



COURSE DESCRIPTION CARD - SYLLABUS

Course name

Machine learning tools [S2Inf1-SzInt>NUM]

Course

Field of study

Computing

Year/Semester

1/1

Area of study (specialization)

Artificial Intelligence

Profile of study

general academic

Level of study

second-cycle

Course offered in

Polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

16

Laboratory classes

16

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

2,00

Coordinators

dr hab. inż. Mikołaj Morzy prof. PP
mikolaj.morzy@put.poznan.pl

Lecturers

Prerequisites

Student partaking this course should have basic knowledge in the areas of machine learning and data processing. Student should be able to solve basic problems related to information systems' design and implementation (versioning, testing, code integration). Basic command of Python programming language is required. Student should be able to utilize external APIs and integrate external resources. Student should also understand the need to broaden one's competences and be able to effectively cooperate within a project team. Regarding social competences student should exhibit qualities such as responsibility, endurance, intellectual curiosity, creativity, respect for other people, ability to work in a group.

Course objective

The main objective of the course is to present a rich set of tools required to apply machine learning solutions to information systems in practice. During lectures students learn techniques and tools for statistical model productization, in particular, tools allowing for a seamless integration of machine learning models with the existing computing infrastructure or ecosystem. During laboratories students experiment with the tools using various scenarios. The list of topics covered by the course includes: - versioning of data and statistical models, - workflow management tools for machine learning, - monitoring of the learning process, - practical aspects of machine learning models' productization, - tools for managing of machine learning projects.

Course-related learning outcomes

Knowledge:

student has advanced and in-depth knowledge of machine learning and of practical aspects of productization of machine learning solutions [k2st_w1].

student has knowledge of good practices related to the development and practical application of machine learning solutions in information systems, in particular, good practices related to the testing and verification of statistical models [k2st_w2].

student has detailed knowledge of the collection, annotation, and versioning of data used for machine learning models' training [k2st_w3].

student is aware of the currently available tools, libraries, and frameworks for development, integration, and maintenance of information systems utilizing machine learning solutions [k2st_w4].

student understands the full life cycle of information systems utilizing machine learning solutions, is able to evaluate the correctness of the life cycle and identify non-trivial dependencies between subsequent steps of the life cycle (data collection and annotation, training of statistical models, validation and optimization of statistical models, monitoring of statistical models) [k2st_w5]

student knows basic methods, techniques and tools used to design complex information systems and is able to apply these methods, techniques and tools to the specific case of designing systems utilizing machine learning solutions [k2st_w6].

Skills:

student knows how to use various apis and documentation of complex information systems [k2st_u1].

during the design of an information system utilizing machine learning solutions the student is able to plan and carry out measurement experiments in accordance with scientific method and to interpret the results of conducted experiments [k2st_u3].

student knows how to use visualization tools to monitor the process of machine learning model training [k2st_u4].

student is able to use agile programming methodologies to manage a project containing statistical models at its core. student understands the need to include domain expertise and knowledge in the process of designing machine learning based solutions [k2st_u5].

student is able to construct information systems with machine learning components using the containerization technique which allows a seamless integration of the existing workflow with new tools and solutions [k2st_u6].

student is able to evaluate the time required to complete development steps of an information system utilizing statistical models [k2st_u7].

student understands the nature of the technological debt incurred by machine learning and is able to use available tools to mitigate the negative impacts that potential errors in the statistical model training process can project on the remaining part of an information system [k2st_u8].

during the design of an information system utilizing machine learning solutions the student is able to analyze available data in search for latent biases and correlations. the student is able to analyze the life cycle of data and spot threats to the integrity of the model training process [k2st_u9].

student is able to design and develop a solution to a given economic, technological, or social problem using machine learning tools [k2st_u10].

Social competences:

student understands the exceptional dynamics of the area of machine learning and is aware of the existence of multiple tools [k2st_k1].

student understands the need for life-long learning in the area of machine learning tools due to a rapid cycle of tool exchange [k2st_k2].

student can effectively communicate in a group and collaborate within the ramifications of agile

programming techniques [k2st_k3].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Students receive a combined grade for the lecture and laboratory work. The grading criteria for the laboratory work are as follows:

Completion of 4 mini-projects during the semester:

- Pytorch Lightning; Model monitoring; Hyper-parameter optimization (1 point, 1 bonus point)
- Model serving and deployment (0.5 points)
- Serverless deployment on the AWS platform as an example (1 point, 1 bonus point)
- Inference Optimization (1.5 points)
- Basics of RAGs (0.5 points)
- 5-minute presentation on a tool not presented in class (1 point)

The required passing threshold for the course is 3 points.

Programme content

During the lecture, more general ramifications of individual tools are presented. The laboratories are dedicated to a detailed practical presentation of a selected tool at a specific stage of the machine learning software development process. The subject matter includes, among other things:

- the development cycle of applications using statistical models
- the concept of technical debt
- MLOps anti-patterns
- most commonly used MLOps tools (Pytorch, Pytorch Lightning, Docker, Optuna, ONNX format, AWS SageMaker, AWS Lambda, AWS EC2, Google Compute Engine, transformers package, sentence-transformers package, timm package)
- training loop standardization and model monitoring
- hyper-parameter optimization in machine learning and deep learning
- model serving and deployment
- the use of cloud environments
- basics of RAG

Course topics

General ramifications of machine learning tools are presented during lectures. Laboratories present detailed case studies of tool usage at a given stage of the development of a machine learning-based system. Topics covered during the course include:

- data versioning
- manual and programming annotation of data, including text and image data
- synthetic data generation
- feature stores
- tools for the visualization of the machine learning processing
- tools for containerization of machine learning systems
- machine learning workflows
- universal platforms for machine learning

Teaching methods

Lecture: multimedia presentation, seminar with students' presentations, information retrieval

Laboratory: programming examples, small individual programming exercises, presentation

Bibliography

Main sources

1. Treveil, M., Omont, N., Stenac, C., Lefevre, K., Phan, D., Zentici, J., ... & Heidmann, L. (2020). Introducing MLOps. O'Reilly Media.

2. Gift, Noah, and Alfredo Deza. Practical MLOps. O'Reilly Media, Inc., 2021.
3. Lakshmanan, Valliappa, Sara Robinson, and Michael Munn. Machine learning design patterns. O'Reilly Media, 2020.
4. Raj, Emmanuel. Engineering MLOps. Packt Publishing, 2021.

Auxiliary sources

1. Burkov, Andriy. Machine learning engineering. Vol. 1. True Positive Incorporated, 2020.
2. Hapke, Hannes, and Catherine Nelson. Building machine learning pipelines. O'Reilly Media, 2020.
3. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. O'Reilly Media, Inc., 2019.
4. Kleppmann, Martin. Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. O'Reilly Media, Inc., 2017.
5. McMahon, Andrew, Machine Learning Engineering with Python: Manage the production life cycle of machine learning models using MLOps with practical examples, Packt Publishing Ltd, 2021

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	32	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	18	1,00