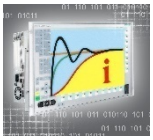
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"



Information systems and technologies

METHODS AND TECHNOLOGIES OF ARTIFICIAL INTELLIGENCE

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	**First (undergraduate)**
Branch of knowledge	12 Information technologies
Specialty	126 Information systems and technologies
Educational program	Integrated information systems
Discipline status	Academic discipline of professional and practical training (chosen by students)
Form of education	full-time/correspondence/distance
Year of training, semester	3rd year, autumn semester
Scope of the discipline	120 hours (36 hours – Lectures, 18 hours – Laboratory, 66 hours – SRS)
Semester control/ control measures	Assessment/assessment work
Lessons schedule	http://rozklad.kpi.ua/Schedules/ScheduleGroupSelection.aspx
Language of teaching	Ukrainian, English
Information about the course leader / teachers	Lecturer: candidate of technical sciences, associate professor Volodymyr Mykolayovych Shymkovich, v.shymkovych@kpi.ua, Telegram:@volodymyr_shymkovych Laboratory: candidate of technical sciences, associate professor Volodymyr Mykolayovych Shymkovich, v.shymkovych@kpi.ua, Telegram:@volodymyr_shymkovych
Placement of the course	https://campus.kpi.ua

Program of educational discipline

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

Description of the discipline. When studying this discipline, students will learn the theoretical foundations of artificial intelligence and get initial experience in the development of systems that implement artificial intelligence technologies. Laboratory classes will provide initial experience in creating systems with artificial intelligence. They will model and explore technologies such as fuzzy logic, neural networks, and evolutionary algorithms using programming languages or automated design systems. The course provides quality control of the acquired knowledge in the form of express tasks with the help of software packages of control and modular control works.

The subject of the academic discipline:basic concepts, methods and technologies of artificial intelligence, fuzzy logic and fuzzy sets, methods of building fuzzy control and decision-making systems, basic concepts of neural networks, topologies of neural networks, methods of learning neural networks, deep neural networks, neuro-fuzzy systems, evolutionary and genetic algorithms

Interdisciplinary connections. Discipline "Methods and technologies of artificial intelligence" is based on disciplines: Special sections of mathematics-1. Discrete Math; Theory of algorithms; Programming - 1. Basics of programming; Programming - 2. Data structures and algorithms; Software development technologies.

The purpose of the educational discipline. Training of highly qualified specialists who possess the basic methods and technologies of artificial intelligence, the theory of fuzzy sets, methods of building fuzzy systems, terms of neural network systems, the structure and properties of neural network systems, paradigms and methods of learning neural network models, principles of operation and construction of neuro-fuzzy systems, evolutionary and genetic algorithms.

The main tasks of the academic discipline

Knowledge:

- basic concepts of artificial intelligence;
- artificial intelligence technologies;
- theory of fuzzy sets, methods of constructing fuzzy systems;
- theory of neural networks, basic concepts and properties;
- different architectures of neural networks;
- paradigms and methods of learning neural network models;
- principles of operation and construction of neuro-fuzzy systems;
- evolutionary and genetic algorithms;

Skills:

- apply operations on fuzzy sets, build fuzzy models;
- to model fuzzy management and decision-making systems;
- implement fuzzy data classification systems;
- build and simulate neural network models of various architectures;
- apply genetic algorithms to find optimal solutions;

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Prerequisites:be able to use a computer at the administrator level, be able to work with virtual machines (create, configure, modify), basic knowledge of set theory.

Post-requisites:design and implementation of software using neural network applications.

After completing the discipline, students will be able to model and investigate systems with fuzzy logic, with neural networks and apply the method of error back propagation for learning neural networks, model neuro-fuzzy systems, find optimal solutions using evolutionary algorithms.

3. Content of the academic discipline

1. Structure of the discipline "Methods and technologies of artificial intelligence", RSO. The concept of artificial intelligence. Intelligence and its main provisions. Technologies of artificial intelligence.
2.Unclear information and conclusion. The concept of a fuzzy set. Examples of writing a fuzzy set. Linguistic variable. Basic characteristics of fuzzy sets. Operations on fuzzy sets. Logical operations on fuzzy sets. Properties of operations on fuzzy sets.
3.Types of membership functions of fuzzy sets. Fuzzy logic in managing complex systems. Concept of fuzzy and linguistic variable.
4. Fuzzy inference system. Fasification. Aggregation. Activation. Accumulation. Defuzzification. Methods of defuzzification. Mamdani's vague conclusion. Tsukamoto's vague conclusion. Sugeno's vague conclusion. A simplified fuzzy inference algorithm.
5. Neural networks and artificial intelligence. Neural network. Development of neural networks. Implementations of neural networks. Basic properties of neural networks. Advantages of neural networks. Disadvantages of neural networks. Tasks solved by neural networks. Biological neuron. Artificial neuron. Activation functions.
6. Classification of neural networks. Parceptron. Basic concepts of perceptron theory. Multi-layer forward propagation neural networks. Cascade neural networks. Dynamic multilayer neural networks. Recirculation neural networks. Hopfield neural network. Elman's neural network. Choosing the structure of neural networks.
7. Kohonen's self-organizing maps. An example of the Kohonen network. Counterpropagation network. Convolutional neural network. A multi-channel version of a convolutional neural network. Convolutional neural network parameters.
8. Learning artificial neural network. Learning NM with a teacher, without a teacher, with reinforcement. Learning algorithms. The method of backpropagation of the error.
9. Backpropagation in convolutional neural networks. Gauss-Newton and Levenberg-Marquardt methods.
10. Neuro-fuzzy systems. Combining fuzzy systems with neural networks. Cooperative fuzzy neural network. Hybrid fuzzy neural network. An overview of developed hybrid neuro-fuzzy networks. Adaptive Neuro-Fuzzy System (ANFIS). Hybrid learning algorithm. Modeling of a nonlinear function of two variables. Advantages of ANFIS. Disadvantages of ANFIS.
11. Introduction to genetic algorithms. Genetic search as an optimization method. Genetic search and traditional methods of optimization. Generalized scheme of work of genetic methods.
12. Classification of evolutionary search methods. Genetic search models. Canonical models. Genitor. Hybrid genetic method. Parallel and multilevel genetic methods. Genetic search with decreasing population size. Initialization and launch of genetic search. Definition of the objective function. Initialization. Selection. Crossing. Mutation. Formation of a new generation. Stop criteria.
13. Parametric synthesis of neural networks. Evolutionary method of parametric synthesis of neural network models using a priori information. Structural synthesis of neural networks. Presentation of information about the structure of the neural network in the chromosome. Definition of the fitness function. The sequence of execution of structural synthesis based on methods of evolutionary optimization. Evolutionary operators for structural synthesis of neuromodels.
14. When to apply deep learning. Why deep learning? Classification of approachesdeep learning. Deep learning with a teacher. Deep learning with partial teacher application. Deep learning without a teacher. Deep learning with reinforcement. Types of deep learning networks. Recursive neural networks. Recurrent neural networks. Convolutional neural networks. Advantages of using CNN. Regulation in CNN. Choosing an optimizer. Improving the performance of CNNs.

15.CNN architectures. AlexNet network architecture. Networkinnetwork. ZefNet. Visual geometry group (VGG). GoogleNet. Highway network. ResNet. Inception: ResNet and InceptionV3/4. DenseNet. ResNext. WideResNet. Xception.
16. Training data. Transfer learning. Data augmentation techniques. Imbalanced data. Interpretability of data. Uncertainty scaling. Model compression. Overfitting. Vanishing gradient problem. Exploding gradient problem. Underspecification. Applications of deep learning. Computational approaches. GPUbased approach. FPGAbased approach.
17.Long Short-Term Memory. How to train a model.
18.Time series forecasting. Natural language processing (NLP). Sentiment analysis. Subtitles for images and videos. Computer Vision. Text recognition.

Lecture classes

Chapter 1. General provisions of artificial intelligence.

Chapter 2. Fuzzy sets, fuzzy logic and construction of fuzzy systems.

Chapter 3. Theory of neural networks.

Chapter 4. Neuro-fuzzy systems.

Chapter 5. Evolutionary algorithms.

Chapter 6. Deep neural networks.

Laboratory classes

1. Study of ways of forming fuzzy sets and operations on them.
2. Modeling of a control object with two inputs and one output by means of fuzzy mathematics.
3. Study of fuzzy clustering algorithm.
4. Simulation of a control object with two inputs and one output based on neural.
5. Modeling the Hebb neural network.
6. Neuro-fuzzy modeling.
7. Finding the minimum and maximum of functions using genetic algorithms.
8. WITHthe use of genetic algorithms in optimization problems.

4. Educational materials and resources

Basic literature

1. Shakhovska N. B. Systems of artificial intelligence: study guide / N.B. Shakhovska, R. M. Kaminsky, O. B. Vovk. – Lviv: Publishing House of Lviv Polytechnic, 2018. – 392 p.
2. Zaichenko Yu.P. Fundamentals of designing intelligent systems. Study guide / Yu.P. Zaichenko. - K.: Slovo, 2004. - 352 p.
3. Kutkovetsky V.Ya. Image recognition: Study guide / V.Ya. Kutkovetskyi. - Mykolaiv: Department of the Moscow State University named after P.Mohyly, 2017. – 420 p.
4. Nilsson, Nils (2009). The Quest for Artificial Intelligence: A History of Ideas and Achievements. New York: Cambridge University Press.
5. Charu C. Aggarwal. Neural Networks and Deep Learning. A Textbook. Springer Cham. 2019 – 497 p.
6. Subotin, S. O. Non-iterative, evolutionary and multi-agent methods of synthesis of fuzzy logic and neural network models: monograph / S. O. Subotin, A. O. Oliynyk, O. O. Oliynyk; in general ed. S. O. Subotina. – Zaporizhzhia: ZNTU, 2009. – 375 p.

Supporting literature

1. Li, Zewen & Yang, Wenjie & Peng, Shouheng & Liu, Fan. (2020). A Survey of Convolutional Neural Networks: Analysis, Applications, and Prospects.
2. Chen, Xiaoxue & Jin, Lianwen & Zhu, Yuanzhi & Luo, Canjie & Wang, Tianwei. (2020). Text Recognition in the Wild: A Survey.
3. Yang YX, Wen C, Xie K, Wen FQ, Sheng GQ, Tang XG. Face Recognition Using the SR-CNN Model. Sensors (Basel). 2018;18(12):4237. Published 2018 Dec 3. doi:10.3390/s18124237
4. Kocić J, Jovičić N, Drndarević V. An End-to-End Deep Neural Network for Autonomous Driving Designed for Embedded Automotive Platforms. Sensors. 2019; 19(9):2064.
5. A. Kumar, S. Verma and H. Mangla, "A Survey of Deep Learning Techniques in Speech Recognition," 2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida (UP), India, 2018, pp. 179-185, doi: 10.1109/ICACCCN.2018.8748399.
6. Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, Illia PolosukhinAttention is All you Need. Part ofAdvances in Neural Information Processing Systems 30 (NIPS 2017)
7. Thierry Bouwmans,Sajid Javed,Soon Ki Jung.Deep neural network concepts for background subtraction: A systematic review and comparative evaluation.Neural Networks.Volume 117, September 2019, Pages 8-66

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

No. z/p	The name of the topic of the lecture and a list of the main questions (a list of didactic tools, references to the literature and tasks on the SRS)
1	Chapter 1. General provisions of artificial intelligence. Topic 1.1. Structure and content of the course. RSO Topic 1.2. General concepts of artificial intelligence. Lecture 1. Basic concepts and definitions of artificial intelligence. Structure of the discipline "Methods and technologies of artificial intelligence", RSO. The concept of artificial intelligence. Intelligence and its main provisions. Technologies of artificial intelligence. Literature: [2, Chapter 1], [3, Chapter 1] Tasks on SRS. Artificial intelligence - application and implementation examples.
2	Chapter 2. Fuzzy sets, fuzzy logic and construction of fuzzy systems. Topic 2.1.Fuzzy logic. Lecture 2.Fuzzy logic. Unclear information and conclusion. The concept of a fuzzy set. Examples of writing a fuzzy set. Linguistic variable. Basic characteristics of fuzzy sets. Operations on fuzzy sets. Logical operations on fuzzy sets. Properties of operations on fuzzy sets. Literature: [1, Chapter 1], [3, Chapter 1] Tasks on SRS.Fuzzy operators.

3	Chapter 2. Fuzzy sets, fuzzy logic and construction of fuzzy systems. Topic 2.2.Membership functions. Lecture 3.Fuzzy logic. Membership functions. Types of membership functions of fuzzy sets. Fuzzy logic in managing complex systems. Concept of fuzzy and linguistic variable. Literature: [1, Ch. 1.1.2; Ch. 3], [3, Ch. 1] Tasks on SRS.Linguistic variables of truth.
4	Chapter 2. Fuzzy sets, fuzzy logic and construction of fuzzy systems. Topic 2.3.Fuzzy inference systems. Lecture 4.Fuzzy logic. Fuzzy inference systems. Fuzzy inference system. Fasification. Aggregation. Activation. Accumulation. Defuzzification. Methods of defuzzification. Mamdani's vague conclusion. Tsukamoto's vague conclusion. Sugeno's vague conclusion. A simplified fuzzy inference algorithm. Literature: [1, Chapter 5], [3, Chapter 6] Tasks on SRS. Fuzzy inference systems - applications and implementation examples.
5	Chapter 3. Theory of neural networks. Topic 3.1. Basic provisions of artificial neural networks. Lecture 5. Artificial neural networks Neural networks and artificial intelligence. Neural network. Development of neural networks. Implementations of neural networks. Basic properties of neural networks. Advantages of neural networks. Disadvantages of neural networks. Tasks solved by neural networks. Biological neuron. Artificial neuron. Activation functions. Literature: [1, Ch. 14], [3, Ch. 6; Ch. 9], [6, Ch. 2] Tasks for SRS.Types of neural networks and their classification.
6	Chapter 3. Theory of neural networks. Topic 3.2.Basic models. Lecture 6.Basic models. Classification of neural networks. Parceptron. Basic concepts of perceptron theory. Multi-layer forward propagation neural networks. Cascade neural networks. Dynamic multilayer neural networks. Recirculation neural networks. Hopfield neural network. Elman's neural network. Choosing the structure of neural networks. Literature: [1, Ch. 5; Ch. 6], [3, Ch. 10], [6, Ch. 3; Ch. 4] Tasks for SRS. Review and analysis of neural network models of various objects and decision-making systems.
7	Chapter 3. Theory of neural networks. Topic 3.2.Basic models. Lecture 7.Basic models. Kohonen self-organizing maps. An example of the Kohonen network.

	Counterpropagation network. Convolutional neural network. A multi-channel version of a convolutional neural network. Convolutional neural network parameters. Literature: [1, Chapter 12], [2, Chapter 6], [3, Chapter 9] Tasks for SRS. Examples of using the Kohonen network. Application examplesconvolutional neural network.
8	Chapter 3. Theory of neural networks. Topic 3.3.Methods of learning neural networks. Lecture 8.Teaching methods. Learning artificial neural network. Learning NM with a teacher, without a teacher, with reinforcement. Learning algorithms. The method of backpropagation of the error. Literature: [1, Chapter 1; Chapter 4], [2, Chapter 4; Chapter 5] Tasks for SRS.Learning with the partial involvement of the teacher.
9	Chapter 3. Theory of neural networks. Topic 3.3.Methods of learning neural networks Lecture 9.Teaching methods. Backpropagation in convolutional neural networks. Gauss-Newton and Levenberg-Marquardt methods. Tasks for SRS. Review and analysis of software and hardware tools for learning neural networks.
10	Chapter 4. Theory of neural networks. Topic 4.1.Neuro-fuzzy systems Topic 4.2. Adaptive neuro-fuzzy system. Lecture 10.Fuzzy neural networks. Neuro-fuzzy systems. Combining fuzzy systems with neural networks. Cooperative fuzzy neural network. Hybrid fuzzy neural network. An overview of developed hybrid neuro-fuzzy networks. Adaptive Neuro-Fuzzy System (ANFIS). Hybrid learning algorithm. Modeling of a nonlinear function of two variables. Advantages of ANFIS. Disadvantages of ANFIS. Literature: [7, Chapter 2] Tasks for SRS. Examples of systems with neuron-fuzzy systems.
11	Chapter 5. Evolutionary algorithms. Topic 5.1.Genetic algorithms. Lecture 11.Genetic algorithms. Introduction to genetic algorithms. Genetic search as an optimization method. Genetic search and traditional methods of optimization. Generalized scheme of work of genetic methods. Literature: [7, Chapter 4] Tasks for SRS. Types of evolutionary algorithms.

12	Chapter 5. Evolutionary algorithms. Topic 5.1.Genetic algorithms. Lecture 12.Genetic algorithms. Classification of evolutionary search methods. Genetic search models. Canonical models. Genitor. Hybrid genetic method. Parallel and multilevel genetic methods. Genetic search with decreasing population size. Initialization and launch of genetic search. Definition of the objective function. Initialization. Selection. Crossing. Mutation. Formation of a new generation. Stop criteria. Literature: [7, Ch. 2; 3] Tasks for SRS. Review and analysis of evolutionary search methods, their scope, advantages and disadvantages.
13	Chapter 5. Evolutionary algorithms. Topic 5.2.Synthesis of neural networks. Lecture 13.Synthesis of neural networks by genetic algorithms. Parametric synthesis of neural networks. Evolutionary method of parametric synthesis of neural network models using a priori information. Structural synthesis of neural networks. Presentation of information about the structure of the neural network in the chromosome. Definition of the fitness function. The sequence of execution of structural synthesis based on methods of evolutionary optimization. Evolutionary operators for structural synthesis of neuromodels. Literature: [1, Ch. 9], [2, L. 9], [3, Ch. 10], [7, Ch. 11] Tasks for SRS. Methods of solving the problem of structural synthesis of neural networks.
14	Chapter 6. Deep neural networks Topic 6.1. An overview of deep learning Lecture 14. Overview of deep learning. When to apply deep learning. Why deep learning? Classification of approachesdeep learning. Deep learning with a teacher. Deep learning with partial teacher application. Deep learning without a teacher. Deep learning with reinforcement. Types of deep learning networks. Recursive neural networks. Recurrent neural networks. Convolutional neural networks. Advantages of using CNN. Regulation in CNN. Choosing an optimizer. Improving the performance of CNNs. Literature: [1, Ch. 4], [2, L. 13] Tasks for SRS. Rthe difference between "neural networks" and "deep learning"?
15	Chapter 6. Deep neural networks Topic 6.2. CNN networks. Lecture 15. CNN networks. CNN architectures. AlexNet network architecture. Networkinnetwork. ZefNet. Visual geometry group (VGG). GoogleNet. Highway network. ResNet. Inception: ResNet and InceptionV3/4. DenseNet. ResNext. WideResNet. Xception.

	Tasks for SRS. The architecture of YOLO neural networks for object detection.
16	Chapter 6. Deep neural networks Topic 6.2. CNN networks. Lecture 16. CNN networks. Training data. Transfer learning. Data augmentation techniques. Imbalanced data. Interpretability of data. Uncertainty scaling. Model compression. Overfitting. Vanishing gradient problem. Exploding gradient problem. Underspecification. Applications of deep learning. Computational approaches. GPUbased approach. FPGA-based approach. Literature: [7, Chapter 10] Tasks for SRS. Methods of learning neural networks and their software implementations.
17	Chapter 6. Deep neural networks Topic 6.3. LSTM networks. Lecture 17. Overview of the model of long-term short-term memory. Long Short-Term Memory (LSTM). Long Short-Term Memory. How to train a model. Literature: [7, Chapter 10], [8] Tasks for SRS. Types of long-term short-term memory model architectures.
18	Chapter 6. Deep neural networks Topic 6.3. LSTM networks. Lecture 18. Application of the long-term short-term memory model. Time series forecasting. Natural language processing (NLP). Sentiment analysis. Subtitles for images and videos. Computer Vision. Text recognition. Literature: [7, Chapter 8] Tasks for SRS. Other areas of application of the long-term short-term memory model.

Laboratory classes

No	The name of the laboratory work	Number of aud. hours
1	Laboratory work 1. Study of methods of forming fuzzy sets and operations on them. Construct fuzzy sets using different types of membership functions. Perform the most common logical operations on fuzzy sets. Literature: [3, Chapter 2]	4
2	Laboratory work 2. Modeling a function with two variables by means of fuzzy mathematics. Model a function of two variables using fuzzy logic. Conduct a study of the shape of the membership function on the quality of modeling. Literature: [3, Chapter 2]	2
3	Laboratory work 3. Study of fuzzy clustering algorithm. Solving the practical task of clustering by methods of fuzzy logic. Literature: [3, Chapter 6]	2
4	Laboratory work 4. Modeling the function of two variables with two inputs and one output based on neural networks. To study the structure and principle of operation of a neural network. Use a neural network to model the function of two variables. Literature: [7]	2
5	Laboratory work 5. Modeling the Hebb neural network Model and explore a Hebb neural network. Literature: [7], [8]	2
6	Laboratory work 6. Neuro-fuzzy modeling. Obtaining and consolidating knowledge about modeling methods and principles of functioning of neurofuzzy systems, as well as formation of practical skills in the construction of neurofuzzy networks. Literature: [7]	2
7	Laboratory work 7. Finding the minimum and maximum of functions using genetic algorithms Find the minimum (minimization) and maximum (maximization) of functions of one and two variables using genetic algorithms.	2
8	Laboratory work 8. Application of genetic algorithms in optimization problems. Obtaining and consolidating knowledge, forming practical skills of applying genetic algorithms to various optimization tasks.	2

6. Independent work of student

No. z/p	The name of the topic submitted for independent processing	Number of hours of SRS
1	Artificial intelligence - application and implementation examples.	2
2	Fuzzy operators.	2
3	Linguistic variables of truth.	4
4	Fuzzy inference systems - applications and implementation examples.	4
5	Types of neural networks and their classification.	2
6	Review and analysis of neural network models of various objects and decision-making systems.	2
7	Examples of using the Kohonen network. Application examplesconvolutional neural network.	4
8	Learning with the partial involvement of the teacher.	4
9	Independently master the materials onnoise perspectives.	4
10	Examples of systems with neuron-fuzzy systems.	4
11	Types of evolutionary algorithms.	8
12	Review and analysis of evolutionary search methods, their scope, advantages and disadvantages.	2
13	Methods of solving the problem of structural synthesis of neural networks.	4
14	Rthe difference between "neural networks" and "deep learning"?	4
15	The architecture of YOLO neural networks for object detection.	2
16	Methods of learning neural networks and their software implementations.	4
17	Types of long-term short-term memory model architectures.	3
18	Other areas of application of the long-term short-term memory model.	3
	Hours in general	66

Policy and control

7. Policy of academic discipline (educational component)

The system of requirements for the student:

- attending lectures and laboratory classes is a mandatory component of studying the material;
- the teacher uses his own presentation material at the lecture; uses Google Drive for teaching the material of the current lecture, additional resources, laboratory work, etc.; the teacher opens access to a certain Google Drive directory for downloading electronic laboratory reports and answers to the MKR;
- during lectures, it is forbidden to distract the teacher from teaching the material, all questions, clarifications, etc. students ask at the end of the lecture in the time allotted for this;
- laboratory works are defended in two stages - the first stage: students perform tasks for admission to the defense of laboratory work; the second stage is protection of laboratory work. Points for laboratory work are taken into account only if there is an electronic report;
- modular test papers are written in lectures without the use of aids (mobile phones, tablets, etc.); the result is forwarded in a file to the corresponding Google Drive directory;
- incentive points are awarded for: active participation in lectures; participation in faculty and institute olympiads in academic disciplines, participation in work competitions, preparation of reviews of scientific works; presentations on one of the topics of the SRS discipline, etc. The number of encouraged points is more than 10;
- penalty points are issued for: untimely submission of laboratory work. The number of penalty points is no more than 10.

8. Types of control and rating system for evaluating learning outcomes (RSE)

The student's rating in the discipline consists of the points he receives for:

1. execution and protection of 8 laboratory works;
2. execution of modular control work (MCW);
3. incentive and penalty points.

System of rating points and evaluation criteria

Laboratory works:
"excellent", a complete answer to the questions during the defense (at least 90% of the required information) and a properly prepared electronic protocol for laboratory work - 10 points;
"good", a sufficiently complete answer to the questions during the defense (at least 75% of the required information) and a properly prepared electronic protocol for laboratory work - 9/7 points;
"satisfactory", incomplete answer to the questions during the defense (at least 60% of the required information), minor errors and properly prepared electronic protocol for laboratory work - 6/5 points;
"unsatisfactory", an unsatisfactory answer and/or an improperly prepared electronic protocol for laboratory work - 0 points.

For late submission of laboratory work before the deadline, i.e. late submission of laboratory work by more than one class, the grade is reduced by 2 points.

Modular control work:
"excellent", complete completion of the task (at least 90% of the required information in the report to the MCW) - 20 points;
"good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor errors - 16-18 points;
"satisfactory", incomplete answer (but not less than 60% of the required information) and minor errors - 10-16 points;
"unsatisfactory", unsatisfactory answer (incorrect problem solution), requires mandatory rewriting at the end of the semester - 0 points.

Incentive points
– for the performance of creative works from the credit module (for example, participation in faculty and institute olympiads in academic disciplines, participation in work competitions, preparation of reviews of scientific works, etc.); for active work at the lecture (questions, additions, comments on the topic of the lecture, when the lecturer invites students to ask their questions) 1-2 points, but not more than 10 in total;
– presentations on SRS - from 1 to 5 points.

Intersessional certification
According to the results of educational work for the first 7 weeks, the maximum possible number of points is 20 points (2 laboratory points). At the first certification (8th week), the student receives "credited" if his current rating is not less than 10 points.

According to the results of 13 weeks of training, the maximum possible number of points is 70 points (4 laboratory, MKR). At the second certification (14th week), the student receives "credited" if his current rating is not less than 40 points.

The maximum sum of weighted points of control measures during the semester is:

$$RD = 7*rlab+rmkr=7*10+30\ (rz - rsh)=100 + (rz - rsh),$$

where rlab is a score for laboratory work (0...10);
rmkr – score for writing MKR (0...20);

rz - incentive points for active participation in lectures, presentations, participation in Olympiads, work competitions, scientific works on the subject of the discipline (0...10);
rzsh - penalty points.

Test:
The condition for obtaining a credit is the enrollment of all laboratory works, writing modular control papers and a starting rating of at least 42 points.

During the test, students perform a written test. Each ticket contains three theoretical questions (tasks). The list of theoretical questions is given in Appendix 1. Each question (task) is valued at 15 points.

Question evaluation system:
"excellent", a complete answer, at least 90% of the required information, which was completed in accordance with the requirements for the "skills" level (complete, error-free solution of the task) - 14-15 points;
"good", sufficiently complete answer, at least 75% of the required information, fulfilled in accordance with the requirements for the "skill" level or there are minor inaccuracies (complete solution of the task with minor inaccuracies) - 10-14 points;
"satisfactory", incomplete answer, at least 60% of the required information, completed in accordance with the requirements for the "stereotypical" level and some errors (the task was completed with certain shortcomings) - 7-9 points;
"unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0-6 points.

The sum of points for the final test is converted to the final grade according to the table:

Table 1. Conversion of rating points to grades on the university scale

Scores	Rating
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
There are uncredited laboratory works or modular control work is not counted	Not allowed

9. Additional information on the discipline (educational component)

- the list of theoretical questions submitted for semester control is given in Appendix 1;
- at the beginning of the semester, the teacher analyzes the existing courses on the topic of the discipline and offers students to take the corresponding free courses. After the student receives a certificate of completion of remote or online courses on the relevant topic, the teacher closes the relevant part of the course (laboratory or lectures) by prior agreement with the group.

Working program of the academic discipline (Syllabus):

Folded Ph.D., Associate Professor, Volodymyr Mykolayovych Shymkovych

Approved Department of ICT (protocol No. 13 dated 15.06.2022)

Agreed Methodical commission of the faculty[1](protocol No. 11 dated 07.07.2022)

[1]Methodical council of the university - for general university disciplines.

Appendix 1

A list of theoretical questions for assessment in the first part of the course

1. 1. Define the term "artificial intelligence".
2. Give a definition and an example of a fuzzy set.
3. Give a definition and an example of a linguistic variable.
4. What are the main characteristics of fuzzy sets?
5. On what basis can operations be performed on fuzzy sets. Give examples.
6. What logical operations can be performed on fuzzy sets. Give examples.
7. State the properties of operations on fuzzy sets.
8. What operators can be applied to fuzzy sets.
9. Define the membership function.
10. What types of membership functions do you know?
11. The concept of a fuzzy variable. Give a definition and an example.
12. Give the definition and structure of a fuzzy inference system.
13. Give a definition and an example of a fuzzy production rule.
14. Give the definition and example of fuzzification in a fuzzy inference system.
15. Give the definition and example of aggregation in a fuzzy inference system.
16. Give the definition and example of activation in a fuzzy inference system.
17. Give the definition and example of defuzzification in a fuzzy inference system.
18. Describe Mamdani's general fuzzy inference algorithm.
19. Describe a general Tsukamoto fuzzy inference algorithm.
20. Describe a general algorithm for Sugeno's fuzzy inference.
21. Describe a general algorithm for simplified fuzzy inference.
22. Define the term Machine Learning.
23. What methods are included in the field of machine learning.
24. Give the definition and main characteristics of artificial neural networks.
25. List the advantages and disadvantages of artificial neural networks.
26. What tasks in modern science and technology are solved by neural networks?
27. Give the definition and characteristics of a biological neuron.
28. Give a structural diagram and a mathematical model of an artificial neuron.
29. What is an activation function and what activation functions are used inartificial neural networks.
30. Give the types and classification of artificial neural networks.
31. Give the definition of Parceptron, its structural diagram and main characteristics.
32. Give the structural diagram and main characteristics of a forward propagation neural network.
33. Give the structural diagram and main characteristics of a cascade neural network.

34. Give the structural diagram and main characteristics of a recirculating neural network.
35. Give the structural diagram and main characteristics of a Hopfield neural network.
36. Give the structural diagram and main characteristics of the Ellman neural network.
37. Give the structural diagram and main characteristics of the radial-basis neural network RBF.
38. Describe a general algorithm for choosing a neural network structure for building a model.
39. Describe the structure and principle of operation of the Kohonen neural network.
40. Describe the structure and principle of operation of a convolutional neural network.
41. What is meant by neural network training and what training paradigms exist.
42. Describe the neural network learning algorithm with the teacher.
43. Describe the neural network learning algorithm without a teacher.
44. Describe the neural network learning algorithm with partial involvement of the teacher.
45. Describe the neural network learning algorithm with reinforcement.
46. Describe the error backpropagation method for training artificial neural networks.
47. What are the advantages and disadvantages ofmethod of backpropagation of error in training artificial neural networks.
48. How is learning of convolutional neural networks byby the method of backpropagation of the error.
49. Describe the Levenberg-Marquardt method for training artificial neural networks.
50. Give the definition of a neuro-fuzzy system.
51. Give the main characteristics of a neuro-fuzzy system.
52. What types of neuro-fuzzy systems exist?
53. Give the structure and main characteristics of the adaptive neuro-fuzzy ANFIS system.
54. List the advantages and disadvantagesadaptive neuro-fuzzy ANFIS system.
55. Give a definition of a genetic algorithm, a formal description, and indicate the areas of its application.
56. State the advantages and disadvantages of the genetic algorithm as an optimization method.
57. Give and describe a generalized scheme of work of genetic methods.
58. Give the classification of evolutionary search methods.
59. List and describe genetic search models.
60. How is genetic search initialized and launched?
61. How is the target function of genetic search determined?
62. How does the genetic search selection operator work?
63. How does the genetic search crossover operator work?
64. How does the genetic search mutation operator work?
65. How is the formation of a new generation of genetic research?

66. What are the criteria for stopping the genetic search?
67. Describe the algorithm for parametric synthesis of neural networks using genetic search.
68. Describe the algorithm of parametric synthesis of neural networks using genetic search, taking into account the significance of features of the training sample.
69. Describe the algorithm for structural synthesis of neural networks using genetic search.
70. List the main types of deep neural networks.
71. List the types of optimizers used in training deep neural networks.
72. Give the architecture of the AlexNet network and describe it.
73. Give the architecture of Networkinnetwork and describe it.
74. Give the ZefNet network architecture and describe it.
75. Give the architecture of the VGG network and describe it.
76. Outline the Inception network architecture and describe it.
77. Give the architecture of the ResNet network and describe it.
78. Give the DenseNet network architecture and describe it.
79. Give the Xception network architecture and describe it.
80. Give the architecture of an LSTM network and describe it.
81. How does transfer learning work in deep neural networks?
82. What are the methods of increasing training data in deep neural networks?
83. What is the vanishing gradient problem in deep neural networks?
84. What is the exploding gradient problem in deep neural networks?
85. What software frameworks exist for implementing neural networks?
86. What hardware tools exist for implementing neural networks?
87. What are the advantages and disadvantages of CPU when implementing neural networks?
88. What are the advantages and disadvantages of GPU when implementing neural networks?
89. What are the advantages and disadvantages of TPU when implementing neural networks?
90. What are the advantages and disadvantages of FPGA when implementing neural networks?

    What are the advantages and disadvantages of ASIC when implementing neural networks?
91. Architecture of LSTM networks
92. LSTM network learning algorithm.
93. Application of LSTM networks.