GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Quantum machine learning, PG_00064604		
Field of study	Technical Physics		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2027/2028
Education level	second-cycle studies	Subject group	Obligatory subject group in the field of study 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	2	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	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 inż. Marcin Nowakowski	
	Teachers		

Lesson types

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	5.0	25.0	75

Subject objectives

The aim of this course is to familiarize students with the fundamentals of contemporary quantum machine learning methods, particularly those using quantum algorithms for efficient data processing and analysis. Students will gain knowledge of the theoretical foundations of quantum information processing, including superposition, quantum entanglement, and quantum measurements, and will learn how these phenomena can be used to create new, more effective machine learning models.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W01] demonstrates advanced knowledge of key branches of physics, including quantum mechanics and molecular electronics.	Has knowledge of quantum computation and quantum mechanics.	[SW1] Assessment of factual knowledge
[K7_W04] possesses advanced knowledge of mathematical, numerical and simulation methods used in the description and modelling of physical phenomena.	Has knowledge of quantum machine learning models for both classical and quantum systems.	[SW1] Assessment of factual knowledge
[K7_K02] demonstrates readiness to apply competences creatively for the benefit of society, including in an entrepreneurial context.	Possesses the ability to work effectively in a team, including jointly implementing a project in accordance with established goals and schedule.	[SK1] Assessment of group work skills
[K7_U05] is able, individually or as part of a team (including in a leadership role), to plan and conduct advanced theoretical calculations, experimental studies and computer simulations aimed at solving complex and non-standard scientific and engineering problems, and to critically analyse results and formulate well-founded conclusions	Possesses knowledge of programming methodology and techniques for selected issues in the quantum environment.	[SU1] Assessment of task fulfilment

<table>
<tr><td>Subject contents</td><td>Course content – lecture
What is QML about? QM and QC: quantum states, evolution in closed systems, measurements, and gates (towards qCNN). Quantum algorithms (Quantum Fourier Transform, Quantum Phase Estimation, Quantum Matrix Inverse). Open quantum systems: the classical Ising model. Quantum many-body physics and QML methods. ML strategies for solving many-body problems. Adiabatic quantum computation. Sampling of thermal states. Quantum annealing and implementations. Quantum Approximate Optimization Algorithm (QAOA). Variational circuits and methods. Quantum information encoding. Ensemble learning. Clustering by quantum optimization. (Quantum-enhanced) nuclear methods. Probabilistic graph models. Optimization and sampling. Quantum-assisted Gaussian processes. Quantum CNNs, GANs. Towards Quantum Generative Methods. Future Prospects: Technological and Market Trends.

Course content – laboratory
Simulations of quantum algorithms and quantum machine learning algorithms in Qiskit.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Discrete mathematics, linear algebra, probability theory, quantum mechanics - fundamentals, basic artificial intelligence methods. Knowledge of programming in object-oriented languages.</td></tr>
<tr><td>Assessment methods and criteria</td><td><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>60.0%</td><td>100.0%</td></tr></table></td></tr>
<tr><td>Recommended reading</td><td><table><tr><td>Basic literature</td><td>1. E. R. Johnston et al., Komputer Kwantowy, Helion, 2020.

2. I. Goodfellow, Deep Learning, MIT, 2020

3. M. Le Bellac, Wstep do Informatyki Kwantowej, PWN, 2018</td></tr><tr><td>Supplementary literature</td><td>4. M. Ekman, Learning Deep Learning, NVidia DL Institute, 2023.

5. M. Schuld, F. Pettrucione, Machine Learning with Quantum Computers, Springer, 2021.</td></tr><tr><td>eResources addresses</td><td></td></tr></table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>Simulation of a quantum neural network performing stratification of a selected feature space.</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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