Syllabus
Course Program

Fundamentals of Machine Learning

Specialty
121 – Software Engineering
122 – Computer Science

Institute
Institute of Computer Science and Information Technology

Educational program
Software Engineering
Computer Science and Intelligent Systems

Department
Software Engineering and Management Intelligent Technologies (321)

Level of education
Bachelor's level

Course type
Special (professional), Elective

Semester
7

Language of instruction
English, Ukrainian

Lecturers and course developers

Valentyna Moskalenko

Valentyna.Moskalenko@khpi.edu.ua
Doctor of Technical Sciences, Professor, Professor of SEMIT Department.
Number of scientific and educational publications is more than 100, 13 articles in publications indexed in Scopus.
(https://publons.com/researcher/1588564/valentyna-moskalenko/;
Web of Science ResearcherID R-9960-2018;
https://scholar.google.com.ua/citations?user=eUidJHIAAAAJ&hl;
https://www.scopus.com/authid/detail.uri?authorId=36021571200;
https://orcid.org/0000-0002-9994-5404)
Leading lecturer in disciplines: "Fundamentals of computer science and artificial intelligence methods", "Probability theory and mathematical statistics", "Business analysis methods for requirements management", "Methods of computational intelligence", "Software requirements engineering", "Fundamentals of Machine Learning", "Introduction to neural networks".
Scientific directions: development of information systems for strategic company management; application of computer intelligence methods and models for solving problems of managing complex organizational systems; business analytics.
More about the lecturer on the department's website

General information

Summary

The course is aimed at knowledge of machine learning methods. Studying the discipline will allow the student to analyze the latest trends in Machine Learning. A feature of the discipline is consideration of the most relevant areas of machine learning: Supervised learning, Unsupervised learning, Reinforcement learning for the design of intelligent systems.
The discipline integrates theoretical and practical knowledge of machine learning. The acquired knowledge on solving the problems of classification, clustering, dimensionality reduction and finding

rules, as well as the use of Deep neural network methods for solving artificial intelligence problems will allow the student to effectively engage in the development of algorithms for intelligent systems.

Course objectives and goals

The purpose of the course is to provide students with theoretical knowledge and practical skills in the basics of machine learning, as well as to acquire the skills of a researcher and developer of machine learning models and algorithms.

Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of a test.

Competencies

GC1. Ability to think abstractly, analyze and synthesize.
GC2. Ability to apply knowledge in practical situations.
GC3. Knowledge and understanding of the subject area and understanding of professional activities.
GC6. Ability to learn and master modern knowledge.
GC7. Ability to search, process and analyze information from various sources.
PC2. Ability to identify statistical regularities of non-deterministic phenomena, apply methods of computational intelligence, in particular statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc.
PC4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to take into account the errors of approximate numerical solution of professional problems.
PC6. Ability to think systematically, apply the methodology of system analysis to study complex problems of different nature, methods of formalizing and solving systemic problems with conflicting goals, uncertainties and risks.
PC11. Ability to intelligently analyze data based on computational intelligence methods, including large and poorly structured data, their operational processing and visualization of analysis results in the process of solving applied problems.
PC17. Ability to apply the theoretical and practical foundations of modern management theory of complex organizational, technical and socio-economic systems to build intelligent management systems, to use modern information processing technologies and methods of computational intelligence in the design of intelligent systems.

Learning outcomes

PLO3. To use knowledge of the laws of random phenomena, their properties and operations on them, models of random processes and modern software environments to solve problems of statistical data processing and build predictive models.
PLO4. To use methods of computational intelligence, machine learning, neural network and fuzzy data processing, genetic and evolutionary programming to solve problems of recognition, forecasting, classification, identification of control objects, etc.
PLO8. To use the methodology of system analysis of objects, processes and systems for the tasks of analysis, forecasting, management and design of dynamic processes in macroeconomic, technical, technological and financial objects.
PLO12. Apply methods and algorithms of computational intelligence and data mining in the tasks of classification, forecasting, cluster analysis, search for associative rules using software tools to support multivariate data analysis based on DataMining, TextMining, WebMining technologies.
PLO17. Apply theoretical and practical foundations of modern management theory to build intelligent control systems, design intelligent systems using modern information processing technologies and methods of computational intelligence.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 16 hours, laboratory classes - 16 hours, self-study - 88 hours.

Course prerequisites

The basis of studying the discipline is general knowledge of higher mathematics, numerical methods, operations research, probability theory and mathematical statistics.

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

Teaching and learning methods:
interactive lectures with presentations, discussions, laboratory classes, teamwork, case method, student feedback, problem-based learning.
Forms of assessment:
written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express surveys (CAS), online tests (CAS), final/semester control in the form of a semester test, according to the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1. Methods of machine learning with a teacher (Supervised learning)
Machine learning as a subdivision of artificial intelligence. Basic principles of classical machine learning Types of machine learning. Learning tasks. Needs of ML
Machine learning algorithms with a teacher for the task of classification. Regression and other methods of classification. The method of k-nearest neighbors. Naïve Bayes algorithm. Method of support vectors (support vector machine). Decision tree construction algorithms.
Topic 2. Methods of machine learning without a teacher (Unsupervised learning)
Machine learning algorithms without a teacher for clustering problems. Methods of cluster analysis. Hierarchy Algorithms (Hierarchy Algorithms). Hierarchical divisive (divisive) methods (DIvisive ANAlysis, DIANA). Non-hierarchical methods of cluster analysis: DBSCAN - spatial clustering, Mean-shift clustering algorithm. Quality assessment in the clustering problem.
Dimensionality reduction and rule finding methods. Feature selection methods. Feature extraction methods. methods of feature selection: filters; wrapping methods; built-in methods; hybrid; ensemble Finding associative rules.
Topic 3. Machine learning algorithms with reinforcement (Reinforcement learning) and deep learning.
Algorithms of machine learning with reinforcement (reinforcement learning). Formulation of the task of reinforcement learning. Learning strategies, greedy and ε-greedy strategies. Machine learning models with reinforcement: Markov decision-making process; Q- training. Genetic algorithms.
Neural networks and deep learning. Using Deep neural network for problem solving. Software systems for learning deep neural networks. Principles of image classification. Convolutional networks (CNN). Recurrent neural networks. Neural networks for forecasting processes of various nature.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Machine learning methods with a teacher for solving the classification problem.
Topic 2. Machine learning methods without a teacher for solving the clustering problem.
Topic 3. Methods of machine learning with reinforcement for solving artificial intelligence problems.

Self-study

Topic 1. Methods of machine learning with a teacher (Supervised learning).
Using Python libraries (Scikit-Learn) to implement machine learning algorithms, Using Machine Learning and Deep Learning and Statistics and Machine Learning Toolbox in the Matlab package to solve problems using machine learning methods.
Topic 3. Machine learning algorithms with reinforcement (Reinforcement learning) and deep learning.
Reinforcement Learning Designer toolkit of the MatLab environment for solving problems using reinforcement learning methods.

Possibilities of neuroapplications for modeling neural systems.

Individual assignments are not provided in the curriculum.
Students are recommended with additional materials (videos, articles) for self-study and processing.

Course materials and recommended reading

Key literature

1. Flach, P. (2012). Machine learning: The art and science of algorithms that make sense of data. Cambridge University Press. https://doi.org/10.1017/CBO9780511973000
2. Brink H., Richards J.W., Fetherolf M. (2016) Real-World Machine Learning. Manning Publications, 264 p.
3. Müller A. C., Guido S. (2016) Introduction to Machine Learning with Python. O'Reilly Media, Inc., 392 p.
4. Zgurovsky M.Z., Zaychenko Y.P. The Fundamentals of Computational Intelligence: System Approach. Springer International Publishing Switzerland, 2016. – 375 p.
5. Sutton R. S., Barto A. G. (2018) Reinforcement Learning: An Introduction. Second Edition. MIT Press, Cambridge, MA, 552 p.
6. Nielsen M. Neural Networks and Deep Learning //https://static.latexstudio.net/article/2018/0912/neuralnetworksanddeeplearning.pdf.
7. Murphy K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press, 1096 p.
8. Bishop C. M. (2016) Pattern Recognition and Machine Learning. Springer New York, 758 p
9. Deisenroth M. P., Faisal A. A., Ong C. S. (2020) Mathematics for Machine Learning. Cambridge University Press, 412 p.

Additional literature

1. Zaichenko Yu.P. Fundamentals of designing intelligent systems. Education manual. - K.: "Slovo" publishing house. 2004. - 352 p.
2. Luge G. F., Stubblefield W. A (2013) Artificial intelligence: structures and strategies for complex problem solving. 3rd ed. Harlow, England; Reading, Mass. Addison-Wesley, 740 p.
3. Russell S., Norvig P. (2021) Artificial Intelligence: A Modern Approach, 4th US ed. Hoboken Pearson.
4. Melanie M. (2020) Artificial Intelligence/ A Guide for Thinking Humans. Pelican.
5. Hastie T., Tibshirani R., Friedman J. (2011). The Elements of Statistical Learning. Springer Dive into Deep Learning //http://www.d2l.ai/index.html.
6. Géron A. (2019) Hands-On Machine Learning with Scikit-Learn, Keras, and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems. O'Reilly Media.
7. Zgurovsky M.Z., Zaychenko Y.P. Big Data: Conceptual Analysis and Applications. Springer International Publishing Switzerland, 2019. – 277 p.

Web resources

1. Machine Learning in MATLAB //https://www.mathworks.com/help/stats/machine-learning-in-matlab.html.
2. Mastering Machine Learning: A Step-by-Step Guide with MATLAB //https://www.mathworks.com/campaigns/offers/mastering-machine-learning-with-matlab.html
3. Machine Learning Tutorial //https://www.javatpoint.com/machine-learning.

Assessment and grading

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

100% final assessment in the form of
a test (10%) and a current assessment (90%).
10% credit: semester credit, according to the schedule of the educational process;
90% current assessment:
Laboratory work №1 (30%)
Laboratory work №2 (30%)
Laboratory work №3 (30%)

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-dobrochesnist/

Approval

Approved by	08.06.2023	Head of the department Ihor HAMAIUN
	08.06.2023	Guarantors of the educational programs Andrii KOPP Uliya LITVINOVA