COURSE DESCRIPTION CARD - SYLLABUS

Course name
Bio-inspired algorithms and models

Course

Field of study
Computing

Year/semester
1/2

Area of study (specialization)
Artificial Intelligence

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)

Tutorials

Projects/seminars

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Students starting this course should have basic knowledge of computational complexity, machine learning algorithms and artificial neural networks. They should have the ability to model and solve simple optimization problems, programming skills and the ability to obtain information from provided sources. They should also understand the need to expand their competences. Moreover, in terms of social competences, students should exhibit honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, and respect for other people.

Course objective

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1. To provide knowledge on biologically inspired optimization algorithms such as evolutionary, ant colony, particle swarm, and artificial bee colony algorithms.

2. To present the role of biological mechanisms used in computation, their advantages and disadvantages.

3. To demonstrate common features and a unified approach to all optimization algorithms.

4. To present the field of artificial life and explain simulation models of biological systems.

5. To develop skills in efficient implementation and evaluation of the optimization algorithms - both in terms of running time and quality.

6. To learn to draw conclusions from self-conducted research, create reports on computational experiments and properly visualize the results.

Course-related learning outcomes

Knowledge

has a structured and theoretically founded general knowledge related to key issues in biologically-inspired algorithms [K2st_W2]

has advanced detailed knowledge regarding simulations and modeling of biological phenomena [K2st_W3]

has knowledge about development trends and the most important cutting edge achievements in computer science and other selected and related scientific disciplines [K2st_W4]

has advanced and detailed knowledge of the processes occurring in the life cycle of hardware or software information systems [K2st_W5]

knows advanced methods, techniques and tools used to solve complex engineering tasks and conduct research in biologically-inspired algoritms [K2st_W6]

Skills

is able to obtain information from literature, databases and other sources (both in Polish and English), integrate them, interpret and critically evaluate them, draw conclusions and formulate and fully justify opinions [K2st_U1]

is able to plan and carry out experiments, including computer measurements and simulations, interpret the obtained results and draw conclusions and formulate and verify hypotheses related to complex engineering problems and simple research problems [K2st_U3]

can use analytical, simulation and experimental methods to formulate and solve engineering problems and simple research problems [K2st_U4]

can - when formulating and solving engineering tasks - integrate knowledge from different areas of computer science (and if necessary also knowledge from other scientific disciplines) and apply a systemic approach, also taking into account non-technical aspects [K2st_U5]

is able to assess the suitability and the possibility of using new achievements (methods and tools) and new IT products [K2st_U6]

POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

can carry out a critical analysis of existing technical solutions and propose their improvements (streamlines) [K2st_U8]

is able - using among others conceptually new methods - to solve complex IT tasks, including atypical tasks and tasks containing a research component [K2st_U10]

Social competencies

understands that in the field of IT the knowledge and skills quickly become obsolete [K2st_K1]

understands the importance of using the latest knowledge in the field of computer science in solving research and practical problems [K2st_K2]

is aware of the need to develop professional achievements and comply with the rules of professional ethics [K2st_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) lectures:

- based on answers to questions about the material discussed in previous lectures,

b) laboratories:

- based on an assessment of the current progress in the implementation of tasks.

Summative assessment:

a) lectures: verification of the learning outcomes is carried out by:

- assessment of the knowledge and skills demonstrated in a test consisting of several questions or short tasks. Exceeding 50% of the points allows to obtain a satisfactory grade.

- discussion of the test results,

b) laboratories: verification of the learning outcomes is carried out by:

- assessment of skills related to the implementation of laboratory exercises,

- continuous assessment during each class (oral answers) - rewarding the increase in the ability to use the learned principles and methods,

- evaluation of reports prepared partly during the classes and partly after their completion, with the possibility of using the Moodle platform,

- presenting the results of individual experiments.

Obtaining additional points for activity during classes, especially for:

- carrying out extended, non-obligatory experiments as part of laboratory tasks and describing them in the report,

- remarks to improve teaching materials.

Programme content

Lectures:

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EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

Architecture and evaluation of evolutionary algorithms. Techniques of selection, crossover, mutation, scaling the fitness of solutions. Schema theorem and epistasis. Messy genetic algorithm. Hierarchical genetic algorithm. Mechanisms inspired by nature in evolutionary algorithms. Evolutionary strategies. Differential evolution. Evolutionary programming: floating point representation, embryogenesis, genetic operators and global convexity. Genetic programming and symbolic regression. Classifier systems: evolutionary machine learning. Solving multi-criteria problems with evolutionary algorithms. Parallel evolutionary algorithms. Co-evolutionary architectures – cooperative and competitive. Problems and pathologies in co-evolution and ways to reduce them. Discussion of other biologically inspired optimization techniques: ant algorithms (AA/ACO) and stigmergy, particle swarm algorithms (PSO), artificial immune systems (AIS), artificial bee colony algorithms (ABC). Spontaneous and directed evolution. Closed-ended versus open-ended evolution. Evolutionary design and evolutionary robotics; genotype-phenotype mapping, morphogenesis and modularity.

Laboratories:

Choosing a combinatorial optimization problem, determining the solution space, solution representation, and the definition of the objective function. Proposing a heuristic algorithm. Implementation of the local search algorithm and one of the bio-inspired metaheuristics. Comparison of the quality of the obtained solutions and the running time of the algorithms. Experiments with the evolutionary design of three-dimensional structures and evolutionary robotics.

Teaching methods

Lecture: multimedia presentation illustrated with examples.
Laboratory exercises: presentation illustrated with examples; carrying out the tasks given by the teacher (practical exercises).

Bibliography

Basic

1. D.E. Goldberg, Algorytmy genetyczne i ich zastosowania, WNT, Warszawa, 2009.

2. Z. Michalewicz, Algorytmy genetyczne + struktury danych = programy ewolucyjne, WNT, Warszawa, 2003.

Additional

1. Jason Brownlee, Clever Algorithms: Nature-Inspired Programming Recipes, 2012. https://github.com/clever-algorithms/CleverAlgorithms

2. El-Ghazali Talbi, Metaheuristics: From Design to Implementation, Wiley, 2009.

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Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3
Classes requiring direct contact with the teacher	30	1,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exams, project preparation)[1]	45	1,5

[1]delete as appropriate or add other activities