Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Computational Intelligence and Its Applications	
Course name in Polish:	Inteligencja obliczeniowa i jej zastosowania	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	lecture	
Code of course:	ITQ100464W/W04ITT-SD0160W	
Course leader:	*Olgierd Unold*	
Faculty of the course leader:	W4 Faculty of Information and Communication Technology	
Email address of the course leader:	Olgierd.unold@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, and electrical engineering	☒
	Information and communication technology	☒
	Biomedical engineering	☐
	Chemical engineering	☐
	Civil engineering and transport	☐
	Mechanical engineering	☐
	Environmental engineering, mining, and energy	☐
	Mathematics	☒
	Chemical sciences	☐
	Physical sciences	☐
	Management and quality studies	☒

2. Objectives

fundamental knowledge in fuzzy sets theory
knowledge of safety analysis using fault trees with fuzzy probabilities and event trees with fuzzy probabilities
knowledge acquisition on dimensionality reduction and feature extraction from massive data
knowledge acquisition on multi-way data analysis
knowledge acquisition on the selected methods for blind source separation
knowledge acquisition on the selected issues of statistical data classification
knowledge of basic evolutionary computation models
fundamental knowledge in data mining
fundamental knowledge in artificial immune systems
knowledge of learning classifier systems and their applications
fundamental knowledge in reinforcement learning, deep reinforcement learning

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	Fundamentals of fuzzy sets theory	4	lecture
2	Safety analysis in nuclear energy production using fault trees with fuzzy probabilities	3	lecture
3	Analysis of serious air transportation incident using event trees with fuzzy probabilities	2	lecture
4	Current trends in safety analysis	1	lecture
5	Principal Component Analysis (PCA) methods: variance analysis, models, applications	2	lecture
6	Nonnegative Matrix Factorization (NMF) – algebraic and geometric approaches	2	lecture
7	Tensor decompositions methods: Tucker decomposition, CP and NTF	2	lecture
8	Unsupervised learning methods for blind source separations problems: whitening, AMUSE algorithm, Fast ICA, tensorial ICA	2	lecture
9	Data classification: k-NN, LDA, SVM and KSVM	2	lecture
10	Basic evolutionary computation models: GA, GP, EP, ES	2	lecture
11	Fundamentals of data mining	2	lecture
12	Artificial immune systems	2	lecture
13	Learning Classifier Systems	1	lecture
14	Fundamentals of RL, DQN	2	lecture
15]	Test	1	Select form

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	KNOWLEDGE. Doctoral student knows and understands:	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☒
SzD_W6	the fundamental dilemmas of modern civilization;	☐
SzD_W7	the legal and ethical conditions of scientific activity;	☐
SzD_W8	the economic and other relevant conditions of scientific activity;	☐

SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☒
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☒
SzD_U4	disseminate research results, including in popular forms;	☒
SzD_U5	initiate debates and participate in a scientific discourse;	☐
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☐
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☒
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☐
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☐
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☒
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☐

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Written test or final report

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

multimedia presentation, discussion, literature studies

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

1. Computational Intelligence, An International Journal, Wiley Periodicals, Inc.
2. S. Sumathi, P. Surekha, Computational intelligence paradigms: theory and applications using MATLAB. Taylor&Francis Group, 2010
3. E. Alpaydin, Introduction to Machine Learning, The MIT Press, Cambridge, Massachusetts, 2010
4. A. Cichocki, R. Zdunek, A. H. Phan, S.-I. Amari, Nonnegative Matrix and Tensor Factorization: Applications to Exploratory Multi-way Data Analysis and Blind Source Separation, Wiley and Sons, UK, 2009
5. S. Kumar Tyagi, D. Pandey, R. Tyagi, Fuzzy set theoretic approach to fault tree analysis, International Journal of Engineering, Science and Technology, Vol. 2, No. 5, 2010, 276-283.
6. N. Leveson, Engineering a Safer World, Systems Thinking Applied to Safety, MIT Press, 2012.
7. R.S. Sutton, A.G. Barto, Reinforcement Learning: An Introduction, MIT Press 1998-2018
8. S.J. Russel, P. Norvig, Artificial Intelligence. A Modern Approach, Prentice Hall, 2010
9. R. J. Urbanowicz, W. N. Browne, Introduction to learning classifier systems. Springer, 2017

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

English