COURSE DESCRIPTION CARD

Course name	**Advanced time-frequency algorithms for processing of non-stationary signals**				
Course type	**optional**	**Course code**	**SDPB0013**	**ECTS credits**	**2**
Forms and number of hours	**Lecture: 20 h**	**Scientific discipline**	**automatic control, electronics and electrical engineering**		
Course objectives	To acquaint PhD students with the theoretical foundations of time-frequency algorithms including linear time-frequency transformations, higher order time-frequency transformations, time-scale transformations. Overview of the basic applications of time-frequency transformations in the classification, detection and estimation of non-stationary signals.				
Course content	1. Basic concepts of time-frequency analysis: non-stationary signal, location in time and frequency, Heisenberg-Gabor uncertainty principle, instantaneous frequency. 2. Linear time-frequency transforms: Short Time Fourier Transform STFT, Gabor expansion, discrete Gabor expansion, wavelet transform (continuous wavelet transform, discrete wavelet transform). 3. Quadratic (energy) time-frequency transformations: Cohen class transformations (Wigner-Ville transform, Choi-Williams transform), affine transformations. 4. Adaptive representations: adaptive spectrogram, adaptive Gabor representation. 5. Higher order time-frequency representations: polynomial Wigner-Ville transform (PWVD), higher order ambiguity function (HAF). 6. Applications of join time-frequency analysis: classification, detection, estimation of non-stationary signals, radar applications, extraction of information from a time-frequency image.				
Teaching methods	A multimedia lecture, enriched with simulations experiments				
Assessment method	Lecture - written test				

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study for the 8th level of Polish Qualification Framework (PRK)**	**Methods of assessing the learning outcomes**
LO1	PhD student describes the basic concepts of time-frequency analysis	SD_W1	Written test
LO2	PhD student defines linear time-frequency and time-scale transformations	SD_W1	Written test
LO3	PhD student defines higher order time-frequency transformations	SD_W1	Written test

LO4	PhD student is able to formulate the problem of time-frequency classification, select appropriate detection and estimation algorithms in the time-frequency domain	SD_W3	Written test

Student workload (in hours)	
Lecture	20
Consultations	2
The unassisted studentwork	20
Implementation of project tasks and preparation for and participation in exams/tests	8
Total	**50**
ECTS credits	**2**

Basic references	1. L. Debnath. (Ed.), *Wavelet transforms and time-frequency signal analysis*, Springer, Berlin, 2001. 2. T. Zieliński*, Cyfrowe przetwarzanie sygnałów. Od teorii do zastosowań*, WKŁ, Warszawa, 2005. 3. F. Hlawatsch., F. Auger, *Time-Frequency Analysis, Concepts and Methods*, John Wiley & Sons, Inc., London, 2008. 4. B. Boashash. (Ed), *Time-Frequency Signal Analysis and Processing, Comprehensive Reference*, Academic Press, Elsevier, Amsterdam, 2016. 5. V. G. Chen Ling H, *Time-frequency transforms for radar imaging and signal processing*, Atrech House, London, 2002.
Supplementary references	1. A. Boggess, F.J. Narcowich, *A first course in wavelets with Fourier analysis*. John Wiley and Sons, New York, 2009. 2. AW. Moukadem, D.O. Abdeslam, A. Dieterlen, Time-Frequency Domain for Segmentation and Classification of Non-Stationary Signals, Wiley, NJ, 2014.
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