

Subject card

Subject name and code	Advanced optimization techniques, PG_00063188								
Field of study	Automation, Robotics and Control Systems								
Date of commencement of studies	February 2023		Academic year of realisation of subject			2023/2024			
Education level	second-cycle studies		Subject group						
Mode of study	Full-time studies		Mode of delivery			at the university			
Year of study	2		Language of instruction			Polish			
Semester of study	3		ECTS credits			3.0			
Learning profile	general academic profile		Assessment form			assessment			
Conducting unit	Katedra Inteligentnych Systemów Sterowania i Wspomagania Decyzji -> Faculty of Electrical and Control Engineering					ind Control			
Name and surname	Subject supervisor		dr inż. Jarosław Tarnawski						
of lecturer (lecturers)	Teachers								
Lesson types and methods of instruction	esson type Lecture		Tutorial	Laboratory Project		t	Seminar	SUM	
	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 includ plan	n didactic led in study	Participation i consultation h	n Iours	Self-study		SUM	
	Number of study hours	30		10.0		40.0		80	
Subject objectives	Deepening knowledge about the theory of key methods for solving optimization tasks. Recognizing the type of optimization task and selecting the appropriate method and solver. Practical skills in defining an optimization task using existing packages. Ability to independently build software containing methods for solving optimization tasks. Knowledge of the principles of taking into account constraints (on parameters, equality and inequality) in optimization problems. Application of optimization in the synthesis of control systems and decision support systems.								
Learning outcomes	Course outcome		Subject outcome			Method of verification			
	K7_W06		The student is able to apply optimization methods in the synthesis of control systems and decision support systems.			[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects			
	K7_U04		The student is able to further his/ her education by searching, studying and using the knowledge contained in scientific articles. The student has the ability to work with technical documentation of optimization software			[SU4] Assessment of ability to use methods and tools [SU2] Assessment of ability to analyse information			
Subject contents	Nonlinear least squares method - Levenberg-Marquardt method and Trust Region Reflective. Recursive optimization methods Normalized Gradient Method, Recursive Least Squares. Implementation in Matlab and PLC for the purpose of estimating parameters of a real object model. Global optimization methods: simulated annealing, GA genetic algorithms, evolutionary algorithms ES-(µ,), ES-(µ +), CMA-ES, DE, review of the properties of other methods inspired by evolution and swarming. Introducing constraints (on parameters, equality, inequality) to evolutionary algorithms. Practical programming in the Matlab environment: Optimization Toolbox (LP, MILP, QP, SOCP, NLP, constrained linear least squares, nonlinear least squares), Global Optimization (GlobalSearch and MultiStart, Surrogate Optimization, Pattern Search, Genetic Algorithm, Particle Swarm, Simulated Annealing, Multiobjective Optimization). Alternative optimization packages: GAMS, TOMLAB. External optimization libraries and their integration into your own programs in C++, Python, etc. Application of parallel computing technology in graphics cards using CUDA in optimization. Model construction and search by optimizing model parameters based on available experimental data (model-fitting, curve-fitting).								
Prerequisites and co-requisites									
Assessment methods and criteria	Subject passing criteria		Passing threshold			Percentage of the final grade			
	Project		50.0%			50.0%			
	Lecture		50.0%			50.0%			
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Recommended reading	Basic literature	Soderstrom T., Stoica P., Identyfikacja systemów, Wydawnictwo Naukowe PWN 1997					
		D. E. Goldberg, Algorytmy genetyczne i ich zastosowania, WNT, 1995					
		Michalewicz, Zbigniew. Algorytmy genetyczne + struktury danych. Polska: Wydawnictwa Naukowo-Techniczne, 1996.					
		R. Schaefer, Podstawy genetycznej optymalizacji globalnej, Wydawnictwo Uniwersytetu Jagiellońskiego, 2002					
		J. Arabas, Wykłady z algorytmów ewolucyjnych, WNT, 2004					
		H. P. Schwefel, Numerical Optimization of Computer Models, John Wiley & Sons, New York,1981					
		Hans-Paul Schwefel. Evolution and Optimum Seeking. Wiley- Interscience, New York, 1st edition edition, 1995.					
		Thomas Bäck, Christophe Foussette, Peter Krause, Contemporary Evolution Strategies (Natural Computing Series), Springer, 2013					
Supple							
	Supplementary literature	Marquardt, D. An Algorithm for Least-squares Estimation of Nonlinear Parameters. SIAM Journal Applied Mathematics, Vol. 11, 1963, pp. 431441.					
		Moré, J. J. The Levenberg-Marquardt Algorithm: Implementation and Theory. Numerical Analysis, ed. G. A. Watson, Lecture Notes in Mathematics 630, Springer Verlag, 1977, pp. 105116.					
		Coleman, T.F. and Y. Li. An Interior, Trust Region Approach for Nonlinear Minimization Subject to Bounds. SIAM Journal on Optimization, Vol. 6, 1996, pp. 418445, 2011					
		Efrén Mezura-Montes, Carlos A. Coello Coello, Constraint-handling in nature-inspired numerical optimization: Past, present and future, Swarm and Evolutionary Computation, Volume 1, Issue 4,					
		Carlos A. Coello Coello, Theoretical and numerical constraint-handling techniques used with evolutionary algorithms: a survey of the state of the art, Computer Methods in Applied Mechanics and Engineering, 2002					
	eResources addresses	Adresy na platformie eNauczanie:					
Example issues/ example questions/ tasks being completed	Study on the differences between gradient and non-gradient optimization methods with a recommendation to use a specific method for a specific problem. Report on the practical formulation of optimization tasks in the Matlab package (Isqnonlin, GA). Development of an evolutionary strategy code ES-(μ +), ES-(μ ,) taking into account constraints (for parameters, equality and inequality).						
Work placement	Not applicable						