COURSE DESCRIPTION CARD - SYLLABUS

Course name

Fundamentals of Robotics [S1AiR2>PR]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

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
0

Other
0

Tutorials
30

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

Students starting this course should have a basic knowledge of linear algebra (matrix operations: addition of matrices, matrix multiplication, matrix transpose, matrix inversion, matrix pseudo-inversion), mathematical analysis and general engineering. Must have the ability to solve basic problems from the scope of the required knowledge and the ability to obtain information from the indicated sources. Student should understand the need to extend his/her competences. In addition, in respect to the social skills the student should show attitudes as honesty, responsibility, perseverance, curiosity, creativity, manners, and respect for other people.

Course objective

1. Provide students with knowledge of the basics of robotics and in particular knowledge associated with manipulators to their substantive matters of robot dynamics and the synthesis and analysis of robot control systems. 2. Develop students' ability to solve problems related to the mathematical description of the kinematics of the location and differential kinematics of manipulators.

Course-related learning outcomes

Knowledge:
1. has knowledge of the classification, structure and kinematic structures, mathematical description, principles of operation and programming manipulators; [K1_W15]
2. versed in the current state and recent trends of development of robotics; [K1_W21]
3. knows the basic methods used to solve simple engineering tasks in the field of manipulators kinematics; [K1_W23]

Skills:
1. obtain information from the literature, technical documentation and other sources in English; [K1_U1]
2. determine the mathematical models of the manipulator kinematics, and use it for the purpose of solving the basic tasks related to programming a robot; [K1_U11, K1_U17]
3. formulate specifications and identify simple tasks related to programming manipulator: the identification of the actual cell manipulator kinematic parameters, tool identification and designation of the base of the slot machining; [K1_U23]

Social competences:
1. is aware of the need for a professional approach to technical issues, careful look at the documentation and the environmental conditions in which the devices and their components can operate; [K1_K5]

Methods for verifying learning outcomes and assessment criteria

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,
a) in the exercise:
based on an assessment of the progress of the task,
Total assessment:
a) verification of assumed learning objectives related to lectures:
• assessment of knowledge and skills listed on the written test, which consists of five problem tasks for which you can get 25 points (5 points for the task) and a multiple-choice T consisting of 11 questions for which you can get 22 points - the final evaluation set is based on the weighted by W = T 2 * Z (score 3.0 requires the result of the test W = 36 points). The exam can be replaced by an extended test administered via an e-learning platform,
• assessment of knowledge and skills based on an individual discuss the results of the written exam (additional questions),
b) verification of assumed learning objectives related to exercises is provided by:
• assessment of student preparation for each auditorium exercise and assess the skills associated with laboratory exercises,
• continuous assessment on each course (oral response) - rewarding increase in ability to use new principles and methods,
• assessment of knowledge and skills associated with learning outcomes through two written tests.
Getting bonus points for activities in the classroom, especially for:
• discussing additional aspects of the subject,
• effective use of the knowledge gained during solving particular problem,
• comments related to the improvement of teaching materials,
• pointing perceptual difficulties, enabling ongoing improvement of the teaching process

Programme content

The course syllabus covers basic robotics topics: basic definitions; manipulator structures and their classification; description of the position and orientation of a rigid body in 3D space; direct kinematics of the manipulator (DH and ZDH notations); inverse kinematics; differential kinematics of the manipulator and including geometric and analytical Jacobian; planning of the trajectory of the manipulator in task space and joint space.

Course topics

The lecture cover the following topics:

1. Manipulator mechanical structures and classification:
• degrees of freedom and type of joints,
• types of mechanical chain of manipulators,
• manipulator classification,
• basic definitions and parameters of industrial robots.
2. Description of the position and orientation of the rigid body in 3D space:
• definition of rotation matrix and its properties,
• parameterization the rotation matrix (parameterization using Euler angles: ZYZ, RPY, axis-angle parameterization, quaternion representation),
• composition of rotation matrixes in 3D,
• homogeneous transformations,
• composition of translations and rotations.
3. Direct kinematics of manipulator:
• link description - Denavit-Hartenberg parameters,
• kinematic diagram of manipulators,
• direct kinematics solution algorithm - DH notation,
• direct kinematics solution algorithm - MDH notation,
• kinematics of typical manipulator structures.
4. Inverse kinematics of manipulator:
• definition of the problem, a prerequisite for solving the problem manipulator inverse kinematics,
• strategies for solving inverse kinematics,
• geometric method of solving inverse kinematics,
• algebraic method of solving inverse kinematics
• kinematic decoupling,
• numerical methods of solving inverse kinematics.
5. Differential kinematics of manipulator:
• derivative of a rotation matrix,
• differentiating the position vector in the global reference system and the local coordinate system,
• propagation velocity and acceleration along the kinematic chain in both notations,
• geometric and analytical jacobian of manipulators,
• differential kinematics inversion for redundant and non-redundant manipulators.
6. Planning the trajectory of the manipulator in the task, and the inner space.
Auditorium exercises are conducted as fifteen two-hours classes (15 x 2 hours), where students solve accounting tasks involving contents passed during the lecture. During the course, the kinematic structure of most popular industrial manipulators is examined in detail with the solution of the task of direct and inverse kinematics. Then analyzed the differential kinematics of these structures and in particular geometric and analytical jacobians of manipulators in connection with the determination of kinematic singularities. Singular points have a great importance to the proper planning of the manipulator motion. Moreover, the class solves the task of the manipulator trajectory planning in internal coordinates and the task.

Teaching methods

1. Lectures: presentation illustrated with examples supplied on the board, multimedia presentations
2. Auditorium exercises: problem solving, case studies

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. Podstawy robotyki. Teoria i elementy manipulatorów, praca zbiorowa pod red. Adama Moreckiego i Józefa Knapczyka, WNT, Warszawa 1993,1999.

Additional:
1. Modeling and Control of Robot Manipulators, Sciavicco, B. Siciliano, Springer-Verlag, London, 2000.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	63	2,50