COURSE DESCRIPTION CARD - SYLLABUS

Course name

Digital signal processing

Course

Field of study	Year/Semester
Automation and robotics	1/2
Area of study (specialization)	Profile of study
Automation and robotics systems	general academic
Level of study	Course offered in
Second-cycle studies	Polish
Form of study	Requirements
part-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
12	12	0
Tutorials	Projects/seminars	
0	0	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Knowledge: The student starting this course should have basic knowledge of signal theory and information processing.

Skills: The student should have the ability to use algebra in processing algorithms and the ability to obtain information from indicated sources. They should also understand the need to expand their competences and be ready to cooperate in a team.

Social Competence: In addition, the student should demonstrate such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. To provide students with expanded knowledge of digital signal processing in the field of applications in automation and robotics.

2. To show students the possibilities that digital signal processing provides, with an emphasis on information processing for use in control.

Course-related learning outcomes

Knowledge

1. The student possess extended and deepened knowledge of selected mathematical problems used in signal processing - [K2_W1].

2. The student possess detailed knowledge of selected issues of artificial intelligence and their application in digital signal processing for the purposes of automation - [K2_W2].

3. The student understands the benefits of using specialized analog and digital electronic systems - [K2_W4].

4. The student possess knowledge of adaptive algorithms - [K2_W9].

Skills

1. The student can organize self-education in order to raise and update competences related to digital signal processing - [K2_U6].

2. The student can use advanced methods of signal processing and analysis and extracting information from the analyzed signals - [K2_U11].

3. The student can evaluate the suitability and possibilities of using new signal processing algorithms for applications in the field of automation and robotics - [K2_U16].

Social competences

1. The student is aware of the need for a professional approach to the issues of digital signal processing, meticulous reading of documentation and environmental conditions in which devices and their components can operate- [K2_K2].

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 answers to questions about the material discussed in previous lectures

b) in the scope of laboratories, assesment of the assumed learning outcomes is based on:

i. assessment of student's preparation for individual sessions of laboratory classes ("entrance" test)and assessment of skills related to the implementation of laboratory exercises,

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

iii. assessment of the laboratory reports prepared partly during the classes and partly at home; this assessment also includes teamwork skills.

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

i. discuss of additional aspects of the issue,

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

iii. ability to work as part of a team that practically performs a specific task in the laboratory,

iv. comments related to the improvement of teaching materials,

v. indicating students' perceptive difficulties enabling ongoing improvement of the didactic process.

Summative assessment:

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

i. assessment of the knowledge and skills shown in the exam - written work containing problem questions and written calculation tasks; getting 50% of the number of total points give a positive rating, the questions are a detailed version of the issues made available to students in order to prepare for the exam,

ii. discussion about exam results,

b) in the scope of laboratories , it is a resultant assessment resulting from the formative assessments.

Programme content

The lecture covers the following topics:

1. Introduction to digital signal processing - differences between analog and digital signal processing, areas of knowledge used in CPS, contemporary sources of demand for CPS; microcontrollers, signal microcontrollers, signal processors, other specialized devices using CPS algorithms; software and hardware tools to quickly implement CPS algorithms.

2. Basic CPS concepts: sampling, sampling theorem, aliasing, Fourier series, linear and non-linear systems, quantization, signal-to-noise ratio, difference equation; circuit diagram - form 1 direct non-canonical IIR digital filter, system impulse response, frequency response; cascade connection of circuits, linear convolution, zeros and poles of Z-domain transmittance; Matlab as an example tool used in digital signal processing.

3. Signal transformation: purpose of signal transformation, general form of signal transform, Fourier transform as frequency transform, Parseval theorem, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Goertzel algorithm, Two-dimensional Fourier transform.

4. Discrete wavelength transformation: Haar expansion, multi-resolution signal representation, coarse representation, detail representation, orthonormality between Haar wavelets, straight and inverse Haar transform graphs; continuous wave transform, wavelets as base functions, uncertainty principle, discrete wave transform (DWT), signal analysis and synthesis, Mallat algorithm, DWT calculations in Matlab.

5. Adaptive filtering: adaptation model, deterministic and stochastic algorithm for optimal filter calculation, Wiener filter, structure of adaptive FIR filter, mean square error area, autocorrelation matrix, cross-correlation matrix, mean square error of estimation, iterative solution, steepest descent algorithm, steepest descent algorithm convergence , LMS and RLS algorithms, adaptive linear prediction, adaptive noise suppression, suppression of network interference on the example of ECG signal, adaptive echo suppression, adaptive identification of dynamic objects.

6. Artificial neural networks: neural network in adaptive signal processing, features of the natural neural network, structure of the natural neuron, linear and non-linear model of the neuron, activation functions - non-linear functions of the neuron, structure of the artificial neural network, analysis of the operation of a single neuron and multilayer network, supervised learning and unattended, weight correction delta rule, correction of nonlinear neuron weights, back propagation error algorithm, nonlinear network learning difficulties, local and global minimum, methods of implementing artificial neural networks, applications. Blind signal separation: static and dynamic model of signal mixing, blind separation of signals as a reversal of mixing, dynamic mixing in the frequency domain, indeterminacy of scale and permutation, independent component analysis (ICA), principal component analysis (PCA), infomax algorithm, entropy maximization, central limit theorem.

Laboratory exercises topics:

1. Sampling and quantization

2. Filtering the signals

3. Signal transformations

4. Adaptive filtration

5. Artificial neural networks

6. Blind signal separation

Teaching methods

1. Lecture: multimedia presentation, presentation illustrated with examples given on the board, solving problems

2. Laboratory classes: problem solving, practical exercises, conducting experiments, case studies, teamwork

Bibliography

Basic

1. Od teorii do cyfrowego przetwarzania sygnałów, Zieliński T., Akademia Górniczo-Hutnicza, Kraków, 2002

2. Intelligent signal processing, Haykin S., Kosko B., IEEE Press, 2001

Additional

1. Falki i aproksymacje, Białasiewicz J., WNT, Warszawa, 2000

2. Cyfrowe przetwarzanie sygnałów - od teorii do zastosowań, Zieliński T., WKŁ, Warszawa, 2009

3. Cyfrowe przetwarzanie sygnałów, Smith S., Wydawnictwo BTC, Warszawa, 2007

4. Cyfrowe przetwarzanie sygnałów, Stranneby D., Wydawnictwo BTC, Warszawa, 2004

5. Filtry adaptacyjne i adaptacyjne przetwarzanie sygnałów - teoria i zastosowania, Rutkowski L., WNT, Warszawa, 1994

6. Sztuczne sieci neuronowe - laboratorium, Rybarczyk A. (red.), Wydawnictwo Politechniki Poznańskiej, Poznań, 2007

7. Sieci neuronowe do przetwarzania informacji, Osowski S., Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2000

8. Adaptive Blind Signal and Image Processing: Learning Algorithms and Applications, Cichocki A., Amari S., John Wiley & Sons, Ltd, 2003

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,0
Classes requiring direct contact with the teacher	26	1,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	49	2

[1] delete or add other activities as appropriate