COURSE DESCRIPTION CARD - SYLLABUS

Course name
Processing of Images and Audio Signals [S2AiR2-SW>POiSA]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Vision Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
15

Number of credit points

4,00

Coordinators

dr inż. Marcin Dąbrowski
marcin.dabrowski@put.poznan.pl

Lecturers

Prerequisites

Knowledge: A student starting this course should have knowledge of the basics of signal theory, signal processing and information. Skills: He or she should have the ability to use basic methods of signal processing and analysis in the time and frequency domain, coding digital signals (compression, encryption and redundant coding), as well as the ability to obtain information from the indicated sources. He or she should also understand the need to expand their competences and be ready to cooperate in a team. Social Competences: In addition, he or she should demonstrate such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Provide students with knowledge about image processing techniques, and audio signals and video signals processing techniques. 2. Developing the ability to solve problems related to the selection of appropriate techniques for processing images and audio signals in vision systems in automation, communication and monitoring with the use of computer systems. 3. Developing teamwork skills in students. Teaching the use of software and laboratory equipment available in class to process images and audio signals.

Course-related learning outcomes

Knowledge
A student has:
1. extended and in-depth knowledge of selected areas of mathematics necessary to formulate and solve complex tasks in the field of control theory, optimization, modeling, identification and signal processing - [K2_W1]
2. detailed knowledge of the construction and use of advanced sensory systems - [K2_W6]
3. extended knowledge within selected areas of automation and robotic - [K2_W10]
Skills
A student:
1. can use advanced methods of signal processing and analysis, including video signal, and extract information from the analyzed signals - [K2_U11]
2. is able to assess the usefulness and the possibility of using new achievements (including techniques and technologies) in the field of automation and robotics - [K2_U16]
Social competences
He or she is aware of responsibility for their own work and is ready to work in a team and be responsible for jointly performed tasks; can lead a team, set goals and define priorities leading to the implementation of tasks related to the processing of images and audio signals - [K2_K3]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Formative assessment:
a) in the scope of lectures: on the basis of answers to questions concerning the material discussed in previous lectures and on the basis of presentations made by the students themselves
b) in the scope of laboratory and design activities: based on the assessment of the current progress of the tasks implementation.
Summative assessment:
a) in the field of lectures, verification of the assumed learning outcomes is carried out by:
i. assessment of knowledge and skills in the form of a problem-based test and by verifying the achieved learning outcomes during meetings with students on the dates agreed with them,
ii. discussion of the results of the test,
b) in the field of laboratory classes, verification of the assumed learning outcomes is carried out by:
i. assessment of the student's preparation for individual laboratory classes and assessment of skills related to the implementation of laboratory exercises,
ii. evaluation of reports from the performed laboratory exercises,
iii. grading scale: 0 ... 50% of possible points - unsatisfactory, 51 ... 60% - satisfactory, 61 ... 70% - satisfactory plus, 71 ... 80% - good, 81 ... 90% - good plus, 91 ... 100% - very good,
c) in the field of project activities, verification of the assumed learning outcomes is carried out by:
i. assessment of knowledge and skills related to the implementation of project tasks,
ii. evaluation of the presentation prepared by the student.
Obtaining additional points for activity during classes, in particular for:
i. discuss additional aspects of the issue,
ii. the effectiveness of applying the acquired knowledge while solving a given problem,
iii. the ability to cooperate as part of a team practically carrying out a detailed task in the laboratory,
iv. comments related to the improvement of teaching materials,
v. identifying students' perceptual difficulties, enabling the ongoing improvement of the teaching process.

Programme content

The Image and Audio Signal Processing subject covers knowledge about image recording (digital photography), image processing, recording and processing of video sequences, recording and processing of audio signals, and speech generation and coding.

The lecture program includes the following topics:
1. Structure and properties of human sight and hearing - structure of the eye and perception of images and moving video signals; ear structure and perception of audio signals; technical aspects of images, video sequences and audio signals that result from the properties of human sight and hearing.
2. Color, grayscale and monochrome images - pixel and pel as image elements, image formats and resolutions, the concept of color, brightness (brightness), hue and color saturation, physical and technical

color spaces - HSL (HSI), HSB (HSV), RGB, CMY(K), YUV, YIQ, YCbCr.
3. Methods for processing and extracting information from images - morphological operations, noise reduction, detection of edges in images, image segmentation, skeletal calculation, Hough transform.
4. Image and video sequence compression - image compression techniques and standards (cosine transform and JPEG standard, wavelength transform and JPEG2000 standard), video sequence compression techniques and standards (intraframe encoding and MJPEG standard, interframe encoding and review of MPEG standards with particular emphasis on standards H.264 and H.265).
5. Processing and compression of audio signals - basics of psychoacoustics, analysis and modeling of sound masking phenomena; structure and development of audio codecs, telephone standards and codecs, properties of the speech signal, models of speech generation and perception, vocoders and their applications, recording and editing of audio signals.
6. Digital photography and stereovision - history of techniques related to photography and film, photometry, modern devices for recording images and video signals, stereovision and stereovision devices, holography, film conversion to video sequences and video sequence editing.
7.Digital television - the history of television including the contribution of Polish inventors, visionaries and engineers, contemporary television systems and services, television standards (SDTV, HDTV, 4K), broadcast television (DVB, DVB-T, DVB-T2, DVB-S, DVB-H), OFDM and SFN techniques, Internet TV, hybrid TV, interactive TV, Closed Circuit TV (CCTV).
Laboratory classes are conducted in the form of 2-hour exercises, preceded by an instructional session at the beginning of the semester. Exercises are carried out by 2-person teams in the laboratory room.
The program of laboratory classes includes the following issues:
1. Digital images - basics of processing
2. Morphological operations - conversion of color images to black and white, thresholding, erosion, dilatation, closing and opening operations; use of a transform mask structural element in image processing; using the Matlab programming environment to perform morphological operations.
3. Edge detection and image quality improvement - application of logical operators in image processing; edge detection, object recognition, Roberts cross, Sobel operator, Prewitt operator, selection of the appropriate filter for specific applications in image processing; detection of vertical and horizontal edges, image segmentation, detection of structures in the image.
4. Progressive image coding - SBC, EZW, SPIHT encoders; evaluating image quality using SNR and PSNR, splitting the image into subbands, data-rate units and evaluating of the image quality; comparison of the effectiveness of different image encoders.
5. Editing digital images in RAW format
6. Analysis and compression of audio streams
7. Improving the quality and processing of audio streams
8. Improving the quality of video sequences
9. Lossy compression of images and video sequences
10. Nonlinear editing of video sequences
11. Streaming of audio-video signal
12. 3D graphics
13. Fractals - generating fractals, the set of Julia and Mandelbrot; modeling objects in 3D graphics with the use of fractals.
During design classes, tasks in the field of image and audio signal processing are carried out. The subject and scope of each project is determined individually and usually concerns automatic image or sound analysis, with particular emphasis on applications that recognize specific objects or situations, as well as tracking given objects in video recordings. In tasks related to audio recordings, speech or speaker recognition algorithms are most often developed. The projects complement the lectures and laboratory classes and require knowledge of the content presented there. Design classes are carried out in 2/3-person groups throughout the entire semester.

Course topics

The lecture program includes the following topics:
1. Structure and properties of human sight and hearing - structure of the eye and perception of images and moving video signals; ear structure and perception of audio signals; technical aspects of images, video sequences and audio signals that result from the properties of human sight and hearing.
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Teaching methods

1. Lecture: multimedia presentation, presentation illustrated with examples given on the blackboard, solving problems, multimedia show, demonstration.
2. Laboratory classes: conducting experiments, practical exercises, solving problems, analysis of results, case studies, evaluation of the reasons for obtaining different results by different groups of students, teamwork.
3. Design classes: multimedia presentations, discussion, team work

Bibliography

Basic

1. Didactic materials on the website www.put.poznan.pl
2. Przetwarzanie sygnałów przy użyciu procesorów sygnałowych, Dąbrowski A. (red.), Wydawnictwo Politechniki Poznańskiej, 1998
3. Cyfrowe przetwarzanie sygnałów - praktyczny poradnik dla inżynierów i naukowców, Smith S., BTC, Warszawa, 2007
4. Transmisja internetowa danych multimedialnych w czasie rzeczywistym, Antosik B., WKŁ, Warszawa, 2010
Additional
1. Multimedia - algorytmy i standardy kompresji, Skarbek W., Akademicka Oficyna Wydawnicza PLJ, 1998
2. Wprowadzenie do cyfrowego przetwarzania sygnałów, Lyons R., WKŁ, Warszawa, 1999
3. Cyfrowe przetwarzanie sygnałów, Oppenheim A., Schafer R., WKŁ, Warszawa, 1979

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	75	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00