COURSE DESCRIPTION CARD - SYLLABUS

Course name
Control of under-actuated systems [S2AiR1E-ISLiSA>O1-SU]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

Area of study (specialization)
Smart Aerospace and Autonomous Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
45

Number of credit points

4,00

Coordinators

dr inż. Bartłomiej Krysiak
bartlomiej.krysiak@put.poznan.pl

Lecturers

Prerequisites

Knowledge: Student starting this module should have basic knowledge regarding control theory, foundations of autonomous systems. Skills: He/she should have skills to solve basic problems related to using of sensory information in control and the ability to acquire information from given sources. He/she should have skills allowing solving basic problems related to programming in Matlab/Simulink environment, high level and low-level programming in C/C++, simulation of dynamic continuous and discrete systems. The student should understand the necessity of extending his/her competences. Social competencies: In addition, in respect to the social skills the student should represent such features as honesty, responsibility, perseverance, curiosity, creativity, manners, and respect for other people.

Course objective

1. Provide students knowledge regarding classification of underactuated systems, modeling of kinematics and dynamics of systems with nonintegrable dynamics, description of fundamental properties of underactuated systems, description of selected open and closed-loop control methods. 2. Develop students skills in modeling and simulation of kinematics and dynamics of underactuated systems and motion control algorithms.

Course-related learning outcomes

Knowledge
1. Acquire knowledge on real-time control structure at kinematic and dynamic level - [K_W3]
2. Have wide and in-depth knowledge on modeling of kinematics and dynamics of underactuated systems - [K_W5]
3. Have wide and in-depth knowledge on design of control algorithms for nonlinear systems - [K_W7]
4. Have wide and in-depth knowledge on mobile robotics - [K_W10]
Skills
1. Is able to conduct simulations of control algorithms and to implement the algorithms in practice. - [K_U9]
2. Is able to implement numerical models of robot environment. - [K_U10]
3. Is able to verify hypothesis related to problem of autonomization of mobile robots. - [K_U14]
Social competences
1. is responsible for his/her own work, is able to collaborate and cooperate in a team, and take responsibility for the jointly performed tasks - [K2_K3]
2. is aware of the necessity to approach technical aspects professionally, to acquaint themselves in detail with documentation and environmental conditions in which devices and elements will operate - [K2_K4]
3. is aware of the complexity of the methods and algorithms and the necessity for an individual approach in solving the tasks and problems - [-]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) project classes:
evaluation of doing correctly assigned tasks,
Total assessment:
a) verification of assumed learning objectives related to lectures:
i. evaluation of acquired knowledge on the basis of the written exam.
ii. discussion of correct answers in the exam
b) verification of assumed learning objectives related to laboratory classes:
i. evaluation of students knowledge necessary to prepare, and carry out the lab tasks,
ii. monitoring students activities during classes,
iii. evaluation of project report

Programme content

The lecture should cover the following topics
Fundamental concepts: underactuated system, classification of underactuated systems in robotics, modelling of kinematics and dynamics, integrable and non-intergrable phase constraints, motion control algorithms, strutures of control architectures. Basic definitions: underactuated system, types of underactuated systems and their examples (nonholonomic wheeled mobile robots, multi-body mechanical systems, inverted pendulum, flying vehicles, water vehicles, walking and hopping machines). Modeling of nonholonomic systems, source of nonholonomic constaints. Description of selected nonholonomic systems (vehicles with trailer, flying multi body structures) at kinematic and dynamic level. Analysis of fundamental properties of nonholonomic systems referring to differential geometry, controllability and properties of linear approximation. Symmetry of configuration space, systems defined on Lie groups, examples. Integrable and nonintegrable dynamics, underactuated systems with nonintegrable dynamics, examples. Discussion considering stabilizability of underactuated systems. Open-loop control algoritms: Lie-algebraic method, jacobian method. Closed-loop control algorithms: discontinuous techniques, time-varying techniques, transverse function approach. Underactuated systems with hybrid dynamics. Stability of periodic cycle based on Pioncare maps. Zero dynamics and decoupling method in control of selected dynamic systems.

The project will be focused on practical oriented problems which will be solved by students working in groups. The classes cover:
Studying literature considering subject of the given problem. Modeling of underactuated system at kinematic and dynamic level in numerical environment. Implementation of selected motion control algorithms in simulation environment. Analysis and comparative study of the control algorithms, discussion of possibility of implementation in practice, formulation of engineering and technical requirements for the implementation.

Course topics

none

Teaching methods

1. Lectures: multimedia presentation, presentation illustrated with examples presented on black board, solving tasks
2. Project: solving tasks, practical exercises, experiments, teamwork

Bibliography

Basic
1. S. Sastry, Nonlinear Systems, Springer Verlag, 1999
2. Tchoń, Mazur, Hossa, Dulęba, Manipulatory i roboty mobilne, Akademia Oficyna Wydawnicza PLJ, 2002.
3. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer 2009.
4. M. Michałek, D. Pazderski, Sterowanie robotów mobilnych. Laboratorium, Wydawnictwo Politechniki Poznańskiej, Poznań 2012
5. R. C. Arkin (edytor), Principles of Robot Motion Theory, Algorithms and Implementation, Massachussets Institute of Technology (MIT), 2005
6. R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT, 2011
7. S. Sastry, Nonlinear Systems, Springer Verlag, 1999
8. Tchoń, Mazur, Hossa, Dulęba, Manipulatory i roboty mobilne, Akademia Oficyna Wydawnicza PLJ, 2002.
9. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer 2009.
10. M. Michałek, D. Pazderski, Sterowanie robotów mobilnych. Laboratorium, Wydawnictwo Politechniki Poznańskiej, Poznań 2012
11. R. C. Arkin (edytor), Principles of Robot Motion Theory, Algorithms and Implementation, Massachussets Institute of Technology (MIT), 2005
12. R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT, 2011
Additional
1. B. Siciliano, O. Khatib (Ed.), Handbook of Robotics, Springer 2009.
2. J. Borenstein (edytor), Where am I - Systems and Methods for Mobile Robot Positioning, 1996, http://www-personal.umich.edu/~johannb/shared/pos96rep.pdf
3. B. Siciliano, O. Khatib (Ed.), Handbook of Robotics, Springer 2009.
4. J. Borenstein (edytor), Where am I - Systems and Methods for Mobile Robot Positioning, 1996, http://www-personal.umich.edu/~johannb/shared/pos96rep.pdf

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	75	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00