



## Subject card

Subject name and code	High Performance Machine Learning, PG_00047495						
Field of study	Informatics						
Date of commencement of studies	February 2024	Academic year of realisation of subject			2024/2025		
Education level	second-cycle studies	Subject group			Optional 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	2	Language of instruction			English		
Semester of study	3	ECTS credits			3.0		
Learning profile	general academic profile	Assessment form			assessment		
Conducting unit	Department of Computer Architecture -> Faculty of Electronics, Telecommunications and Informatics						
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Tomasz Boiński					
	Teachers	dr inż. Tomasz Boiński					
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	0.0	0.0	30
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	30		6.0		39.0	75
Subject objectives	The aim of the course is presentation of methods for optimizing execution time of algorithms used in Machine Learning utilizing modern frameworks and hardware.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_U04] can apply knowledge of programming methods and techniques as well as select and apply appropriate programming methods and tools in computer software development or programming devices or controllers using microprocessors or programmable elements or systems specific to the field of study, making assessment and critical analysis of the prepared software as well as a synthesis and creative interpretation of information presented with it	The student can use the Jupyter notebook environment for running and analyzing advanced computations in the field of machine learning. The student can implement advanced advanced training process handling mechanisms, as well as multi-process communication in the TensorFlow environment.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools
	[K7_U06] can analyse the operation of components, circuits and systems related to the field of study; measure their parameters; examine technical specifications; interpret obtained results and draw conclusions	The student can monitor the parameters and current utilization of CPUs and GPUs, memory and hard drives, broken down to individual processes in the GNU/Linux operating system. The student can perform performance profiling of particular operations in computation graphs used in machine learning.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools
	[K7_U07] can apply advanced methods of process and function support, specific to the field of study	The student knows methods for reducing execution time of machine learning computations through selection of appropriate algorithms, vectorization, efficient utilization of available computing resources and parallelization.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
	[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.	The student knows the architecture of GPU-based computing systems, utilized for machine learning computations. The student can find bottlenecks among particular stages of machine learning model training process.	[SW1] Assessment of factual knowledge
	[K7_W42] Knows and understands, to an increased extent, the principles and trends in the analysis and design of local and distributed IT systems and the basics of computer modeling and computerization of complex cognitive and decision-making processes.	Student knows contemporary trends in designing computing systems dedicated for machine learning applications and is able to analyze their performance.	[SW1] Assessment of factual knowledge
Subject contents	<ol style="list-style-type: none"> <li>1. Introduction to the course, motivations for High Performance Computing in Machine Learning</li> <li>2. Recap of primitives, loss functions and gradient methods used in Machine Learning</li> <li>3. Methods for minimizing evaluation time of Machine Learning models</li> <li>4. Methods for Machine Learning model training parallelization</li> <li>5. Monitoring utilization of distributed computing resources used in Machine Learning</li> <li>6. Techniques for profiling Machine Learning applications</li> <li>7. Methods for distributed data representation and loading for artificial neural network training</li> <li>8. Characteristics of hardware used for efficient Machine Learning</li> <li>9. Parallelization capabilities of chosen Machine Learning frameworks</li> <li>10. Case studies of artificial neural network training optimization in the fields of text analysis, visual and speech recognition</li> </ol>		
Prerequisites and co-requisites	Basic knowledge in the fields of parallel computing and machine learning, programming in Python.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	laboratories	50.0%	50.0%
	mid-term test	50.0%	50.0%
Recommended reading	Basic literature	B. Sjardin, L. Massaron, and A. Boschetti, Large scale machine learning with Python. 2016. M. R. Karim and Md. Mahedi Kaysar, Large Scale Machine Learning with Spark. Packt Publishing, 2016.	

	Supplementary literature	<p>F. Seide, H. Fu, J. Droppo, G. Li, and D. Yu, "On parallelizability of stochastic gradient descent for speech DNNs," in 2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2014, pp. 235–239.</p> <p>J. Dean et al., "Large scale distributed deep networks," in Advances in Neural Information Processing Systems, 2012, pp. 1223–1231.</p> <p>J. Keuper and F. J. Preundt, "Distributed Training of Deep Neural Networks: Theoretical and Practical Limits of Parallel Scalability," in 2016 2nd Workshop on Machine Learning in HPC Environments (MLHPC), 2016, pp. 19–26.</p> <p>Gupta, S.; Zhang, W. &amp; Milthorpe, J. (2015), 'Model Accuracy and Runtime Tradeoff in Distributed Deep Learning.', CoRR abs/1509.04210.</p>
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	<p>Evaluating performance of chosen parallelization methods for artificial neural network training.</p> <p>Analyzing the influence of chosen optimization methods on model quality for a chosen application.</p> <p>Comparing capabilities of chosen Machine Learning frameworks based on a chosen application.</p> <p>Comparing performance of chosen hardware models for a chosen Machine Learning application.</p>	
Work placement	Not applicable	