A COURSE SYLLABUS – DOCTORAL SCHOOL
regarding the qualification cycle from 2025/2026 to 2028/2029

GENERAL INFORMATION ABOUT COURSE	
Course title	***OPTIONAL SPECIALISED SUBJECT:*** ***Application of fuzzy set theory in medicine.***
Name of the unit running the course	Doctoral School at the University of Rzeszów
Type of course *(obligatory, optional)*	compulsory - optional specialist
Year and semester of studies	year I, semester: II
Discipline	technical informatics and telecommunications
Language of Course	Polish language/English language
Name of Course coordinator	Dr Barbara Pękala, Prof. UR
Name of Course lecturer	Dr Barbara Pękala, Prof. UR
Prerequisites	In-depth knowledge of discrete mathematics, statistics, artificial intelligence and data analysis. Knowledge of programming and data modelling methods. Knowledge of English at least at level B2 of the Common European Framework of Reference for Languages, in particular scientific vocabulary in the field of computer science and data analysis.

BRIEF DESCRIPTION OF COURSE
(100-200 words)

The aim of the course 'Application of fuzzy set theory in medicine' is to familiarise doctoral students with methods of modelling uncertainty and imprecision in medical data using fuzzy set theory and approximate reasoning systems. The course covers the basics of fuzzy logic, knowledge representation models, and fuzzy inference methods used in medical decision support systems.
Particular attention will be paid to the applications of artificial intelligence methods, including fuzzy inference systems, in biomedical data analysis, medical diagnostics, and decision support in healthcare. Examples of real expert systems and predictive models used in disease diagnosis, medical image analysis, and patient health monitoring will also be analysed.
The course develops doctoral students' competences in the design of computational models, interpretation of research results, and critical analysis of scientific literature.

COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES

Learning outcome	The description of the learning outcome defined for the course	Relation to the degree programme outcomes (symbol)	Learning Format (Lectures, classes,...)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,...)
Knowledge (no.)	knows and understands, has knowledge			
P8S_WG1	Has knowledge of fuzzy set theory, approximate reasoning systems, and artificial intelligence methods used in medical data analysis and decision support systems.	**P8S_WG1**	Seminar	oral and written exam, project, colloquium
P8S_WG2	Is familiar with current research trends in the application of fuzzy logic, expert systems, and machine learning	**P8S_WG2**	Seminar	oral and written exam, project, colloquium

	methods in medical diagnostics and biomedical data analysis.			
P8S_WG3	Knows and understands the scientific terminology used in medical informatics and is able to use scientific literature in Polish and English.	**P8S_WG3**	Seminar	oral and written exam, project, colloquium
P8S_WK1	Understands the importance of information technology and artificial intelligence methods in the development of modern medicine and clinical decision support systems.	**P8S_WK1**	Seminar	oral and written exam, project, colloquium
Skills (no.)	can			
P8S_UW1	Based on interdisciplinary knowledge in the field of engineering, technical and medical sciences, is able to formulate and set ambitious research goals related to research on decision-making systems. Able to identify and improve research methods, techniques and tools, as well as draw constructive conclusions based on the results of research work.	**P8S_UW1**	Seminar	oral and written exam, project, colloquium
P8S_UW2	On the basis of available interdisciplinary scientific publications, he/she can recognize and solve a research problem that can be used to create a new element of achievements.	**P8S_UW2**	Seminar	oral and written exam, project, colloquium
P8S_UW3	Is able to use his/her interdisciplinary knowledge and research experience to analyse and evaluate scientific achievements, expert opinions and other studies, and formulate opinions on this basis, including critical judgments.	**P8S_UW3**	Seminar	oral and written exam, project, colloquium
P8S_UK6	Is able to carry out and present scientific work and actively participate in the national and international scientific and professional environment, communicating in a foreign language at the B2 level of the European Framework of Reference for Languages.	**P8S_UK6**	Seminar	oral and written exam, project, colloquium
Social competence (no.)	is ready to			
P8S_KK3	Is ready to exchange ideas, conduct substantive scientific discussions and solve cognitive and practical problems using his/her knowledge in the field of	**P8S_KK3**	Seminar	oral and written exam, project, colloquium

	technical information technology and telecommunications.					
Semester	Lectures	Seminar	Conversatory/ Lab classes	Internships	others	ECTS
II	**-**	**15 hrs.**	**-**	**-**	**-**	**2**

METHODS OF INSTRUCTION

***- MULTIMEDIA PRESENTATION*,**
***- SEMINAR*,**
***- DISCUSSION*.**

COURSE CONTENT

Seminar:

Topic 1.
Fundamentals of fuzzy set theory – representing uncertainty and imprecision in data.
Topic 2.
Fuzzy logic and fuzzy inference systems.
Topic 3.
Approximate inference systems and knowledge representation models in intelligent systems.
Topic 4.
Artificial intelligence methods in medical data analysis.
Topic 5.
Medical decision support systems based on fuzzy logic.
Topic 6.
Application of fuzzy methods in medical image analysis and disease diagnosis.
Topic 7.
Modeling uncertainty in biomedical data and integrating fuzzy methods with machine learning.
Topic 8.
Presentation of doctoral students' projects on the application of fuzzy methods in medicine.

COURSE ASSESSMENT CRITERIA

An exam is held after each semester of the course.

Credit for the course is based on:
• preparation of a project or scientific paper on the application of fuzzy set theory methods to a selected medical problem,
• active participation in scientific discussions during classes,
• presentation of the results of the work in the form of a multimedia presentation.

The final grade takes into account:
• the substantive level of the prepared project or paper,
• the ability to critically analyze scientific literature,
• active participation in classes and participation in scientific discussions.

A very good grade:
- very high activity and engagement during classes,
- visible ability to lead discussions and draw constructive conclusions,
- a visible awareness of one's own artistic stance, characterized by openness to substantive discourse and sometimes constructive criticism;
- very high substantive value of the paper and the artistic value of the visual project;
- attendance for at least 4/5 of the total class load;
- active use of the suggested literature, expanded and deepened at their own pace.

A plus grade of good:
- high activity during the course;
- high substantive value of the paper and the artistic value of the visual project;
- attendance at least 4/5 of the total class time;
- demonstrations of creative maturity and awareness of one's own artistic approach;
- visible satisfactory ability to lead discussions and draw conclusions;
- active use of the suggested literature.

A plus grade of good:
- satisfactory activity during the course;
- satisfactory substantive value of the paper and the artistic value of the visual project;
- attendance at least 4/5 of the total class time;
- moderate ability to lead discussions and draw conclusions;
- satisfactory use of the suggested literature.

A plus grade of satisfactory:
- moderate activity during the course;
- relatively poor substantive value of the paper and the artistic value of the visual project;
- attendance at least 3/5 of the total class load;
- moderately poor ability to lead discussions and draw conclusions;
- moderate use of the suggested literature.

Satisfactory grade:
- low level of activity during class;
- poor substantive value of the paper and artistic value of the visual project;
- attendance for at least 3/5 of the total class time;
- poor ability to lead discussions and draw conclusions;
- sporadic use of the suggested literature.

Unsatisfactory grade:
- lack of activity during class;
- unacceptable substantive value of the paper and artistic value of the visual project;
- lack of ability to lead discussions and draw conclusions;
- absence for more than 3/5 of the total class time;
- failure to use the suggested literature.

TOTAL PhD STUDENT WORKLOAD REQUIRED TO ACHIEVE THE INTENDED LEARNING OUTCOMES – NUMBER OF HOURS AND ECTS CREDITS

Activity	Number of hours
Scheduled course contact hours	**15 hrs.**
Other contact hours involving the teacher (consultation hours, examinations)	**1 hrs.**
Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	**44 hrs.**
Total number of hours	**60 hrs.**
Total number of ECTS credits	**2 ECTS**

INSTRUCTIONAL MATERIALS	
Basic literature:	1. *Fuzzy Logic with Engineering Applications*, 4th ed., Wiley, 2016. 2. **Pedrycz W., Chen S.M. (eds.)** *Granular Computing and Decision-Making: Interactive and Iterative Approaches*, Springer, 2018. 3. **Cazzaniga P., Besozzi D., Mauri G.** *Fuzzy Logic for Knowledge-Driven and Data-Driven Modeling in Biomedical Sciences*, Wiley, 2024. 4. **Benmoujane A., Madani A.** *Integrating Fuzzy Logic with AI in Healthcare*, Springer, 2026. 5. **Sahu B., Sarangi L., Ghosh A.** *Application of Fuzzy Logic to Healthcare Industry*, Springer, 2022.
Supplementary literature:	1. **Ouifak H. et al.** *A Comprehensive Review of Fuzzy Systems for Explainable Artificial Intelligence*, Neurocomputing / Elsevier, 2025. 2. **Tajodin A., Ünver M.** *Trends and Developments in Fuzzy Logic for Medical Diagnosis: A Bibliometric Analysis*, Baltic Journal of Modern Computing, 2025. 3. **Singh R.** *Fuzzy Soft Set Theory Applications in Medical Diagnosis*, World Scientific, 2025. 4. **Kaur J., Khehra B.** *Fuzzy Logic and Hybrid Approaches for Heart Disease Detection: State-of-the-Art Review*, Journal of the Institution of Engineers (India), 2021. 5. **Arya L. et al.** *Fuzzy Logic-Driven Machine Learning Algorithms for Early Disease Diagnosis*, International Journal of Advanced Computer Science and Applications, 2024. 6. **Saxena P. et al.** *Fuzzy-Based Medical Image Processing and Analysis*, International Journal of Intelligent Systems Applications in Engineering, 2024.

*(1 ECTS CREDIT CORRESPONDS TO 25 - 30 HOURS OF THE TOTAL WORKLOAD OF A DOCTORAL STUDENT, NEEDED TO ACHIEVE THE ESTABLISHED EFFECTS).

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Date and signature of the Course lecturer

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Approved by the Head of the Department or an authorised person