COURSE DESCRIPTION CARD - SYLLABUS

Course name
SELECTED PROBLEMS IN SIMULTANEOUS LOCALIZATION AND MAPPING

Course

Proposed by Discipline
automation, electronics, electrical engineering, and space technologies
Type of studies
Doctoral School
Form of study
full-time

Year/Semester
II/3, III/5
Course offered in
English
Requirements
elective

Number of hours

Lecture
4

Tutorials

Projects/seminars

Number of credit points

1

Lecturers

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

Prerequisites

Knowledge: PhD student starting this course should have extended knowledge of programming practice, architectures of computer systems and operating systems, robotics and artificial intelligence.

Skills: PhD student should have the ability to obtain information from indicated sources.

Social competences: the student should be aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which devices and their components can function.

Course objective

The aim of this course is to explore the operation and application of autonomous vehicles and mobile robots, focusing on navigation systems, sensor integration, and algorithm development for self-localization and mapping.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:
1) key developmental trends of science disciplines in which education takes place at the doctoral school, [P8S_WG/SzD_W02]
2) scientific research methodology in disciplines represented at the doctoral school, [P8S_WG/SzD_W03]
3) fundamental dilemmas of the contemporary civilization, [P8S_WK/SzD_W05]

Skills

A PhD student who graduated from doctoral school can:
1) use the knowledge from different branches of science to creatively identify, formulate and to innovatively solve complex problems or to execute research tasks, [P8S_UW/SzD_U01]
2) critically analyze and asses scientific research results, work of experts and other creative activities together with their contribution into knowledge development, [P8S_UW/SzD_U02]
3) communicate on specialist issues on the level that allows active participation in the international scientific community, [P8S_UK/SzD_U04]

Social competences

A PhD student who graduated from doctoral school is ready to:
1) critically assess the achievements within a given scientific discipline,[P8S_KK/SzD_K01]
2) critically evaluate their own contribution to the development of a given scientific discipline, [P8S_KK/SzD_K02]
3) acknowledge the importance of knowledge in solving cognitive and practical problems, [P8S_KK/SzD_K03]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W02, W03, W05,	written report or essay on a topic related to the aims of the course	sufficient quality of the written report or essay, delivering the work on time
U01, U02, U04	written report or essay on a topic related to the aims of the course	sufficient quality of the written report or essay, delivering the work on time
K01, K02, K03	written report or essay on a topic related to the aims of the course	sufficient quality of the written report or essay, delivering the work on time

Programme content

The program covers the architecture of mobile robot navigation systems, addressing key aspects of autonomous navigation such as map building, localization, and SLAM. It explores various applications of mobile robots and delves into SLAM (Simultaneous Localization and Mapping) methods. The program also includes the implementation issues of self-localization algorithms, and integrating deep learning tools to enhance navigation capabilities.

Course topics

Lecture 1: Foundations of Localization and Mapping for Mobile Robots
Topics:

- Introduction to Localization and Mapping: definitions and importance in robotics
- Key Concepts in Localization: absolute vs. relative localization, sensor fusion and integration
- Mapping Techniques: grid maps, feature-based maps, and topological maps
- SLAM algorithms: Overview and basic principles
- Types of SLAM: Visual, Lidar-based, and others
- Challenges in Localization and Mapping: environmental factors and sensor limitations

Lecture 2: Advancing Localization and SLAM with Deep Learning
Topics:

- Introduction to Deep Learning in Robotics
- Deep Learning for Localization: using CNNs for feature extraction and scene understanding
- Integrating Deep Learning with SLAM: Deep SLAM: Concept and architecture, applications of deep learning in map building
- Real-world applications and case studies: examples of deep learning-enhanced SLAM in autonomous vehicles and drones
- Future directions and research trends: emerging technologies and their potential impact on localization and SLAM

Teaching methods

Lecture: multimedia presentation, illustrated with examples and movie clips, own work of the student with recommended literature.

Bibliography

Basic

1. S. Thrun, W. Burgard, D. Fox, Probabilistic robotics, MIT Press , Cambridge, 2005
2. I. Nourbakhsh, R. Siegwart, D. Scaramuzza, Introduction to Autonomous Mobile Robots, The MIT Press, 2011
3. C. Stachniss, Robotic Mapping and Exploration, Springer, 2009

Additional

1. J. Będkowski, Large-Scale Simultaneous Localization and Mapping, Springer, 2023
2. R. Murphy, Introduction to AI Robotics, 2nd Edition, The MIT Press, 2019
3. J. Borenstein, H. R. Everett, L. Feng, Where am I? Sensors and methods for mobile robot positioning,

University of Michigan, 1996

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,0
Classes requiring direct contact with the teacher	4	0,0
Doctoral student's own work (literature studies, preparation for tutorials, project preparation) [1]	21	1,0

[1] delete or add other activities as appropriate