FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Sztuczna inteligencja w automatyce elektroenergetycznej**
Name in English:	**Artificial intelligence in power system protection and control**
Main field of study (if applicable):	**Industrial Control Engineering**
Specialization (if applicable):	**Automation and Control in Electrical Power Systems**
Level and form of studies:	**2nd level, full-time**
Kind of subject:	**obligatory**
Subject code:	**APR012115**
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):	120			30	
Form of crediting:	examination			crediting with grade	
For group of courses mark (X) final course:					
Number of ECTS points:	4			1	
including number of ECTS points for practical (P) classes :				1	
including number of ECTS points for direct teacher-student contact (BK) classes:	2.80			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
3. Creativity in thinking and working

SUBJECT OBJECTIVES

C1. Mastering artificial intelligence techniques and fundamentals of decision theory as related to automation 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 and 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.	2
Lec 7	Linguistic variables, operators of aggregation, fuzzy reasoning.	2
Lec 8	Elements of FL in power system protection – fuzzy criteria signals, fuzzy settings, fuzzy comparison, amount of information, multi-criterial decision making.	2
Lec 9	Examples of FL technique application in power system protection.	2
Lec 10	Artificial Neural Networks (ANN) – neurone models, activation functions, multilayer perceptron.	2
Lec 11	ANN architectures:, feed-forward networks, ANNs with feedback connections, Hopfield networks, Kohonen networks.	2
Lec 12	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 13	Examples of ANN application in power system control.	2
Lec 14	Genetic algorithms – evolutionary strategies, genetic modification of individuals, genetic optimisation, application examples.	2
Lec 15	Comparison of described AI techniques, hybrid structures, examples.	2
	Total hours:	**30**

Form of classes - project		**Number of hours:**
Proj 1	Design and optimization 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	Presentation of the projects performed, crediting.	1
	Total hours:	**15**

TEACHING TOOLS USED
N1. Informative lecture
N2. Matlab and ATP-EMTP programs
N3. Project presentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**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 examination
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 completion of the project
P(P)	P = 0,2F1 + 0,8F2	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Flasiński M., Wstęp do sztucznej inteligencji, PWN, Warszawa 2011
[2] Rutkowski L., Metody i techniki sztucznej inteligencji, PWN, Warszawa 2009
[3] Rosołowski E.: Cyfrowe przetwarzanie sygnałów w automatyce elektroenergetycznej. Akademicka Oficyna Wydawnicza EXIT, Warszawa 2002
[4] Grzech A., Inżynieria wiedzy i systemy ekspertowe, Exit, Warszawa 2009
[5] Markowska-Kaczmar U., Kwaśnicka H., Sieci neuronowe w zastosowaniach, Oficyna Wyd. PWr, Wrocław 2005

SECONDARY LITERATURE:

[1] Rebizant W., Szafran J., Wiszniewski A., Digital signal processing in power system protection and control, Springer, London 2011
[2] Russel S.J., Norvig P., Artificial intelligence: a modern approach, Prentice Hall, Pearson, 2010
[3] James J. Buckley, Esfandiar Eslami, An introduction to fuzzy logic and fuzzy sets, Heidelberg Physica-Verlag, 2002
[4] Dillon T.S. and Niebur D. (edited by), Neural Network Applications in Power Systems, CRL Publishing Ltd., London, 1996
[5] Liebowitz J., The Handbook of applied expert systems, Boca Raton, CRC Press, 1998

SUBJECT SUPERVISOR

Waldemar Rebizant, waldemar.rebizant@pwr.edu.pl