COURSE DESCRIPTION CARD - SYLLABUS

Course name
Machine perception [S1DSwB1>PM]

Course

Field of study
Data Science in Business

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
30

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Basic knowledge of mathematics and physics. Knowledge of machines and production processes.

Course objective

The aim of the course is to familiarize students with the basics and selected advanced topics of machine perception, with particular emphasis on its applications in robotics, autonomous vehicles, drones, and industrial automation. Students will gain knowledge about methods for processing sensory data, including algorithms for localization, mapping, semantic segmentation, and object detection and tracking. The course will also cover data integration techniques from various sensors, such as LiDARs, depth cameras, inertial sensors, and their use in machine learning and artificial intelligence. Students will acquire practical skills in implementing machine perception systems and teamwork on projects related to the processing and analysis of sensory data.

Course-related learning outcomes

Knowledge:
Characterizes key technologies and algorithms used in machine perception, including LiDAR sensors, depth cameras, inertial sensors, and sensory data processing [DSB1_W02].

Describes localization and mapping methods (SLAM), state estimation, and object detection and tracking in autonomous systems [DSB1_W03].
Analyzes data fusion processes from various sensors, machine learning techniques in machine perception, and their applications in robotics and autonomous vehicles [DSB1_W05].
Explains ethical aspects and challenges related to the safety of autonomous systems and the responsibility of AI algorithms in machine perception [DSB1_W06].

Skills:
Applies sensory data analysis methods, including Bayesian, Kalman, and particle filter algorithms, for state estimation of objects [DSB1_U02].
Designs and implements machine perception systems, using neural networks for object classification and detection [DSB1_U04].
Analyzes and optimizes object motion trajectories in 3D space, using exploration algorithms and motion planning methods [DSB1_U07].
Uses multi-sensor systems for data integration, analyzing their impact on the accuracy and reliability of machine perception [DSB1_U09].

Social competences:
Applies acquired knowledge and skills in practical team projects, analyzing the application of machine perception in real-world autonomous systems [DSB1_K02].
Considers ethical and social aspects when designing and implementing machine perception systems, keeping in mind the safety and responsibility of AI algorithms [DSB1_K05].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:
a) In the case of exercises: continuous checking of knowledge and skills during exercises
b) In the case of lectures: based on discussions regarding the material covered in previous lectures
Summative assessment:
a) In the case of exercises: based on the average results of partial formative assessment grades
b) In the case of lectures: knowledge test

Programme content

The program includes an introduction to machine perception as a key area of application for artificial intelligence and machine learning, as well as an analysis of its role in modern autonomous systems, robotics, and industry. Basic concepts and technologies used in machine perception are discussed, including range and depth sensors, vision cameras, inertial sensors, and sensory data processing techniques. The course also covers topics related to state estimation, localization and mapping, semantic segmentation, as well as object detection and tracking in 3D space. Students will learn methods for data fusion from different sensors, scene analysis in the context of system autonomy, and techniques for modeling and implementing machine perception systems.

Course topics

Introduction to machine perception - definition, role in artificial intelligence and machine learning, applications in robotics, autonomous vehicles, and industrial automation.
Sensors and machine perception technologies - classification and characteristics of sensors: LiDAR, depth cameras, inertial sensors, vision sensors, sensory data processing.
Localization and mapping (SLAM) - principles of simultaneous localization and mapping algorithms, position estimation methods, visual and inertial odometry.
Sensory data processing - state estimation theory, Bayesian, Kalman, and particle filters, methods for analyzing sensory data streams.
Segmentation and scene analysis - object detection methods, semantic segmentation, 2D image and 3D point cloud analysis, deep learning for machine perception.
Computer vision and vision geometry - camera modeling, calibration, stereo vision, epipolar disparity, depth image processing.
Multisensory systems - integration of data from different sources, sensor data fusion, factor graph as a tool for multisensory data processing.

Machine learning in machine perception - application of neural networks in sensory data analysis, convolutional and recurrent models (LSTM), object classification and detection.
Optimization and pathfinding algorithms - methods for determining robot trajectories, exploration algorithms, motion planning.
Perception in autonomous systems - use of machine perception in robot navigation, autonomous vehicles, and drones.
Design and implementation of machine perception systems - practical applications, team project execution, testing, and result analysis.
Ethical aspects and challenges of machine perception - technological limitations, responsibility of AI algorithms, safety of autonomous systems.

Teaching methods

Lectures with multimedia presentations; task-based exercises related to the topics covered in the lectures.

Bibliography

Basic:
Szeliski R., Computer Vision: Algorithms and Applications, 2nd edition, Springer, 2022.
Barfoot T.D., State Estimation for Robotics, Cambridge University Press, 2017.
Thrun S., Burgard W., Fox D., Probabilistic Robotics, MIT Press, 2005.
Bishop C. M., Pattern Recognition and Machine Learning, Springer, 2006.
Forsyth D. A., Ponce J., Computer Vision: A Modern Approach, 2nd edition, Pearson, 2011.
Hartley R., Zisserman A., Multiple View Geometry in Computer Vision, 2nd edition, Cambridge University Press, 2004.
Ranjan S., Senthamilarasu S., Applied Deep Learning and Computer Vision for Self-Driving Cars, Packt, 2020.

Additional:
Cyganek B., An Introduction to 3D Computer Vision Techniques and Algorithms, Wiley, 2009.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	47	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	53	2,00