GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Optimization methods, PG_00060231		
Field of study	Technical Physics		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2025/2026
Education level	first-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	3	Language of instruction	Polish
Semester of study	6	ECTS credits	6.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Division of Electron Collisions Physics -> Institute of Physics and Applied Computer Science -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr Maciej Kuna	
	Teachers		

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	30.0	0.0	0.0	60
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	60	5.0	85.0	150

Subject objectives

The aim of the lecture is to present classical and machine learning inspired optimization methods to allow quick implementation them in the form of appropriate algorithms.There are discussed in the lecture modern optimizing algorithms with an emphasis on their inspiration in physics and biology.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_K01] Understands the need to learn and improve professional and personal competencies. Can inspire and organize other people’s learning process	The student is aware of changes in modern optimization.	[SK5] Assessment of ability to solve problems that arise in practice
[K6_W03] Has systematized knowledge of higher mathematics, including algebra, analysis, probability theory and numerical methods, allowing for basic description, understanding and modelling of physical phenomena and some technical processes.	The student understands how to apply mathematical analysis and algebra tools to evaluate the modeling of phenomena.	[SW2] Assessment of knowledge contained in presentation
[K6_U04] Can plan and conduct experiments, critically analyze their results, draw conclusions and form opinions. Has laboratory work experience.	The student knows algorithmic methods for verifying and analyzing data.	[SU4] Assessment of ability to use methods and tools

Subject contents

Course content – lecture

Mathematical foundations of optimization. Numerical linear algebra. Vector norms, operations on vectors and matrices. Mathematical analysis. Conditions of existence of extremes of functions of one and many variables and methods of their checking. Methods of finding derivatives.
Classic optimization methods. Algorithms for optimizing functions of one variable: dividing the interval into half, golden ratio, Fibonacci, Newton-Raphson and secant method. Algorithms for optimization of multivariable functions: cubic interpolation, Nelder-Mead, conjugate directions, Cauchy, Newton.
Optimization issues in machine learning:
Linear regression, simple gradient regression, polynomial regression, regularized linear models, logistic regression, linear and non-linear SVM regression, decision trees, team learning, including random forests, dimensionality reduction, deep neural network training.

Course content – laboratory

PyCharm: IDE for Software Development with Python
Linear regression
Singular value decomposition (SVD) and pseudo-inverse of a matrix
Optimization using KKT conditions
Scikit-learn
Non-linear SVM (changing kernels and kernel parameters)
Bagging classifier
VotingClassifier (hard and soft voting)
Kernel PCA using radial basis functions
Neural Networks: Stochastic Gradient Descent, Momentum, RMSprop, AdaGrad, Adam
Tensorflow
Keras: functional API
Q Learning, Generative Adversarial Networks

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Positive completion of laboratories	50.0%	50.0%
Test	50.0%	50.0%

Recommended reading

Basic literature

1. A. Geron - Uczenie maszynowe z użyciem Scikit-Learn i TensorFlow, 2 wydanie Helion, 2020
2. Singiresu S.Rao Engineering Optymalization - Theory and Practie, Wiley 2009.
3. Findestein. Metody obliczeniowe optymalizacji, PWN, 1977
4. R.Wieczorkowski, Z, Zieliński, Komputerowe generatory liczb losowych, WNT, 1997
5. X. Yang. Engineering Optimization - An Introduction With Metaheuristic Applications, Wiley, 2010

Supplementary literature

1. K.Kukuła, Badania Operacyjne w przykładach i zadaniach, PWN 2011
2. M. Wahde, Biologically Inspired Optimization Methods - An Introduction (WIT, 2008)
3. S. Luke, Essentials of Metaheuristics, Lulu, second edition, available at http://cs.gmu.edu/sean/book/metaheuristics/
4. G. Rozenberg, Handbook of Natural Computing, Springer 2012
5. T.Weise Global Optimization Algorithms Theory and Application , http://www.it-weise.de/, 2013

eResources addresses

Example issues/ example questions/ tasks being completed

Application of linear regression to data optimization.

Regularization of linear models.

Linear and nonlinear SVM regression.

Learning deep neural networks.

Practical activites within the subject

Not applicable

Document generated electronically. Does not require a seal or signature.