STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Fundamentals of Autonomous Systems**		Code **1010532111010559180**
Field of study **Automatic Control and Robotics**	Profile of study (general academic, practical) **general academic**	Year /Semester **1 / 1**
Elective path/specialty **Smart Aerospace and Autonomous Systems**	Subject offered in: **English**	Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **full-time**	
No. of hours Lecture: **30** Classes: **-** Laboratory: **30** Project/seminars: **-**		No. of credits **4**
Status of the course in the study program (Basic, major, other) **major**	(university-wide, from another field) **from field**	
Education areas and fields of science and art		ECTS distribution (number and %**)**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Student starting this module should have basic knowledge regarding foundations of robotics, probability calculus and statistics, measurement systems, control theory and programming.
2	**Skills**	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 and skills that are necessary to acquire information from given sources of information. Student should understand the need to extend his/her competences.
3	**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.

Assumptions and objectives of the course:

1.Provide students knowledge regarding foundations of autonomous systems and mobile robotics, classification of mobile robots, general structure of control system designed for mobile robots, modeling of kinematics and dynamics of selected holonomic and nonholonomic vehicles, fundamental methods of motion control algorithms for wheeled mobile robots, localization and navigation techniques, motion planning methods for systems with holonomic and phase constraints and selected control architectures for mobile robots.

2.Develop students? skills in modeling and simulation of kinematics and dynamics of wheeled mobile robots and motion control algorithms, implementation of algorithms of navigation and motion planning.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. acquire knowledge on methods of modeling of kinematics and dynamics of mobile robots - [K_W5]
2. have wide and in-depth knowledge on design of control algorithms for nonlinear systems - [K_W7]
3. have wide and in-depth knowledge on mobile robotics - [K_W10]

Skills:

1. is able to acquire, integrate, interpret and evaluate information from literature on techniques of motion control, localization and motion planning - [K_U1]
2. is able to conduct simulations of control algorithms and to implement the algorithms in practice - [K_U9]
3. is able to implement numerical models of robot environment - [K_U10]
4. is able to verify hypothesis related to problem of autonomization of mobile robots - [K_U15]
5. is able to formulate design specification of mobile robot control system - [K_U21]

Social competencies:

1. is able to work in group to solve engineering and scientific problems - [K_K3]

Assessment methods of study outcomes

Formative assessment:

a) laboratory classes:

i. evaluation of doing correctly assigned tasks (following provided lab. instructions),

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 student?s knowledge necessary to prepare, and carry out the lab tasks,

ii. monitoring students? activities during classes,

iii. evaluation of lab reports (partly started during classes, finished after them)

iv. showing how to improve the instructions and teaching materials.

Course description

The lecture should cover the following topics

Fundamental concepts: autonomous system, classification of mobile robots, modeling of kinematics and dynamics of wheeled mobile robots, motion control, motion planning, navigation, control architectures. Basic definitions: autonomy, autonomous mobile robot, types of mobile robots and their examples. Scheme of general control architecture for a mobile robot. Fundamental structures of wheeled mobile robots. Phase constraints, holonomic and nonholonomic constraints. Types of kinematic planar structures designed for motion without slip, concepts of steerability and mobility. Modeling of wheeled mobile robots, examples of kinematics and dynamics. Definition of motion control tasks, admissible and nonadmissible trajectories. Selected algorithms of motion control of nonholonomic mobile robots. Review of fundamental methods of localization: relative localization methods (dead reckoning, inertial localization), global localization methods (trilateration, triangulation). Review of fundamental methods of environment mapping (grid, vector and topology maps), sensor models. General motion planning algorithms in constrained taks (coordinate) space: graph searching, probabilistic planning, potential functions in the continuous and discrete domain, navigation function.

The lab-classes (15 x 2 hours) will be focused on practical exercises which will be solved by students working in groups. The classes cover:

Modeling of wheeled mobile robots at kinematic and dynamic level. Implementation of selected motion control algorithms for laboratory robots taking advantage of linear (Taylor linearization, decoupling technique) and nonlinear methods. Analysis and comparative study of the control algorithms. Examination of odometry and analysis of systematic and stochastic errors. Implementation of selected algorithms of environment mapping using virtual and real data. Examination of selected planing motion algorithms.

Learning methods:

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

Basic bibliography:

1. R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT, 2011

2. Michałek, D. Pazderski, Sterowanie robotów mobilnych. Laboratorium, Wydawnictwo Politechniki Poznańskiej, Poznań 2012

3. R. C. Arkin (edytor), Principles of Robot Motion Theory, Algorithms and Implementation, Massachussets Institute of Technology (MIT), 2005

4. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer 2009

5. J. Borenstein (edytor), Where am I - Systems and Methods for Mobile Robot Positioning, 1996, http://www-personal.umich.edu/~johannb/shared/pos96rep.pdf

6. R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT, 2011

7. Michałek, D. Pazderski, Sterowanie robotów mobilnych. Laboratorium, Wydawnictwo Politechniki Poznańskiej, Poznań 2012

8. R. C. Arkin (edytor), Principles of Robot Motion Theory, Algorithms and Implementation, Massachussets Institute of Technology (MIT), 2005

9. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer 2009

10. J. Borenstein (edytor), Where am I - Systems and Methods for Mobile Robot Positioning, 1996, http://www-personal.umich.edu/~johannb/shared/pos96rep.pdf

Additional bibliography:

1. B. Siciliano, O. Khatib (Ed.), Handbook of Robotics, Springer 2009.
2. Tchoń, Mazur, Hossa, Dulęba, Manipulatory i roboty mobilne, Akademia Oficyna Wydawnicza PLJ, 2002.
3. P. Skrzypczyński, Metody analizy i redukcji niepewnosci percepcji w systemie nawigacji robota mobilnego, Rozprawy, nr 407, Wydawnictwo Politechniki Poznańskiej, Poznan 2007.
4. B. Siciliano, O. Khatib (Ed.), Handbook of Robotics, Springer 2009.
5. Tchoń, Mazur, Hossa, Dulęba, Manipulatory i roboty mobilne, Akademia Oficyna Wydawnicza PLJ, 2002.
6. P. Skrzypczyński, Metody analizy i redukcji niepewności percepcji w systemie nawigacji robota mobilnego, Rozprawy, nr 407, Wydawnictwo Politechniki Poznańskiej, Poznan 2007.

Result of average student's workload

Activity	Time (working hours)
1. participating in laboratory classes / tutorials	30
2. preparing to laboratory classes	6
3. finishing reports from laboratory classes (in addition to laboratory classes)	5
4. finishing programs and laboratory excercises (in addition to laboratory classes)	12
5. participating in lectures	30
6. participating in exam	2
7. studying literature / learning aids	5
8. preparing to exam	10

Student’s workload

Source of workload	hours	ECTS
Total workload	100	4
Contact hours	62	2
Practical activities	53	2