: Podstawy robotyki. Wydawnictwo Politechniki Śląskiej, 2012.
6. Szkodny, T: Podstawy robotyki. Wydawnictwo Politechniki Śląskiej, 2012.
7. Buratowski, T.: Podstawy robotyki. AGH Uczelniane Wydawnictwa Naukowo-Dydaktyczne, Kraków, 2006.

Additional:
1. Modeling and Control of Robot Manipulators, Sciavicco, B. Siciliano, Springer-Verlag, London, 2000
2. McKerrow, Ph. J.: Introduction to Robotics, Addison-Wesley 1991.
3. Jezierski, E.: Dynamika robotów. WNT, Warszawa, 2006
4. Podstawy robotyki. Teoria i elementy manipulatorów, praca zbiorowa pod red. Adama Moreckiego i Józefa Knapczyka, WNT, Warszawa 1993,1999

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	77	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	48	2,00