GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

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| Subject name and code | Deep learning, PG_00067981 | | |
| Field of study | Automatic Control, Cybernetics and Robotics | | |
| Date of commencement of studies | October 2025 | Academic year of realisation of subject | 2027/2028 |
| Education level | first-cycle studies | Subject group | Optional subject group<br>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 | 5 | ECTS credits | 3.0 |
| Learning profile | general academic profile | Assessment form | exam |
| Conducting unit | Department of Decision Systems and Robotics -> Faculty of Electronics Telecommunications and Informatics -> Wydziały Politechniki Gdańskiej | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | dr hab. inż. Michał Czubenko | |
| | Teachers | dr hab. inż. Michał Czubenko | |

| 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 | 3.0 | 27.0 | 75 |

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| Subject objectives | The aim of the Deep Learning subject is to familiarize the student with the principles of operation and use of deep learning methods, enabling him to understand the architectures, applications and mechanisms of operation of deep neural networks. The student will learn how to analyze and select appropriate deep learning techniques to solve various problems, including those related to signal, image and natural language processing. As part of the subject, the student will gain the ability to plan and conduct experiments, interpret the obtained results and draw conclusions from the conducted analyses. The knowledge acquired will allow the student to understand the process of designing and training models based on deep neural networks in both classification and regression tasks, as well as in more advanced applications, such as language processing, image analysis or generative applications. The student will also develop practical skills related to preparing and modifying computer programs using deep learning, learning to identify and solve problems related to their operation and interpret the results of the models' operation. The student will also be prepared to use deep learning in analysis and solving problems characteristic of various areas of engineering, computer science and data analysis. |

## Learning outcomes

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| [K6_W01] knows and understands, to an advanced extent, mathematics necessary to formulate and solve simple issues related to the field of study | The student is able to design and implement a solution using deep neural networks in the analysis of signals and images, identify errors in program operation and apply techniques for their elimination using high-level programming languages. | [SW1] Assessment of factual knowledge |
| [K6_W03] knows and understands, to an advanced extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum | The student recognizes different types of deep learning applications and is able to analyze and compare neural network architectures used in deep learning, selecting learning methods for the problems being solved. | [SW1] Assessment of factual knowledge |
| [K6_U07] can apply methods of process and function support, specific to the field of study | The student is able to optimize model hyperparameters. | [SU1] Assessment of task fulfilment |
| [K6_U04] can apply knowledge of programming methods and techniques as well as select and apply appropriate programming methods and tools in computer software development or programming devices or controllers using microprocessors or programmable elements or systems specific to the field of study | The student is able to design and implement a solution using deep neural networks in the analysis of signals and images, identify errors in program operation and apply techniques for their elimination using high-level programming languages. | [SU3] Assessment of ability to use knowledge gained from the subject |

## Subject contents

Lecture
1. Introduction.
2. Definition and Applications of Deep Learning
3. History and Development of Neural Networks
4. Differences Between Machine Learning and Deep Learning
5. Components of Neural Networks
6. Activation Functions
7. Backpropagation Algorithm
8. Cost Function
9. Optimization Methods
10. Multilayer Networks
11. Convolutional Neural Networks
12. Recurrent Neural Networks
13. Transformer Models
14. Neural Networks in Classification and Regression
15. Autoencoders
16. Generative Networks
17. Natural Language Processing
18. Hybrid Natural Language and Image Processing
19. Reinforcement Learning
20. Normalization and Regularization
21. Software Tools Used in Deep Learning
22. Neural Network Optimization Methods
23. Training Deep Neural Networks Using Multiple Hardware Accelerators
24. Gradient Accumulation Method
25. Weight Averaging Method
26. Interpretability of Deep Learning Models

Lab
1. Preparing the Deep Learning Environment
2. Implementing and Training a Multilayer Perceptron (MLP)
3. Experiments with Activation Functions
4. Training Convolutional Neural Networks (CNNs)
5. Recurrent Neural Networks (RNNs) in Sequence Analysis
6. Autoencoders and Dimensionality Reduction
7. Generative Networks (GANs)
8. Normalization and Regularization in Deep Neural Networks
9. Deep Learning in Natural Language Processing (NLP)
10. Optimization and Tuning of Hyperparameters of Deep Models
11. Interpretability Analysis of Deep Models

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| Prerequisites and co-requisites | • Basics of linear algebra (matrices, vectors, derivatives)<br>• Basics of mathematical analysis,<br>• Basics of probability,<br>• Basics of statistics<br>• Basics of programming, including the ability to use a high-level programming language. |

**Assessment methods and criteria**

| Subject passing criteria | Passing threshold | Percentage of the final grade |
|---|---|---|
| laboratory | 60.0% | 50.0% |
| exam | 60.0% | 50.0% |

**Recommended reading**

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|---|---|
| Basic literature | Charu, Aggarwal, Neural Networks and Deep Learning: A Textbook, Springer, 2023<br>Atienza, Roberto, Advanced Deep Learning with TensorFlow 2 and Keras, 2nd Edition, Packt, 2021<br>Goodfellow, Ian; Bengio, Yoshua; Courville, Aaron. Deep Learning. MIT Press, 2021 |
| Supplementary literature | Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer, 2022 |
| eResources addresses | |

**Example issues/ example questions/ tasks being completed**

Explain the difference between deep learning and classical machine learning.
Describe the architecture of a convolutional neural network and provide examples of its applications.
Discuss the role of activation functions in neural networks and provide examples of activation functions used in deep learning.
List the optimization methods used to train deep neural networks and discuss one of them.
What is backpropagation in the process of training neural networks?

**Work placement**

Not applicable

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