Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-000000C-0106	Name of the course	Polish	**Metody Obliczeniowe w Warunkach Niepewności Danych**
			English	**Computational Methods in the Data Uncertainty Conditions**
Type of the course	General courses			
Course coordinator	Dr hab. inż. Piotr Bilski			
Implementing unit	WEiTI	Scientific discipline / disciplines*	information and communication technology,	

Level of education	Doctoral studies	Semester	Summer		
Language of the course	English				
Type of assessment:	Graded credit	Number of hours in a semester	45	ECTS credits	4
Minimum number of participants	10	Maximum number of participants	20	Available for students (BSc, MSc)	Yes/~~No~~

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	2	0	1	0	0
	in a semester	30	0	15	0	0

* does not apply to the Researcher's Workshop

1. Prerequisites

Basic programming skills and knowledge about the computer algorithms.

2. Course objectives

The aim of the course is get the students acquainted with the artificial intelligence algorithms specializing in the data analysis, where the uncertainty is concerned (caused by the additive noise, acquisition inaccuracies, etc.). The content of the lecture are sophisticated methods solving classification, regression or prediction tasks. Because of the data uncertainty, decisions must be made with the high possibility of errors. Therefore it is important to minimize such a risk (knowing that it can't be completely eliminated). The algorithms presented in the course include Support Vector Machines, Fuzzy Logic, Fuzzy Neural Networks, Fuzzy k-Means clustering or Grey Systems. The particular implementations will be discussed in detail, along with their hyperparameters influencing the algorithm's operation and examples of applications. The practical part of the course covers the implementation and testing of the selected approach, for instance on data provided by the lecturer.

3. Course content (separate for each type of classes)

Lecture

The content of the course covers methods and algorithms belonging to the artificial intelligence domain, solving classification, regression or clustering problems. The common feature for all mentioned methods is the approach to processing data, which were obtained in the un certainty conditions (like, for instance, in the presence of the additive noise). This way there is the need to implement decision-making process, where the probability of the incorrect result is high. Such an error should be suppressed if possible (knowing that it can't be completely eliminated). As the uncertainty is the inherent effect (for instance, because its source remains unknown), the more sophisticated methods are required, having the high accuracy despite the mentioned problems in data. The detailed content of the course is as follows:

1. Introduction to the course and the problems being solved - 4h
2. Kernel methods and Support Vector Machines - 4h
3. Theory and reasoning of Fuzzy Logic - 4h
4. Fuzzy Neural Networks - 2h
5. Fuzzy clustering methods - Fuzzy c-Means Support Vector Clustering - 2h
6. Rough Sets – basics and reasoning - 4h
7. Grey Systems and their variations for the decision making and control - 6h

Laboratory

The student during the course is not only learning about the theoretical aspects of the discussed algorithms (specifics of the problems, details of the approach), but also implementing the selected algorithm to solve one of the tasks indicated by the lecturer. The software project will require application of the specialized library in the selected language in order to implement the particular method. Next, the code will be verified during the meticulous tests regarding the accuracy and computational complexity. The software project will be executed as the own work of the student in cooperation with the lecturer (during tutorials).

4. Learning outcomes

	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
K01	Knowledge about the taxonomy of the computational problems (classification, regression, clustering, etc.) considering the data uncertainty.	SD_W2	written test
K02	Knowledge about the concept and the structure of the particular methods including the implementation details.	SD_W3	written test
K03	Knowledge about the particular application fields of the presented methods.	SD_W2	written test
Skills			
S01	The ability to use the specialized software libraries for the application of the selected algorithm.	SD_U1	software project evaluation
S02	The ability to analyze the applied algorithm regarding the accuracy and computational complexity.	SD_U2	software project evaluation
Social competences			
SC01	Ability to critically evaluate applications of the particular algorithms and their influence on the economy and society.	SD_K3	active participation during classes

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria

The student's evaluation will cover checking the ability to gain theoretical knowledge (during the tests) and the ability to implement algorithms during the project activities.

6. Literature

Primary references:

[1] G. J. Klir, B. Yuan, "Fuzzy Sets and Fuzzy Logic. Theory and Applications," Prentice Hall, New Jersey, 1995.

[2] Z. Pawlak, "Rough Sets: Theoretical Aspects of Reasoning about Data," Springer, 1991.

[3] S. Liu, Y. Lin, "Grey Systems. Theory and Applications," Springer, 2011.

Secondary references:

[1] N. K. Kasabov, " Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering," MIT Press, London, England, 1998.

[2] A. Gosain and S. Dahiya, "Performance Analysis of Various Fuzzy Clustering Algorithms: A Review," Procedia Computer Science, Vol. 79, 2016, pp. 100-111.

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	45
2	Hours of consultations with the academic teacher, exams, tests, etc.	10
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	30
4	Amount of time devoted to the preparation for exams, test, assessments	20
	Total number of hours	**105**
	ECTS credits	**4**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)