A COURSE SYLLABUS – DOCTORAL SCHOOL

REGARDING THE QUALIFICATION CYCLE FROM 2025/2026 TO 2028/2029

GENERAL INFORMATION ABOUT COURSE	
Course title	**DOCTORAL SEMINAR**
Name of the unit running the course	Rzeszów University Doctoral School
Type of course *(obligatory, optional)*	compulsory subject
Year and semester of studies	years I-IV, semesters: I-VII
Discipline	**Technical informatics and telecommunications**
Language of Course	Polish language/English language
Name of Course coordinator	Wiesław Paja
Name of Course instructor	Wiesław Paja
Prerequisites	Academic education at master's degree level. Knowledge, skills and social competences at level 7 of the Polish Qualifications Framework. Foreign language proficiency at level B2.

BRIEF DESCRIPTION OF COURSE
(100-200 words)

The doctoral seminar is devoted to methods using interval statistics in feature significance assessment and significance value aggregation in data analysis and machine learning. The course focuses on the problems of uncertainty, variability and stability of feature significance measures, which are not fully captured by the classical point approach. The doctoral seminar discusses the formal foundations of interval arithmetic, methods for determining interval measures of significance, methods for comparing and ordering features, and techniques for aggregating information from multiple models, experiments, or data sets.

The aim of the course is to develop advanced research skills in doctoral students, enabling them to independently design and conduct scientific research in the field of interval methods, critically analyse literature and formulate original methodological solutions. The doctoral seminar also supports the process of preparing scientific publications and doctoral dissertations, emphasising methodological consistency, correct reasoning and reliable interpretation of research results.

The aim of the doctoral seminar is to provide systematic support to doctoral students in the development of scientific research on interval methods in:

- feature importance assessment,
- analysis of uncertainty and variability of importance measures,
- aggregation and ordering of features based on interval values,
- applications in machine learning, data analysis and decision-making systems.

The doctoral seminar ranges from in-depth literature analysis, through modelling and own research, to the preparation of a doctoral dissertation and scientific publications.

COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES

Learning outcome	The description of the learning outcome defined for the course	Reference to learning outcomes for qualifications at Level 8 of the Polish Qualification Framework (PRK) (symbol)	Learning Format (Lectures, classes,...)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,...)
Knowledge: (no.)	***knows and understands***			

P8S_WG1	He has extensive theoretical knowledge, supported by research experience, and is familiar with current scientific achievements, including global ones, in the field of education in the scientific discipline of technical informatics and telecommunications. He also knows general issues in related disciplines and research topics to a degree that allows him to confirm or refute existing theories. technical informatics and telecommunications, as well as general issues in related disciplines, with a degree of research interest that allows for the confirmation or refutation of existing paradigms.	**P8S_WG**	seminar	oral presentation, discussion,
P8S_WG2	They are familiar with the directions of scientific research in the scientific discipline of technical informatics and telecommunications and the latest discoveries, including global ones, in the discipline in which the education takes place.	**P8S_WG**	seminar	oral presentation, discussion,
P8S_WG3	Knows, understands and is able to apply concepts used by scientists and specialists in the discipline of technical informatics and telecommunications and in disciplines in their native and foreign languages, which are leading in the discipline.	**P8S_WG**	seminar	oral presentation, discussion,
Skills: (no.)	***is able to***			
P8S_UW1	Based on their knowledge in various fields of science, they are able to identify and solve scientific research problems, define objectives, formulate hypotheses and research topics, select and refine research techniques, methods and tools, and draw conclusions based on research results.	**P8S_UW**	seminar	oral presentation, discussion, written assignments,
P8S_UW2	They are able to select and use available scientific literature to diagnose and solve research problems and innovative activities in their research work, as well as apply the appropriate tools to create new elements of scientific output.	**P8S_UW**	seminar	oral presentation, discussion, written assignments,
P8S_UW3	Using their interdisciplinary knowledge to analyse and evaluate the results of scientific research, expert works and other scientific studies, they are able to formulate opinions, including critical judgements.	**P8S_UW**	seminar	oral presentation, discussion, written assignments,
P8S_UK6	They are able to speak in public to present the results of scientific research and participate in discussions on scientific, social	**P8S_UK**	seminar	oral presentation, discussion,

	and professional topics in an international environment, using a foreign language at level B2 of the Common European Framework of Reference for Languages.			written assignments,
Social competence: (no.)	***is ready to***			
P8S_KK1	Is prepared to critically evaluate the achievements of their scientific research and to critically evaluate the contribution of their own research results to the scientific development of the discipline in which they are studying.	**P8S_KK**	seminar	oral presentation, discussion, written assignments,
P8S_KK3	Thanks to their extensive knowledge, solves various cognitive and practical problems.	**P8S_KK**	seminar	oral presentation, discussion, written assignments,

LEARNING FORMAT – NUMBER OF HOURS

Semester (no.)	Lectures	Seminars	Lab classes	Placements	other	ECTS
I - VII	-	**-**	-	-	**7 x 15 hrs. - 105 hrs.**	**7 x 2 ECTS – 14 ECTS**

METHODS OF INSTRUCTION

- ACADEMIC DISCUSSION,
- STUDY OF ACADEMIC LITERATURE,
- MULTIMEDIA PRESENTATION,
- PREPARATION AND PRESENTATION OF RESEARCH OBJECTIVES, RESEARCH METHODS, RESEARCH RESULTS,
- FINAL PROJECTS,
- PROGRESS IN THE PREPARATION OF A DOCTORAL DISSERTATION

COURSE CONTENT

Topics covered in the course, divided into semesters:

Semester 1 (15 hours)

- Introduction to the subject and overview of theoretical foundations
- Objectives and scope of the doctoral seminar
- Feature importance assessment in data analysis and machine learning
- Classic feature importance measures (filter, wrapper, embedded)
- Limitations of point-based relevance measures
- The concept of uncertainty, variability and stability of feature relevance
- Introduction to interval arithmetic
- Discussion of doctoral student research problems

Semester 2 (15 hours)

- Interval formalism in feature significance analysis
- Interval numbers and vectors – definitions and properties
- Measures of significance for interval-type features
- Interval representation of data and model uncertainty
- Methods for determining confidence intervals (resampling, bootstrap, data perturbation)

- Interpretation of confidence intervals
- Literature review – doctoral students' papers

Semester 3 (15 hours)
- Interval feature selection and ranking
- Comparison and ordering of interval significance measures
- Dominance relations and partial orders
- Feature selection criteria for overlapping intervals
- Stability of feature rankings
- Feature selection algorithms using intervals
- Presentation of the doctoral student's own methods

Semester 4 (15 hours)
- Aggregation of interval significance values
- The need to aggregate significance measures from multiple models and experiments
- Aggregation operators for interval data
- Interval measures of central tendency and dispersion
- Multi-criteria aggregation
- Fuzzy-interval approaches
- Discussion of partial research results

Semester 5 (15 hours)
- Practical and experimental applications
- Application of interval statistics in classification and regression
- Case studies
- Model quality assessment using interval significance
- Comparison of classical and interval methods
- Designing computational experiments
- Presentation of doctoral student's experimental results

Semester 6 (15 hours)
- Validation, generalisation and publication of results
- Validation of interval methods
- Analysis of computational complexity
- Limitations and directions for further research
- Preparation of scientific articles
- Selection of journals and conferences
- Peer review of doctoral students' work

Semester 7 (15 hours)
- Integration of results and preparation of doctoral thesis
- Methodological consistency of doctoral thesis
- Structure of doctoral thesis
- Synthesis of research results
- Open research problems
- Attempt to generalise proposed methods
- Summary seminar – presentation of doctoral student's entire body of work

COURSE ASSESSMENT CRITERIA

The assessment covers the doctoral student's continuous work in each semester and academic year in the following areas: conducting research, expanding knowledge, studying literature, commitment and progress in preparing the doctoral dissertation.
The course ends after each semester of implementation:
pass – pass,
fail – fail.

Requirements
The following percentage of points obtained is used in the assessment of the course:
- up to 60% - fail - the doctoral student is not making progress in scientific research, is not expanding their knowledge, is not studying the literature, is not participating in substantive discussions, is not fulfilling their scientific obligations;

- 61% - 100% - pass - the doctoral student is making progress in scientific research, expanding their knowledge, studying basic and supplementary literature, participating in substantive discussions, fulfilling all scientific obligations.

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

Activity	Number of hours
Scheduled course contact hours	**7 x 15 hrs. – 105 hrs.**
Other contact hours involving the instructor (duty hours, examinations)	**10**
Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	**305**
Total number of hours	**420**
Total number of ECTS credits	**7 x 2 ECTS – 14 ECTS**

INSTRUCTIONAL MATERIALS

Compulsory literature:	Moore R.E., Kearfott R.B., Cloud M.J., Introduction to Interval Analysis, Society for Industrial and Applied Mathematics, Philadelphia, 2009 Hansen E., Walster G., Global Optimization Using Interval Analysis, CRC Press, 2003 S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Pearson Education, 2021
Complementary literature:	Bishop C. M., Pattern Recognition and Machine Learning, Springer New York, 2016 Guyon I., Elisseeff A., An Introduction to Variable and Feature Selection, Journal of Machine Learning Research 3 (2003) 1157-1182 Artykuły z czasopism: IEEE Transactions on Pattern Analysis and Machine Intelligence, Information Sciences, Knowledge-Based Systems, i innych

***(1 ECTS POINT CORRESPONDS TO 25–30 HOURS OF TOTAL WORK BY THE DOCTORAL STUDENT REQUIRED TO ACHIEVE THE INTENDED RESULTS)**

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Date and signature of the Course instructor

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Approved by the Head of the Department or an authorised person