Syllabus
Course Program

Introduction to neural networks

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

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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 student acquires knowledge of the theory of artificial neural networks (NM), various architectures of NT and methods of their configuration, practical experience of creating neural networks, mastering methods of application and modeling technologies of NT for solving artificial intelligence problems.

Course objectives and goals

The aim of mastering the discipline is to study the methods of synthesis of neural networks and their practical application for solving various problems in the creation of intelligent systems, as well as for students to achieve modern fundamental thinking in the field of data processing and analysis with the help of neural networks.

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 - 32 hours, self-study - 72 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. Introduction to neural networks.
Biological aspects of nervous activity. Neuron. Axon. Synapse. Reflex arcs. Central nervous system. Artificial neuron models. Activation functions. Neuron with vector input. Artificial neural networks. Architecture of artificial neural networks. A set of tools for creating, initializing, training, modeling and visualizing a network.
Topic 2. Perceptron networks.
Methods and algorithms for learning artificial neural networks. Gradient learning algorithms. Algorithms based on the use of the method of conjugate gradients. Perceptron architecture and special functions for creating a perceptron, setting its weights and biases.
Topic 3. Linear neural networks.
Setting the parameters of the Woodrow-Hoff method. Construction and training of linear networks for vector classification, linear approximation, prediction, tracking and filtering of signals, identification, and modeling of linear systems Radial basis networks of general appearance. Architectures of radial basis neural networks of general appearance and their application for vector classification and function approximation. Radial basic networks of the GRNN type. Application of GRNN networks for solving problems of generalized regression, analysis of time series and approximation of functions.
Topic 4. Radial basic networks.
Solving classification problems based on calculating the probability of vectors belonging to the considered classes. Kohonen layers are self-organizing. Architectures of self-organizing Kohonen neural layers and special functions for their creation, initialization, weighting, accumulation, activation, adjustment of weights and shifts, adaptation, and learning. The use of self-organized layers for researching the topological structure of data, combining them into clusters (groups) and dividing them into classes of self-organized Kohonen maps.
Topic 5. Recurrent neural networks.
Construction of networks for the control of moving objects. Building technical vision systems and solving other dynamic tasks. Application of Hopfield's networks to solve problems of pattern recognition and creation of associative memory.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Construction of perceptron architecture networks using special software packages and libraries. Construction and training of linear networks for vector classification. Radial basis function (RBF).
Topic 2. Convolutional neural network (CNN). Recurrent neural network (RNN). Generalized Regression Neural Network (GRNN).
Topic 3. Application of Hopfield networks for pattern recognition and creation of associative memory. Self-organizing Kohonen layers.

Self-study

Topic 1. Introduction to neural networks.
Using Python libraries and the Matlab package to build neural networks.
Topic 3. Linear neural networks.
Possibilities of neuropackages for modeling neural systems. Application and development of linear neural networks.
Topic 4. Radial basic networks.
Application of self-organizing maps to solve problems of clustering input vectors of self-organizing LVQ networks. Architectures of self-organized neural networks of the LVQ type and special functions for their creation, adjustment of weights and training.
Topic 5. Recurrent neural networks.
Application of neural networks for designing control systems of dynamic processes.

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. Subbotin S. O. Neural networks: theory and practice: teaching. manual / S. O. Subbotin. - Zhytomyr: Ed. O. O. Evenok, 2020. - 184 p.
2. Nielsen M. Neural Networks and Deep Learning //https://static.latexstudio.net/article/2018/0912/neuralnetworksanddeeplearning.pdf.
3. Charu C. Aggarwal (2018)Neural Networks and Deep Learning: A Textbook. Springer Cham //https://doi.org/10.1007/978-3-319-94463-0
4. Nicholson C. V. A Beginner's Guide to Neural Networks and Deep Learning //http://wiki.pathmind.com/neural-network
5. Haykin S. (2009) Neural networks and learning machines. New York : Prentice Hall, 906 p.

Additional literature

1. Russell S., Norvig P. (2021) Artificial Intelli.gence: A Modern Approach, 4th US ed. Hoboken Pearson.
2. Zgurovsky M.Z., Zaychenko Y.P. Big Data: Conceptual Analysis and Applications. Springer International Publishing Switzerland, 2019. – 277 p.
3. Duval F. (2018) Artificial Neural Networks. Concepts, Tools and Techniques explained for Absolute Beginners. CreateSpace Independent Publishing Platform, 128p.
4. Bishop C. M. (2016) Pattern Recognition and Machine Learning. Springer New York, 758 p
5. Deisenroth M. P., Faisal A. A., Ong C. S. (2020) Mathematics for Machine Learning. Cambridge University Press, 412 p.
6. Hagan M. T., Demuth H. B., Beale M. (1995) Neural Network Design. Pws Pub Co, 736 p.
7. Gurney K. (1997) An Introduction to Neural Networks. CRC Press 248 p.
8. Zgurovsky M.Z., Zaychenko Y.P. The Fundamentals of Computational Intelligence: System Approach. Springer International Publishing Switzerland, 2016. – 375 p.

Web resources

1. Deep Learning Resources. Online Courses // http://wiki.pathmind.com/deeplearning-research-papers
2. Machine Learning Tutorial //https://www.javatpoint.com/machine-learning.
3. Deep Learning vs. Neural Networks // https://blog.purestorage.com/purely-informational/deep-learning-vs-neural-networks/

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