COURSE DESCRIPTION CARD - SYLLABUS

Course name
Smart signal processing [S2Eltech1E-ISP>IPS]

Course

Field of study
Electrical Engineering

Year/Semester
1/2

Area of study (specialization)
Smart Measurement Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

dr inż. Piotr Kuwałek
piotr.kuwalek@put.poznan.pl

Lecturers

Prerequisites

Student should have basic knowledge of mathematics, electrical engineering and programming basics, as well as the ability to work in a laboratory group. Student should also have the ability to in-depth understanding and interpretation of the informations and effective self-education in the field related to the selected field of study. Student should be aware of the need to expand their competences and should be ready to cooperate as part of the team.

Course objective

Increase of the student's knowledge of general signal theory, including advanced signal processing algorithms used in the expert systems. The student's understanding of the limitations of digital signal processing resulting from, e.g., from aliasing, spectrum leakage, problem of recreation of signal from samples. Increase of the student's knowledge in the field of signal analysis tools in the time, frequency, time and frequency domains. Increase of the student's knowledge in the field of filter design. Improvement practical skills in using engineering tools in signal processing.

Course-related learning outcomes

Knowledge:

1. Student has knowledge of the basics of signal processing theory.
2. Student has knowledge of the limitations of discrete signal processing.
3. Student has knowledge of the frequency analysis of analog and discrete signals.
4. Student has knowledge of the operation and design of digital filters.
5. Student has knowledge of advanced tools for signal processing, which are used, e.g., in expert systems.

Skills:
1. Student is able to experimentally verify the limitations of discrete signal processing.
2. Student is able to use engineering tools for the analysis and processing of analog and discrete signals.
3. Student is able to design a filter with specific properties with the use of computer aid.

Social competences:
1. Understanding a need of the act enterprisingly in the area of the advanced signal processing.
2. Understanding a need of the broad populatrization of the knowledge in the area of simple and complex signal processing tools.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
evaluation of knowledge and skills by tests. The test pass threshold is 50%. Considering activities of students in the laboratory classes as well as lectures.
Laboratory:
The skills obtained during the laboratory exercises are verified either on the basis of reports made by students at home after the exercises, or on the basis of an application prepared in a selected environment, in which advanced methods for signal processing learned during the classes are implemented. Exercises are held in a parallel form. During the laboratory classes, verbal preparation of students for the exercise is verified. Completion the laboratory classes requires the completion of all exercises and individual implementation indicated reports or applications with indicated functionalities.

Programme content

The program content covered in lectures is related to:
- conventional signal processing methods;
- modern advanced signal processing techniques that take into account automatic adaptation (so-called smart signal processing methods);
- analyzing data exhibiting additive features, i.e. multidimensional multiresolution signal analysis;
- analyzing data exhibiting multiplicative features and functional compositions, i.e. issues related to demodulation;
- using machine learning methods for signal processing.

The program content covered in laboratory classes is closely related to the program content presented in lecture classes. Laboratory classes present the possibilities of using modern programming languages for signal analysis using advanced signal processing techniques (so-called smart signal processing methods). During laboratory classes, students become familiar with the conceptual operation of selected methods and learn about their limitations in practical applications.

Course topics

Methods of education are orientated to students to motivate them to parti cipate actively in education process by discussion and reports.
Lecture:
L1: General elements of signal processing theory (signal concept, signal classification, signal-information relationship, signal representations, signal parameters, distribution signals).
L2: Signal sampling. Analysis of discrete stationary signals - DFT algorithm. Analysis of discrete non-stationary signals - STFT analysis. Introduction to the wavelet theory - CWT and DWT.
L3: Correlation analysis of the signal (autocorrelation function, cross-correlation function, relationship of the autocorrelation function with the spectrum). The problem of estimation of the fundamental frequency of a signal.
L4: Selected issues of filtering discrete signals. Statistical filters. Filters with finite and infinite impulse

response. The problem of signal decomposition and a conceptual presentation of new decomposition methods (EMD, VMD, EWT, HHT).
L5: AM/FM/PM modulation of signals and analytic representation of the signal.
L6: Basics of machine learning. Supervised and unsupervised learning. Selected methods of clustering.
L7: Smart signal processing with the use of artificial intelligence methods.
Laboratory:
Lab1: OHS + introduction to Matlab/Python.
Lab2: Introduction to Matlab/Python.
Lab3: Determination of selected signal parameters. FFT analysis of signals.
Lab4: Determination of the fundamental frequency of the signal (autocorrelation function, cepstrum, FFT, zero-crossing detection).
Lab5: Construction of statistical filters with a finite and infinite impulse response.
Lab6: Determination of the analytic representation of the signal. Signal decomposition with the use of selected empirical decomposition methods (EWT, VMD, EMD).
Lab7: Presentation of the Scikit-Learn package to support signal processing using artificial intelligence methods.

Teaching methods

Lecture: Multimedia presentations (including figures, photos, videos) with examples given on the blackboard. Theoretical issues are presented in close connection with practice.
Laboratory: carrying out laboratory exercises individually or in small teams (implementation of signal processing methods, use of engineering signal processing tools) with the help and supervision of the teacher.

Bibliography

Basic:
1. Szabatin J., Przetwarzanie sygnałów, https://doc.lagout.org/dsp/J.Szabatin-PrzetwarzanieSygnalow.pdf , 2003.
2. Zieliński T.P., Cyfrowe przetwarzanie sygnałów - od teorii do zastosowań, Wydawnictwo Komunikacji i Łączności Sp. z o.o., Warszawa 2014.
3. Marven C., Ewers G., A Simple Approach to Digital Signal Processing, John Wiley & Sons, 1996.
4. McKinney W., Python for data analysis, O'Reilly Media, 2013

Additional:
1. Tretter S.A., Communication System Design Using DSP Algorithms, Springer, Boston 2008.
2. Madisetti V., The Digital Signal Processing Handbook, 2nd ed. Boca Raton, CRC Press, FL, USA 2009.
3. Downey A.B., Digital Signal Processing in Python, Green Tea Press, Needham, Massachusetts 2016.
4. Charbit M., Digital Signal Processing (DSP) with Python Programming, Wiley-ISTE, 2017.
5. Porr Bernd, Uniwersytet w Glasgow, Kurs projektowania filtrów z Pythonem: https://www.youtube.com/user/DSPcourse/playlists.
6. Kuwałek P., AM Modulation Signal Estimation Allowing Further Research on Sources of Voltage Fluctuations, IEEE Trans. on Industrial Electronics, vol. 67, no. 8, pp. 6937-6945, 2020.
7. Kuwałek P., Estimation of Parameters Associated with Individual Sources of Voltage Fluctuations, IEEE Trans. on Power Delivery, vol. 36, no. 1, pp. 351-361, 2020.

Breakdown of average student's workload

	Hours	ECTS
Total workload	59	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	29	1,00