POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Artificial intelligence methods in robotics

Course

Field of study	Year/semester
Computing	1/2
Area of study (specialization)	Profile of study
Artificial Intelligence	general academic
Level of study	Course offered in
Second-cycle studies	Polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	30	
Tutorials	Projects/seminars	

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
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Responsible for the course/lecturer:
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Prerequisites

A student starting this course should have an extensive knowledge of programming, computer systems architectures and artificial intelligence, as well as knowledge of the basics of automation and robotics. He should also have the ability to obtain information from indicated sources and work in a team.

Course objective

The aim of the course is to familiarize students with the basic concepts, computational models and techniques used in modern robotics, which is understood as an interdisciplinary area of science and engineering focusing on physical agents with intelligent features.

1. To provide students with basic knowledge in the field of robotics: structure and kinematics of manipulators and mobile robots, the use of sensors, control and decision-making algorithms, state estimation for agents/robots and environment modeling.

2. To develop students' ability to use artificial intelligence methods in solving problems related to physical agents and their interaction with the environment in real time.

3. To shape the teamwork skills of the students and their ability to solve interdisciplinary engineering tasks typical to robotics.

Course-related learning outcomes

Knowledge

Has a structured and theoretically founded general knowledge related to key issues in the field of computer science, including real-time systems and the integration of software and hardware systems [K2st_W2]

Has advanced detailed knowledge regarding selected IT issues and artificial intelligence methods used in robotics [K2st_W3]

Has knowledge about development trends and the most important cutting edge achievements in computer science, particularly in the area of real-time sensory data processing and methods/algorithms used in robotics as a related discipline [K2st_W4]

Has advanced and detailed knowledge of the processes occurring in the life cycle of hardware or software information systems, including complex software/hardware systems, such as robots [K2st_W5]

Skills

Is able to plan and carry out experiments, including measurements and computer simulations, interpret the obtained results and draw conclusions and formulate and verify hypotheses related to the processing of sensory data, estimation of the state of physical agents and planning in the physical world [K2st_U3]

Can use analytical, simulation and experimental methods typical to robotics and selected artificial intelligence methods used in robotics to formulate and solve engineering problems and simple research problems [K2st_U4]

Can - when formulating and solving engineering tasks - integrate knowledge from different areas of computer science, artificial intelligence and robotics, and apply a systemic approach, also taking into account non-technical aspects [K2st_U5]

Is able to assess the suitability and the possibility of using new achievements (methods and tools) and new IT products in the field of robotics [K2st_U6]

Can carry out a critical analysis of existing technical solutions in the field of robotics and the application of artificial intelligence methods, and propose their improvements (streamlines) [K2st_U8]

Is able - using among others conceptually new methods - to solve complex IT tasks, including atypical tasks related to robotics and physical agents, also when such tasks include a research component [K2st_U10]

Is able - in accordance with a given specification, taking into account non-technical aspects - to design a complex device, IT system or agent/robot subsystem and implement this project - at least in part - using appropriate methods, techniques and tools, including adapting to this purpose existing tools used in the field of robotics or developing new ones [K2st_U11]

Social competencies

Understands that in the field of IT and robotics the knowledge and skills quickly become obsolete [K2st_K1]

Understands the importance of using the latest knowledge in the field of computer science, artificial intelligence and robotics in solving research and practical problems [K2st_K2]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures: knowledge is verified by a written test. The pass mark is 51% of the points, and it is not allowed to use any auxiliary materials during the test.

Laboratories: knowledge and skills are verified on the basis of the assessment of the current progress in the implementation of tasks; checking the assumed learning outcomes is carried out by evaluating written reports on individual laboratory topics.

Programme content

Lecture

1. Introduction - concepts, definitions, history of robots and robotics, modern applications.

2. Structure and principles of operation of manipulators, basics of kinematics.

3. Structure, principles of operation, sensors and mobility configurations of mobile robots.

4. Structure and principles of operation of walking and anthropomorphic robots.

5. IT architectures of robot control systems, introduction to ROS.

6. Basic concepts of autonomous navigation - building an environment model, probabilistic methods.

7. Basic concepts of autonomous navigation - localization, simultaneous localization and mapping (SLAM), Kalman filter.

8. Advanced navigation - the use of graph-based representations and optimization, visual SLAM.

9. Advanced navigation - recognition of places, topological location, the use of machine learning.

10. Planning of robot motion and actions - classical planning methods (STRIPS in robotics, heuristic search in path planning, state space representation).

11. Advanced methods of motion planning - probabilistic algorithms, machine learning in motion planning.

12. Application of Markov models in robot navigation and planning.

13. Processing of sensory data using classification, segmentation and detection with artificial intelligence methods.

14, 15. Autonomous car as an example of the application of artificial intelligence methods in robotics.

Laboratory (exercises in modules covering 1 or 2 consecutive classes).

1. Simple algorithms for steering wheeled robots in the ROS system (use of sensors, reflex agent)

2. Building a model of the environment - example (grid map, application of Bayesian models).

3. Planning with state space search - applications of the A * algorithm, probabilistic algorithms (RRT, PRM), planning agent.

4. Kalman filter, the use of motion model, simple localization of a mobile robot.

5. The use of selected SLAM algorithms in the ROS system.

6. The use of optimization methods for factor graphs in navigation, visual SLAM and closing loops with the recognition of places (bag of words, neural networks).

7. Recognition of 2D and 3D objects in autonomous navigation and manipulation, the use of 3D models (grasping objects).

8. Deep learning in robotics - end-to-end learning methods for robot control (autonomous car).

Teaching methods

1. Lecture: multimedia presentation illustrated with examples.

2. Laboratory exercises: carrying out the tasks given by the teacher - practical exercises, team work, the use of real robots and sensors and simulation environments.

Bibliography

Basic

1. S. Thrun, D. Fox, W. Burgard, Probabilistic Robotics, MIT Press, Cambridge, 2005

2. I. Nourbakhsh, R. Siegwart, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, Cambridge, 2011

3. P. Corke, Robotics, Vision and Control, Springer International Publishing, 2017.

4. R. Murphy, Introduction to AI Robotics, 2nd Edition, MIT Press, Cambridge, 2019

5. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 3rd ed., Pearson, 2010.

Additional

1. P. Skrzypczyński, Metody analizy i redukcji niepewności percepcji w systemie nawigacji robota mobilnego, Wyd. PP, Poznań, 2007 (in Polish).

2. A. Borkowski, R. Chojecki, M. Gnatowski, W. Mokrzycki, B. Siemiątkowska, J. Szklarski, Reprezentacja otoczenia robota mobilnego, EXIT, Warszawa, 2011 (in Polish).

3. Technical documentation of systems, devices and software used during classes.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5
Classes requiring direct contact with the teacher	60	3
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exams, project preparation)[1]	65	2

[1]niepotrzebne skreślić lub dopisać inne czynności