FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Metody sztucznej inteligencji w automatyce elektroenergetycznej**
Name in English:	**Artificial intelligence methods in power system protection and control**
Main field of study (if applicable):	**Electrical Engineering**
Specialization (if applicable):	**Electrical Power Engineering**
Level and form of studies:	**2nd level, full-time**
Kind of subject:	**optional**
Subject code:	**ELR042115**
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:	examination		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. 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 EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01	Possesses knowledge related to expert systems: basic features, structure, inference methods, conflict resolution strategies, application fields.
PEK_W02	Possesses knowledge related to fuzzy logic systems: fuzzy signals, membership functions, fuzzy settings, fuzzyfication and defuzzyfication methods, realization of multi-criteria algorithms.
PEK_W03	Possesses knowledge related to artificial neural networks (features, neurone types, activation functions, neural network structures, learning methods, application fields) as well as knowledge related to genetic algorithms (evolutionary strategies, genetic modifications).

relating to skills:

PEK_U01	Is able to apply expert systems for power system control and protection purposes.
PEK_U02	Is able to apply fuzzy logic technique for power system control and protection purposes.
PEK_U03	Is able to apply artificial neural networks and genetic algorithms for power system control and protection purposes.

relating to social competences:

PEK_K01	Is able to carry out a complex engineering project in a competent way.

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 - laboratory		**Number of hours:**
Lab 1	Introduction, familiarizing with health and safety-at-work rules and lab regulations, presenting of available software.	2
Lab 2	Design and implementation of an expert system for chosen decision task.	2
Lab 3	Design and evaluation of the fuzzy logic based measurement/decision unit.	4
Lab 4	Design and evaluation of the neural network based measurement/decision unit.	4
Lab 5	Implementation of genetic optimization procedures for selected measurement/decision task.	2
Lab 6	Make up for date, crediting.	1
	Total hours:	**15**

TEACHING TOOLS USED
N1. Informative lecture.
N2. Matlab and ATP-EMTP programmes.
N3. Reports from assignments.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**Educational effect number**	**Way of evaluating educational effect achievement**
F1(W)	PEK_W01 PEK_W02 PEK_W03	Participation in the course.
F2(W)	PEK_W01 PEK_W02 PEK_W03	Final examination.
P(W)	P = 0,1F1 + 0,9F2	
F1(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Activity during the classes.
F2(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Reports from the lab assignments.
P(L)	P = 0,2F1 + 0,8F2	

PRIMARY AND SECONDARY LITERATURE

PRIMARY 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

SECONDARY 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

SUBJECT SUPERVISOR

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
ELR042115 - Artificial intelligence methods in power system protection and control
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**
AND SPECIALIZATION **Electrical Power Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01	S2EEN_W11	C.1	Lec1 Lec2 Lec3 Lec4 Lec5	N.1
PEK_W02	S2EEN_W11	C.1	Lec6 Lec7 Lec8 Lec9	N.1
PEK_W03	S2EEN_W11	C.1	Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1
PEK_U01	S2EEN_U12	C.2	Lab1 Lab2	N.2 N.3
PEK_U02	S2EEN_U12	C.2	Lab1 Lab3	N.2 N.3
PEK_U03	S2EEN_U12	C.2	Lab1 Lab4 Lab5	N.2 N.3
PEK_K01	K2ETK_K02 K2ETK_K06	C.2	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6	N.3