COURSE DESCRIPTION CARD - SYLLABUS

Course name

Introduction to Artificial Intelligence

Course

Field of study

Artificial Intelligence

Year/Semester

1/1

Area of study (specialization)

Profile of study

general academic

Level of study

First-cycle studies

Course offered in

English

Form of study

full-time

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:

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Responsible for the course/lecturer:

Prerequisites

Basic mathematical knowledge from secondary school. Basic programming skills in Python developed simultaneously at the course on "Introduction to programming".

Course objective

The course aims to introduce the students to the main trends of Artificial Intelligence (AI). These include data mining, machine learning, optimization, decision analysis, and artificial neural networks. The students should get to know the basic methods, techniques, and algorithms for each of these sub-fields to use them for practical problem-solving. The considered topics will be subsequently extended by the detailed courses at the second and third years of studies, specifically focusing on a given sub-field of AI.

Course-related learning outcomes

Knowledge

K1st_W3: has a well-grounded knowledge of fundamental computer science problems within the scope of artificial intelligence, including data mining, machine learning, optimization techniques, and multiple criteria decision analysis

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 clustering, classification, optimization, and decision support

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; knows the history and recent trends in Artificial Intelligence

Skills

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_U9: can adapt the existing algorithms as well as formulate and implement the novel algorithms in Python, including the algorithms typical for different streams of AI such as data mining, machine learning, artificial neural networks, multiple criteria decision analysis, and optimization

K1st_U10: can retrieve, analyze and transform different types of data, and carry out data synthesis to knowledge and conclusions useful for solving a variety of decision 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

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 at the last lecture. The students need to solve several computational task concerning the subjects presented during all lectures. Each task is evaluated individually, being allocated a certain number of points. The points are summed up and a standard scale is used to derive the final marks: <50% - 2.0, [50% , 60%) - 3.0, [60% , 70%) - 3.5, [70% , 80%) - 4.0, [80% , 90%) - 4.5, and [90% , 100%] - 5.0.

Laboratory classes: After each class, students solve practical, programming assignments and report their solutions to the instructors leading the laboratory classes within two weeks. Each assignment is evaluated on a scale from 2.0 to 5.0. The final grade is computed as an average from the individual marks with the proviso that the two worst out of seven marks obtained throughout the semester may be neglected.

Programme content

Introduction to Artificial Intelligence: Defining AI. Main application areas and example applications from recent years. Brief history and main trends in AI.

Data Mining with Clustering Algorithms: Data mining as a process of discovering patterns in data sets. Clustering as a process of partitioning a set of data in a set of meaningful subclasses. Why do we need clustering? Popular clustering applications. Clustering task - basic steps. Representation of objects/items - focus on user-pageview matrix. Popular similarity measures. Overview of clustering approaches. Partitioning approaches with a focus on K-Means and its extensions. Hierarchical approaches with a focus on Agglomerative Hierarchical Clustering.

Classification Algorithms: Basics of text analysis and natural language processing. Types of problems considered in data mining. Examples of text classification. How to perform a classification? Representation of text documents. Distance-based classification. Jaccard similarity and cosine similarity. Rocchio classifier and k-Nearest Neighbour Classifier. Bayesian classification with smoothing. How to evaluate the classification model? The role of training, test, and validation sets. Popular measures such as classification accuracy, confusion matrix, recall, precision, and F-measures.

Decision Trees and Overfitting: Examples of classification tasks. Decision tree - interpretation, characteristics, and use for classification. ID3 as the famous algorithm for learning decision trees. Basics

of information theory - information gain and conditional entropy. Employment of split information and gain ratio for selecting the best splitting attributes. Preventing over-fitting with post- or pre-pruning.

Genetic Algorithms for Optimization Problems: Overview of nature-inspired algorithms. The essence of optimization problems. Basics of discrete/combinatorial optimization. Knapsack problem and its real-world applications. Traveling salesman problem and its real-world applications. Genetic algorithms as meta-heuristics. Representation of solutions. Mutation, crossover, and selection operators. Fitness computation. Why are genetic algorithms so popular?

Multiple Criteria Decision Analysis: Multiple criteria decision problems: alternatives, criteria, and types of decision problems. Dominance, Pareto optimality, and preference information. Outranking relation as one of the prevailing preference models. Preference information required in ELECTRE methods. Construction of outranking relation in ELECTRE I through concordance and discordance tests. The exploitation of the outranking graph with graph-kernel algorithms. Elimination of cycles.

Introduction to Artificial Neural Networks: History and applications of ANNs. Natural inspiration, processing unit, and weights. The architecture of ANNs. The most popular activation functions. Loss and error functions. Gradient descent algorithm. Backpropagation algorithm. Popular extensions such as batch updating and momentum. Preventing overfitting with stopping conditions, regularization, and dropout. The basics of convolutional neural networks: layers, filters, hyper-parameters, and why they work so well in practice?

Search Algorithms: search problems with a focus on the shortest path problem and its applications. Graph searching algorithms. The Dijkstra's algorithm, The A* (A star) algorithm as a combination of Dijkstra's algorithm and Best First Search.

Teaching methods

Lecture: slide show presentations on different sub-fields of AI and computational methods, illustrated with examples and practical assignments that serve as a summary of the lectures and preparation for the assessment test.

Laboratory classes: solving illustrative examples on board and coding problem solutions in Python, conducting computational experiments, discussion on the chosen methods, teamwork.

Bibliography

Basic

P. Stone et al., Artificial Intelligence and Life in 2030. One Hundred Year Study on Artificial Intelligence. Stanford, 2016.

Data Mining: Concepts and Techniques, 3rd Edition J. Han, M. Kamber, J. Pei, Morgan Kaufman, 2011.

Introduction to Machine Learning with Python: A Guide for Data Scientists, 1st Edition, A. Muller, S. Guido, O'Reilly Media, 2016.

An Overview of ELECTRE Methods and their Recent Extensions. J.R. Figueira, S. Greco, B. Roy, R. Słowiński, Journal of Multi-Criteria Decision Analysis, 20: 61-85, 2013.

Introduction to Evolutionary Computing, A. Eiben, J. Smith, Springer, 2003.

Convolutional Neural Networks for Visual Recognition - Module 1: Neural Networks, F.-F. Li, 2020 (https://cs231n.github.io/).

Additional

Principles of Data Mining (Adaptive Computation and Machine Learning), 1st Edition, D. Hand, H. Mannila, P. Smyth, A Bradford Book, 2001.

Convolutional Neural Networks for Visual Recognition - Module 2: Convolutional Neural Networks, F.-F. Li, 2020 (https://cs231n.github.io/).

Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L.; Stein, Clifford (2001). "Section 24.3: Dijkstra's algorithm". Introduction to Algorithms (Second ed.). MIT Press and McGraw–Hill. pp. 595–601

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, preparation for the assessment test, project preparation - solving programming assignments, solving practical exercises) [1]	35	1,5

[1] delete or add other activities as appropriate