DOCTORAL STUDY

COURSE DESCRIPTION

Course title	Scientific area	Faculty	Department
Digital signal processing	Informatics Engineering (T 007)	Faculty of Mathematics and Informatics	Institute of Data Science and Digital Technologies

Methods of studies	Credits, ECTS	Methods of studies	Credits, ECTS
Lectures	1 (autumn sem.)	Consultation	1
Individual work	4	Seminars	1

Course summary

The main goal of the course is to obtain and deepen knowledge in digital signal processing. The course provides basic and highly specialized knowledge, enabling a thorough analysis of one-dimensional and two-dimensional signals. The course focuses on the fundamental properties of signals and frequency-domain signal analysis methods, while also introducing alternative analysis methods. At the end of the course, students are introduced to the key principles and concepts of applying artificial neural networks to digital signal processing.

The studies are carried out in the following forms: individual work (literature analysis, practical assignments), seminars, and consultations (as required). The final format of the studies is agreed upon individually. The topics and assignments may align with the student's doctoral research.

- Theoretical knowledge is acquired through independent study of the literature and consultation.
- Theoretical knowledge is reinforced through experimental work in digital signal processing: various assignments on one-dimensional and two-dimensional signal processing. Course participants are assigned up to 5 practical assignments covering the course's main topics.
- During seminars, presentations are given on pre-agreed topics, and the results of practical assignments are discussed.

The content of the course:

1. SIGNALS AND SYSTEMS. Signal definition. Types of signals. Signal parameters. System concept. Types of systems. Stability and causality of the systems.
2. SIGNAL DIGITIZATION. Sampling. Nyquist sampling theorem. Quantization. Coding. Signal interpolation.
3. ANALYSIS OF SIGNALS IN THE TIME DOMAIN. Operations and manipulations with signals. Correlation and autocorrelation. Convolution and deconvolution. Difference equations. Impulse response of the system. Time domain characteristics.
4. FREQUENCY ANALYSIS OF SIGNALS. The concept of the signal transform. Fourier transform. Discrete Fourier transform. Fast Fourier transform. Frequency characteristics of signals and systems. Parametric frequency analysis. The concept of cepstrum. Cepstral analysis of signals.
5. ALTERNATIVE ANALYSIS TECHNIQUES OF SIGNALS. Parametric and nonparametric analysis of signals. Hartley transform. Sinusoidal and cosinusoidal transforms. Wavelet theory and transform. Other transform types.
6. Z-TRANSFORM. Convergence of z-transform. Properties of z-transform. Z-transform of signals and systems. Rational z-transforms. The inverse z-transform.

7. FILTERS. DESIGN OF FILTERS. Filter concept. Characteristics of filters. Infinite-impulse-response (IIR) and finite-impulse-response (FIR) filters. Adaptive filters. Design of IIR filters. Design of FIR filters. 8. SIGNAL PROCESSING USING ARTIFICIAL NEURAL NETWORKS. Signal representation. Data augmentation. Optimization of model parameters. Integration of digital signal knowledge into models.
Literature list
S. Palani. *Principles of digital signal processing*. 2022, Springer, 689 psl. (el. išteklius).
T. Holton. *Digital signal processing: principles and applications*. 2021, San Francisco State University, 1032 psl. (el. išteklius).
J. M. Carvalho. *Digital signal processing*. 2019, Momentum Press, 143 psl. (el. išteklius).
J. G. Proakis, D. G. Manolakis. *Digital signal processing: principles, algorithms, and applications.* 2014, 4-asis leidimas, 1156 psl.

Consulting persons	Scientific degree	Key publications
Gražina Korvel	D. Sc.	https://elaba.mb.vu.lt/dmsti/?aut=Gražina+Korvel
Gintautas Tamulevičius	D. Sc.	https://elaba.mb.vu.lt/dmsti/?aut=Gintautas+Tamulevičius
Povilas Treigys	D. Sc.	https://elaba.mb.vu.lt/dmsti/?aut=Povilas+Treigys