

## Subject card

Subject name and code	Hardware Support of Artificial Intelligence Algorithms, PG_00064019							
Field of study	Electronics and Telecommunications							
Date of commencement of studies	February 2025		Academic year of realisation of subject			2024/2025		
Education level	second-cycle studies		Subject group			Optional subject group Specialty subject group Subject group related to scientific research in the field of study		
Mode of study	Full-time studies		Mode of delivery			at the university		
Year of study	1		Language of instruction			Polish		
Semester of study	1		ECTS credits			2.0		
Learning profile	general academic profile		Assessment form			assessment		
Conducting unit	Department of Micros	electronic Syste	ems -> Faculty	of Electronics,	Telecor	mmunic	ations and In	formatics
Name and surname	Subject supervisor	dr hab. inż. Waldemar Jendernalik						
of lecturer (lecturers)	Teachers		dr hab. inż. Waldemar Jendernalik				_	
Lesson types and methods	Lesson type	Lecture	Tutorial	Laboratory	Projec	t	Seminar	SUM
of instruction	Number of study hours	15.0	0.0	15.0	0.0		0.0	30
	E-learning hours inclu	ided: 0.0						
Learning activity and number of study hours	Learning activity	Participation in classes include plan		Participation in consultation hours		Self-study		SUM
	Number of study hours	30	3.0		17.0		50	
Subject objectives	The student learns about the design of integrated circuits supporting artificial intelligence algorithms.							
Learning outcomes	Course out				Method of verification [SW1] Assessment of factual knowledge			
	[K7_W03] knows and understands, to an increased extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum							
	[K7_U07] can apply advanced methods of process and function support, specific to the field of study		The student can correctly select software tools to implement design processes.			[SU4] Assessment of ability to use methods and tools		
[K7_W04] knows and understands, to an increased extent, the principles, methods and techniques of programming and the principles of computer software development or programming devices or controllers using microprocessors or other elements or programmable devices specific to the field of study, and organization of work of systems using computers or such devices  [K7_K02] is ready to provide critical evaluation of received content and to acknowledge the importance of knowledge in solving cognitive and practical problems		The student has in-depth knowledge of professional computer tools for designing large-scale integrated circuits.			[SW1] Assessment of factual knowledge			
		The student uses knowledge from lectures and laboratories to solve practical problems in the design of large-scale-integrated systems.			[SK5] Assessment of ability to solve problems that arise in practice			

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1. Artificial Intelligence (AI) - basic terms and definitions. 2. Problems dimitations rotated to physical implementation. 3. Integrated circuits for supporting AI - a review of selected solutions. 4. Implementation of operators and functions (addition, multiplication, convolution, etc.) in integrated circuits. 5. Problems of performance, power consumption and area.  Prerequisites and co-requisites and co-requisites Subject passing orders Basic illustrature Supplementary liberature Supplementary liberature Supplementary liberature Operations of the functional supplementary liberature Supplementary liberature Operations of the functional supplementary liberature	Subject contents								
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### Recommended reading    Practical exercises		No requirements							
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Supplementary literature  O. Dreessen. Introduction to Convolutional Neural Networks: What Is Machine Learning?Part 1. Analog Dialogue Magazine, vol. 57, Feb. 2023. https://www.nalog.com/en/resources/analog-dialogue/articles/max/8000-article-series-part-1.html  O. Dreessen. Training Convolutional Neural Networks: What Is Machine Learning?Part 2. Analog Dialogue Magazine, vol. 57, Mar. 2023. https://www.analog.com/en/resources/analog-dialogue/articles/training-convolutional-neural-networks-white-machine-learning-part-2.html  O. Dreessen. Hardware Conversion of Convolutional Neural Networks: What Is Machine Learning?Part 3. Analog Dialogue Magazine, vol. 57, Apr. 2023. https://www.analog.com/en/resources/analog-dialogue/articles/arti	and criteria	Practical exercises	60.0%	100.0%					
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What Is Machine Learning?Part 3. Analog Dialogue Magazine, vol. 57, Apr. 2023. https://www.nalog.com/en/resources/analog-dialogue/articles/hardware-conversion-of-cnns-what-is-machine-learning-part-3.html  Dudek, P.; Richardson, T.; Bose, L.; Carey, S.; Chen, J.; Greatwood, C.; Liu, Y.; Mayol-Cuevas, W. Sensor-level computer vision with pixel processor arrays for agile robots. Sci. Robot. 2022. DOI: 10.1126/scirobotics.abl7755.  W. Shan et al. A 510nW 0.41V Low-Memory Low-Computation Keyword-Spotting Chip Using Serial FFT-Based MFCC and Binarized Depthwise Separable Convolutional Neural Network in 28nm CMOS. ISSCC 2022, USA. DOI: 10.1109/ISSCC19947.2020.9063000.  K. Kim et al. A 23W Solar-Powered Keyword-Spotting ASIC with Ring-Oscillator-Based Time-Domain Feature Extraction. ISSCC 2022, USA. DOI: 10.1109/ISSCC42614.2022.9731708.  M. Yang et al. Design of an always-on deep neural network-based 1 µW voice activity detector aided with a customized software model for analog feature extraction. IEEE JSSC, 2019. DOI: 10.1109/JSSC. 2019.2894360.  M. Lefebvre et al. A 0.2-to-3.6TOPS/W Programmable Convolutional Imager SoC with In-Sensor Current-Domain Ternary-Weighted MAC Operations for Feature Extraction and Region-of-interest Detection. IEEE ISSCC 2021. DOI: 10.1109/ISSCC42613.2021.9365839.			Learning?Part 2. Analog Dialogue Magazine, vol. 57, Mar. 2023. https://www.analog.com/en/resources/analog-dialogue/articles/training-						
C.; Liu, Y.; Mayol-Cuevas, W. Sensor-levél computer vision with pixel processor arrays for agile robots. Sci. Robot. 2022. DOI: 10.1126/scirobotics.abl7755.  W. Shan et al. A 510nW 0.41V Low-Memory Low-Computation Keyword-Spotting Chip Using Serial FFT-Based MFCC and Binarized Depthwise Separable Convolutional Neural Network in 28nm CMOS. ISSCC 2022, USA. DOI: 10.1109/ISSCC19947.2020.9063000.  K. Kim et al. A 23W Solar-Powered Keyword-Spotting ASIC with Ring-Oscillator-Based Time-Domain Feature Extraction. ISSCC 2022, USA. DOI: 10.1109/ISSCC42614.2022.9731708.  M. Yang et al. Design of an always-on deep neural network-based 1 µW voice activity detector aided with a customized software model for analog feature extraction. IEEE JSSC, 2019. DOI: 10.1109/JSSC. 2019.2894360.  M. Lefebvre et al. A 0.2-to-3.6TOPS/W Programmable Convolutional Imager SoC with In-Sensor Current-Domain Ternary-Weighted MAC Operations for Feature Extraction and Region-of-Interest Detection. IEEE ISSCC 2021. DOI: 10.1109/ISSCC42613.2021.9365839.			What Is Machine Learning?Part 3. Analog Dialogue Magazine, vol. 57, Apr. 2023. https://www.analog.com/en/resources/analog-dialogue/articles/hardware-conversion-of-cnns-what-is-machine-learning-						
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eResources addresses Adresy na platformie eNauczanie:			Imager SoC with In-Sensor Current-Domain Ternary-Weighted MAC Operations for Feature Extraction and Region-of-Interest Detection.						
		eResources addresses	Adresy na platformie eNauczanie:						

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Example issues/ example questions/ tasks being completed	
Work placement	Not applicable

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