University of Gdańsk

Subject card

<table>
<tr><td>Subject name and code</td><td colspan="6">Medical Data Analysis Using Neural Networks, PG_00210210</td></tr>
<tr><td>Field of study</td><td colspan="6">Medical Physics</td></tr>
<tr><td>Date of commencement of studies</td><td colspan="2">October 2025</td><td colspan="2">Academic year of realisation of subject</td><td colspan="2">2026/2027</td></tr>
<tr><td>Education level</td><td colspan="2">Master’s studies</td><td colspan="2">Subject group</td><td colspan="2">Optional subject group
Subject group related to scientific research in the field of study</td></tr>
<tr><td>Mode of study</td><td colspan="2">full-time studies</td><td colspan="2">Mode of delivery</td><td colspan="2">at the university</td></tr>
<tr><td>Year of study</td><td colspan="2">2</td><td colspan="2">Language of instruction</td><td colspan="2">Polish
pl</td></tr>
<tr><td>Semester of study</td><td colspan="2">4</td><td colspan="2">ECTS credits</td><td colspan="2">3.0</td></tr>
<tr><td>Learning profile</td><td colspan="2">academic</td><td colspan="2">Assessment form</td><td colspan="2">credit</td></tr>
<tr><td>Conducting unit</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Name and surname of lecturer (lecturers)</td><td colspan="2">Subject supervisor</td><td colspan="4">dr inż. Krzysztof Dorywalski</td></tr>
<tr><td colspan="2">Teachers</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Lesson types</td><td>Lesson type</td><td>Lecture</td><td>Tutorial</td><td>Laboratory</td><td>Project</td><td>Seminar</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>30.0</td><td>15.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>45</td></tr>
<tr><td colspan="7">E-learning hours included: 0.0</td></tr>
<tr><td rowspan="2">Learning activity and number of study hours</td><td>Learning activity</td><td colspan="2">Participation in didactic classes included in study plan</td><td colspan="2">Participation in consultation hours</td><td>Self-study</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td colspan="2">45</td><td colspan="2">0.0</td><td>30.0</td><td>75</td></tr>
<tr><td>Subject objectives</td><td colspan="7">An introductory course on modern neural network architectures used in the analysis and processing of specialized medical data. The course focuses on the practical solution of complex diagnostic problems (segmentation, detection, and classification) using deep convolutional neural networks (CNNs), recurrent neural networks (RNNs/LSTMs), and transformers in Python environments (PyTorch/TensorFlow).</td></tr>
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Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMEDMU2_W02] Knows and understands in depth the issues of mathematics and mathematical methods used in physics and medicine, as well as the relationships between them.	Knows and understands, at an advanced level, the mathematical framework underlying modern deep neural network architectures, including tensor calculus, nonlinear multidimensional optimization methods, stochastic approaches to loss function minimization, and the relationships between network topology and its ability to mathematically model and generalize complex biomedical processes.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[FIZMEDMU2_U02] Can plan and conduct an experiment using new or adapt existing methods and tools, and critically analyse the results of measurements, observations or numerical calculations, assessing the accuracy of the results using known methods and tools.	Is able to independently design and conduct a numerical research experiment by adapting existing deep neural network architectures (Transfer Learning / Fine-tuning) or developing new processing pipelines for a given medical problem, as well as critically analyze and evaluate the accuracy of the obtained results using advanced statistical metrics.	[SU2] presentation/project/paper/report [SU5] implementation of a problem task [SU6] demonstration of practical skills
	[FIZMEDMU2_U04] Can formulate and test hypotheses related to simple research problems within the scope of acquired knowledge in physics and medicine.	Is able to formulate research hypotheses regarding the impact of network architecture, loss functions, and optimization methods on the quality and stability of modeling pathophysiological processes, and subsequently verify them experimentally through rigorous statistical testing and cross-validation of trained neural network models.	[SU2] presentation/project/paper/report [SU5] implementation of a problem task [SU6] demonstration of practical skills
	[FIZMEDMU2_W05] Knows and understands in depth the theoretical foundations of computational methods and computer techniques used to model and simulate physical and biological systems.	Knows and understands, in depth, the theoretical foundations of numerical optimization methods, information theory, and advanced deep learning techniques, which form the basis for the computational modeling, segmentation, and simulation of biological structures and pathophysiological systems using digital clinical data.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/report [SW5] implementation of a problem task

<table>
<tr><td>Subject contents</td><td>Lectures:

1.
Introduction to Medical Data Analysis: Characteristics of medical data (images, signals, tabular data), key challenges (noise, artifacts, low resolution).

2.
Foundations of Neural Networks: The Perceptron, activation functions, backpropagation, and the vanishing gradient problem.

3.
Convolutional Neural Networks (CNNs): Classical architectures (VGG, ResNet) and their applications in medical imaging.

4.
Medical Image Segmentation: The U-Net architecture and its variants (Attention U-Net, 3D U-Net).

5.
Biomedical Signal Processing: Utilization of Recurrent Neural Networks (RNNs, LSTMs) and Transformers in time-series analysis (e.g., ECG, EEG).

6.
Transfer Learning and Fine-tuning: Applying pre-trained models from natural image datasets to medical diagnostic tasks.

Laboratory:
1.
Introduction to PyTorch: Working with tensors.

2.
Building a Simple Classifier: Implementing a fully connected network for a classification problem.

3.
Implementation of Convolutional Networks: Classification of medical images.

4.
Data Augmentation: Techniques for expanding training datasets specifically for medical imaging (rotations, elastic deformations).

5.
Implementation of Recurrent Networks: Analyzing biomedical signals.

6.
Final Project.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Ability to program in Python (data structures, NumPy libraries, Matplotlib/Seaborn).

Basic knowledge of linear algebra (matrix operations, vectors) and mathematical analysis (partial derivatives, function optimization).</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>Knowledge test</td><td>51.0%</td><td>20.0%</td></tr><tr><td>Stage 1 project.</td><td>51.0%</td><td>10.0%</td></tr><tr><td>Stage 2 project.</td><td>51.0%</td><td>10.0%</td></tr><tr><td>Final project</td><td>51.0%</td><td>60.0%</td></tr></table></td></tr>
<tr><td>Recommended reading</td><td><table><tr><td>Basic literature</td><td>1. S. Raschka, J. Liu, V. Mirjalili, Uczenie maszynowe i głębokie w języku Python (Wydanie IV), Wydawnictwo Helion.

2. A. Géron, Uczenie maszynowe z użyciem Scikit-Learn i TensorFlow (najnowsze wydanie), Helion.</td></tr><tr><td>Supplementary literature</td><td>1. Goodfellow I., Bengio Y., Courville A., Deep Learning, MIT Press

2. Aggarwal C.C., Neural Networks and Deep Learning: A Textbook, Springer.</td></tr></table></td></tr>
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	eResources addresses	Basic https://docs.pytorch.org/tutorials/ - Technical documentation of the PyTorch library https://github.com/rasbt - Complete introductory courses on neural networks. https://github.com/KrzysztofDorywalski - Course materials
Example issues/ example questions/ tasks being completed	Implement a convolutional neural network for medical image classification.	
Work placement	Not applicable	

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