



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Machine learning techniques [S1Eltech2>PO11-TUM]

### Course

Field of study

Electrical Engineering

Year/Semester

4/7

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

Polish

Form of study

full-time

Requirements

elective

### Number of hours

Lecture

15

Laboratory classes

15

Other

0

Tutorials

0

Projects/seminars

0

### Number of credit points

2,00

### Coordinators

dr inż. Stanisław Mikulski

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### Lecturers

### Prerequisites

Students starting this course should have basic knowledge of mathematics (including linear algebra, statistics, and probability theory). Students should be familiar with the basic concepts of programming in Python (data types, conditional statements, loops, and functions).

### Course objective

The aim of the course is to familiarize students with selected machine learning techniques and their potential applications in electrical engineering. The course introduces basic concepts and ideas related to machine learning and develops practical skills in the use of modern IT tools for data preparation, model training, and performance evaluation.

### Course-related learning outcomes

Knowledge:

1. Has knowledge of the classification of machine learning methods and understands the differences between the concepts of artificial intelligence, machine learning, and deep learning.
2. Knows the basics of supervised, unsupervised, and reinforcement learning and understands their applications in practical problems.

### Skills:

1. Can prepare data sets for supervised learning tasks, including their preliminary processing, selection, and proper representation.
2. Can select an appropriate machine learning technique to solve a specific engineering problem in the field of electrical engineering.
3. Is able to carry out the process of training a machine learning model and evaluate the quality of the obtained solution using appropriate validation methods.

### Social competences:

1. Is aware of the importance of machine learning and artificial intelligence and their impact on the economy, industry, and the functioning of modern society.
2. Understands the potential risks of the misuse of artificial intelligence technology and the need for its responsible use.
3. Recognizes the need to continuously improve their qualifications in order to keep up with the dynamic development of modern technologies.

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge acquired during the lecture is verified by passing a test during the last lecture. The passing score is 50% of the points. The test questions are made available through the university's e-learning system at least two weeks before the test date.

The laboratory exam is based on points obtained from tasks performed during classes, homework assignments, and the exam held during the last class. The exam during the last class will consist of developing a solution to a specific engineering problem using the machine learning methods learned during the course. In total, students can earn 100 points. The pass mark is 50%.

## Programme content

Linear algebra and gradient. Linear regression: least squares approximation, approximation metrics. Decision trees and random forests. Gradient boosting. Data standardization and feature extraction. Problem dimension reduction. Neural networks. Backpropagation algorithm. K-means algorithm. Panda, NumPy, and PyTorch libraries. Deep learning. Convolutional neural networks. Model validation.

## Course topics

### Lecture:

Introduction to machine learning. Explanation of concepts: artificial intelligence (AI), machine learning (ML), neural network (NN), and deep learning (DL). Discussion of Python tools, in particular PyTorch, Pandas, and NumPy packages. Linear regression, including Ridge and Lasso regression. Regression metrics: MAE, RMSE, R2, MAPE. Classification algorithms using ML. Decision trees and random forests. Gradient boosting with XGBoost. Input data preparation: standardization, feature extraction (e.g., mean, kurtosis, FFT). Dimension reduction with PCA. Neural network construction. Types of neurons, multilayer network architecture. Backpropagation algorithm. Deep learning using convolutional neural networks (CNN) as an example. Cross-validation. Discussion of best practices in ML model design.

### Laboratory:

Preparation of the working environment, installation of the Python environment with the necessary packages (PyTorch, Numpy, Pandas, Matplotlib). Linear regression of MAE, MSE, RMSE metrics. k-NN classification. Decision trees and random forests. Feature extraction from measurement data. Clustering using k-means and DBSCAN. Multilayer neural network.

## Teaching methods

### Lecture:

Lectures are conducted using multimedia presentations containing drawings, diagrams, photos, animations, and short films, supplemented with code examples presented live by the lecturer. Examples of machine learning techniques in electrical engineering are also discussed. Lecture materials and additional supporting content are made available to students via the university's e-learning platform.

### Laboratory:

Laboratory classes include presentations and joint creation of sample scripts under the guidance of the

instructor. Students also perform practical tasks during classes and receive tasks to solve independently at home. All materials and task sets are available on the university's e-learning platform.

## Bibliography

Basic:

[1] I. Goodfellow, Y. Bengio, i A. Courville, Deep learning. w Adaptive computation and machine learning. Cambridge, Mass: The MIT press, 2016.

[2] C. M. Bishop, Pattern recognition and machine learning. w Information science and statistics. New York: Springer, 2006.

[3] G. James, D. Witten, T. Hastie, i R. Tibshirani, An introduction to statistical learning: with applications in R, Second edition. w Springer texts in statistics. New York: Springer, 2021

Additional:

[1] S. Weidman i T. Walczak, Uczenie głębokie od zera: podstawy implementacji w Pythonie. Gliwice: Helion, 2020.

[2] R. Kneusel i F. Kamiński, Matematyka w deep learningu: co musisz wiedzieć, aby zrozumieć sieci neuronowe. Gliwice: Helion, 2024.

## Breakdown of average student's workload

	Hours	ECTS
Total workload	55	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00