POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Artificial Life and Cognitive Science

Course

Field of study
Artificial Intelligence

Area of study (specialization)

Level of study
First-cycle studies

Form of study
full-time

Year/Semester
1/1

Profile of study
general academic

Course offered in
English

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
Maciej Komosiński
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Faculty of Computing and Telecommunications
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Responsible for the course/lecturer:
Konrad Miazga
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Prerequisites

Mathematical knowledge from secondary school (sets, permutations, combinations, etc.)

Course objective

To discuss the relationship between Intelligence and Life, and in consequence, between Artificial Intelligence and Artificial Life. To demonstrate how life and biological phenomena inspire technological solutions – in particular, algorithms, models and simulations in computer science. To present components of artificial cognitive systems.

Course-related learning outcomes

Knowledge

K1st_W3: has a well-grounded knowledge of fundamental computer science problems within the scope of artificial intelligence, including optimization techniques, modeling of complex systems, and developing artificial cognitive systems

K1st_W4: knows and understands basic techniques, methods, algorithms, and tools used for combinatorial optimization, building models of biological phenomena and cognitive systems

K1st_W5: has a basic knowledge of the relation between artificial intelligence and artificial life, and the important role of biologically-inspired algorithms in artificial intelligence

Skills

K1st_U3: can formulate and solve optimization problems using artificial intelligence approaches by applying appropriately selected methods such as random search, exhaustive search, local search, evolutionary algorithms or other biologically-inspired algorithms

K1st_U4: can efficiently plan and carry out experiments, including computer measurements and simulations, interpret the obtained results and draw conclusions based on the experimental outcomes for optimization and modeling of biological phenomena

K1st_U9: can adapt existing algorithms as well as formulate and implement novel algorithms in Python, including algorithms for optimization

K1st_U11: can adapt and make use of models of biological phenomena (e.g., evolutionary algorithms, artificial ant colony algorithms, multi-agent systems and swarm intelligence, L-systems)

K1st_U16: can plan and carry out life-long learning, and is aware of the possibilities of MSc studies

Social competences

K1st_K1: understands that knowledge and skills quickly become outdated in AI, and perceives the need for constant additional training and raising one's qualifications

K1st_K2: is aware of the importance of scientific knowledge and research related to AI in solving practical problems which are essential for the functioning of individuals, firms, organizations as well as the entire society within such example application fields as transport, healthcare, education, home/service robots, public safety, and entertainment

K1st_K3: knows the examples of poorly functioning AI systems, which led to the economic, social, or environmental losses

K1st_K5: can think and act in an enterprising way, finding the commercial application for the created AI-based systems, having in mind the economic benefits as well as legal and social issues

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: assessment test is conducted after the last lecture. Students answer a number of questions regarding material presented during lectures and laboratory classes. Reaching above 50% of total points is sufficient to get a "3" grade, and this is scaled linearly to "5" for 100% of points.

Laboratory classes: During the semester, students complete four reports related to the main topics discussed during the classes. The reports include theoretical and practical verification of knowledge, modeling, and programming skills. The final grade is computed based on the average of the points gained from these four reports. Reaching above 50% of total points is sufficient to get a "3" grade, and this is scaled linearly to "5" for 100% of points.

Programme content

Lecture:

Artificial Life: introduction, definition, methodology, goals; artificial life vs. artificial intelligence; research interests and applications.

Optimization: computational complexity, single-solution neighborhood search (local, tabu search, simulated annealing); evolutionary algorithms: structure and parameters, selection, crossover, mutation; evolutionary strategies; genetic programming; hyper-heuristics and self-programming algorithms.

Classifier systems (CFS/LCS/GBML): input and output interfaces, main cycle, learning, adaptation by credit assignment, the Bucket Brigade algorithm.

Other nature-inspired optimization techniques: ant systems, ant colony optimization (AS, ACO) and swarm intelligence, particle swarm optimization (PSO).

Remaining aspects of artificial life: modeling plants using L-systems, emergence in Boids, spatio-temporal dynamics in Cellular Automata, agent and environment, Complex Adaptive Systems (CAS), Multi-Agent Systems (MAS).

Robotics: hierarchical control with layers, levels of autonomy, components of cognitive architectures and artificial general intelligence.

Laboratory classes:

Cellular Automata: life as an emergent process, elementary Cellular Automata, Langton's Ant, Game of Life, four classes of behavior.

Agent-based modeling: a definition of an agent in computer science, designing an agent-based model, NetLogo, Mesa, Schelling's model, epidemic model.

Evolutionary algorithms: theory and implementation, practical experiments, traveling salesman problem.

Evolutionary design of three-dimensional creatures: genotypes and phenotypes, body and brain simulation, Framsticks environment, evolution of artificial creatures, designing evolutionary experiments.

Developmental genetic representations: direct and developmental genetic representations, epistasis, artificial gene regulatory networks, L-systems.

Teaching methods

Lecture: slide shows and script-based presentations, whiteboard sketches with discussions, occasional demonstrations of programs.

Laboratory classes: whiteboard-sketches-based presentation, interaction with artificial life software models, solving illustrative examples on the board and coding problem solutions in Python, conducting computational experiments, discussions, teamwork.

Bibliography

Basic

”Artificial Life and Nature-Inspired Algorithms”, Maciej Komosinski, 2021.

“40 years of cognitive architectures: core cognitive abilities and practical applications“, Iuliia Kotseruba and John K. Tsotsos. In: Artificial Intelligence Review 53.1, pp.17-94. DOI:10.1007/s10462- 018- 9646- y, 2020.

Additional

“A New Kind of Science”, Stephen Wolfram, Wolfram Research, 2002.

Breakdown of average student's workload

	Hours	ECTS
Total workload	70	3.0
Classes requiring direct contact with the teacher	35	1.5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)[1]	35	1.5

[1]delete or add other activities as appropriate