Syllabus
Course Program

Fuzzy logic and fuzzy systems

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
Elective

Semester
7

Language of instruction
English, Ukrainian

Lecturers and course developers

Valeriy Volovshchykov

valeriy.volovshchykov@khpi.edu.ua
Candidate of Technical Sciences, Associate Professor, Associate Professor of Software Engineering and Management Intelligent Technologies Department

Google Scholar:
https://scholar.google.com.ua/citations?user=YnZ2JQQAAAAJ&hl=uk
ORCID: https://orcid.org/0000-0003-4454-2314
Scopus:
https://www.scopus.com/authid/detail.uri?authorId=57208908501&eid=2-s2.0-85066097891
Детальніше про викладача на сайті кафедри

General information

Summary

The discipline is aimed at forming in students the basic concepts, terms, principles and approaches of fuzzy logic and fuzzy systems.

Course objectives and goals

Training of specialists capable of setting and solving decision-making problems in conditions of uncertainty, formalizing them in the form of fuzzy systems using the apparatus of fuzzy logic in combination with the formation of a scientific worldview and providing a broad outlook in the fundamental field of decision support systems.

Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of an credit.

Competencies

121 - Software Engineering
K01. Ability to abstract thinking, analysis and synthesis

K02. Ability to apply knowledge in practical situations
K05. Ability to learn and master modern knowledge
K06. Ability to search, process and analyze information from various sources
K07. Ability to work in a team
K19. Knowledge of information data models, the ability to create software for data storage, retrieval and processing
K20. Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering problems
K26. Ability to algorithmic and logical thinking
122 - Computer Science and Intelligent Systems
GC1. Ability to abstract thinking, analysis and synthesis
GC2. Ability to apply knowledge in practical situations
GC3. Knowledge and understanding of the subject area and understanding of professional activity
GC6. Ability to learn and master modern knowledge
GC7. Ability to search, process and analyze information from various sources
GC9. Ability to work in team
PC2. Ability to detect statistical patterns of non-deterministic phenomena, the use of computational intelligence methods, including statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc
PC5. Ability to provide a formalized description of operations research tasks in organizational, technical, and socio-economic systems for different purposes, to determine their optimal solutions, to build optimal management models taking into account changes in the economic situation, to optimize management processes in different systems and hierarchies
PC6. Ability to think systematically, apply the systems analysis methodology to study complex problems of different nature, methods of formalization and solution of system problems with conflicting goals, uncertainties, and risks

Learning outcomes

121 - Software Engineering
PL001. Analyze, purposefully search for and select the necessary information and reference resources and knowledge to solve professional problems, taking into account modern advances in science and technology
PL005. Know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modelling for software development
PL007. Know and apply in practice the fundamental concepts, paradigms and basic principles of operation of language, tools and computing software engineering
PL008. Be able to develop a human-machine interface
PL010. Conduct a pre-project survey of the subject area, systematic analysis of the design object
PL011. Choose source data for design, guided by formal methods of describing requirements and modelling
PL013. Know and apply methods of algorithm development, software design and data and knowledge structures
122 - Computer Science and Intelligent Systems
PC1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation
PC4. Ability to use modern methods of mathematical modelling of objects, processes, and phenomena, to develop models and algorithms for the numerical solution of mathematical modelling problems, to take into account the errors of approximate numerical solution of professional problems
PC5. Ability to provide a formalized description of operations research tasks in organizational, technical, and socio-economic systems for different purposes, to determine their optimal solutions, to build optimal management models taking into account changes in the economic situation, to optimize management processes in different systems and hierarchies
PC17. Ability to apply the theoretical and practical basics of modern management theory for complex organizational, technical and socio-economic systems to build intelligent management systems, in the

process of designing intelligent systems to use 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

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

Teaching and learning methods:
Lectures, laboratory classes, work in small groups, brainstorming, presentations that develop communication and leadership skills, self work with literary sources, mixed forms of learning using distance platforms.
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: The task of decision making
Types of uncertainty in decision-making tasks. Approaches to the formalization of uncertainty in decision-making tasks.
Topic 2. Fundamentals of fuzzy logic
The main characteristics of fuzzy sets. The main types of membership functions. Logical-linguistic description of the problem.
Topic 3. Methods of constructing membership functions
Direct and indirect methods for constructing a membership function, including on the basis of paired comparisons, using expert assessments.
.
Topic 4. Operations on fuzzy sets
Unary and binary operations. Properties of operations.
Topic 5. Fuzzy preference relation
Fuzzy preference relation and ways to determine it. Basic characteristics, properties and operations on fuzzy preference relations
Topic 6. Fuzzy quantities, numbers and intervals
Basic definitions and methods of performing operations on fuzzy numbers.
Topic 7. Fuzzy inference
Fuzzy inference algorithms - Mamdani, Tsukamoto, Sugeno, Larsen, simplified fuzzy inference algorithm. Methods of clarity. Falling fuzzy conclusions.
Topic 8. Fuzzy, hybrid and hybrid fuzzy systems
Theoretical foundations of fuzzy, hybrid and hybrid fuzzy systems. Generalization of some software engineering problems. Ways to present uncertainty in databases, fuzzy databases, knowledge extraction.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Research of methods of construction of membership functions
Topic 2. Research of methods of performing arithmetic operations on fuzzy numbers
Topic 3. Research of fuzzy inference algorithms

Topic 4. Modeling of fuzzy system by means of fuzzy logic tools

Self-study

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. Michael Voskoglou Fuzzy Sets, Fuzzy Logic and Their Applications. – 2020. – 366 p.
2. Chander Mohan An introduction to fuzzy set theory and fuzzy logic. 2019. – 392 p.
3. Guanrong Chen, Trung Tat Pham Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems. – 2019. – 328 p.
4. Jenny Carter, Francisco Chiclana, Arjab Singh Khuman, Tianhua Chen Fuzzy Logic: Recent Applications and Developments. – 2021. – 385 p.

Additional literature

1. Lotfi A Zadeh, Rafik A Aliev Fuzzy Logic Theory and Applications: Part I and Part II . – 2018. – 610 p.
2. M.K. Hasan Fuzzy Sets and Fuzzy Logic with Applications: Imprecision , Uncertainty and Vagueness. – 2019. – 328 p.
3. Andreas Meier, Edy Portmann, Kilian Stoffel, Luis Terán The Application of Fuzzy Logic for Managerial Decision Making Processes: Latest Research and Case Studies (Fuzzy Management Methods). – 2017. – 115 p..

Assessment and grading

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

100% of the final grade consists of the results of the assessment in the form of an exam (40%) and current assessment (60%):
- 4 laboratory works (6% each);
- 3 tests (12% each).

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