COURSE DESCRIPTION CARD - SYLLABUS

Course name
Teleoperation systems [S2AiR2-SSiR>PO3-ST]

Course

Field of study	Year/Semester
Automatic Control and Robotics	2/3
Area of study (specialization)	**Profile of study**
Control and Robotic Systems	general academic
Level of study	**Course offered in**
second-cycle	Polish
Form of study	**Requirements**
full-time	elective

Number of hours

Lecture	Laboratory classes	Other
15	0	0
Tutorials	**Projects/seminars**	
0	30	

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Knowledge: The student starting this course 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, as well as he/she should have the ability to obtain information from the indicated sources. He/she should know methods of modeling mobile robots and issues related to the control of such a robot. He 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. To provide students with basic knowledge in the field of teleoperation systems. Review of communication protocols useful in the teleoperation task execution. User interface solutions, effectors, control methods, delay compensation methods. 2. Developing students' skills in designing and implementing a teleoperation 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 an 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 teleoperation, communication, human-system and system-environment interactions - [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 assess 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 elements can operate - [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 the field of project:
based on the assessment of the current progress in the implementation of tasks
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 demonstrated 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 issues: teleoperation, system structure for the teleoperation task, remote control, telepresence, virtual telepresence, telemanipulation, human-machine interface. Teleoperated robot versus autonomous

robot. Applications in space, military, telemedicine, microsurgery; dangerous and inspection tasks. Structured and unstructured environment, hand-eye coordination, situational awareness, 'Filtering' threats and disruptions, economic issues of using teleoperation systems.
The issue of delays in teleoperation systems, causes of delays, their impact on the operator's perception. Energy in mobile systems. Closed-loop teleoperation, coordinated teleoperation, operator supervision. Wired and wireless communication, network protocols, their advantages and disadvantages in terms of teleoperation applications; connection-based and connectionless communication; properties of various communication methods in terms of mobility, energy efficiency, range, required bandwidth.
Simple and complex user interfaces, the use of the operator's senses, the amount and precision of information provided by the senses, object recognition by touch, hand movement mapping, hand touch mapping. Operator consoles, head tracking, eye tracking, touch, kinesthetic information. Sensors used. Mono and stereovision in teleoperation: solution architecture, network links, protocols, obtained resolutions, visual comfort, telepresence. The use of virtual reality (VR) and augmented reality (AR); strengthening the message, prediction.
Review of control methods. Bilateral control, stability, inertia and damping, tracking, stiffness, drift. Force reflection, position error, shared compiliance control, passive force reflection, predictive methods. Comparison of properties of control methods. Teleoperation with local, autonomous collision avoidance. Design classes are conducted in the form of fifteen 2-hour meetings, held in the laboratory. Projects are carried out in teams of 2 students. As part of the project, students learn such issues as: the use of communication protocols to exchange information between the operator console and the robot, design data frames. Communication implementation. Task decomposition into functionalities implemented by various system components. Implementation of the designed components of the teleoperation system.

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Teaching methods

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.

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