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

PO8: Controlling of autonomous vehicles - Automated guiding systems of vehicles

Course

Field of study

Electromobility

Area of study (specialization)

Level of study

First-cycle studies

Form of study

full-time

Year/Semester

3/6

Profile of study

general academic

Course offered in

Polish

Requirements

elective

Number of hours

Lecture

30

Tutorials

Laboratory classes

15

Projects/seminars

Other (e.g. online)

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

A student starting the course should have a basic knowledge on kinematics and dynamics, control of electric servodrives, fundamental knowledge on control and systems theory. Moreover, the student should be able to to implement programs in the Matlab language, and should have skills in implementing and simulating block schemes in the Simulink environment, should be able to interpret and present the simulation and experimental result by using selected information-communication techniques, and should be able to acquire information from selected sources. The student should also be ready to cooperate with others in a team.

Course objective

Objectives of the course are the following: presentation of selected topics on automated guiding systems for electric wheeled vehicles, including mobile robots, and on intelligent driver assistance systems; drawing a state of the art in the field of modelling and motion control of automated commercial and special ground vehicles (including articulated vehicles); analysis of practical problems in the context of designing and implementing motion control systems for wheeled automated vehicles, and discussing examples of their solutions; shaping the skills in implementing, testing, and control performance assessing for selected motion control laws devised for automated vehicles in the context of selected motion tasks; shaping the skills for cooperation in small working teams.

Course-related learning outcomes

Knowledge

1. Basic knowledge on modelling of wheeled vehicles on the kinematic and dynamic levels; knowledge of classification and properties of basic kinematics of wheeled / wheeled-tracked / articulated vehicles; ordered basic knowledge in the area of designing of control systems for automated vehicles (especially of the car-like and differentially driven kinematics) in the context of selected control tasks; knowledge on underlying control structures of automated vehicles (including articulated vehicles), and knowledge of functions played by particular blocks of these control systems; consciousness of fundamental limitations characteristic to designing and realizing control laws for restricted-mobility wheeled vehicles; knowledge on selected control techniques and algorithms of automated vehicles and their properties; knowledge on practical issues, benefits and limitations related to applications of selected control methods in practice; knowledge of selected quality criteria being applied to assess performance of control systems.
2. Basic knowledge in the area of contemporary development trends in automated (commercial and special) vehicles, and motion/control tasks being defined for these vehicles; knowledge on examples of practical applications of automated and robotized (commercial and special) vehicles; basic knowledge on groups of connected automated vehicles (CAV) and automated highway systems (AHS); basic knowledge on sensors and actuators used in automated wheeled vehicles; knowledge on selected (advanced) driver assistance systems (DAS/ADAS) and on examples of their applications.

Skills

1. Skills for implementing and testing of wheeled vehicle models and selected functional blocks of control systems in a simulation environment on a fast-prototyping testbed using a physical laboratory vehicle.
2. Skills needed for performing a basic analysis of a resultant control performance obtained during classes, and for comparing of selected control laws by applying known quality criteria.
3. Skills for a synthesis of control systems paying attention to environmental and economic issues.

Social competences

1. Competences for cooperation in a team with responsibility of commonly realized tasks.
2. Consciousness of a necessity for professional approach to technical problems and permanent updating the skills and knowledge in the area of automated vehicles.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

(A) For lectures, the teaching effects are verified by assesing the student's knowledge during a final selection-test. The test contains 20 questions; for every question there are four answers (A, B, C, D), where the two of them are correct while other two are incorrect. Selection by the student of two correct answers implies earning 1.0 point for the question. Selection of one correct answer and one incorrect answer leads to zero points for the question. Selection of one correct answer and leaving one non-asigned answer leads to 0.5 point for the question. Other selections (or their lack) leads to zero points for the question. The test is treated as passed if the resultant sum of points is larger than 10.0.
(B) Student's work during laboratory classes is assessed upon the results of practical tasks imposed to the students and realized during the classes. One checks the following ingredients: obtained performance of the implemented control systems, and answers to questions formulated by the instructor in the topics of the practical tasks done by the students.

Programme content

The course covers the following topics:
- fundamental concepts: mobility, restricted mobility, wheeled autonomous / intelligent / semiautonomous / teleoperated vehicle, automated vehicle, driver assistance system, vehicle guidance system;
- levels of automation defined for commercial vehicles by the SAE J3016 standard (with emphasis on levels 1-3);
- contemporary applications and examples of automated guiding systems of vehicles and driver assistance systems used for commercial and special vehicles; examples of robotized commercial vehicles, practical motivation for automation of wheeled vehicles;
- properties of wheeled and wheeled-tracked locomotion;
- Connected Automated Vehicles (CAV) systems and Automated Highway Systems (AHS), vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication;
- mathematical description of models used for motion control of car-like vehicles and differentially driven vehicles;
- kinematic models of articulated vehicles (N-trailers and N-segment structures) for control purposes;
- degrees of freedom in a planar movement and kinematic indexes (mobility index, steerability index, maneuverability index), kinematic constraints and their satisfaction in practical conditions (nonholonomic models vs. constraints-free models);
- ways of motion transmission and motion execution in wheeled vehicles, differential and Ackermann steering mechanisms;
- posture and configuration vectors for a vehicle body, representations of a vehicle body orientation, instantaneous center of rotation of a single-body vehicle and of bodies of articulated vehicles;
- basic sensors and actuators of automated vehicles;
- general functional scheme of a control system used in wheeled autonomous vehicles;
- motion task vs. control task; fundamental motion and control tasks being defined for automated vehicles, and examples of their practical realization (trajectory tracking, path following, set-point control); non-classical motion tasks; the problem of collision avoidance with obstacles;

- mathematical formulation of motion tasks (reference signals generator - the ways of computations);
- structures and designing of cascaded control systems being applied in commercial and special automated vehicles (including articulated vehicles); description of control algorithms for selected control tasks;
- qualitative criteria for comparing the control algorithms; robustness and sensitivity of control laws;
- practical issues in control systems realization for automated vehicles: control performance under practical conditions, limitations of control input signals and the velocity scaling block, the problem of measuring feedback signals, physical realization of control signals, basic hardware blocks of control systems used for automated vehicles;
- selected examples of practical and experimental control systems of automated commercial and special vehicles (including articulated ones);
- selected driver assistance systems (DAS/ADAS) for human-drivers of automated vehicles (adaptive cruise controller, platoon control systems, driver assistance for pantograph-docking manoeuvers with electric buses).

Laboratory classes are organized in the form of eight 2-hours meetings conducted in a laboratory room. Classes are executed by two- or multi-persons groups of students. The programme of classes is divided into three parts (demonstration, simulation, and practical), which cover the following topics:
- demonstration of the robotized articulated RMP vehicle, with vision feedback, in the context of automatic guidance of a trailer for selected motion tasks;
- demonstration of the emulator of a bus-driver testbed equipped with the ADAS for the tasks of parking maneuvering;
- implementation and testing of selected wheeled vehicle models, the velocity scaling block, and the reference signals generator in the Matlab-Simulink environment;
- implementation and parametric synthesis of inner regulatory loops of a cascaded control system for an autonomous vehicle (the Matlab-Simulink environment);
- implementation, commissioning, and testing (on the fast-prototyping testbeds) a selected motion control algorithm for the wheeled mobile robot of (2,0) type using physical robots.

Teaching methods

(A) Lectures: multimedia presentations (slides, animations, video, simulations) additionally illustrated by selected examples and derivations provided on a blackboard.
(B) Laboratory classes: demonstration sessions, programming-simulation tasks, and practical implementation and verification of control systems using fast-prototyping setups.

Bibliography

Basic
1. Sterowanie robotów mobilnych. Laboratorium, M. Michałek, D. Pazderski, WPP, Poznań, 2012
2. Vehicle dynamics and control. Second edition, R. Rajamani, Springer, 2012

Additional
1. Wheeled mobile robotics. From fundamentals towards autonomous systems, G. Klancar, A. Zdesar, S.

Blazic, I. Skrjanc, 2017
2. Handbook of intelligent vehicles, A. Eskandarian (ed.), Springer, 2012
3. Autonomous intelligent vehicles. Theory, algorithms, and implementation, H. Cheng, Spinger, 2011
4. Automated driving. Safer and more efficient future driving, D. Watzenig, M. Horn (eds.), Springer, 2017
5. Handbook of driver assistance systems, H. Winner, S. Hakuli, F. Lotz, C. Singer (eds.), Springer, 2016

Breakdown of average student's workload

	Hours	ECTS
Total workload	82	3,0
Classes requiring direct contact with the teacher	47	2,0
Student's own work (literature studies, preparation for laboratory classes, testing the implementation schemes and control programs after classes, preparation for a final test) [1]	35	1,0

[1] delete or add other activities as appropriate