POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Vision and spectral systems in automation

Course

Field of study	Year/Semester
automatic control and robotics	1/2
Area of study (specialization)	Profile of study
intelligent automation systems	general academic
Level of study	Course offered in
Second-cycle studies	polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
15	15	
Tutorials	Projects/seminars	

Number of credit points

2

Lecturers

Responsible for the course/lecturer:

Konrad Urbański Ph.D.

email: Konrad.Urbanski@put.poznan.pl

tel. 48 61 665 2810

Faculty of Control, Robotics and Electrical Engineering

ul. Piotrowo 3A 60-965 Poznań

Responsible for the course/lecturer:

PhD eng. Dominik Łuczak

email: Dominik.Luczak@put.poznan.pl

tel. 48 61 665 2557

Faculty of Control, Robotics and Electrical Engineering

ul. Piotrowo 3A 60-965 Poznań

Prerequisites

Knowledge: Students starting this subject should have knowledge of automation and robotics corresponding to level 6 of the Polish Qualifications Framework, in particular knowledge of digital signal processing and programming.

Skills: The student should have the ability to solve and implement problems of digital signal processing in the field of automation and robotics, as well as the ability to obtain information from specified sources. He should also understand the need to expand his competences and be ready to cooperate in a team.

Social competences: In addition, in the area of social competences, the student must exhibit such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. To provide students with knowledge regarding the construction, operation and use of vision and spectral sensors.

2. Developing students' skills in using digital signal processing algorithms on data from vision and spectral sensors.

3. Developing in students the importance of knowledge of technology and recommendations related to the construction and programming of data exchange interfaces.

Course-related learning outcomes

Knowledge

1. Student has detailed knowledge of the construction and use of advanced sensory systems; [K2_W6]

2. has knowledge of development trends and the most important new achievements in the field of automation and robotics and related scientific disciplines [K2_W12]

Skills

1. Student is able to use advanced methods of signal processing and analysis, including video signal and extract information from the analyzed signals; [K2_U11]

2. is able to integrate and program specialized robotic systems; [K2_U12]

3. is able to select and integrate elements of a specialized measuring and control system including: control unit, executive system, measuring system as well as peripheral and communication modules; [K2_U13]

4. is able to assess the usefulness and possibility of using new achievements (including techniques and technologies) in the field of automation and robotics; [K2_U16]

Social competences

1. The student is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which devices and their components can function; [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) in the scope of lectures:

based on homework assignments and answers to questions about the material discussed in previous lectures,

b) in the scope of the laboratory:

based on assessment of knowledge and understanding of current issues presented in the course of the subject.

Summative rating:

a) in the scope of lectures, verification of assumed learning outcomes is carried out by:

i. assessment of knowledge and skills demonstrated on the written credit in the form of a test

ii. discussion of passing results.

b) in the scope of laboratory, verification of assumed learning outcomes is carried out by:

i. assessment of student's preparation for individual classes,

ii. continuous assessment, during each class (oral answers) - rewarding the increase in the ability to use known principles and methods,

iii. assessment of tasks prepared partly during classes and also after their completion.

Obtaining additional points for activity during classes, in particular for:

i. independent construction of the control and measurement system with vision and spectral sensors and preparation of documentation,

ii. effectiveness of applying the acquired knowledge while solving a given problem

iii. comments related to the improvement of teaching materials.

Programme content

The lecture program includes the following topics:

1. Spectral imaging and laser spectroscopy. Visible range, near infrared - NIR, medium infrared, far infrared. Light absorption.

2. Signal analysis methods used in spectroscopy (FTIR - Fourier transform infrared spectroscopy, WMS - Wavelength Modulation Spectroscopy). Analysis of digital signals to detect the characteristics of the substance being analyzed.

3. Applications of spectral imaging, in particular for automatic evaluation of product quality.

4. Selected image processing issues.

5. Selected detection and classification issues.

6. Application of image processing methods in control.

The program of laboratory classes includes:

1. Analysis and submission of spectra from available databases. The effect of temperature and pressure on the spectrum.

2. Analysis of the spectra of a complex mixture using digital signal processing methods. Spectrum matching methods using gradient algorithms (Levenberg-Marquardt algorithm).

3. Construction of the spectrometer. Implementation of a folding spectrometer (Spectral Workbench).

4. Calibration of the spectrometer.

5. Using the lens equation for calculations.

6. Image filtering.

7. Creating your own detectors.

8. The use of visual feedback in control.

Teaching methods

1. Lecture: multimedia presentation illustrated with literature data and sample projects

2. Laboratory classes: the use of a system with a vision and / or spectral sensor, an environment for collecting and processing digital signals.

Bibliography

Basic

1. Machine Learning-Based Multifunctional Optical Spectrum Analysis Technique, 2019, https://doi.org/10.1109/ACCESS.2019.2895409

2. Calibration-Free WMS Using a cw-DFB-QCL, a VCSEL, and an Edge-Emitting DFB Laser With In-Situ Real-Time Laser Parameter Characterization, 2017, https://doi.org/10.1109/JPHOT.2017.2655141

3. Stereopsis-Inspired Time-Stretched Amplified Real-Time Spectrometer (STARS), 2012, https://doi.org/10.1109/JPHOT.2012.2213588

4. A New RAM Normalized 1f-WMS Technique for the Measurement of Gas Parameters in Harsh Environments and a Comparison With 2f / 1f, 2018, https://doi.org/10.1109/JPHOT.2018.2883548

5. Spectral Workbench documentation, https://spectralworkbench.org/ [2020-04]

6. HITRAN database, https://hitran.org/

7. Computer Vision, Richard Szeliski, Springer 2011

8. Rapid object detection using a boosted cascade of simple features, P. Viola i M. Jones, Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition. CVPR 2001.

Additional

1. A Controllable DCCS-Based PT Temperature Sensor in High Precision Molecular Spectroscopy Application, 2020, https://doi.org/10.1109/ACCESS.2020.2977163

2. Fully Integrated Optical Spectrometer in Visible andNear-IR in CMOS, 2017, https://doi.org/10.1109/TBCAS.2017.2774603

3. A Highly Sensitive Optical Sensor Design by Integrating a Circular-Hole Defect With an Etched Diffraction Grating Spectrometer on an Amorphous-Silicon Photonic Chip, 2012, https://doi.org/10.1109/JPHOT.2012.2188097

4. High-Resolution Compact On-Chip Spectrometer Based on an Echelle Grating With Densely Packed Waveguide Array, 2019, https://doi.org/10.1109/JPHOT.2018.2888592

5. „Handbook of Machine Vision", ed. A. Hornberg, Willey 2006.

6. P. Kluczyński K. Siembab, J. Derezynski, M. Straszewski, J. Peziak, D. Luczak, S. Tomczyk, M. Suski, A. Wojcik, Multi-component Mid-IR tunable laser analyzers for process control, Mirsens 4 – International workshop on opprtunities and challengs in mid-infrared laser-based gas sensing, 15-17 May 2017, Wroclaw, Poland

7. P. Kluczynski K. Siembab, J. Derezynski, M. Straszewski, S. Tomczyk, J. Peziak, D. Luczak, Multi-component tunable laser analyzers for process control, ISA Analysis Division Symposium, 22-26 April 2017, Pasadena, USA

8. K. Urbański, Visual Feedback for Control using Haar-Like Classifier to Identify the Quadcopter Position, The 23rd International Conference on Methods and Models in Automation and Robotics, 2018.

9. K. Urbański, Control of the Quadcopter Position Using Visual Feedback, The 18th International Conference on Mechatronics – Mechatronika, 2018.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,0
Classes requiring direct contact with the teacher	25	1,0
Student's own work (literature studies, preparation for laboratory classes, preparation for tests, project tasks preparation) [1]	25	1,0

[1] delete or add other activities as appropriate