Załącznik nr 6 do ZW 121/2020

FACULTY OF MECHANICAL AND POWER ENGINEERING

**SUBJECT CARD**

| | |
|---|---|
| **Name of subject in Polish:** | Sztuczna inteligencja |
| **Name of subject in English:** | **Artificial intelligence** |
| **Main field of study (if applicable):** | Power engineering |
| **Specialization (if applicable):** | Computer aided mechanical and power engineering |
| **Profile:** | academic |
| **Level and form of studies:** | 2nd level, full-time |
| **Kind of subject:** | Optional/specialization |
| **Subject code:** | W09ENG-SM0060 |
| **Group of courses:** | NO |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 15 | | |
| Number of hours of total student workload (CNPS) | | | | | |
| Form of crediting | crediting with grade | | crediting with grade | | |
| For group of courses mark final course with (X) | | | | | |
| Number of ECTS points | 1 | | 1 | | |
| including number of ECTS points for practical (P) classes | | | 1 | | |
| including number of ECTS points for direct teacher-student contact (BU) classes | 0,5 | | 0,75 | | |

*delete as applicable

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

1. differential equation course
2. computer programming course
3. control systems course

**SUBJECT OBJECTIVES**

C1 mastering the methods of artificial intelligence with applications to energy and control systems

**SUBJECT LEARNING OUTCOMES**

relating to knowledge:
PEU_W01 - knowledge relating to artificial neural networks
PEU_W02 - knowledge relating to fuzzy logic
PEU_W03 - knowledge relating to genetic algorithms

relating to skills:
PEU_U01 - Skills in using artificial neural networks
PEU_U02 - Skills in using fuzzy logic
PEU_U03 - Skills in using genetic algorithms

| PROGRAM CONTENT | | |
|---|---|---|
| | **Lectures** | **Number of hours** |
| Lec 1 | **How our brain works**<br>1.1 Few surprises about brain<br>1.2 Scanning the brain<br>1.3 A journey through the brain<br>1.4 Brain functions<br>1.5 Brain cells<br>1.6 Nerve impulses<br>1.7 Brain mapping and simulation<br>1.8 What is consciousness? | **2** |
| Lec 2 | **History and present day of artificial intelligence**<br>2.1 Brief history of intelligent systems<br>2.2 Biological and cognitive paradigms<br>2.3 Essential characteristics of intelligence<br>2.4 Philosophical questions about artificial intelligence<br>2.5 Acquiring knowledge, ageing behaviour and regulation<br>2.6 Biological control paradigms | **1** |
| Lec 3 | **Turing machines and formal logic**<br>3.1 Intelligent systems<br>3.2 The cognitive paradigm<br>3.3 Essential characteristics of intelligence<br>3.4 Hierarchy of algorithmic and reflective activities<br>3.5 Autonomous system model<br>3.6 Formal logic of the autonomous system<br>3.7 Sentence calculus<br>3.7.1 Diadic operations<br>3.7.2 Unary operations<br>3.7.3 Truth table<br>3.7.4 Subsequent concepts in logic<br>3.8 Algorithms<br>3.9 Numerical systems<br>3.10 Turing machine<br>3.10.1 Logic processing<br>3.10.2 Machine components<br>3.10.3 Operation of the machine<br>3.10.4 Further evolution of the Turing machine<br>3.10.5 Examples<br>Production of proteins in a cell<br>Polymerase and ribosomes | **1** |
| Lec 4 | **Set calculus**<br>4.1 Predicate calculus<br>4.2 1st order logic<br>4.3 Sharp and fuzzy sets<br>4.4 Set theory | **1** |
| Lec 5 | **Artificial neural networks**<br>5.1 Natural and artificial neurons | **2** |

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| | 5.1.1 Biological inspiration<br>5.1.2 Mathematical description<br>5.1.3 Linear network<br>5.1.4 Neural activation functions<br>5.2 Neural networks<br>5.2.1 linear<br>5.2.2 perceptron<br>5.2.3 Sigmoid<br>5.2.4 Network with threshold yes/no<br>5.2.5 Selecting the activation function<br>5.3 Learning neural networks<br>5.3.1 Supervised and unsupervised learning<br>5.3.2 The Hebb Rule<br>5.3.3 Adaline network<br>5.3.4 Linear network - teaching a single neuron<br>5.3.5 Perceptron network - teaching a single neuron<br>5.3.6 Sigmoid network - learning a single neuron<br>5.3.7 Sigmoid network - learning neural layers<br>5.3.8 Delta rule<br>5.3.9 Method for identifying any object (linear or non-linear) by means of an artificial neural network<br>5.3.10 Neural reverse model of an object (process)<br>5.3.11 Neural controller<br>5.3.12 Widrow-Hoff Rule<br>5.3.13 Correlation rule<br>5.4 Self-organising maps of Kohonen<br>5.5 Recurrent networks: Hopfield and Grossberg<br>5.6 Neural network applications<br>5.6.1 Example. Test signals for the identification of $NO_2$ emissions from the OP-650 boiler | |
| Lec 6 | **Fuzzy logic**<br>6.1 History<br>6.2 Formalities<br>6.2.1 Set theory<br>6.2.2 Set operations<br>6.2.3 Fuzzy sets<br>6.2.4 Membership functions<br>6.2.5 Fuzzy operations<br>6.2.6 Fuzzy sets of Mamdani and Takagi-Sugeno<br>6.2.7 Fuzzyfing of inputs, rules base and output sharpening (de-fuzzifing)<br>6.2.8 Fuzzy controller<br>6.3 Applications<br>6.3.1 Ventilation control<br>6.3.2 Fuzzy control and state controller<br>6.3.3 The movement of robots<br>6.3.4 Recognition of feelings<br>6.3.5 Steam turbine control<br>6.3.6 From the diary of the cement mill operator...<br>6.3.7 Train control in Japan | **2** |

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| | 6.3.8 Fuzzy investing in the stock market<br>6.3.9 Diagnosis of emphysema of the lungs<br>6.3.10 Prevention of aviation accidents | |
| Lec 7 | **Genetic algorithms and optimisation methods**<br>7.1 Local and global search<br>7.2 Numerical optimisation<br>7.2.1 Newton's method<br>7.2.2 Gradient method<br>7.2.3 Gradientless method<br>- based on a network of points in the field of<br>- random search<br>- symplex method (Nelder-Mead)<br>7.3 Monte Carlo methods<br>7.4 Simulated annealing<br>7.5 Genetic algorithms<br>7.5.1 Characteristics<br>7.5.2 Evolution<br>7.5.3 Reproduction<br>7.5.4 Gene exchange<br>7.5.5 Mutation<br>7.5.6 A new generation<br>7.6 Implementation of a genetic algorithm<br>7.6.1 Population development process<br>7.6.2 Creating a new population<br>7.6.3 Changes in population<br>7.6.4 Crossing<br>7.6.5 Mutation<br>7.6.6 Environmental assessment<br>7.6.7 Ending evolution<br>7.6.8 Selection of a new population<br>7.7 Examples<br>7.7.1 Control signal<br>7.7.2 Minimum cost function<br>7.7.3 Circle and cross<br>7.7.4 Mouse is looking for cheese<br>7.7.5 Salesman problem<br>7.7.6 Minimum of complex function<br>7.7.7 Minimum of two-dimensional function<br>7.7.8 Stocks exchange | **2** |

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| Lec 8 | **Algorithmic methods**<br>8.1 Introduction<br>8.2 Artificial life : Boids (birds), Vants (ants), L-systems (plants), Life game<br>8.3 Machine learning<br>8.3.1 Feedback and adaptation<br>8.3.2 Object identification<br>8.3.3 Selected methods<br>- Unit step,<br>- Dirac's impulse,<br>- Fourier's transformer,<br>- Kuepfmueller, Rotach, Strejc, ARX models<br>8.3.4 Search<br>- Graphs<br>- Bellman's dynamic programming<br>8.3.5 Entropy of signal<br>8.3.6 Supervised classification<br>8.4 Optimisation in control systems<br>8.4.1 Necessary and sufficient conditions for a minimum in static optimization<br>8.4.2 Equality constraints<br>8.4.3 Lagrange multipliers<br>8.4.4 Dynamic optimization | **3** |
| Lec 8 | **Test** | **1** |
| | Total hours | **15** |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Use of artificial neural networks in control | **2** |
| Lab 2 | Fuzzy Logic | **2** |
| Lab 3 | Fuzzy Logic. Continued. | **2** |
| Lab 4 | Genetic algoritms | **2** |
| Lab 5 | Algoritmic methods | **2** |
| Lab 6 | Bird algoritms | **2** |
| Lab 7 | Dynamic programming | **2** |
| Lab 8 | Summary of course | **1** |
| | Total hours | **15** |

**TEACHING TOOLS USED**

N1. Presentations
N2. Computer programming of examples
N3.

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming (during | Learning outcomes number | Way of evaluating learning outcomes achievement |
|---|---|---|

| | | |
|---|---|---|
| semester), P – concluding (at semester end) | | |
| C (lecture) | PEU_W01- PEU_W03 | test |
| C (laboratory) | PEU_U01-PEU_U03 | Grades for completed exercises |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Rita Carter, The human brain, Weidenfeld / Nicholson 1998,
[2] Kevin M. Passino, Fuzzy Control
[3] Jan Jantzen, Tutorial On Fuzzy Logic/Design Of Fuzzy Controllers /Tuning Of Fuzzy PID Controllers
[4] Fuzzy Logic Toolbox/Matlab
[5] Kaczorek T., Teoria układów regulacji automatycznej. Część I., Wydanie czwarte, Wydawnictwa Politechniki Warszawskiej, 1971
[6] Michalewicz Z., Algorytmy genetyczne + struktury danych = programy ewolucyjne, WNT, Warszawa, 1996
[7] Michalewicz, Zbigniew, Genetic Algorithms + Data Structures = Evolution Programs.
[8] Zbigniew Czech, Analiza algorytmów, Instytut Informatyki Politechnika Śląska, Materiały dydaktyczne, Gliwice, wrzesień 2004
[9] Jakubczyk, Rozdział 4. Algorytmy grafowe
[10] Żurada, Barski, Jędruch, Sztuczne sieci neuronowe, PWN, 1996
[11] Googfellow, Bengio, Courville, Deep Learning, PWN, 2018
[12] Cichosz, Systemy uczące się, WNT 2000, 2007


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


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