

FACULTY OF ELECTRICAL  
ENGINEERING**SUBJECT CARD**

Name in Polish: **Techniki sztucznej inteligencji**  
 Name in English: **Artificial Intelligence Techniques**  
 Main field of study (if applicable): **Electrical Engineering**  
 Specialization (if applicable): **Control in Electrical Power Engineering**  
 Level and form of studies: **2nd level, full-time**  
 Kind of subject: **obligatory**  
 Subject code: **ELR052135**  
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30			15	
Number of hours of total student workload (CNPS):	60			30	
Form of crediting:	crediting with grade			crediting with grade	
For group of courses mark (X) final course:					
Number of ECTS points:	2			1	
including number of ECTS points for practical (P) classes :				1	
including number of ECTS points for direct teacher-student contact (BK) classes:	1.40			0.70	

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of basics of power system control, digital signal processing and numerical methods
2. Practical skills of using MATLAB and ATP-EMTP software

**SUBJECT OBJECTIVES**

- C1. Acquaintance of knowledge related artificial intelligence techniques application to digital power system protection and control systems
- C2. Acquiring practical skills to design and analyze control and protection units for power systems, with application of artificial intelligence techniques

**SUBJECT LEARNING OUTCOMES***relating to knowledge:*

- PEU\_W01 Possesses knowledge related to expert systems: basic features, structure, inference methods, conflict resolution strategies, application fields.
- PEU\_W02 Possesses knowledge related to fuzzy logic systems: fuzzy signals, membership functions, fuzzy settings, fuzzyfication and defuzzyfication methods, realization of multi-criteria algorithms.
- PEU\_W03 Possesses knowledge related to artificial neural networks (features, neurone types, activation functions, neural network structures, learning methods, application fields) as well as genetic algorithms (evolutionary strategies, genetic modifications).

*relating to skills:*

- PEU\_U01 Is able to apply expert systems for power system control and protection purposes.
- PEU\_U02 Is able to apply fuzzy logic technique for power system control and protection purposes.
- PEU\_U03 Is able to apply artificial neural networks as well as genetic algorithms for power system control and protection purposes.

*relating to social competences:*

- PEU\_K01 Is able to carry out a complex engineering project in a competent way, unaided, undertaking multi-criterial analysis.

## PROGRAMME CONTENT

Form of classes - lecture		Number of hours:
Lec 1	Introduction. Setting rules of course crediting. Definition of artificial intelligence (AI), AI as a branch of science, AI techniques in power systems, statistics of AI application in power system protection and control.	2
Lec 2	AI approach to protection and control tasks – problems of contemporary digital protection systems, protection relay as a classifying unit, protection tasks as pattern recognition tasks.	2
Lec 3	Expert Systems (ES) – definitions, knowledge base, data base, inference mechanisms.	2
Lec 4	ES – semantic rules and structures, acquisition of rules, inference methods, conflict resolving strategies.	2
Lec 5	Expert Systems – application fields, examples.	2
Lec 6	Fuzzy Logic (FL) – basics of fuzzy sets theory, operations on fuzzy sets, fuzzy arithmetic. Linguistic variables, operators of aggregation, fuzzy reasoning.	2
Lec 7	Elements of FL in power system protection – fuzzy criteria signals, fuzzy settings, fuzzy comparison, amount of information, multi-criterial decision making.	2
Lec 8	Examples of FL technique application in power system protection.	2
Lec 9	Artificial Neural Networks (ANN) – neurone models, activation functions, multilayer perceptrons, feed-forward networks.	2
Lec 10	ANN architectures: feed-forward networks, ANNs with feedback connections, Hopfield networks, Kohonen networks.	2
Lec 11	ANN design problems – network structure selection, generation of training patterns, training algorithms with and without the teacher, learning process acceleration techniques, knowledge generalisation vs. overfitting.	2
Lec 12	Examples of ANN application in power system control.	2
Lec 13	Genetic algorithms – evolutionary strategies, genetic modification of individuals, genetic optimisation, application examples.	2
Lec 14	Comparison of described AI techniques, hybrid structures, examples.	2
Lec 15	Crediting test.	2
Total hours:		<b>30</b>

Form of classes - project		Number of hours:
Proj 1	Design and implementation of an expert system for chosen decision task.	4
Proj 2	Design and evaluation of the fuzzy logic based measurement/decision unit.	4
Proj 3	Design and evaluation of the neural network based measurement/decision unit.	4
Proj 4	Implementation of genetic optimization procedures for selected measurement/decision task.	2
Proj 5	Presentations of executed projects, crediting.	1
Total hours:		<b>15</b>

## TEACHING TOOLS USED

- N1. Informative lecture.  
 N2. Matlab and ATP-EMTP programmes.  
 N3. Project presentation.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation <small>F – forming (during semester) P – concluding (at semester end)</small>	Educational effect number	Way of evaluating educational effect achievement
F1(W)	PEU_W01 PEU_W02 PEU_W03	Participation in the course.
F2(W)	PEU_W01 PEU_W02 PEU_W03	Final colloquium/test.
P(W)	$P = 0,1F1 + 0,9F2$	
F1(P)	PEU_U01 PEU_U02 PEU_U03 PEU_K01	Activity during the classes.
F2(P)	PEU_U01 PEU_U02 PEU_U03 PEU_K01	Presentation of the projects done.
P(P)	$P = 0,2F1 + 0,8F2$	

<b>PRIMARY AND SECONDARY LITERATURE</b>
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<b>PRIMARY LITERATURE:</b>
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| <ul style="list-style-type: none"><li>[1] Rebizant W., Szafran J., Wiszniewski A., Digital signal processing in power system protection and control, Springer, London 2011</li><li>[2] Russel S.J., Norvig P., Artificial intelligence: a modern approach, Prentice Hall, Pearson, 2010</li><li>[3] James J. Buckley, Esfandiar Eslami, An introduction to fuzzy logic and fuzzy sets, Heidelberg Physica-Verlag, 2002</li><li>[4] Dillon T.S. and Niebur D. (edited by), Neural Network Applications in Power Systems, CRL Publishing Ltd., London 1996</li><li>[5] Liebowitz J., The Handbook of applied expert systems, Boca Raton, CRC Press, 1998</li></ul> |
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<b>SECONDARY LITERATURE:</b>
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| <ul style="list-style-type: none"><li>[1] Gottlob G. And Nejdl W. (ed. by), Expert Systems in Engineering: Principles and Applications, Proceedings of the International Workshop, Vienna, Austria, Sept. 1990</li><li>[2] Cichocki A., Unbehauen R., Neural Networks for Optimization and Signal Processing, John Wiley &amp; Sons, 1993</li><li>[3] Yager R.R. and Filev D.P., Essentials of Fuzzy Modelling and Control, J. Wiley &amp; Sons, Inc., New York, USA, 1994</li><li>[4] Ringland G.A. and Duce D.A. (ed. By), Approaches to Knowledge Representation: An Introduction, Research Studies Press Ltd., Wiley &amp; Sons, Chichester, England, 1988</li><li>[5] Pao Y.A., Adaptive Pattern Recognition and Neural Networks, Addison-Wesley, Reading, MA, 1989</li></ul> |
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<b>SUBJECT SUPERVISOR</b>
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