COURSE DESCRIPTION CARD - SYLLABUS

Course name
Information processing [S1AiR2>PInf]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

The student starting this course should have basic knowledge of mathematics, statistics and signal processing. Should have computer skills, spreadsheet skills, and be willing to learn to use other computer programs such as Matlab. The student should be able to obtain information from the indicated sources. Should also understand the need to expand his/her competences, be able to search for information sources and be ready to cooperate within the team. In addition, in terms of social competences, the student must present attitudes and features such as: honesty, responsibility, perseverance, cognitive curiosity, creativity, creative thinking, diligence, reliability, personal culture, good upbringing, respect for other people, care for laboratory equipment.

Course objective

1. Provide students with the basics of knowledge about information processing techniques and teach how to use this knowledge in practice. 2. Developing students' problem-solving skills related to the selection of appropriate information processing techniques for specific purposes with the use of computer systems. 3. Teaching the correct application of methods of information analysis and processing.

Course-related learning outcomes

Knowledge:
The student acquires knowledge in the field of mathematics including algebra, geometry, analysis, probability and elements of discrete mathematics and logic (K1_W1, K1_W5), including mathematical methods and numerical methods necessary for: description and analysis of the properties of linear and basic nonlinear dynamic and static systems, description and analysis of complex quantities, description of random processes and uncertain quantities, description and analysis of combinational and sequential logic systems, description of algorithms of control and analysis of the stability of dynamic systems, description, analysis and methods of signal processing in the time and frequency domain, numerical simulation of dynamic systems in the domain of continuous time and discrete time. The student also acquires basic knowledge of the operation and use of IT tools for these purposes (K1_W10).

Skills:
As a result of the course, the student should demonstrate skills in the use of basic methods of signal processing and analysis in the time and frequency domain and extract information from the analyzed signals (K1_U9).

Social competences:
The student is ready to critically assess the acquired knowledge, understands and feels the need for continuous training and improvement of professional, personal and social competences, can inspire and organize the learning process of other people (K1_K1). He/she is also aware of the need for a professional and responsible approach to technical issues, scrupulous reading of the documentation and environmental conditions of the used devices. Moreover, he/she is ready to follow the rules of profession ethics and requires it from others, respects the diversity of views (K1_K5).

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:
a) in the field of lectures - on the basis of answers to questions about the material discussed in previous lectures,
b) in the field of laboratories/tutorials - on the basis of the assessment of the knowledge and understanding of the current issues presented in the course.
Summative assessment:
a) in the field of lectures, verification of the assumed learning outcomes is carried out by: assessing the knowledge and skills shown in the problem-based written exam (the use of auxiliary materials, including electronic devices, is not allowed), the exam consists of 4 problem tasks; the student can get 20 points, a minimum of 10 points must be obtained for a positive mark; for outstanding students the exam may have elements of checking knowledge spread over time in the form of self-performed tasks using a variety of auxiliary materials
b) in terms of tutorials, verification of the assumed learning outcomes is carried out by: assessing the student's preparation for individual classes, continuous assessment, at each class (oral answers) - rewarding the increase in the ability to use the learned principles and methods, assessment of solving tasks partially solved during classes and partially after their completion, the assessment of knowledge and skills related to solving tasks through a final test,
c) in the field of laboratories, verification of the assumed learning outcomes is carried out by: assessing the student's preparation for individual laboratory classes and assessing the skills related to the implementation of laboratory exercises, continuous assessment, during each class (oral answers) - rewarding the increase in the ability to use the learned principles and methods, evaluation of the report prepared during the classes (this evaluation also takes into account the ability to work in a team of 2-3 people).
There is a possibility of obtaining additional points for activity during classes, in particular for:
- discussing additional aspects of the issue, the effectiveness of applying the acquired knowledge when solving a given problem,
- the ability to cooperate as part of a team practically implementing a detailed task in the laboratory,
- comments related to the improvement of teaching materials, indicating perceptual difficulties of students, enabling ongoing improvement of the teaching process.

Programme content

The lecture program includes the following topics:

1. Elements of information theory and data coding (formal definition of information - entropy and autoinformation, entropy properties, total entropy, conditional entropy and shared information, data coding, prefix code concept, Kraft's inequality, lossless data compression, Shannon coding theorem, coders and their efficiency, Shannon encoder, Shannon-Fano encoder, Huffman encoder (optimal encoder), arithmetic encoder, spectrum estimation, periodogram, Welch estimators, conversion of the probability density in automation systems).
2. Filtering random signals (processing discrete random signals, noise, white noise and Gaussian noise, adding noise, mutually weakly stationary processes, spectral power density, random signal filtration process, Wiener-Chinczyn theorem, Wiener filter, Kalman filter - description in state space).
3. Analytical signals (instantaneous signal frequency, notion of analytical signal, Hilbert transformation, time-frequency representations).
4. Wavelet transformation (principle of indeterminancy in signal pocessing, envelope and fine structure of the signal, continuous wavelet transformation, discrete wavelet transformation).
5. Speech signal and human hearing system (frequency, dynamic and spatial sound features, outer, middle and inner ear, hearing filters, sound loudness scaling, speech signal generation, speech properties, phoneme types, vocoders).
6. Compression of audio signals (sound masking, psychoacoustic model, examples of audio coding: MP3, AAC).
7. Human vision system (human eye, three-stimulus theory of vision, Grassmann's laws, primary colours and matching functions, colour as a vector in the colour space, RGB space, chromatic coordinates, luminance and chrominance, CMY and CMYK spaces, HSL (HSI) and HSB (HSV) spaces).
8. Extraction of information from images (multidimensional dynamic operations, multidimensional linear systems, multidimension convolution, linear stationary systems, separable systems, multidimensional digital filters, morphological filtration (median filters, opening and closing operations), edge recognition, image segmentation, frame calculation, Hough transformation).
9. Digital photography (basics of geometrical optics, lens types, camera structure, image registration, image matrix types, two-dimensional model of a three-dimensional scene, calibration of the vision system).
10. Image compression (lossy and lossless image compression, transparent compression, cosine transformation and jpeg algorithm, application of discrete wavelet transformation).
11. Vision signal compression (intraframe compression, single- and double-sided prediction, motion estimation and motion vectors, object-oriented coding, examples of video coding: m-jpeg, mpeg, H.264 etc.).
12. Television (history of television, television standards, vision signal, vision signal sampling, contemporary digital television, SFN technology, DVB standards, interactive television, hybrid television, CCTV and monitoring systems, development of digital television in Poland).
13. Signal separation (blind and information signal separation concepts, SVD decomposition, PCA method, ICA method, support vector machine (SVM), non-negative matrix decomposition (NMF), examples of signal separation).
14. Adaptive filtering and artificial neural networks (LMS and RLS filters, neuron models, neural network learning methods, multilayer neural networks, feedback neural networks, associative memory, cellular neural networks, convolutional and deep neural networks).
15. Human-computer interfaces (biometrics: recognition of face, voice, iris, fingerprints, gestures etc., new telecommunication systems, Internet of things and ubiquitous surveillance).

The tutorials program includes the following topics:

1. Linear and circular convolution vs correlation.
2. Linear dynamic systems. Z transformation.
3. Random signals and signal correlations. Random signal filtration.
4. Elements of information theory and data coding.
5. Hurwitz polynomials. Analog and digital filters.
6. Convertion of the probability density in automation systems.
7. Image processing.

The laboratory program includes the following topics:

1. Z transformation.
2. FIR filters.
3. IIR filters.
4. Lossless coding.
5. Lossy coding.
6. Adaptive filters.
7. Signal separation: maxim. of entropy, Infomax alg.

Course topics

The lecture program covers the following topics:
1. Elements of information theory
2. Lossless compression (data archiving, Huffman coding, arithmetic coding)
3. Digital image representations
4. Information extraction from images (image filtering)
5. Image compression
6. Audio signal compression
7. Video signal compression
8. Symmetric cryptographic algorithms
9. Asymmetric cryptographic algorithms
10. Data correction – block codes
11. Data correction – convolutional codes
12. PCA data dimensionality reduction
13. Bayesian inference (LDA)
14. Quantum algorithms
15. Summary

The tutorials program covers the following topics:
1. Linear and circular convolution and cignal correlation
2. The Z transform
3. Linear dynamic systems
4. Information theory and lossless data coding
5. Data encryption
6. Redundant coding
7. Test
8. Summary (45 min.)

The laboratory program covers the following topics:
1. Introduction to the Lab
2. FIR Filtering
3. IIR Filtering
4. Image Filtering
5. Lossless Coding
6. Lossy Coding
7. Data Encryption (Cryptool)
8. Summary (45 min.)

Teaching methods

1. Lecture: multimedia presentation, presentation illustrated with examples given on the board, solving problems, multimedia show, demonstration.
2. Tutorials: task solving, problem solving, case studies.
3. Laboratory classes: practical exercises, carrying out experiments, solving tasks, team working.

Bibliography

Basic:
1. Smith S.W., "Digital signal processing - practical handbook for engineers and scientists" (in Polish), BTC Publishing House, Warsaw 2007.
2. Przelaskowski A., Data Compression – Basics, Lossless Methods, Image Encoders (in Polish), BTC Publishing House , Warszawa 2005.
3. Mochnacki W., "Correction Codes and Cryptography, Wrocław University of Science and Technology Publishing House" (in Polish), Wrocław 2000.
4. Dąbrowski A., Figlak P., Gołębiewski R., Marciniak T., "Signal processing with the use of signal processors" (in Polish), Poznan University
of Technology Publishing House, Poznań 1998.
5. Szabatin J., "Signal theory basics" (in Polish), WKŁ Publishing House, Warsaw 2007.
6. Wojciechowski J., "Signals and systems" (in Polish), WKŁ Publishing House, Warsaw, 2008.
7. Zieliński T.P., "Digital signal processing: from theory to implementations" (in Polish), WKŁ Publishing

House, Warsaw 2013.

Additional:
1. Kulczycki P., Korbicz J., Kacprzyk J. (red. naukowa), „Automatyka, robotyka i przetwarzanie informacji", Warszawa : Wydawnictwo Naukowe PWN, 2020.
2. MitOpenCourseWare, Massachusetts Institute of Technology, http://ocw.mit.edu/ (courses: 6.011 "Introduction to Communication, Control, and Signal Processing", 6.003 "Signals and Systems").
3. Oppenheim A.V., Willsky A.S., Nawab S.H., "Signals & Systems", Pearson, 2016.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	63	2,50