POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Basics of robotics [S1MNT1>PR]

Course

Field of study

Mathematics of Modern Technologies

Year/Semester

3/5

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

0

Projects/seminars

0

Number of credit points

4,00

Coordinators

dr inż. Piotr Dutkiewicz
piotr.dutkiewicz@put.poznan.pl

Lecturers

Prerequisites

Knowledge: A student entering this subject should have a basic knowledge of linear algebra (matrix operations: matrix addition, matrix multiplication, matrix transpose, matrix inverse, matrix pseudoinverse), mathematical analysis, and general mechanics. Skills: He should have the ability to solve basic problems in the field covered by the required knowledge and the ability to obtain information from the indicated sources. He should also understandthe need to expand hiscompetencies. Social competences: In addition, intermsof social competence, the student must present such attitudes as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

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. 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:

• knows and understands to an advanced degree the terminology of mathematics and selected issues from the area of engineering sciences related to the field of study, also in a foreign language [K_W03(P6S_WG)];
• knows and understands to a sufficient degree the issues in the area of engineering sciences, including automation, robotics, electrical engineering and electronics [K_W04(P6S_WG)];
• knows and understands the relationship between mathematics and modern technologies [K_W 05(P 6S_W G)].

Skills:
• is able to construct an algorithm to solve a simple engineering task and implement and test it in a selected programming environment [K_U04(P6S_UW)];
• is able to apply mathematical tools to support and develop modern technologies used in engineering sciences [K_U06(P6S_UW)];
• isabletoselectappropriatesourcesofknowledgeandobtainthenecessaryinformationfromthem,and critically analyze and evaluate solutions to complex and unusual engineering problems [K_U 08(P 6S_U W)];
• is able, in accordance with general requirements and technical documentation, to exploit equipment, tools, etc.; knows how to apply the principles of occupational safety and health [K_U11(P6S_UW)].

Social competences:
• is ready to critically evaluate the level of his/her knowledge in relation to ongoing research in science and natural sciences and engineering sciences [K_K01(P6S_KK)];
• is ready to deepen and expand his knowledge to solve newly developed technical problems [K_K02(P6S_KK)];
• is ready to fulfill his/her social role as a graduate of a tech university, to convey popular science content and to identify and solve basic problems related to the field of study [K_K05(P6S_KR)].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures:
• formative assessment: on the basis of answers to questions on the material discussed in previous lectures;
• summative evaluation: verification of the established learning outcomes is realized by:
- evaluation of knowledge and skills demonstrated on the written test of the lecture, which consists of 5 problem tasks Z for which 25 points can be obtained (5 points per task) and a multiple-choice test T consisting of 11 questions for which 22 points can be obtained - the final grade is determined on the basis of the weighted score W=T+2*Z (a grade of 3.0 requires a score of W=36 points); an extensive test using the PP e-course platform may be an alternative form of credit;
- evaluation of knowledge and skills on the basis of individual discussion of results from the written test (additional control questions)

Laboratory classes:
• formative assessment: on the basis of the evaluation of the current progress of the tasks and the ability to solve the problems posed;
• summative evaluation: verification of the assumed learning outcomes is realized by:
- evaluation of student's preparation for individual laboratory exercises and evaluation of skills related to the implementation of laboratory exercises,
- continuous assessment, during each class (oral answers) bonus for the increase of the student's ability to use known principles and methods.
- obtaining additional points for activity during classes, especially for: discussion of additional aspects of the issue;
effectiveness of the application of the acquired knowledge when solving a given problem; remarks connected with the improvement of teaching materials; indicating the students' perceptual difficulties enabling the 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

Update: 01.06.2024r.
Lectures: Introductory news: robotics, basic concepts, industrial robot, overview of robot applications, manipulator structures. Description of a solid in 3D space: position and orientation of a rigid solid, rotation matrix, elementary rotations, vector representation, vector rotation, rotation folding. Parameterization of rotation matrix: Euler angles, Atan2 function, ZYZ angles, Roll-Pitch-Yaw angles, axis-angle representation, unit quaternions. Homogeneous transformations; names of systems used in robotics. Kinematics of a manipulator: direct kinematics task, open kinematic chain, description of a manipulator link (D-H parameters), Denavit-Hartenberg notation, modified Denavit-Hartenberg notation. Direct kinematics of typical manipulator structures: 3DOF planar manipulator, spherical manipulator, anthropomorphic manipulator, spherical wrist, Stanford manipulator, anthropomorphic manipulator with spherical wrist. Configuration space
vs. task space: workspace, kinematic redundancy, kinematics calibration, tool and base systems calibration. Inverse kinematics of a manipulator: planar 2DOF, spherical wrist manipulator, spherical manipulator, anthropomorphic manipulator, spherical wrist, kinematic decoupling. Differential kinematics and statics: geometric Jacobian, derivative of rotation matrix, link velocity, link acceleration, determination of Jacobian. Jacobians of typical manipulators: planar 3DOF, anthropomorphic, stanford, kinematic singularities,
singularity decomposition, wrist singularities, arm singularities. Redundancy analysis. Inverse differential kinematics task for redundant and non-redundant manipulators. Determination of analytical Jacobian. Orientation error. Algorithms for solving the inverse differential kinematics task and iterative algorithms for solving the inverse kinematics task. Statics: kineto-static duality, velocity and force transformation, manipulability ellipsoid. Robot motion trajectory planning: trajectory design in generalized coordinates, trajectory planning in task space. Elements of robot programming.

Laboratory classes: The student takes classes in groups of 2. The prerequisite for receiving credit is the completion of all exercises. Before starting the exercises, training in the basics of operation and programming of industrial robots located in the laboratory is conducted. Exercises performed by students are divided into two cycles (at the discretion of the instructor). After each cycle, there is a deadline for making up any overdue or failed exercise. The organization of the classes is as follows:
• health, safety and training;
- classes organization of the laboratory and health and safety training;
- training on the operation of KUKA robots;
- staubli robot operation training;
- fanuc robot operation training.
• exercises to be performed
- the basics of operating and programming the Staubli TX60 manipulator;
- programming of the Staubli TX60L robot - palletizing task;
- basics of operation and programming of KUKA KR6 manipulator;
- programming of the KUKA KR6 manipulator - extended manipulation task;
- fundamentals of operation and programming of Fanuc LR Mate 200iD/7L manipulator;
- fundamentals of operation and programming of Fanuc LR Mate 200iD/7L manipulator - extended manipulation task;
- 3D rotations, homogeneous transformations and manipulator kinematics;
- building a local map of the environment - infrared sensor scanner.

Teaching methods

Lectures: traditional presentation illustrated with numerous examples solved on the blackboard;
Laboratory classes: discussion of exercises and joint implementation of laboratory tasks (this is especially important because manipulative robots are dangerous devices and working with them can only be under the control of the instructor).

Bibliography

Basic:

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

Additional:
• Modeling and Control of Robot Manipulators, Sciavicco, B. Siciliano, Springer-Verlag, London, 2000;
• McKerrow, Ph. J.: Introduction to Robotics, Addison-Wesley 1991;
• Jezierski, E.: Dynamika robotów. WNT, Warszawa, 2006;
• 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	100	4,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50