COURSE DESCRIPTION CARD - SYLLABUS

Course name
Design of Control Systems

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 studies

Course offered in
english

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes

Other (e.g. online)

Tutorials

Projects/seminars
45

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
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Prerequisites

Knowledge: The student starting this module should have basic knowledge of linear algebra, digital signal processing, 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 with knowledge of using visual information in control systems.

2. Develop students' skills to select the appropriate control techniques, depending on the given tasks and the ability to design and use visual feedback in the control.

3. Provide students with knowledge of designing control systems for robotics applications.

4. Provide students knowledge regarding classification of control systems, modeling of kinematics and dynamics of systems, description of fundamental properties of linear and nonlinear systems, description of selected closed-loop control methods.

5. Develop skills in modeling and simulation of kinematics and dynamics of control systems and motion control algorithms.

Course-related learning outcomes

Knowledge

1. have knowledge on designing and use of advanced sensory systems - [K2_W6]

2. have wide and in-depth knowledge on vision measurement and control systems - [K2_W11]

3. have knowledge of the development trends and most crucial new achievements in the field of automation and robotics and related disciplines - [K2_W12]

4. know and understand the methods of image processing and analysis techniques in the field of image preprocessing, segmentation, recognition and interpretation of visual information - [-]

5. Acquire knowledge on real-time control structure at kinematic and dynamic level. - [[K_W3]]

6. Have wide and in-depth knowledge on modeling of kinematics and dynamics of control systems. - [[K_W5]]

7. Have wide and in-depth knowledge on design of control algorithms for nonlinear systems. - [[K_W7]]

8. Have wide and in-depth knowledge on mobile robotics. - [[K_W10]]

Skills

1. is able to employ advanced methods of processing and analyzing images acquired from vision signals, and extract information from analyzed signals - [K2_U11]

2. is able to assess usefulness and possibility of employing new developments in the field of automation and robotics (methods and tools) - [K2_U16]

3. is able to evaluate usefulness of methods and tools for solving a robotics and automation problem using knowledge on vision systems - [K2_U22]

4. is able to solve research problem related to control systems by developing necessary software and test it in selected integrated development environment - [K2_U25]

5. is able to design control system with vision feedback using available hardware and software tools; is able to shape the properties of vision measurement systems - [K2_U27]

6. Is able to conduct simulations of control algorithms and to implement the algorithms in practice. - [[K_U9]]

7. Is able to implement numerical models of robot environment. - [[K_U10]]

8. 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:

Verification of assumed learning objectives related to lectures is performed based on evaluation of acquired knowledge on the basis of the written exam in the test form with 25-30 questions and with few open questions (pass threshold 50%).

In the scope of the project, the objectives are verified on the basis of an assessment of the current progress of the project, evaluation of student's knowledge and skills related to implementation, and evaluation of report connected with presentation of the project.

Programme content

The lecture should cover the following topics:

Applications of vision feedback in robotics and control tasks. The control based on the error in the task space and the image features space. The concept of a digital image, image representations, models of color spaces, transformations between models. Characteristics of machine vision components and design of visual feedback. Industrial vision systems and smart cameras. Image acquisition techniques, tools for data acquisition and image processing. Camera model and camera calibration procedure. Some techniques for image segmentation. Basic methods of representation and analysis of shapes in images. Complex image recognition techniques, the SIFT algorithm.

Basic properties of linear and nonlinear system. Standard examples of nonlinear systems. Basic definitions for unmanned aerial vehicles (UAV), description of body frame, kinematisc and dynamics, basic linear controller. Kinematic and dynamic controller synthesis for mobile robots with consideration of nonholonomic constraints. Motion control algorithms for mobile robots, strutures of control architectures.

Project meetings took place in the laboratory. Exercises are performed by two-person teams of students. During the course teams perform the selected project task. Project tasks include the following: calibration of cameras and vision measuring system. Image acquisition, marker identification, a mobile robot localization. The use of visual information in the control of mobile robot. Designing and testing control software for specific problems.

Teaching methods

1. Lectures: multimedia presentation illustrated with examples using Matlab and other demonstration showing specific control systems and application of vision systems.

2. Project: teamwork solving project tasks.

Bibliography

Basic

1. Gonzalez R.C., Woods R.E., Digital Image Processing, Prentice Hall, SE, 2002

2. B. Siciliano, O. Khatib (Eds.) Springer Handbook of Robotics, Springer-Verlag 2008

Additional

1. Fu K.S., Gonzalez R.C., Lee C.S.G., ROBOTICS, Control, Sensing, Vision, and Intelligence, McGraw-Hill 1987

2. S. Sastry. Nonlinear Systems: Analysis, Stability and Control. Interdisciplinary applied mathematics: Systems and control. Springer, 1999.

3. Linear fight control techniques for unmanned aerial vehicle - J. P. How, E. Frazzoli and G. Chowdhary.

4. Erick J. Rodriguez-Seda, Chinpei Tang, Mark W. Spong, and Dusan M. Stipanovic. Trajectory tracking with collision avoidance for nonholonomic vehicles with acceleration constraints and limited sensing. Int. J. Rob. Res., 33(12):1569 1592, October 2014.

5. C. Samson. Velocity and torque feedback control of a nonholonomic cart. In C. Canudas de Wit, editor, Advanced Robot Control, pages 125 151. Birkhauser, Boston, 1991.

6. Nilanjan Sarkar, Xiaoping Yun, and Vijay Kumar. Control of mechanical systems with rolling constraints application to dynamic control of mobile robots. The International Journal of Robotics Research, 13(1):55 69, 1994.

7. Yin-Tien Wan, Yu-Cheng Chen, and Ming-Chun Lin. Dynamic object tracking control for a non-holonomic wheeled autonomous robot. Tamkang Journal of Science and Engineering, 12(3):339 350, 2009.

Breakdown of average student's workload

	Hours	ECTS
Total workload	120	4,0
Classes requiring direct contact with the teacher	77	2,5
Student's own work (literature studies, preparation for project classes, preparation for exam, final raport preparation) [1]	43	1,5

[1] delete or add other activities as appropriate