POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Control Theory in Robotics [N2AiR1-RiSA>TSwR]

## Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Autonomous Robots and Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

## Number of hours

Lecture
20

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
20

## Number of credit points

4,00

## Coordinators

dr inż. Krzysztof Walas
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## Lecturers

## Prerequisites

The student starting the course should have basic knowledge of mathematical analysis as well as probability and statistics. In particular, in the use of differential calculus and basic concepts of probability. In addition, knowledge of the basics of computer science and structured and object-oriented programming is useful. In particular, in the field of algorithmic problem description and construction of data structures required for modeling control systems. As for degree specific courses, knowledge of the basics of automation, the basics of robotics and control theory is needed. In particular, in the field of automatic regulation and modeling the dynamics of control objects.

## Course objective

The aim of the course is to extend the knowledge of control theory and its applications in the field of robotics. Students will be introduced to the modeling of discrete-event systems and the methods of continuous systems control theory used in robotics.

## Course-related learning outcomes

Knowledge
1. has detailed knowledge of the modeling and analysis of discrete event systems

2. has knowledge of modeling and analysis of systems using Petri nets
3. has knowledge of the methods of control theory in robotics
4. has a basic knowledge of the use of artificial intelligence methods in control
Skills
1. has the ability to model systems with discrete events
2. has the ability to use Petri nets to model robotic industrial processes
3. has the ability to apply the methods of control theory in robotics, in particular in autonomous systems
4. has the ability to use basic machine learning methods to control autonomous systems
Social competences
1. understands the need and knows the possibilities of continuous learning
2. is ready to work in a team and understands responsibility for jointly performed tasks

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
A) In the scope of lectures, the assumed learning outcomes are verified by conducting an oral exam. The questions are drawn from the database of questions created from the topics introduced during the lecture. Each student receives 2 questions on the basis of which the material acquired is assessed. The questions are assessed jointly and depending on the completeness of the answer given to each of them, a final grade is given.
B) In terms of the project, the group of students prepare two projects, each of the tasks is assessed separately. The first project concerns issues related to modeling systems with discrete events. The second project concerns the application of the methods of continuous control theory in robotics. The evaluation is determined on the basis of the current progress in the project, the introduction of each subsequent functionality designated for a given project results in obtaining a higher grade.

## Programme content

The lecture program covers the following topics:
- Introduction to discrete event systems
- Languages and automata in the description of discrete event systems
- Operations on automatas
- Finite automata
- Analysis of systems with discrete events
- Petri nets - introduction
- Petri nets - analysis
- Application of classical control theory in robotics
- Linear-quadratic regulator
- Predictive control
- Robust control
- Machine learning in control
- Case studies for control methods in robotics

The project program consists of two tasks:
- preparation of software modeling the selected system with discrete events
- preparation of software demonstrating the application of continuous control theory methods in robotics

## Course topics

none

## Teaching methods

A) Lecture: multimedia presentations (slides) illustrated with examples analyzed on the board and program code fragments implementing selected content described during the lecture
B) Project: overview of project tasks and requirements on the progress of the project for each of the grades. The project is executed as a code development task. Weekly project consultations, during which students receive the tutor's support allowing them to continue work on the project and the progress of work is assessed.

## Bibliography

Basic
Christos G. Cassandras, Stéphane Lafortune, Introduction to Discrete Event Systems, Springer, Boston, MA, 2008
Karl J. Åström and Richard M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, 2nd edition, Princeton University Press, 2021
Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson,2010
Additional
Eugene Lavretsky, Kevin A. Wise, Robust and Adaptive Control, With Aerospace Applications, Springer-Verlag London, 2013
Rushikesh Kamalapurkar, Patrick Walters, Joel Rosenfeld, Warren Dixon, Reinforcement Learning for Optimal Feedback Control, A Lyapunov-Based Approach, Springer, Cham, 2018
Marc P. Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 100 | 4,00 |
| Classes requiring direct contact with the teacher | 40 | 1,50 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 60 | 2,50 |