COURSE DESCRIPTION CARD - SYLLABUS

Course name
Reinforcement learning and multi-agent systems [S1SI1E>MAS]

Course

Field of study
Artificial Intelligence

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

A person starting this course should have basic knowledge in mathematics, in particular in the theory of probability, and programming skills.

Course objective

The aim of the course is to familiarize students with reinforcement learning and selected related problems of computational intelligence - in particular in the fields of active learning and Bayesian optimisation - and to teach them the practical application of selected methods to solve exemplary problems.

Course-related learning outcomes

Knowledge:
K1st_W3: has detailed, well-grounded knowledge of fundamental computer science problems within the scope of artificial intelligence including problem solving by searching, machine learning, knowledge representation, reasoning, and handling uncertainty
K1st_W4: knows and understands the basic techniques, methods, algorithms, and tools used for solving computer problems as well as problems in artificial intelligence, including an automated recognition of patterns in data of different types and their synthesis to knowledge, conclusions, and recommendations

K1st_W5: has a basic knowledge of key directions and the most important successes of artificial intelligence understood as an essential sub-domain of computer science, making use of the achievements of other scientific disciplines and providing solutions with a high practical impact

Skills:
K1st_U1: is able to collect information from the appropriate sources of different nature, perform its critical analysis, interpretation and synthesis as well as comprehensively justify the formulated opinions, especially in the context of artificial intelligence
K1st_U3: can formulate and solve complex data mining, optimization, and decision problems within the scope of computer science and, in particular, artificial intelligence, by applying appropriately selected methods such as clustering algorithms, classification techniques, optimization approaches, graph search methods, or decision analysis tools
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 in the context of data mining problems, machine learning tasks, and decision problems requiring finding an optimal solution or the most preferred subset of alternatives
K1st_U7: can carry out a critical analysis and an assessment of the functioning of both computer systems and AI methods
K1st_U8: can design - following a pre-defined specification - and create an IT system that uses AI by first selecting and then using the available methods, techniques and computer tools (including programming languages)
K1st_U9: is capable of adapting existing and implementing new web application mechanisms
K1st_U10: can design a web application which securely processes various data types in a way enabling performing various analyses useful for solving business problems
K1st_U11: can adapt and make use of the models of intelligent behavior (e.g., genetic algorithms, artificial neural networks, or decision support methods) as well as computer tools simulating such a behavior

Social competences:
K1st_K1: understands that in the world of web applications knowledge and skills are getting outdated very quickly and sees the necessity for continuous learning and updating the previously gained competences
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_K5: can think and act in an enterprising way, finding the commercial application for the created web applications, 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:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) lectures: on the basis of answers to questions about the material discussed in lectures,
b) laboratories: based on an assessment of the current progress in the implementation of tasks.
Summative assessment:
a) lectures: assessment of the knowledge and skills demonstrated during the test consisting of several test questions or short tasks. Exceeding 50% of the points allows to obtain a satisfactory grade.
b) in the field of laboratories: assessment of the implementation of laboratory exercises, oral answers and reports prepared partly during the classes and partly after their completion.

Programme content

Exploration-exploitation tradeoff in reinforcement learning, active learning and Bayesian optimization. Markov decision process. The concept of optimal policy, the utility of states. Bellman equation. Value iteration algorithm, policy iteration. Reinforcement learning. Q-learning. Gradient methods. Actor-Critic algorithm. Decomposed reinforcement learning. Reinforcement learning software tools.

Course topics

Exploration-exploitation tradeoff in reinforcement learning, active learning and Bayesian optimization. Markov decision process. The concept of optimal policy, the utility of states. Bellman equation. Value iteration algorithm, policy iteration. Reinforcement learning. Q-learning. Gradient methods. Actor-Critic algorithm. Decomposed reinforcement learning. Reinforcement learning software tools.

Teaching methods

Lectures: multimedia presentation, illustrated with examples given on the board.
Laboratory: presentation illustrated with examples given on the blackboard and carrying out the tasks given by the teacher - practical exercises.

Bibliography

Basic
1. Richard S. Sutton and Andrew G. Barto, „Reinforcement Learning: An Introduction", 2018 (online: http://incompleteideas.net/book/the-book.html)
2. Russell, S.&Norvig, P. (2016). Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA.
Additional
1. Rudolf Kruse, Christian Borgelt, Frank Klawonn, Christian Moewes, Matthias Steinbrecher, „Computational Intelligence”, 2013
2. B. Shahriari, K. Swersky, Z. Wang, R. P. Adams and N. de Freitas, "Taking the Human Out of the Loop: A Review of Bayesian Optimization," in Proceedings of the IEEE, vol. 104, no. 1, pp. 148-175, Jan. 2016, doi: 10.1109/JPROC.2015.2494218.
3. Brochu, E., Cora, V. M., & De Freitas, N. (2010). A tutorial on Bayesian optimization of expensive cost functions, with application to active user modeling and hierarchical reinforcement learning. arXiv preprint arXiv:1012.2599.

Breakdown of average student's workload

	Hours	ECTS
Total workload	105	4,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	1,50