COURSE DESCRIPTION CARD - SYLLABUS

Course name
Multi-agent systems control [S2AiR2-SSiR>PO3-SUW]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

Area of study (specialization)
Control and Robotic Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
30

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Knowledge: The student starting this subject should have basic knowledge of automation, robotics and computer science. Skills: The student should have the ability to program in a high-level language and understand the source code created by another programmer. He/she should also have the ability to obtain information from the indicated sources. He/she should know the methods of modeling mobile robots and issues related to control of such a robot. He/she should have basic knowledge in the field of sensors. He/she should also understand the need to expand their competences / be ready to cooperate within the team. Social competences: In addition, in terms of social competences, the student must have such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity and personal culture.

Course objective

1. Provide students with basic knowledge in the field of multi-agent systems used in automation and robotics. Overview of wired and wireless communication protocols useful from the point of view of multi-agent systems. Obtaining information about the task environment of the mobile robot, and the impact on this environment. Interaction of a multi-agent system with a human. 2. Developing students' skills in problem analysis as well as designing and implementing a multi-agent system. 3. Shaping in students the ability to work in a team at various stages of the project from analysis of assumptions to implementation and testing.

Course-related learning outcomes

Knowledge
1. He/she has specialist knowledge of distributed systems and network techniques. - [K2_W3]
2. He/she has extended knowledge of the modeling of linear and nonlinear systems, - [K2_W5]
3. He/she has ordered, theoretically founded, detailed knowledge in the field of design of the control systems - [K2_W7]
4. He/she has extended knowledge in selected areas of robotics, in particular in the field of multi-robot systems, communication, interaction with the task environment - [K2_W10]
Skills
1. He/she is able to simulate and analyze the operation of complex automation systems - [K2_U9]
2. He/she can use models of systems and processes for the analysis and design of automation and robotics systems - [K2_U10]
3. He/she can integrate and program specialized robotic systems. - [K2_U12]
4. He/she can, when formulating and solving tasks involving the design of automation and robotics systems, see their non-technical aspects, including environmental and economic - [K2_U14]
5. He/she can evaluate the usefulness and the possibility of using new achievements in the field of automation and robotics (techniques and technologies) - [K2_U16]
6. He/she can design and implement a complex device, object or system, taking into account non-technical aspects - [K2_U23]
Social competences
1. He/she is aware of responsibility for their own work and is ready to adapt to the rules of teamwork and responsibility for jointly performed tasks, can set goals and define priorities leading to the implementation of the task - [K2_K3]
2. He/she is aware of the need for a professional approach to technical issues, scrupulous reading of the documentation and environmental conditions in which the devices and their components may function - [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Formative assessment:
a) in the field of lectures:
based on answers to questions about the material discussed in previous lectures,
b) in terms of projects:
based on the assessment of the current progress of the project implementation,
Summative assessment:
a) in the field of lectures, verification of the assumed learning outcomes is carried out by:
i. assessment of the knowledge and skills shown in the written exam, during which the student answers 5 questions selected from 50 previously provided to students and one question requiring problem analysis. The maximum number of points in the exam is 30, in order to obtain a satisfactory grade, the student must obtain at least 15 points
ii. discussion of exam results,
b) in the scope of the project, verification of the assumed learning outcomes is carried out by:
i. assessment of the implementation of project works and skills related to its implementation,
ii. team work skills assessment,
iii. evaluation and ‘defense’ of the implementation of the project by the student (the report describes the work carried out in the field of analysis, design and implementation as well as tests),

Obtaining additional points for activity during classes, especially for:

i. discuss additional aspects of the issue,
ii. the effectiveness of applying the acquired knowledge while solving a given problem,
iii. the ability to cooperate as part of a team practically carrying out detailed tasks,
iv. identifying students' perceptual difficulties enabling ongoing improvement of the teaching process.

Programme content

The lecture program covers the following topics:
Basic definitions: agent, multi-agent techniques, multi-agent systems and their features; cooperative and selfish types of interactions in multi-agent systems; advantages of solutions using multi-agent techniques; links with other fields of science and technology; modularity, scalability, redundancy, specialization, distributed task execution, resource / information sharing; challenges related to the use of multi-agent systems; examples of applications using multi-agent techniques. Issues related to the interaction of a multi-agent system with a human, ergonomics.
A mobile robot as an enbodied agent: wired and wireless communication, network protocols, their advantages and disadvantages from the point of view of applications in multi-agent systems; architectures of communication systems; connection-based and connectionless communication, broadcasting; properties of various communication methods in terms of mobility, energy efficiency, range, required bandwidth.
Control techniques used in multi-robot systems: behavioral methods, virtual structure method, methods of tracking the leader(s), hybrid solutions. Analytical and non-analytical methods. Applications of individual techniques, their advantages and disadvantages. Nonlinearities; nonholonomic limitations of mobile robots. Robot formations? classification according to the working environment and the types of robots used. Formation function and its use in steering. Complex formations using leader tracking techniques (leaders, virtual leader); the issue of propagation and amplification of errors in robot chains.
The interaction of the agent with the environment, properties of the environment from the point of view of the agent perceiving through sensors and interacting through effectors. Features of an intelligent agent, a target-oriented agent and a reactive agent. Implementation of the robot-agent movement: using local artificial potential functions to avoid collisions between robots and with obstacles, local minima and unstable equilibrium points. The use of navigation functions to control complex task spaces.
Design classes are conducted in the form of fifteen 2-hour meetings, held in the laboratory. Projects for the first 20 hours are carried out in teams of 2 students, and then in larger teams that integrate previously developed solutions. As part of the project, students will learn such issues as: the use of communication protocols to exchange data between agents, designing a data frame. Implementation of communication in unicast and multicast modes. Task decomposition into functionalities performed by various agents. Implementation of the designed components of a multi-agent system. Team launch of a multi-agent system (individual agents are implemented by subgroups).

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Teaching methods

1. lecture: multimedia presentation, presentation illustrated with examples given on the blackboard.
2. project activities: team work, workshops, discussion, performing experiments.

Bibliography

Basic
1. Handbook of Robotics, B. Siciliano, O. Khatib,(Eds.) Springer, 2008.
2. An Introduction to MultiAgent Systems, Michael Wooldrige, Hohn Willey & Sons Ltd, 2002.
Additional
1. Biblia TCP/IP tomy 1-3, R. Stevens, Wyd. RM, 1998.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00