COURSE DESCRIPTION CARD - SYLLABUS

Course name
Automated guiding systems of vehicles [S1Elmob1>PO8-SZPP]

Course

Field of study
Electromobility

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

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 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 tasks done by the students.

Programme content

The course program includes the following content:
- introduction to the problems of automation of wheeled vehicles,
- mathematical models of vehicles used for control purposes,
- definition and features of selected control tasks of automated vehicles,
- blocks and functional subsystems of control systems of automated vehicles,
- selected control algorithms of automated vehicles.

Course topics

The lecture program covers the following topics:
- basic concepts: mobility, limited mobility, wheeled autonomous / intelligent / semi-autonomous / teleoperated vehicle, automated vehicle, driver support system, driving system;
- degrees of automation of commercial vehicles according to SAE J3016 standard (with emphasis on levels 1-3);
- contemporary applications and examples of automated driving and maneuver support systems in commercial and specialty vehicles; examples of robotization of commercial vehicles; practical motivations for vehicle automation;
- features of wheeled and wheel-slide locomotion;
- Connected Automated Vehicles (CAV) and Automated Highway Systems (AHS), Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications;
- mathematical description of motor vehicle and differential vehicle motion models for control purposes;
- kinematics models of articulated vehicles for control purposes;
- vehicle degrees of freedom in flat motion and kinematic indices (degrees of mobility, maneuverability and controllability), kinematic ties and their fulfillment under practical conditions (nonholonomic models vs. models without ties);
- methods of power transmission and realization of motion, differential mechanism, Ackermann mechanism;
- vehicle platform posture and configuration vector, platform orientation representations, instantaneous center of rotation of vehicle platform and articulated vehicle segments;
- basic sensors/sensors and actuators of automated vehicles;
- general functional diagram of the motion control system of an autonomous vehicle;
- motion task vs. control task; definition of selected motion tasks and control tasks for automated vehicles and examples of their practical implementation;
- mathematical formulation of the motion task (reference signal generator - ways to implement calculations);
- structures and design of cascade control systems used in automated commercial and special vehicles (including articulated vehicles); description of control algorithms for selected control tasks;
- qualitative criteria for comparison of control algorithms,
- practical aspects of the implementation of control systems for automated vehicles: quality of control under practical conditions, limitations of control signals and speed scaling block, the problem of measuring feedback signals, basic functional blocks of control systems for automated vehicles;
- selected examples of practical and experimental control systems of automated commercial and special vehicles (including articulated vehicles);
- selected assistance systems (DAS/ADAS) for drivers of automated vehicles (cruise control, adaptive cruise control for vehicle platoon control system, electric bus pantograph-docking-maneuver assistance).

Laboratory classes are conducted in the form of eight 2-hour exercises held in the laboratory. The exercises are carried out by teams of two or more students. The laboratory program includes the following issues (implementation in the Matlab-Simulink environment),
- implementation and testing of selected wheeled vehicle models, velocity scaling block and reference signal generators,
- implementation and testing of selected motion control algorithms for a model of an automated vehicle of class (2,0) or (1,1).

Teaching methods

A) Lectures: multimedia presentation (slides, animations, videos, simulations) further illustrated with selected examples and derivations given on the blackboard.
B) Laboratory exercises: programming and simulation tasks on implementation and verification of control systems in a simulation environment.

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	85	3,00
Classes requiring direct contact with the teacher	47	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	38	1,50