Digital signal processing - course description

General information

Course name	Digital signal processing
Course ID	11.9-WE-INFD-DigSignProc-Er
Faculty	Faculty of Computer Science, Electrical Engineering and Automatics
Field of study	Computer Science
Education profile	academic
Level of studies	Second-cycle Erasmus programme
Beginning semester	winter term 2022/2023

Course information

Semester	2
ECTS credits to win	5
Course type	obligatory
Teaching language	english
Author of syllabus	• dr inż. Mirosław Kozioł

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Laboratory	30	2	-	-	Credit with grade

Aim of the course

- To familiarize students with basic notions of digital signal processing.
- To provide basic knowledge about fundamentals of a spectral analysis and digital filtration of discrete signals.
- To familiarize students with the formal description of discrete systems.
- To give skills in practical implementation of a spectral analysis and filtration of discrete signals in the form of a computer program.

Prerequisites

- fundamentals of mathematical analysis (function, derivative, differential, integral, complex numbers),
- fundamentals of programing in the C language.

Scope

Fundamentals of signal theory. Notion of signal. Classifications of signals. Mathematical models of selected signals. Fourier series and Fourier transform for continuous time signals. Fourier series and Fourier transform properties. An influence of a signal observation in finite time interval on its spectrum.

Analog-to-digital and digital-to-analog conversion. Chain of signal processing during analog-to-digital and digital-to-analog conversion. Sampling, quantization, and coding. Quantization error. Spectrum of a sampled signal. Aliasing. Sampling theorem. Anti-aliasing filter. Recovery of an analog signal from samples.

Discrete Fourier transform (DFT). Derivation of amplitude and phase spectrum. Leakage. Parametric and non-parametric spectral windows. Spectrum resolution improvement by zero padding. Examples of spectral analysis of discrete-time signals and their interpretation.

Fast Fourier transform (FFT). Butterfly computation schema in radix-2 FFT algorithm. Computational profit. Computation of inverse DFT using FFT.

Linear and causal time-invariant (LTI) systems. Definitions of discrete, linear and time-invariant system. Convolution. Stability of LTI systems in BIBO sense. Definition of causal system. Difference equation.

Z-transform. The Z-transform definition. Region of convergence of Z-transform. The inverse Z-transform and methods of its determination. Z-transform properties. The transfer function. Poles and zeros of transfer function. Pole locus and stability of system.

Digital filters. Finite and infinite impulse response filters. Processing discrete-time signals by digital filters. Basic structures of digital filters. Determination and interpretation of the frequency response of digital filters. Significance of linear phase response in the processing of signal. Group delay.

Digital filter design. IIR digital filter design by bilinear transformation method. FIR digital filter design by method based on the windowed Fourier series.

Teaching methods

- Lecture: conventional/traditional lecture with elements of discussion.
- Laboratory: laboratory exercises, work in groups with elements of discussion.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form

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Student can write programs in C language, which make spectral analysis of signals and their filtering with the application of digital filters with finite and infinite impulse response.		• an ongoing monitoring during classes	• Laboratory
Student can describe a discrete system using differential equations and transmittance.		• an exam - oral, descriptive, test and other	• Lecture
Student knows basic notions of digital signal processing.		• an exam - oral, descriptive, test and other	• Lecture
Student can use digital signal processing to analyze discrete signals, perform its spectral analysis, and interpret the obtained graphs of spectra.		• an exam - oral, descriptive, test and other • an ongoing monitoring during classes	• Lecture • Laboratory

Assignment conditions

- Lecture: to receive a final passing grade student has to obtain positive grade from the final exam.
- Laboratory: to receive a final passing grade student has to obtain positive grades for all laboratory exercises provided in the laboratory syllabus.

Calculation of the final grade = lecture 55% + laboratory 45%

Recommended reading

1. Lyons R.G.: Understanding Digital Signal Processing, Prentice Hall, 2004
2. Mitra S.: Digital Signal Processing: A Computer-Based Approach, McGraw-Hill, 2005
3. Orfanidis S.J.: Introduction *to Signal Processing*, Prentice Hall, 1999
4. Oppenheim A.V., Schafer R.W., Buck J.R.: *Discrete-Time Signal Processing*, Prentice Hall, 1999

Further reading

1. Mitra S.K.: *Digital Signal Processing. A Computer-Based Approach*, McGraw-Hill, 2006.
2. Oppenheim A.V., Schafer R.W., Buck J.R.: *Discrete-Time Signal Processing*, Pearson Education Limited, 2015.
3. Oppenheim A.V., Willsky A.S., Nawab H.: *Signals & Systems*, Pearson Education Limited, 2013.
4. Owen M.: *Practical signal processing*, Cambridge University Press, 2007.

Notes

1. Orfanidis S.J.: *Introduction to Signal Processing*. Prentice Hall, 2009. Available at: http://www.ece.rutgers.edu/~orfanidi/intro2sp/orfanidis-i2sp.pdf
2. Smith S.W.: *The Scientist and Engineer’s Guide to Digital Signal Processing.* California Technical Publishing, Sand Diego, California 1999. Available at: http://www.dspguide.com/pdfbook.htm

Modified by dr inż. Mirosław Kozioł (last modification: 12-04-2022 13:40)