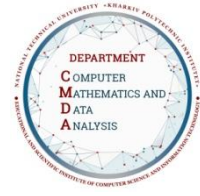




Syllabus

Course Program



Machine Learning Engineering

Specialty

113 Applied mathematics

Educational program

Intelligent Data Analysis

Level of education

Master's level

Semester

2

Institute

Educational and Scientific Institute of Computer Science and Information Technology

Department

Computer Mathematics and Data Analysis

Discipline type

Special (professional), Selective

Language of instruction

Ukrainian, English

Lecturers and course developers



Vladyslav Kolbasin

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Senior teacher of the Department of Computer Mathematics and Data Analysis

Work experience - 15 years. Leading lecturer in the disciplines: "Object-oriented programming", "Computer geometry and graphics"

[More about the lecturer on the website](#)

General information

Summary

The discipline is aimed at mastering the theoretical and practical foundations of machine learning engineering. Problems that arise in real projects related to the use of machine learning are considered.

Course objectives and goals

The purpose of the discipline is the formation of ideas about the main stages, tasks, and methods of solving problems that arise in projects related to the use of machine learning.

Format of classes

Lectures, laboratory works, self-study, consultations. Final control in the form of an exam.

Competencies

GC 3. The ability to continuously study, acquire new knowledge and skills, including in a field other than a professional one.

GC 4. The ability to identify, pose and solve problems in professional activities.

GC 5. The ability to generate new ideas (creativity) and non-standard approaches to their implementation, flexible adaptation to real professional situations, to show a creative approach, initiative.

GC 6. The ability to critically evaluate and rethink the accumulated experience (own and others), to analyze one's professional and social activities.

GC 7. The ability to work with information: to find and use information from various sources, necessary for solving professional tasks.

SC 1. The ability to formulate a mathematical statement of a problem, relying on the statement in the language of the subject field, to check the correctness of the statement, including in conditions of uncertainty.

SC 2. The ability to choose, develop and investigate a mathematical analytical or numerical method for solving practical problems, which ensures the required accuracy and reliability of the result.

SC 4. Ability to develop algorithms for the analysis of uncertain big data, develop appropriate software tools and documentation, design software systems, databases and knowledge bases.

SC 5. The ability to conduct mathematical and computer modeling and computational experiments, collect, visualize, analyze and process the received data, solve formalized problems using specialized software tools.

SC 11. Ability to develop, investigate and apply mathematical methods and algorithms of machine learning, soft computing and computational intelligence for the analysis of uncertain data, forecasting and decision making.

SC 12. Ability to develop and operate specialized software tools for intellectual analysis of data, texts, signals and images.

SC 13. Ability to develop and operate specialized software tools for processing large data sets based on distributed and cloud computing information technologies.

Learning outcomes

LO 1. Demonstrate knowledge and understanding of basic concepts, principles, theories of fundamental and applied mathematics and use them in practice.

LO 2. Be able to formalize problems formulated in the language of a certain subject area and choose a rational solution method; solve problems by analytical or numerical methods, evaluate the accuracy and reliability of the obtained results and perform their interpretation.

LO 3. Possess the methods of development, research and application of mathematical models of complex objects and processes, including with the use of methods of computational intelligence.

LO 7. To be able to apply modern technologies of programming and software development, software implementation of numerical and symbolic algorithms.

LO 12. Know and understand modern methods of solving mathematical problems, statistical and intellectual data analysis, forecasting, etc.

LO 13. To know and understand the methods of solving mathematical problems of intellectual information search and knowledge extraction.

LO 14. To be able to apply existing existing and develop new algorithms and software tools for statistical and intellectual analysis of uncertain data.

LO 15. To be able to apply existing existing and develop new algorithms and software tools for processing data, texts, signals and images.

LO 16. To be able to apply modern information technologies and software for processing large data sets based on distributed and cloud services.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures – 32 hours, laboratory classes – 32 hours, self-study – 86 hours.

Course prerequisites

To successfully pass the course, you must have knowledge and practical skills in the discipline "Mathematical methods of machine learning 1", as well as in the disciplines of the profile package VP1.*, namely, VP1.1 - "Methods and technologies of working with big data", or VP1. 2 - "Analysis of graph data".

Features of the course, teaching and learning methods, and technologies

Programming skills are required. Study materials are available to students on the teacher's website.

Program of the course

Topics of the lectures

- Topic 1. Introduction to the subject. The general scheme of the development of the machine learning project.
- Topic 2. Fundamentals of engineering and machine learning.
- Topic 3. Peculiarities of training data.
- Topic 4. Feature engineering.
- Topic 5. Data Version Control utility.
- Topic 6. MLFlow utility.
- Topic 7. Weights & Bias utility.
- Topic 8. Selection of machine learning models, construction of ensembles of models.
- Topic 9. Data leakage. Methods of assessing the importance of model features.
- Topic 10. Methods of visualization and interpretation of the work of neural networks.
- Topic 11. Methods of evaluating the quality of machine learning models.
- Topic 12. Quantization of models.
- Topic 13. Applications deployment.
- Topic 14. Reproducibility of experiments.
- Topic 15. Adversarial attacks on the machine learning model.
- Topic 16. Review of the course and discussion of the achieved results.

Topics of the laboratory classes

- Topic 1. Development of a simple machine learning pipeline.
- Topic 2. Segmentation of the machine learning pipeline into steps.
- Topic 3. Development of DVC pipeline
- Topic 4. Using MLFlow for tracking model training.
- Topic 5. Using W&B for tracking model training.

Self-study

During self-study, students study lecture material, prepare for tests, and exams.

Non-formal education

In non-formal education according to the relevant Regulation (<http://sur.li/pxssv>), the educational component or its individual topics can be taken into account in case of independent completion of professional courses/trainings, obtaining civic education, online education, professional internship, etc.

In particular, individual topics of this component may be taken into account upon successful completion of the following courses:

- Topics 1-5, 8-16.

<https://stanford-cs329s.github.io/>

Course materials and recommended reading

Main literature

1. Chip Huyen. Designing Machine Learning Systems. O'Reilly Media, Inc. – 2022. – ISBN: 9781098107963.
2. Andrew P. McMahon, Adi Polak . Machine Learning Engineering with Python: Manage the lifecycle of machine learning models using MLOps with practical examples. Packt Publishing; 2nd edition – 2023. – ISBN 978-1837631964.
3. <https://www.datascience-pm.com/crisp-dm-2/>
4. MLOps: Continuous delivery and automation pipelines in machine learning.
<https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning>
5. <https://cs329s.stanford.edu>
6. <https://dvc.org/doc>
7. <https://mlflow.org/>
8. <https://docs.wandb.ai/guide>
9. Attacking Machine Learning with Adversarial Examples.
<https://openai.com/blog/adversarial-example-research/>

Additional literature

10. How ML Breaks: A Decade of Outages for One Large ML Pipeline.
<https://www.youtube.com/watch?v=hBMHohkRgAA>
11. <https://realpython.com/python-data-version-control/>
12. <http://mlwave.com/kaggle-ensembling-guide/>
13. <https://scikit-learn.org/stable/modules/ensemble.html>
14. <https://www.youtube.com/watch?v=dWhdWxgt5SU>
15. "Interpretable Machine Learning" book.
<https://christophm.github.io/interpretable-ml-book/>
16. A Survey Of Methods For Explaining Black Box Models.
<https://arxiv.org/pdf/1802.01933.pdf>
17. Techniques for Interpretable Machine Learning.
<https://arxiv.org/pdf/1808.00033.pdf>
18. <https://www.kaggle.com/code/samueltortinhas/weights-biases-tutorial-beginner>

Assessment and grading

Criteria for assessment of student performance, and the final score structure

A necessary condition for passing the test or exam is the completion of laboratory work.
30 points are awarded for writing control tests.
Passing laboratory tests - 30 points.
Exam - 40 points.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.

Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: <http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochnest/>

Approval

Approved by

Date, signature
31.08.2023



Head of the department
Olena AKHIEZER

Date, signature
31.08.2023



Guarantor of the educational program
Leonid LYUBCHYK