GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	, PG_00063132		
Field of study	Technical Physics		
Date of commencement of studies	February 2024	Academic year of realisation of subject	2023/2024
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	1	Language of instruction	Polish Materials in Polish and English.
Semester of study	1	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Zakład Fizyki Teoretycznej i Informatyki Kwantowej -> Instytut Fizyki i Informatyki Stosowanej -> Faculty of Applied Physics and Mathematics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Marcin Nowakowski	
	Teachers	dr inż. Marcin Nowakowski	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	30.0	0.0	0.0	45

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	45	0.0	0.0	45

Subject objectives

The aim of the course is to acquaint students with the basic issues related to contemporary methods of quantum machine learning, in particular, methods that utilize quantum algorithms for efficient processing and analysis of data. Students will gain knowledge on the theoretical foundations of quantum information processing, including superposition, quantum entanglement, and quantum measurements, as well as learn how these phenomena can be used to create new, more efficient machine learning models.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W04] Has enhanced knowledge of mathematical, numerical and simulation methods applied in the description and modelling of physical phenomena.	Has basic knowledge of quantum machine learning models for both classical and quantum systems.	[SW1] Assessment of factual knowledge
[K7_U05] Can plan and conduct theoretical calculations, experimental research and computer simulations, critically analyze their results, draw conclusions and form reasoned opinions.	Has basic knowledge in the methodology and programming techniques for selected issues in the quantum environment.	[SU1] Assessment of task fulfilment

Subject contents

What is QML about?QM and QC: quantum states, evolution in closed systems,measurements and gates (towards qCNN).Quantum algorithms (Quantum Fourier, Quantum Phase Estimation,Quantum Matrix Inversion).Open quantum systems: the classical Ising model and the transversefield Ising model.Quantum many-body physics and QML methods.ML strategies to solve many-body problems.Adiabatic quantum computing. Sampling thermal states.Quantum Annealing and Implementations.Quantum Approximate Optimization Algorithm (QAOA)Variational circuits and methods.Encoding Quantum Information.Ensemble Learning.Clustering by quantum optimization.(Quantum-enhanced) kernel methods.Probabilistic graph models.Optimization and sampling.Quantum assisted-Guassian processes.Quantum CNN, GANs.Towards quantum generative methods.Future prospects: technology and market trends.

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="2">Discrete Mathematics, Linear Algebra, Probability Theory, Quantum Mechanics - Foundations, Basic Methods of Artificial Intelligence. Knowledge of programming in object-oriented languages.</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="2"><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Lab - Project</td><td>50.0%</td><td>50.0%</td></tr>
<tr><td>Exam</td><td>50.0%</td><td>50.0%</td></tr>
</table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. M. Ekman, Learning Deep Learning, NVidia DL Institute, 2023.
2. M. Schuld, F. Pettrucione, Machine Learning with QuantumComputers, Springer, 2021.
3. M. Le Bellac, Wstep do Informatyki Kwantowej, PWN, 2018.</td></tr>
<tr><td>Supplementary literature</td><td>4. E. R. Johnston et al., Komputer Kwantowy, Helion, 2020.
5. I. Goodfellow, Deep Learning, MIT, 2020.</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:
Kwantowe uczenie maszynowe (FIZ2B009) - Moodle ID: 38563
https://enauczanie.pg.edu.pl/moodle/course/view.php?id=38563</td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2"></td></tr>
<tr><td>Work placement</td><td colspan="2">Not applicable</td></tr>
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