SYLLABUS

Name: ***Autonomous systems (EiTAu>SM1-23-AS-grB)***
Name in Polish:
Name in English: ***Autonomous Systems***

Information on course:

Course offered by department: Faculty of Automatic Control, Electronics and Computer Science
Course for department: Silesian University of Technology

Default type of course examination report:
ZAL
Language:
English
Course homepage:
https://platforma.polsl.pl/rau3/course/view.php?id=80231
Short description:
The main goal of the course is to provide students with a comprehensive understanding of autonomous systems based on unmanned guided vehicles (AGVs). The course introduces fundamental concepts related to the design, operation, and control of AGVs, emphasizing their applications in modern industry and logistics. Students will learn to utilize various tools and software for simulation purposes, enabling them to model and analyze the behavior of autonomous vehicles in different environments.
Description:

Additionally, the course describes Advanced Driver Assistance Systems (ADAS), highlighting their key components and functions designed to improve safety, comfort, and efficiency. Topics include adaptive cruise control, lane keeping systems, collision avoidance, parking assistance, and other safety features. Students will gain an understanding of how these systems work, their integration into vehicle control architectures, and the role of perception, decision-making, and control algorithms in autonomous and semi-autonomous vehicles. The course aims to lay a solid foundation for further study or work in autonomous vehicle development and intelligent transportation systems.

LECTURES:
- Introduction to Autonomous Systems. Basic concepts, level of autonomy, surroundings perception for AGV and vehicles, decsription of ADAS (Adaptive Driver Assistance Systems). Motion Kinematics, Fundamentals of AGV Control, and Data Fusion for Localization, covering the mathematical description of vehicle movement and positioning. It explores the fundamental concepts of control systems used to direct AGV behavior, including open-loop and closed-loop control strategies. A key focus is on data fusion techniques for accurate localization, combining information from multiple sensors such as GPS, IMUs, LIDAR, and cameras to improve positioning accuracy and robustness in various environments. The course also presents an example of fuzzy control, demonstrating how fuzzy logic can be used to develop intelligent control systems that handle uncertainty and nonlinearities, enhancing the stability and performance of AGV navigation and control tasks.
- Automated parking systems are gaining increasing relevance as traditional parking solutions face challenges in meeting safety and efficiency standards in urban areas. The lecture covers various aspects, including the history, types, and underlying technologies of these systems. It also discusses problems and potential solutions associated with puzzle-based parking. Additionally, simulation software is highlighted as a powerful tool for accurately modeling and mapping real-world phenomena using mathematical formulas. Topics include the definition and applications of simulation, high-level architecture used in distributed simulation systems, and the MATLAB environment, emphasizing its role in system design and analysis.

- Vision Systems and Machine Learning for ADAS
This lecture introduced the fundamentals of computer vision and machine learning within the context of Advanced Driver Assistance Systems (ADAS). Key topics covered included sensor architectures, processing of visual data, object detection techniques, semantic segmentation, depth estimation, and the implementation of real-time systems. The session also examined current trends in the field, discussed ethical challenges associated with autonomous driving technologies, and explored the pathway toward achieving full driving autonomy.
- Radar and LIDAR Systems in Automotive
This lecture focused on radar and LIDAR technologies used in modern ADAS and autonomous vehicles. It covered different sensor types, their operating principles, environmental robustness, and their respective strengths and limitations. A major emphasis was placed on sensor fusion, illustrating how integrating radar, LIDAR, and vision data enables reliable and precise perception in real-world driving conditions. The session concluded with a live demonstration showing the processing and filtering of a point cloud obtained from a LIDAR sensor.
- Am overview of communication technologies in autonomous systems, with a focus on Vehicle-to-Everything (V2X) communication. The lectures covered key types such as V2V (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure), V2P (Vehicle-to-Pedestrian), and V2N (Vehicle-to-Network), highlighting their critical roles in traffic coordination, safety, and interaction with infrastructure. The session compared DSRC and C-V2X technologies, outlined practical use cases, and presented real-world examples. Additionally, it included development forecasts up to 2030 and addressed major challenges such as standardization, cybersecurity, and system interoperability across different platforms.

PROJECTS:
students work in teams on hands-on projects exploring advanced challenges in the design and optimization of autonomous systems. Project topics focus on real-world issues related with positioning such as system self-calibration, machine learning–based error correction, signal transmission optimization, and sensor placement strategies. Additional areas include the impact of communication protocols on positioning reliability and system responsiveness. The goal is to simulate the complexity of modern positioning and localization systems by analyzing their performance under varying hardware configurations and environmental conditions.
Project Format and Evaluation
Team-based project (4–6 students)
Project duration: throughout the semester
Topics are assigned or proposed by students (upon approval)

The number of hours of classes with direct participation of academic teachers or other persons teaching courses and students. Contact

hours:
Number of ECTS credits: 2
Total workload: 60 (30 contact hours / 30 student’s own work hours)
Lecture: 15h
Project: 15h

Student's own work:
Project preparation: 5h
Experiments (including simulations): 20h
Project dissemination: 5h

Bibliography:

Yalcin, A. Koberstein, and K.-O. Schocke, ‘An optimal and a heuristic algorithm for the single-item retrieval problem in puzzle-based storage systems with multiple escorts’, International Journal of Production Research, vol. 57, no. 1, pp. 143–165, Jan. 2019, doi: 10.1080/00207543.2018.1461952.

H. Yu, Y. Yu, and R. de Koster, ‘Dense and fast: Achieving shortest unimpeded retrieval with a minimum number of empty cells in puzzle-based storage systems’, IISE Transactions, vol. 55, no. 2, pp. 156–171, Feb. 2023, doi: 10.1080/24725854.2021.2010151.
- https://www.etsi.org/deliver/etsi_ts/122100_122199/122185/14.03.00_60/ts_122185v140300p.pdf
- https://blog.rgbsi.com/7-types-of-vehicle-connectivity
- autocrypt.ioettifos.com

Learning outcomes:

Knowledge
The student knows and understands:
issues related to obtaining data from the environment of an autonomous vehicle and the use of artificial intelligence methods in the process of data analysis and decision-making (K2A_W08)

Skills
The student is able to:
- conduct simulation experiments using advanced computer tools and present the results along with a discussion (K2A_U02)
- use knowledge from artificial intelligence to solve practical problems (K2A_U07)

Social
The students is ready to:
- critical evaluation of solutions, the need to recognize the importance of knowledge in solving practical problems and seeking expert opinions (K2A_K03).

Assessment methods and assessment criteria:

According to SUT regulations, lecture attendance is optional (although highly recommended).
The condition for passing the course is to create, describe and present a project.
A project contains the following elements:
- Project brief / specification document. Describing a student goal(s) and work distribution among students.
- Mid-term presentation
- Final presentation.
- Report (min. 1500 words per student)
- Demo, code and reproducibility of results

A report specific requirements:
- write an introduction/preliminary literature overview containing min. 1-2 scientific papers, (min. 300 words and figures)
- describe the research task, (no limit, the report must contain all your research tasks, min. 900 words)
- draw some conclusions (max. 300 words).

The final grade is calculated based on presentation, report and project difficulties, rounded according to the university grading scale.

The syllabus is valid from the 2024/25 academic year, and its content cannot be changed during the semester.

Course credits in various terms:

<without a specific program>

Type of credits	Number	First term	Last term
European Credit Transfer System (ECTS)	2	2023/2024-L	