Syllabus
«Fuzzy models and methods for computational intelligence»

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Expected learning outcomes
As a result of studying the discipline, the student
must know:

- representation of real-time series and high-frequency data by triangular and trapezoidal fuzzy numbers, main mathematic operators and arithmetic operations in fuzzy data processing;
- types of input data, structure of the intelligent rule base of fuzzy systems, fuzzy rule base properties;
- quality indices of fuzzy systems, activation of MFs for fuzzy rules conclusions, aggregation algorithms in fuzzy data processing, defuzzification methods in fuzzy data processing;
- the structures of the fuzzy inference engines of Sugeno-type, Tsukamoto-type and others with fuzzy data processing, fuzzy data processing based on hierarchical structure of fuzzy systems;
- structural and parametrical optimization of fuzzy systems (computational intelligence and decision-making systems);
- the role of expert evaluation in solving prognosis tasks and problem based on fuzzy approach;

must be able to:

- carry out fuzzy data processing based on fuzzification, aggregation, implication, activation, accumulation, and defuzzification algorithms;
- application of methods for investigations of the impact of aggregation and defuzzification algorithms to quality indices of fuzzy systems;

The scope of the discipline: 5,5 ECTS credits (16 hours of lectures, 40 hours of practice).

Purpose: teaching students the basic principles in fuzzy models and methods for computational intelligence, types of input data, the structures of the intelligent rule base of fuzzy systems, as well as the development and implementation of fuzzy inference engines of Mamdani-type, Sugeno-type, Tsukamoto-type, and others with fuzzy data processing based on expert knowledge. The aim is also to form a system of theoretical knowledge and practical skills on structural and parametrical optimization of fuzzy systems, implementation of fuzzy sets for fuzzy data processing, use fuzzy models and methods for solving multi-criteria problems with uncertain input data.

The content of the discipline

Topic 1. Concepts and types of fuzzy models. Linguistic and analytical-linguistic approximation based on fuzzy models.
Topic 2. Linguistic variables and linguistic terms (LT). Membership functions for LT's representation.
Topic 3. Fuzzy inference system (FIS) with discrete inference. The structure of production rules in fuzzy models: antecedents and consequences.
Topic 4. Fuzzy knowledge base, knowledge matrix. Fuzzy logical equations.
Topic 5. Fuzzification of input data on LTs. Methods of forming consolidated conclusions in discrete fuzzy models.
Topic 6. Mamdani-type FIS with continuous output and its main components: fuzzification, aggregation, activation, accumulation and defuzzification.
Topic 7. Defuzzification methods in continuous fuzzy models and their comparative analysis.
Topic 8. Computational T-norms operators and their main properties. Non-parameterized and parameterized operators for the AND aggregation operation in fuzzy models.
Topic 9. Computational S-norm operators in fuzzy models and their main properties.

- fuzzy data processing based on fuzzy inference engine of Mamdani-type, design of Mamdani-type fuzzy systems;
- design of fuzzy systems based on expert knowledge, reduction of the fuzzy rule base, application of methods of automatic generation and optimization of fuzzy rule base;
- implementation of hesitant fuzzy sets for fuzzy data processing with high level of uncertainty.

Prerequisites
"Fuzzy Sets Theory and Fuzzy Logic", "Decision Making Theory", "Control Systems".

Consequences
The knowledge gained during the discipline can be used in the disciplines or areas "Intelligent decision support systems", "Software intelligent control systems", "Methods of computational intelligence".

Technical support
Practices on the discipline are carried out in computer classes using Microsoft Visual Studio, Java SE, Python, C#.

Deadline policy
Works that are submitted in violation of deadlines without good reason are evaluated at a lower grade.

Academic Integrity Policy
Provides independent performance of practices. Write-off (including using mobile devices) is prohibited. The work is not credited in case of detection of plagiarism or write-off.

Non-parameterized and parameterized operators for OR aggregation operation.
Topic 10. Algorithmic support of hierarchical fuzzy models. Alternative hierarchical structures.

Evaluation criteria of laboratory works / practices / individual works / reports / projects

Maximum number of points – a student with high quality independently performed the entire scope of work, answers all questions related to the work performed, and makes additional calculations, for example, using the models and methods of fuzzy data processing offered to him by the teacher. The teacher has no complaints about the software implementation and performance requirements.
Approximately 70%-99% of the maximum number of points – a student with sufficient quality independently completed all tasks, but in the process he made some mistakes, which, after pointing to them by the teacher, corrected themselves. He answers some questions with a slight error. The additional calculations offered by the teacher make with some complexity. Not all work requirements are met.
Approximately 40%-69% of the maximum number of points – a student of average quality independently completed all tasks, but did not meet all the requirements for implementation. He answers the question with a slight error. The additional calculations offered by the teacher, for example, using fuzzy methods of decision making makes with insignificant errors. Not all requirements for the design of the work are met.
Approximately 1%-39% of the maximum number of points – a student performed all the work independently, but the quality of implementation is insufficient (errors in calculations, not all work requirements are met). The answers to the questions about the work are not entirely clear. There are errors in the answers.
0 points – a student did not perform the entire amount of work, or performed with gross errors. He has problems with calculations by certain methods, does not know the theoretical material, the software implementation does not meet the requirements.