COURSE DESCRIPTION CARD - SYLLABUS

Course name
Cooperative robotics [S2AiR2-SSiR>PO2-RK]

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

The student starting the subject should have a basic knowledge in terms of design and analysis of control systems, control tasks and problems, control systems synthesis, feedback design, should have knowledge in the area of robotics, kinematics and dynamics of robotic systems, modelling of dynamic systems via transmittance and state space, high-level task planning and trajectory generation; should have a basic programmistic skills, at least in a sufficient level to implement tasks concerned in this subject. Moreover, a student should be able to use basic information-communication tools, acquire information from selected sources, and be ready to cooperate in a team.

Course objective

Extension of topics connected with design of manipulator structures and design of control systems, by the aspect of cooperation between robotic systems as well as human-robot interaction; presentation of problems occurring when robotic systems operate in unstructured environment, in close proximity of humans; description of example applications of cooperative robotics, with main focus on medical applications; introduction and presentation of high-level task planning for cooperative robotics.

Course-related learning outcomes

Knowledge
1. has knowledge of the use of advanced measuring systems used in cooperative robotics- [K2_W6]
2. has a structured and in-depth knowledge of adaptive systems – [K2_W9]
3. has expanded knowledge of the use of robotics in human environment (human-machine cooperation, medical applications) - [K2_W10]
4. has the knowledge necessary to understand the social aspects of engineering activities and the possibilities of their application in medicine - [K2_W14]
Skills
1. is able to simulate and analyze the operation of complex robotic systems and to plan and carry out experimental verification; - [K2_U9]
2. is able to identify non-technical aspects when formulating and solving tasks involving the design of cooperative robotic systems - [K2_U14]
3. is able to assess the usefulness and possibility of using new achievements (technologies) in the field of cooperative robotics - [K2_U16]
4. is able to design and implement a complex control system for manipulator taking into account non-technical aspects - [K2_U23]
Social competences
1. is aware of the importance and understands the non-technical aspects and effects of engineering activities, including its impact on human beings and the related responsibility for decisions taken - [K2_K2]
2. is aware of the responsibility for own work and readiness to comply with the principles of teamwork and taking responsibility for jointly implemented tasks - [K2_K3]
3. is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the devices and their components can function - [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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1. For lectures: verification of the assumed learning outcomes is carried out through evaluation of students' knowledge during the final written exam. The exam consists of 10 open-ended questions. To pass the exam more than half of the maximum number points is required. Together with the project grade, the result of the test determines the final grade for the subject. It is a weighted average where the test grade is weighted with the coefficient of 0.6 and the project grade with the coefficient of 0.4.
2. For project classes: the assumed learning outcomes are verified by evaluating the progress of the project on an ongoing basis, as well as by a final evaluation of what has been done for the project, obtained on the basis of a written report and the assessment of answers to substantive questions related to the performed task.

Programme content

The course syllabus covers topics related to cooperative robotics. It addresses issues of safety in designing robotic systems that interact with each other, with the environment, or with humans, in the context of construction, control, and motion planning. Examples of cooperative robot implementations are presented, such as a manipulator robot working with a mobile robot, rehabilitation manipulators, and manipulators assisting in surgical operations.

Course topics

The course program covers the following topics:
1. Preliminaries. Definition and characteristics of collaborative robotics. Classification of cooperative structures. Examples of application of robot cooperation. Challenges and future directions.
2. Safety in construction. Standards and requirements for safe cooperative robotics applications. Risk assessment and its reduction. Manipulators with flexibility (soft robotics).
3. Safety in control. Impedance control, force feedback. Control of flexible manipulators. Reaction control.
4. Planning of cooperation tasks. Cooperation of stationary agents, on the example of two manipulators. Cooperation of a stationary agent with a mobile robot, for example the KUKA youBot mobile manipulator.
5. Cooperative robots in rehabilitation and medicine. Standard robotics tasks in medicine. Examples of applications of medical robots. Precision robots, redundant structures.

6. Human - robot interaction. Characteristics of HMI versus HRI. Basic tasks and techniques of cooperation of agents in an unstructured human environment.
7. Techniques of machine perception. Generating high-level robotic tasks based on video, audio and EMG data.

Teaching methods

Teaching methods:
1. lecture: multimedia presentation, illustrated with films presenting existing solutions.
2. project classes: solving research tasks, presentation of research results, discussion, teamwork in 2-3 person groups.

Bibliography

Basic
1. Caccavale F., Uchiyama M. (2008) Cooperative Manipulators. In: Siciliano B., Khatib O. (eds) Springer Handbook of Robotics. Springer, Berlin, Heidelberg.
2. Villani L., De Schutter J. (2008) Force Control. In: Siciliano B., Khatib O. (eds) Springer Handbook of Robotics. Springer, Berlin, Heidelberg.
3. LaValle S.M. (2008) Planning Algorithms, Cambridge University Press.
Additional
4. Koubâa A., Khelil A. (2014) Cooperative Robots and Sensor Networks, Springer-Verlag.
5. Murray R.M., Li Z., Sastry S.S. (1994) A mathematical introduction to robotic manipulation, CRC Press.
6. Troccaz J. (2012) Medical Robotics, John Wiley & Sons, Ltd.
7. Ge S.S., Lewis F.L. (2006) Mobile Robots, Sensing, Control, Decision Making and Applications, CRC Press.

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