Syllabus
Course Program

Methods of computational intelligence

Specialty
122 – Computer Science

Institute
Institute of Computer Science and Information Technology

Educational program
Computer Science and Intelligent Systems

Department
Software Engineering and Management Intelligent Technologies (321)

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
8

Language of instruction
English, Ukrainian

Lecturers and course developers

Valentyna Moskalenko

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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 study of the academic discipline provides a systematic detailed teaching of the basics of the theory, methods and technologies of computational intelligence (Fuzzy systems, Artificial neural Networks, Evolutionary computation) and their application to the intelligent systems development.

Course objectives and goals

The goal is to provide computer science specialists with theoretical knowledge and practical skills in the basics of computational intelligence for the development of intelligent control systems.

Format of classes

Lectures, laboratory classes, consultations. Final control is an exam.

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, 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 - 10 hours, laboratory classes - 20 hours, self-study - 90 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 exam, according to the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1. Directions of computational intelligence.
System analysis of areas of computational intelligence.
Overview of the main technologies of computational intelligence: Fuzzy systems, Artificial neural Networks, Evolutionary computation.
Topic 2. Fundamentals of fuzzy logic.
Basic concepts and provisions of fuzzy logic.
Stages of fuzzy derivation. Basic fuzzy inference algorithms: Mamdani, Tsukamoto, Sugeno, and Larsen.
Topic 3. Fundamentals of neural networks.
Principles of construction and classification of neural networks.
Learning single-layer and multi-layer neural networks.
Error backpropagation algorithm.
Neural network of radial basis functions.
Topic 4. Fundamentals of genetic algorithms.
The essence of evolutionary computing.
Basics of genetic algorithms.
Solving the optimization problem using genetic algorithms.
Topic 5. Evolutionary modeling.
Basic provisions of evolutionary modeling.
Swarm intelligence. Basic provisions of swarm optimization algorithms. Basic algorithm.
Algorithms based on swarm intelligence: "ant" algorithms, "bee colony" algorithms, algorithms based on the particle swarm method.
Examples of using the Artificial Bee Colony Algorithm for solving optimization problems.
Prospects for the development of computational intelligence methods.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Construction of fuzzy inference systems.
Topic 2. Study of the linear neural network properties, a multilayer nonlinear perceptron, and the backpropagation algorithm
Topic 3. Study of radial basis neural networks, regression networks

Self-study

Topic 1. Directions of computational intelligence
Frameworks used to solve artificial intelligence problems.
Topic 3. Fundamentals of neural networks
The main problems of regression analysis.
Topic 4. Fundamentals of genetic algorithms
Ways to improve mechanisms of crossing over, mutations and selection in genetic algorithms.
Topic 5. Evolutionary modeling
Development directions of evolutionary modeling and evolutionary strategies in problems of computational intelligence

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. Luger G. F. (2021) Knowing our World: An Artificial Intelligence Perspective. Springer.
2. Zgurovsky M. Z., Zaychenko Y. P. The Fundamentals of Computational Intelligence: System Approach. Springer International Publishing Switzerland, 2016. –375 p.
3. Russell S., Norvig P. (2020) Artificial Intelligence: A Modern Approach, 4th US ed.. Pearson
4. Dranyshnikov L. V. Intellectual methods in management: educational manual / L. V. Dranyshnikov. – Kamianske: DDTU, 2018. – 416 p.
5. Melanie M. (2020) Artificial Intelligence/ A Guide for Thinking Humans. Pelican
6. Hlybovets, M. M. Artificial intelligence: textbook / M. M. Hlybovets, O. V. Oletskyi. - K.: Ed. House "KM Academy", 2002. - 366 p.
7. Kavun S. V. Systems of artificial intelligence: education. manual / S. V. Kavun, V. M. Korotchenko. - Kharkiv: Ed. Khneu, 2007. – 320 p.
8. Khaikin S. (2019) Neural Networks: Complete Course. Dialectics, 1104 p.
9. Nguyen H. T., Prasad N. R., Walker C. L., Walker E. A. (2005) A First Course in Fuzzy and Neural Control. Chapman & Hall.
10. Subbotin, S. O. Presentation and processing of knowledge in artificial intelligence and decision support systems: training manual. – Zaporizhzhya: ZNTU, 2008. – 341 p.

Additional literature

1. Turing A.M. (2009) Computing machinery and intelligence. // Parsing the Turing Test, Editors Robert EpsteinGary RobertsGrace Beber, SpringerLink, pp. 23-65.
2. Fenner M. (2019) Machine Learning with Python for Everyone. Addison-Wesley Professional.
3. Zaichenko Yu.P. Fundamentals of designing intelligent systems. Education manual. - K.: "Slovo" publishing house. 2004. - 352 p.
4. Machine Learning in MATLAB // https://www.mathworks.com/help/stats/machine-learning-in-matlab.html.
5. Mastering Machine Learning: A Step-by-Step Guide with MATLAB // https://www.mathworks.com/campaigns/offers/mastering-machine-learning-with-matlab.html.
6.Fuzzy Logic in Intelligent System Design/ Editors: Melin, P., Castillo, O., Kacprzyk, J., Reformat, M., Melek, W. (Eds.) Springer, 2018.
7. What is Fuzzy Logic in AI and What are its Applications? // https://www.edureka.co/blog/fuzzy-logic-ai/
8. What Is A Neural Network? Introduction To Artificial Neural Networks // https://www.edureka.co/blog/what-is-a-neural-network/
9. Perez C. (2019) Neural Networks Using Matlab. Cluster Analysis And CLASSIFICATION. Lulu.com
10. Zgurovsky M. Z., Zaychenko Y. P. Big Data: Conceptual Analysis and Applications. Springer International Publishing Switzerland, 2019. – 277 p.
11. Clarence W. de Silva. (2018) Intelligent Control. Fuzzy Logic Applications. CRC Press; 1st ed. 351 p.

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% semester exam 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	Guarantor of the educational program Andrii KOPP