GDAŃSK UNIVERSITY OF TECHNOLOGY

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		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Jarosław Tarnawski	
	Teachers		

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	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%

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
	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 (lsqnonlin, GA). Development of an evolutionary strategy code ES-(μ +), ES-(μ,) taking into account constraints (for parameters, equality and inequality).	
Work placement	Not applicable	