Warsaw University of Technology

# COURSE OFFERED IN THE DOCTORAL SCHOOL

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| Code of the course | 4606-ES-000000P-0298 | Name of the course | Polish | **Obliczenia Inspirowane Biologią** | |
| | | | English | **Biology-Inspired Computations** | |
| Type of the course | specialized | | | | |
| Course coordinator | Dr hab. inż. Piotr Bilski | | | | |
| Implementing unit | WEiTI | Scientific discipline / disciplines* | biotechnology | | |
| Level of education | Doctoral studies | Semester | Winter | | |
| Language of the course | English | | | | |
| Type of assessment: | Graded credit | Number of hours in a semester | 45 | ECTS credits | 4 |
| Minimum number of participants | 10 | Maximum number of participants | 20 | Available for students (BSc, MSc) | Yes/~~No~~ |

| Type of classes | | Lecture | Auditory classes | Project classes | Laboratory | Seminar |
|---|---|---|---|---|---|---|
| Number of hours | in a week | 2 | 0 | 1 | 0 | 0 |
| | in a semester | 30 | 0 | 15 | 0 | 0 |

* does not apply to the Researcher's Workshop

## 1. Prerequisites

Basic programming skills and knowledge about the computer algorithms.

## 2. Course objectives

The aim of the course is to present methods and computational algorithms used contemporarily in the data analysis, which were inspired by the observation of the behaviour of living organisms (both in the micro- and macroscale). The problems requiring solutions by such algorithms will be introduced (including classification, regression, optimization and prediction).The particular examples of tasks to solve will be supported by computational examples. Described methods will include, among others, artificial neural networks, evolutionary and coevolutionary algorithms, swarm intelligence and immune systems. The practical part of the course will cover the implementation of the selected algorithm to solve the particular problem.

## 3. Course content (separate for each type of classes)

### Lecture

The content of the course covers methods and algorithms belonging to the artificial intelligence domain. The presented approaches are aimed at solving classification, regression or optimization problems. Their common trait is that all are inspired by the behaviour of living organisms and can be divided into two groups. The first one refers to the characteristics of large number of individuals, cooperating and interacting. Most of all, the herd behaviour is considered (such as the bee swarm flight, or the wolfpack hunting traits). The second group contains the microscale, i.e. operation of particular organs or cells inside the living creature. Here belong the artificial neural networks (including the deep learning structures) or immune systems. Each concept will be presented in two stages. First, the biological inspiration for the particular algorithm will be introduced (for instance, organization of the ant colony and methods of exchanging information between them). Second, the details of the algorithm will be discussed, including subsequent steps, and hyperparameters influencing the algorithm's behaviour. The detailed content of the course covers (excluding two tests, in the middle and at the end of the semester):

1. Introduction of the course and problems posing a challenge for the discussed algorithms - 4h
2. Artificial neural networks in the supervised learning scheme (multi-layered perceptrons and RBF networks) - 4h
3. Deep learning network (feedforward and recurrent) - 4h
4. Data clustering methods (ant cemetery organization and self-organizing maps)- 2h
5. Evolutionary algorithms - 2h
6. Coevolutionary methods - 2h

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| 7. Herd algorithms (Particle Swarm Optimization, Ant Colony Optimization, Firefly algorithm, bat algorithm, etc.) - 6h<br>8. Immune systems – 2h |
| Laboratory |
| The student, besides learning theoretical concepts during the lecture will be able to verify the obtained knowledge during the programming project. The task will be to solve the particular problem (assigned by the supervisor) using the selected programming language and appropriate libraries. The algorithm should be implemented according to the particular task (classification, regression, etc.). In specific cases the data for processing will be delivered by the supervisor. Besides implementation, the algorithm should be tested, especially regarding the hyperparameters. Results of the experiments should be presented in the report. |

4. Learning outcomes

| | Learning outcomes description | Reference to the learning outcomes of the WUT DS | Learning outcomes verification methods* |
|---|---|---|---|
| Knowledge | | | |
| K01 | Knowledge about the taxonomy of the computational methods (for classification, regression, clustering, etc.), also considering the data uncertainty. | SD_W2 | written test |
| K02 | Knowledge about the concept and structure of the selected methods including the implementation details. | SD_W3 | written test |
| K03 | Knowledge about the particular fields of applications for the presented algorithms. | SD_W2 | written test |
| Skills | | | |
| S01 | Ability to use the specialized software libraries for the application of the selected algorithms. | SD_U1 | software project |
| S02 | Ability to conduct the comprehensive analysis of the selected algorithms regarding accuracy and computational complexity. | SD_U2 | software project |
| Social competences | | | |
| SC01 | Ability to critically evaluate applications of the particular algorithms and their influence on the economy and society. | SD_K3 | active participation during classes |

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria

Evaluation criteria will include the ability to use knowledge from the lecture (during the tests) and abilities to implement or use the selected algorithms during the programming tutorials.

6. Literature

Primary references:

[1] A.P. Engelbrecht, „Computational Intelligence: An Introduction”, Wiley, 2007

[2] Xin-She Yang, „Nature-Inspired Metaheuristic Algorithms,” Luniver Press, 2008

[3] J. Patterson, A. Gibson, „Deep Learning," O'Reilly, 2017.

Secondary references:

[1] „Swarm Intelligence and Bio-Inspired Computation," Elsevier, 2013

[2] C. C. Aggarwal, C. K. Reddy, "Data Clustering," Chapman and Hall/CRC, 2013

| 7. PhD student's workload necessary to achieve the learning outcomes** | | |
|---|---|---|
| No. | Description | Number of hours |
| 1 | Hours of scheduled instruction given by the academic teacher in the classroom | 45 |
| 2 | Hours of consultations with the academic teacher, exams, tests, etc. | 10 |
| 3 | Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework | 30 |
| 4 | Amount of time devoted to the preparation for exams, test, assessments | 20 |
| | **Total number of hours** | **105** |
| | **ECTS credits** | **4** |

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)