MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
ODESSA I.I. Mechnikov NATIONAL UNIVERSITY
Department of mathematical support of computer systems

"APPROVED"
Vice-rector for scientific and pedagogical work

_____ 20___

WORKING PROGRAM OF EDUCATIONAL COURSE

OK5 *"Fuzzy models and methods in intelligent systems"*
(course name)

Level of higher education _____ Second (master's) _____

Field of knowledge _____ 12 – Information technologies _____

Specialty _____ 126 – Information systems and technologies _____
(code and name of specialty)

Educational and professional program _____ Information systems and technologies _____
(EPP/ESP name)

ONU - 2023

Working program of the study course "Fuzzy models and methods in intelligent systems". – Odesa: ONU, 2023. – 14 p.
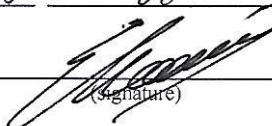

Developers:
Mykhaylenko V.S., Doctor of Sciences (Tech.), Professor of the Department of Computer Systems and Technology;
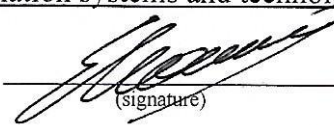Krapivny Yu.M., Ph.D. (Ph.-M.), Associate Professor of the Department of MSCS;
Maksimov O.S., Senior Lecturer of the Department of MSCS.

The work program was approved at the meeting of the Department of Mathematical Support of Computer Systems

Protocol No. _1_ from "_29_" _____08_____ 20_23_year

Head of the department _____ (Eugene MALAKHOV)
                              (signature)   (First Name Surname)

Agreed with the guarantor of the EPP _"Information systems and technologies"_

_____ (Eugene MALAKHOV)
         (signature)   (First Name Surname)

Approved by the educational and methodical commission (EMC) for IT specialties of the FMPhIT

Protocol No. _1_ from "_31_" _____08_____ 20_23_year

Head of EMC. _____ (Alla RACHYNSKA)
                    (signature)   (First Name Surname)

Reviewed and approved at the meeting of the department _____

Protocol No. ___ from "____" _____20__ year

Head of Department _____ (_____)
                              (signature)   (First Name Surname)

Reviewed and approved at the meeting of the department _____

Protocol No. ___ from "____" _____20__ year

Head of Department _____ (_____)
                              (signature)   (First Name Surname)

1. Course Description

Name of indicators	Field of knowledge, direction of training, educational and qualification level	Characteristics of the academic discipline	
		full-time education	**external form of education**
The total number of: credits - 4 hours - 120 content modules - 4	Branch of knowledge 12 - Information technologies Specialty 126 – Information systems and technologies Level of higher education: Second (master's)	*Mandatory*	
		Year of preparation:	
		1st	1st
		Semester	
		1st	1st
		Lectures	
		14 hours	8 hours
		Practical, seminar	
		Laboratory	
		16 hours	6 hours
		Independent work	
		80 hours	96 hours
		Individual tasks: 10 hours	
		Type of control: settlement	

2. The purpose and tasks of the educational course

The purpose of the course is the study of one of the ways of presenting and using fuzzy knowledge in artificial intelligence systems based on fuzzy logic.

Task:

The course is based on the study of one of the ways of presenting and using fuzzy knowledge in artificial intelligence systems based on fuzzy logic. The basics of fuzzy logic and fuzzy sets introduced by Lutfi Zade are considered, models of fuzzy knowledge representation and logical inference are based on the use of linguistic variables. Mamdani, Sugeno models of fuzzy logical inference, fuzzy classification tasks, hierarchical systems of fuzzy logical inference, fuzzy controllers are studied. The practical implementation of the models is demonstrated on the example developed in the Fuzzy TECH package (demo), Fuzzy Logic Toolbox, C#, Python languages.

The study of the discipline is based on the knowledge obtained in the courses of programming, operating systems, databases, computer systems of artificial intelligence.

Process the study of the discipline is aimed at forming elements of the following competencies:

a) general (ZK): —

b) special/professional (SK/FC):

SC01. The ability to develop and apply ICT (Information and Communication Technology) necessary for solving strategic and current tasks.

SC03. The ability to design information systems considering their purpose, incomplete or insufficient information, and conflicting requirements.

SC04. The ability to develop mathematical, informational, and computer models of objects and processes related to informatization.

SCM04. The ability to apply modern models and methods of fuzzy logic inference based on knowledge representation forms and decision-making organization methods; design and develop expert systems.

Program learning outcomes (PRL):

LO04. Manage complex, unpredictable processes related to the development, implementation, and operation of ICT, requiring new strategic and team approaches.

LO08. Develop models of information processes and systems of different classes, using methods of modeling, formalization, algorithmization, and model implementation using modern computer tools.

LOM04. Utilize modern fuzzy models, methods, and artificial intelligence tools in decision-making systems, and apply intelligent algorithms using fuzzy models to solve artificial intelligence problems.

Expected learning outcomes. In the process of studying the course "Fuzzy models and methods in intelligent systems", students study the theoretical and practical foundations of designing and developing fuzzy intelligent systems based on the use of fuzzy.

As a result of studying the academic discipline, the student should know:

– fuzzy sets and membership functions;
– operations on fuzzy sets;
– basic methods of fuzzy modeling and algorithms of I. Mamdani and Tagaki-Sugeno;
– the main stages of developing fuzzy product systems;
– stages of creating fuzzy expert systems in the FuzzyTECH software environment (demo), etc.

It is also provided acquisition by students of basic knowledge in the field of fuzzy modeling, acquisition of abilities and skills of mathematical description of fuzzy logical operations.

***be able*:**

– systematize information about the field of application of fuzzy systems;
– develop fuzzy models;
– use the composition of binary fuzzy relations;
– develop fuzzy expert systems in the software product FuzzyTECH;
– will develop a fuzzy controller control program in climate control systems.

3. Course Content

CONTENT MODULE 1.
Fuzzy sets and fuzzy logic

Topic 1. The history of the development of the theory of fuzzy sets, L. Zade. Fields of application of fuzzy technologies. Expert data analysis. Fuzzy sets, membership functions. Linguistic variables. Thermal baths.

Topic 2. Basics of fuzzy logic. Operations on fuzzy sets. Vague conjunction and disjunction. A vague objection. Unclear implication.

Topic 3. Fuzzy composition operations. Composition of fuzzy relations. Composition of a vague set and a vague relation. Rules of fuzzy implication. Rules of vague implication and their application.

CONTENT MODULE 2.
Fuzzy expert systems

Topic 4. The system of fuzzy logical derivation. A fuzzy logic inference system with many input variables and its applications. Formation of the rule base. Fuzzification

methods. Mamdani's algorithm. Tsukamoto's algorithm. Methods of aggregation and defuzzification. Center of gravity, site center, modal value methods.

Topic 5. Fuzzy expert systems. Algorithms of Larsen and Sugeno. Examples of the development of fuzzy expert systems for diagnosing malfunctions of car components. Unclear expert system of crediting the buyer.

Topic 6. Fuzzy models in management tasks. Fuzzy indoor air conditioner control model. Fuzzy controller.

Topic 7. Software development tools for fuzzy expert systems and management systems. Peculiarities of using MatLab and FuzzyTECH packages. Examples of use.

4. Course structure

Names of content modules and topics	Number of hours									
	Full-time						including			
	That's all	including				That's all	l	p	lab	Wed
		l	p	lab	Wed					
1	2	3	4	5	6	7	8	9	10	11
Content module 1. Fuzzy sets and fuzzy logic										
Topic 1. The history of the development of the theory of fuzzy sets, L. Zade.	14	2		2	10	11	1			10
Topic 2. Basics of fuzzy logic.	16	2		2	12	16	1		1	14
Topic 3 Fuzzy composition operations.	16	2		2	12	16	1		1	14
Together according to content module 1	**46**	**6**		**6**	**34**	**43**	**3**		**2**	**38**
Content module 2. Fuzzy expert systems										
Topic 4. Fuzzy logical inference system	14	2		2	10	14	1		1	12
Topic 5. Fuzzy expert systems.	16	2		2	12	16	1		1	14
Topic 6. Fuzzy models in management tasks.	16	2		2	12	18	1		1	16
Topic 7. Software development tools for fuzzy expert systems and management systems.	18	2		4	12	19	2		1	16
Together according to content module 2	**64**	**8**		**10**	**46**	**67**	**5**		**4**	**58**
INDZ (RGR)	10				10	10				10
Hours in general	**120**	**14**		**16**	**90**	**120**	**8**		**6**	**106**

5. Topics of seminar classes

Seminar classes are not included in the curriculum

6. Topics of practical classes

Practical classes are not provided for in the curriculum

7. Topics of laboratory classes

No s/p	Topic name	Number hours
1	The human temperature comfort zone in the climate control system.	2
2	Fuzzy modeling. Composition of binary fuzzy relations.	2
3	Direct and inverse methods of drawing conclusions in systems of fuzzy products.	2
4	Fuzzy product system for car malfunction diagnosis.	2
5	Creating a project in the FuzzyTECH program	2
6	Creation of a fuzzy buyer lending system in the FuzzyTECH program	2
7	Development of an expert system for determining the amount of tips in a restaurant.	2
8	Development of a vague expert system for assessing the salary level of a candidate for a position.	2
Together		16

8. Independent work

No s/p 1	Title of the topic/types of tasks 2	Number hours 3
1	Fields of application of fuzzy technologies. Expert data analysis. Get acquainted with the modern trend in the development of intellectual technology.	10
2	Fuzzy modeling methodology. Analyze stochastic and linguistic uncertainty.	6
3	Basic types of membership function. To study the method of application of Z, S, P - membership functions.	6
4	Vague relations. Get acquainted with operations on fuzzy relations. Solve the composition of fuzzy relations	6
5	Fuzzy and linguistic variables. Analyze operations on fuzzy numbers and intervals.	6

6	Basic architecture of fuzzy inference systems. Familiarize yourself with the rules of unclear products.	10
7	Methods of defuzzification. Analyze methods of modal value. Solve the example using methods.	12
8	Examples of application of expert fuzzy systems for management tasks. Get acquainted with the fuzzy modeling of climate control systems in the house.	12
9	Programs for fuzzy management. Analyze the main stages of the FCL programming language.	12
10	**RGR – Individual Research Task (INDZ)**"Creating a system that is not clear to an expert on the subject of evaluating students' knowledge on an exam or content control." INDZ includes 3 components 1) substantiation of the features of scientific research using modern information technologies (using the example of the introduction of fuzzy technologies), expediency, etc. (3-5 pages of printed text with relevance, purpose, task); 2) Creation of elements of the IT system (information system) according to the topic and/or direction of scientific research, includes the creation of a system (subsystem) of analysis and/or planning and/or forecasting using modern methods. 2) a multimedia presentation (5-8 slides) on the use of fuzzy systems in information technologies.	10
	Together	90

Evaluation criteria for independent work:

1. Structure - short messages are drawn up on paper (2-3 pages) or in the form of a short presentation using applications for creating presentations. Printed text – 14 point, spacing 1.5, Times New Roman. The requirement for the presentation is brightness, informativeness, presentability (5-7 slides for a short message). All materials must be accompanied by a list of used information sources.

2. Evaluation criteria: – timeliness of execution; – integrity and correctness of submitted texts, presentations and references (in case of proven plagiarism, points for the work are cancelled); – completeness, literacy and correctness of the disclosure of the main provisions; - a creative approach to setting and implementing tasks; – compliance with formal criteria (structure, sequence, logic, language literacy, design quality, etc.). - the ability to apply theoretical knowledge to solve practical problems. 3. Criteria for the implementation and evaluation of INDZ. The completed INDZ is placed in any "cloud environment" with teacher access. The criteria for design and evaluation coincide with the criteria for evaluating independent work.

9.   Teaching methods

1. Methods of organization and implementation of educational and cognitive activities: a) according to the source of information - verbal (explanation, story, conversation), visual (observation, demonstration), practical (modeling). b) according to the logic of transmission and perception of educational information (inductive, deductive, analytical, synthetic); c) by the degree of independence of thinking (reproductive, search, research); d) according to the degree of management of educational activities (under the guidance of a teacher, independent work of students). 2. Methods of stimulating interest in learning and motivating educational and cognitive activities: educational discussions, creating a situation of cognitive novelty, interactive exercises and tasks. Forms of organization: lecture (traditional, binary ("in two"), problem-based, lecture-dispute) with the use of information and communication technologies (presentations), practical classes on the development and testing of information technologies for teaching a discipline by specialty, independent work. Teaching methods: lecture, educational discussion, conversation, instruction, micro-teaching, interactive, problem-solving methods, educational design, project preparation and its defense, situational problem solving, creating a situation of cognitive novelty, heuristic conversation, demonstration, illustration, preparation of reports and presentations, writing essays, making presentations, solving pedagogical situations, independent work with foreign-language scientific and scientific-methodical sources, with regulatory documents.

10. Forms of control and evaluation methods

Current and final control is carried out as a result of evaluating the independent work of graduate students, performing practical exercises and defending an individual task.

Current control: surveys, writing mini-reports, giving presentations, performing practical exercises; solving situational problems, test tasks. Forms of evaluation: oral survey, checking the solution of situational problems, testing, evaluating the student's activity in the course of classes (making suggestions, original solutions, clarifications, additions), evaluating performances and presentations, evaluating the performance of independent work tasks, evaluating the content of an individual task and its protection, evaluation, analysis and self-analysis of tasks.

11. Questions for current and periodic control

1. The concept of "Vague plural". Membership functions.
2. Development of fuzzy technologies and fields of application.

3. The history of the development of fuzzy logic. Modern software tools for the development of fuzzy systems.

4. Ways of presenting fuzzy sets. Diagrams by L. Zade.

5. Equality of fuzzy sets.

6. I. Mamdani's algorithm.

7. Tagaki - Sugeno algorithm.

8. Operations on fuzzy sets.

9. Cartesian product of fuzzy sets.

10. Vague relations.

11. Principles of development of fuzzy products.

12. Methods of aggregation and defuzzification.

13. The rule of generalized fuzzy derivation.

14. Fuzzy systems of logical derivation.

15. Methods of developing fuzzy knowledge bases and expert systems.

16. Defuzzification methods.

17. Fuzzy management systems. Fuzzy controller.

18. Fuzzy diagnostic systems. Fuzzy equations.

12. Distribution of points received by winners

							Individual independent task	Total points
Current and periodic control								
Content module 1			Content module 2					
T1	T2	T3	T4	T5	T6	T7		
10	10	10	10	10	10	10	30	100

T1...T7 - topics.

Distribution of points by types of educational work

Types of educational work	Points for one lesson (task)	Number of classes	Total number of points
Content module 1			
Current control at lectures	5	2	15
Performance and protection of laboratory work	10	1	15
In total, according to content module 1			**0 - 30**
Content module 2			
Current control at lectures	5	4	20
Implementation and protection of practical works	5	4	20
In total, according to content module 2			**0 - 40**
Execution and protection of INDZ			0 - 30

Final sum of points			0 - 100

Evaluation scale: national and ECTS

The sum of points for all types of educational activities	ECTS assessment	Evaluation on a national scale	
		for an exam, course project (work), practice	for credit
90 - 100	**AND**	perfectly	counted
85-89	**IN**	fine	
75-84	**WITH**		
70-74	**D**	satisfactorily	
60-69	**IS**		
35-59	**FX**	unsatisfactory with the possibility of reassembly	not counted with the possibility of retaking
0-34	**F**	unsatisfactory with mandatory repeated study of the discipline	not enrolled with mandatory repeated study of the discipline

When evaluating the level of mastery of the material in points, the general criteria for evaluating the educational achievements of higher education applicants are used:

Evaluation on a national scale	Theoretical training	Practical training
	Education seeker	
90-100/ credited	fully possesses the educational material, freely, independently and reasonedly teaches it during oral presentations and written answers; deeply and comprehensively reveals the content of theoretical issues, while using normative, mandatory and additional literature; draws independent conclusions, reveals cause-and-effect relationships; independently finds additional information and uses it to implement the tasks set before him. The acquirer is able to highlight the essential features of the subject through synthesis and analysis operations, identify cause-and-effect relationships, form conclusions and generalizations, freely operate with facts and information.	deeply and comprehensively reveals the essence of practical tasks, while using normative, mandatory and additional literature; can reasonedly choose a rational way of performing the task and evaluate the results of his own practical activity; performs creative tasks and initiates new ways of their implementation; freely uses acquired theoretical knowledge when analyzing practical material; shows a creative approach to the performance of individual and collective tasks while working independently.
75-89 / included	has a sufficiently complete command of the educational material, presents it reasonably during oral presentations and	correctly solved most of the practical tasks according to the sample; has stable task performance skills

	written answers, while using normative and mandatory literature; when presenting some questions, there is not enough depth and argumentation, applies knowledge to solve standard situations; independently analyzes, summarizes and systematizes educational information, but certain insignificant inaccuracies and minor errors are allowed.	
60-74 / enrolled	possesses educational material at the reproductive level or reproduces a certain part of the educational material with elements of logical connections, knows the basic concepts of the educational material; has complications during the selection of essential features of the subject; when identifying causal relationships and formulating conclusions.	can use knowledge in standard situations, has elementary, unstable task performance skills. Solved half of the practical tasks correctly. The acquirer has complications during the selection of essential features of the learned; when identifying causal relationships and formulating conclusions.
35-59 / not counted with the possibility of retaking	possesses educational material superficially and fragmentarily (without argumentation and justification); unsystematically singles out random features of the subject; does not know how to perform the simplest operations of analysis and synthesis; it is difficult to make generalizations and conclusions; significant mistakes are made during the answer.	does not sufficiently reveal the essence of practical tasks, while admitting significant inaccuracies, correctly solved individual practical tasks with the help of a teacher, lacks formed skills and abilities.
0-34/ not credited with mandatory repeated study of the discipline	does not have educational material	performs only elements of the task, needs constant help from the teacher

Note: the maximum number of points for each topic is specified in clause 12. The form of the final control is the credit, issued according to the number of points scored in the semester (according to the evaluation scale from clause 12).

13. Educational and methodological support

Working program of the academic discipline; syllabus; teaching and methodical materials for lectures, synopsis (texts, schemes) of lectures; multimedia presentations; plans of practical classes; methodological instructions (recommendations) regarding independent study of the discipline.

1. Mykhaylenko V.S., Gunchenko Yu.O., Martynovych L.Ya. Methodical instructions

before performing laboratory workfrom the discipline "Fuzzy modeling in information technologies" for students of the specialty 123 "Computer engineering": ONU., 2022 - 62 p.

14. Recommended Books

Basic literature

1. Krapivnyi Yu.M. Electronic abstract of lectures from the course "Fuzzy models and methods in intelligent systems". Odesa, ONU, 2021 - 54 p.
2. Zadeh LA Fuzzy sets / LA Zadeh // Information and Control. - 1965, No. 8. – P. 338-353
3. Sugeno M. On stability of fuzzy systems expressed by fuzzy rules with singleton consequences / M. Sugeno // IEEE Trans. Fuzzy Systems. - 1997. - No. 7. - P. 201-224.
4. Mamdani EH Application of fuzzy algorithms for control of simple dynamic plant / EH Mamdani // Proc. Inst. Elect. Eng. Contr. Sci., vol. 121, 1974. - P. 1585-1588.
5. Cormorant I.V. Expert systems. Study guide / I.V. Cormorant. - K.: NAU, 2012. - 132 p. - Access mode:
6. Girinova L.V. Information systems and technologies. Part 1. Technical and software support of information technologies and systems: education. manual / L.V. Girinova, I.G. Sibyryakova - Kharkiv: Monograf, 2016. - 121 p.
7. Hrytsunov O.V. Information systems and technologies: education. manual / O.V. Hrytsunov. - Kh.: KhNAMG, 2010. - 222 p.
8. Methods and systems of artificial intelligence: education. manual / incl. D.V. Lubko, S.V. Sharov. – Melitopol: FOP Odnorog T.V., 2019. – 264 p.
9. Sharov S.V. Intelligent information systems: education. manual / S.V. Sharov, D.V. Lubko, V.V. Sedimentary – Melitopol: Department of the MDPU named after B. Khmelnytskyi, 2015. – 144 p.

Auxiliary literature

10. Mykhaylenko V.S. Comparative analysis of methods of analysis of hierarchies and fuzzy logic in the decision support system [Text]/V.S. Mykhaylenko// Informational intellectual systems: materials of the XV International. of science - technical conf. - Kharkiv, KhPI, 2011. - P. 297 - 298.
11. Mykhaylenko V.S. The use of intelligent decision-making support systems for the automation of ship management processes [Text] / V.S. Mykhaylenko// Modern information and innovative technologies in transport MINTT-2011: materials III International. of science -Pract. conf. Volume. 1. - Kherson: KhDMA, 2011. - P. 32 - 33.

12. Mykhaylenko V.S. Defuzzification methods in fuzzy inference algorithms [Text]/V.S. Mykhaylenko // Informatics, information systems and technologies: materials VIII Regional. conf. young scientists - Odesa: ONU, 2011. - P. 34 - 35.
13. Bidyuk, P.Dynamic processes forecasting and risk estimation under uncertainty using decision support systems [presentation] / P. Bidyuk, O. Terentiev, T. Prosyankina-Zharova // 2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON), 29 May-2 June 2017, Kyiv, Ukraine, Igor Sikorsky Kyiv Polytechnic Institute. - Kyiv, 2017. - 27 p.
14. Davis G. Management Information Systems: Conceptual Foundations, Structure, and Development. - New York: McGraw-Hill, 1974.
15. Edwards JS Expert Systems in Management and Administration – Are they really different from Decision Support Systems? // European Journal of Operational Research, 1992. - Vol. 61. - pp. 114–121.
16. Power DJ A Brief History of Decision Support Systems. DSSResources.COM, World Wide Web,http://DSSResources.COM/history/dsshistory.html, version 2.8, May 31, 2003.
17. Turban, E. Decision support and expert systems: management support systems. - Englewood Cliffs, NJ: Prentice Hall, 1995.
18. Wang, Lipo; Fu, Xiuju (2005).Data mining with computational intelligence. Berlin: Heidelberg: Springer. with. 6.ISBN3-540-24522-7.

14. Electronic information resources

1. https://www.youtube.com/watch?v=__0nZuG4sTw
2. https://www.youtube.com/watch?v=rln_kZbYaWc
3. http://matlab.exponenta/fuzzylogic/book2/index.php
4. https://www.youtube.com/watch?v=fqZvzQayx7A