COURSE DESCRIPTION CARD - SYLLABUS

Course name
Vision based control [S2AiR1E-ISLiSA>O2-SW]

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

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Lecturers

Prerequisites

Knowledge: The student starting this module should have basic knowledge of linear algebra and digital signal processing. 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. 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 image processing and analysis techniques in the field of image preprocessing, segmentation, recognition and interpretation of visual information for use in control. 2. Provide students with knowledge of elements of machine vision systems, their structure and possible applications in robotics and automation. 3. Develop students' skills to select the appropriate image processing methods, depending on the given tasks and the ability to use visual feedback in the control.

Course-related learning outcomes

Knowledge

1. have knowledge on construction and use of machine vision 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 - [-]
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 vision systems by developing necessary software and using vision hardware - [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]
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 of image processing and the necessity for an individual approach in solving the tasks and problems, particularly during the implementation of visual feedback - [-]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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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 (pass threshold 50%) and individual discussion on results of the exam.
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 module program covers the following topics:
1) applications of vision feedback in robotics and control
2) characteristics of the components of vision systems
3) industrial vision systems and vision feedback design
4) camera model and camera calibration procedure
5) digital image and color spaces
6) image pre-processing and correction techniques
7) context operations and image filtering
8) morphological transformations
9) selected image segmentation methods
10) basic methods of representing and analyzing shapes in images
11) image recognition methods

Course topics

The lecture covers 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. Preprocessing and image correction techniques: point operations, histogram, brightness and contrast correction, image thresholding, LUTs for point operations. Context processing, image correlation, image filtering in spatial domain, nonlinear filtering, statistical filters.

Morphological operations in image processing: erosion and dilation, complex operations and morphological image filtering. Image processing using frequency methods, image filtering in the frequency domain, cosine transform in image compression. Selected techniques for image segmentation. Basic methods of representation and analysis of shapes in images. Complex image recognition techniques, the SIFT algorithm, convolutional neural networks. Camera model and camera calibration procedure. 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.
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 and manipulator. The use of industrial vision system for the implementation of selected tasks in industrial process control.

Teaching methods

1. Lectures: multimedia presentation illustrated with examples using Matlab and other demonstration showing specific image processing methods 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

Breakdown of average student's workload

	Hours	ECTS
Total workload	120	4,00
Classes requiring direct contact with the teacher	77	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	43	1,50