COURSE DESCRIPTION CARD - SYLLABUS

Course name
Artificial life with cognitive sciences [S1SI1E>SZzK]

Course

Field of study
Artificial Intelligence

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

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:

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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: At the start of each class (except the first class) students take a test on the topics covering the previous class. The final grade is calculated based on the average of the points gained from the tests during the semester. The lowest graded test is omitted from the calculation. 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

The classes cover artificial life and cognitive systems, introducing key concepts, methodologies, and applications. Optimization techniques like evolutionary algorithms, ant colony optimization, and particle swarm optimization are outlined. Modeling approaches like L-systems and cellular automata, and concepts like emergence are presented. Cognitive systems like classifier systems and neural networks for autonomous agents are compared. Agent-based modeling and evolutionary algorithms are used for practical experiments.

Course topics

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, 2023.
“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	75	3,00
Classes requiring direct contact with the teacher	30	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	1,50