



Subject card

Subject name and code	Applications of Artificial Intelligence in Optimization, PG_00064022						
Field of study	Electronics and Telecommunications						
Date of commencement of studies	February 2027	Academic year of realisation of subject			2026/2027		
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			exam		
Conducting unit	Department of Microelectronic Systems -> Faculty of Electronics Telecommunications and Informatics -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Anna Pietrenko-Dąbrowska					
	Teachers	prof. dr hab. inż. Anna Pietrenko-Dąbrowska					
Lesson types	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		4.0		16.0	50
Subject objectives	The aim of the course is competence development in the practical application of artificial intelligence methods for the optimization of engineering problems, with particular emphasis on design tasks, informed selection of digital tools, efficient use of computational resources, and evaluation of the effectiveness of proposed solutions.						

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 is capable of applying specific modern algorithmic approaches to solving complex design tasks, including independently selecting, planning, and implementing modeling and optimization procedures using digital tools, taking practical engineering aspects into account.	[SU1] Assessment of task fulfilment
	[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	The student is familiar with artificial intelligence methods used in the engineering optimization, is able to analyze the stages of this process, and can consciously select algorithms and digital tools to solve real engineering problems, taking into account the quality, and efficiency of the proposed solutions.	[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	The student is able to use digital tools, including artificial intelligence methods, to analyze and implement the engineering system design process, understanding the importance of individual design stages for the quality, computational efficiency, and reliability of the resulting solutions.	[SW1] Assessment of factual knowledge
Subject contents	<p>Course content – lecture</p> <ol style="list-style-type: none"> 1. Introduction to programming and engineering computations in the Matlab environment. Engineering design using artificial intelligence methods. 2. Basic concepts and quantities used in modeling, design, and optimization of engineering systems. Introduction to the mathematical notation. 3. Introduction to engineering design optimization: objective function, unconstrained and constrained optimization problems, classification of optimization algorithms. Implementation of engineering projects using digital tools. 4. Local optimization using gradient-based algorithms. Practical aspects: properties of the objective function, sensitivity to initial solutions, and computational complexity. 5. Optimization using gradient-free algorithms. Solving computational problems where the gradient of the objective function is unavailable or difficult to compute. 6. Solving optimization tasks in engineering systems using Matlab programming environment. Application of digital tools for modeling and design. 7. Stochastic methods: random search, simulated annealing, population-based methods, particle swarm optimization. Analysis of computational complexity, repeatability of obtained solutions, and design quality. 8. Genetic and evolutionary algorithms: representation, encoding/decoding, mutation, crossover, selection. Analysis of computational complexity and design quality. 9. Multi-objective optimization. Practical aspects of engineering design. Use of artificial intelligence methods to solve decision-making problems. 10. Surrogate models and surrogate-based optimization. Design of experiment, sequential sampling. Practical selection of modeling methods, data acquisition cost. 11. Application of surrogate models in the engineering design. Data-driven models and physical models. 12. Selection and application of optimization methods in practical engineering projects. Practical aspects, selection of artificial intelligence techniques and available digital tools. <hr/> <p>Course content – laboratory</p> <ol style="list-style-type: none"> 1. Data visualization. 2. Traveling salesman problem. 3. Element placement. 4. Minimization of multivariable functions. 5. Approximation in the least-squares sense. 6. Random search. 7. Multiple-run gradient-based search using random starting points. 8. Optimization using steepest descent, conjugate gradient, and quasi-Newton methods. 9. Optimization using gradient-free algorithms: pattern search, simplex method. 10. Optimization using genetic algorithms and particle swarm optimization. 11. Classical multicriteria optimization and the weighted sum method. 12. Optimization-based sampling. Latin Hypercube sampling. 		

Prerequisites and co-requisites	Knowledge of mathematics at the undergraduate level		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Attendance	80.0%	10.0%
	Project tasks	50.0%	60.0%
	Lecture	50.0%	30.0%
Recommended reading	Basic literature	<ol style="list-style-type: none"> 1. J. Nocedal, S.J. Wright, <i>Numerical Optimization</i>, Springer Science, 2006 2. S. S. Rao, <i>Engineering optimization: Theory and practice</i>, Wiley, 2019. 3. J. Stadnicki, <i>Teoria i praktyka rozwiązywania zadań optymalizacji</i>, PWN, 2017. 4. Matlab documentation 	
	Supplementary literature	<ol style="list-style-type: none"> 1. Z. Michalewicz, <i>Genetic algorithms + data structures = evolution programs</i>, 3rd edn, Springer, New York, 1996. 2. T. Back, D.B. Fogel, and Z. Michalewicz (Editors), <i>Evolutionary computation 1: basic algorithms and operators</i>, Taylor & Francis Group, 2000. 3. D.B. Fogel, <i>Evolutionary computation: toward a new philosophy of machine intelligence</i>, IEEE Press, 2006. 4. C.A. Coello Coello, G.B. Lamont, and D.A Van Veldhuizen, <i>Evolutionary algorithms for solving multi-objective problems</i>, 2nd ed, Springer-Verlag, 2007. 5. K.C. Tan, E.F. Khor, and T.H. Lee, <i>Multiobjective evolutionary algorithms and applications</i>, Springer-Verlag, 2005. 6. K. Palmer and K.-L. Tsui, A minimum bias Latin hypercube design, <i>IIE Transactions</i>, vol. 33, pp. 793-808, 2001. 	
	eResources addresses		
Example issues/ example questions/ tasks being completed			
Practical activities within the subject	Not applicable		

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