COURSE DESCRIPTION CARD - SYLLABUS

Course name

Navigation and motion planning in robotics

Course

Field of study
Automatic Control and Robotics

Area of study (specialization)
Control and Robotics Systems

Level of study
Second-cycle studies

Form of study
full-time

Year/Semester
1 / 2

Profile of study
general academic

Course offered in
Polish

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
0

Other (e.g. online)
0

Tutorials
0

Projects/seminars
30

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Knowledge: Student starting this module should have basic knowledge of metrology, probabilistics and statistics, measurement systems, mobile robot localization methods, control theory and programming.

Skills: He/she should have skills allowing solving basic problems related to the design and commissioning of measurement systems, programming in the Matlab/Simulink environment, high-level and low-level programming in C/C++, simulation of continuous and discrete dynamic systems over time and the ability to obtain information from indicated sources.

Social competencies: In addition, in respect to the social skills the student should show attitudes as honesty, responsibility, perseverance, curiosity, creativity, manners, and respect for other people.

Course objective

To provide students with knowledge of: the general structure of mobile robot control systems, navigation techniques using formal, probabilistic and heuristic methods, motion planning methods for systems subject to holonomic and phase constraints and control architectures for autonomous mobile robots.

Developing students' skills in implementing motion planning algorithms and non-linear optimization methods, operating and designing localization and navigation systems in mobile robotics taking into account design requirements (required degree of precision, speed, multi-sensor applications).

Course-related learning outcomes

Knowledge

The student

1. learns the artificial intelligence methods used in navigation algorithms – [K2_W2].

2. has detailed knowledge of the construction and use of advanced sensory systems - [K2_W6]

3. has a structured and in-depth knowledge of adaptive systems - [K2_W9]

4. broadens his/her knowledge of mobile robotics - [K2_W10]

Skills

The student:

1. can conduct simulation studies to illustrate the operation of navigation and motion planning algorithms - [K2_U9]

2. is able to analyse the uncertainty of sensory data and take its impact into account when designing a mobile robot control system - [K2_U10]

3. can process and use sensory data in perception, locatization and navigation algorithms - [K2_U11]

4. is able to design perception, localization and navigation modules and implement various motion planning algorithms - [K2_U13]

Social competences

The student:

1. is aware of the necessity of a professional approach to technical issues, can work in a team to solve project tasks - [K2_K3].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) lectures:

based on answers to question in the written test,

b) project classes:

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 project classes:

i. evaluation of student knowledge necessary to prepare, and carry out the project tasks,

ii. monitoring students activities during classes,

iii. evaluation of project reports

Additional elements cover:

i. discussing more general and related aspects of the class topic,

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

Programme content

Basic concepts: navigation and motion planning. Information flow diagram in the control architecture of a mobile robot. Control paradigms in robotics: deliberative, reactive and hybrid structures. Classification and general characteristics of methods of environment description: raster, vector and topological representation. Raster map: probabilistic approach, record theory, fuzzy collection methods, sensor models. Vector map: stages of vector map creation (data acquisition, segmentation, defining feature representation), update of global map, description of uncertainty. Basic concepts: navigation and motion planning methods. Representation of elements in the environment: semi-algebraic sets and others. Basic schemes of traffic planning in continuous/discrete space. Motion planning as a task of optimal control. Graphic search methods. Combinatoric methods of motion planning: visibility graph, generalised Voronoi diagram, silhouette method, space decomposition methods. General methods of motion planning in multidimensional configuration space taking into account constraints: probabilistic planning, methods of potential functions in continuous and discrete version, navigation function, ideal fluid flow modeling, discussion of local minima and saddle points problem. Motion planning for differentially flat systems, polynomial methods, use of vector fields. Kinetodynamic motion planning. and motion planning algorithms for nonholonomic systems.

Project classes are conducted in the form of fifteen 2-hour classes preceded by an instructional session at the beginning of the semester. The projects are carried out by 2 or 3-person teams of students. The topics of the projects include the following issues: Error analysis and verification of the accuracy of selected methods of robot location. Data fusion methods: designing simulation models and testing methods, software/ hardware implementation using multi-sensors systems. Operating systems of mobile robots and their application in navigation, laboratory tests illustrating the operation of these methods on real objects. Software implementation of traffic planning methods in Matlab/Simulink environment and in C/C++ language.

Teaching methods

1. Lectures: multimedia presentation, presentation illustrated with examples presented on black board, solving tasks

2. Project: solving tasks, practical exercises, experiments, teamwork, discussion of project topics.

Bibliography

Basic

1. S. Lavalle, Planning Algorithms. Cambridge: Cambridge University Press, 2006.

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

3. P. Skrzypczyński, Metody analizy i redukcji niepewnosci percepcji w systemie nawigacji robota mobilnego, Rozprawy, nr 407, Wydawnictwo Politechniki Poznańskiej, Poznan 2007.

Additional

1. https://www.ros.org

2. Tchoń, Mazur, Hossa, Dulęba, Manipulatory i roboty mobilne, Akademia Oficyna Wydawnicza PLJ, 2002.

3. R. Siegwart, I. Nourbaksh, Introduction to Autonomous Mobile Robots, MIT, 2004.

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

5. B. Siciliano, O. Khatib (Ed.), Handbook of Robotics, Springer 2009.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,0
Classes requiring direct contact with the teacher	60	2,5
Student's own work (literature studies, preparation for project classes, preparation for the final test, project preparation) [1]	15	0,5

1 delete or add other activities as appropriate