COURSE DESCRIPTION CARD - SYLLABUS

Course name
Automated machine learning

Course

Field of study
Artificial Intelligence
Area of study (specialization)

Level of study
Second-cycle studies
Form of study
full-time

Year/Semester
1/2
Profile of study
general academic
Course offered in
English
Requirements
compulsory

Number of hours

Lecture
30
Tutorials

Laboratory classes
30
Projects/seminars

Other (e.g. online)

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
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Responsible for the course/lecturer:

Prerequisites

A person starting this course should have basic knowledge of machine learning - in particular, basic knowledge of the hyperparameters of machine learning algorithms - as well as programming skills.

Course objective

The aim of the course is to familiarize the student with selected problems of automation of supervised machine learning, in particular in the field of automation of tuning hyperparameters of machine learning algorithms - in accordance with the paradigms of Bayesian optimization and other optimization paradigms that do not use data on the objective function gradient - and to provide basic skills of practical application of selected methods to solve examplary problems.

Course-related learning outcomes

Knowledge

K2st_W1: has advanced and in-depth knowledge of widely understood automated machine learning systems, theoretical foundations of their construction and methods, tools and programming environments used to implement them

K2st_W2: has a structured and theoretically founded general knowledge related to key issues in the field of machine learning automation

K2st_W3: has advanced detailed knowledge regarding selected issues in machine learning automation

K2st_W4: has knowledge about development trends and the most important cutting edge achievements in the field of machine learning automation

K2st_W5: has advanced and detailed knowledge of the processes occurring in the life cycle of automated machine learning systems

K2st_W6: knows advanced methods, techniques and tools used to solve complex engineering tasks and conduct research in the field of automated machine learning

Skills

K2st_U1: 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_U3: 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_U4: can use analytical, simulation and experimental methods to formulate and solve engineering problems and simple research problems

K2st_U5: can - when formulating and solving engineering tasks - integrate knowledge from the area of machine learning automation and apply a systemic approach, taking into account non-technical aspects

K2st_U6: is able to assess the suitability and the possibility of using new achievements (methods and tools) and new IT products, in particular in the field of automated machine learning

K2st_U8: can carry out a critical analysis of existing technical solutions and propose their improvements

K2st_U9: is able to assess the usefulness of methods and tools for solving an engineering task, consisting in the construction or evaluation of an IT system or its components, including the limitations of these methods and tools

K2st_U10: is able - using among others conceptually new methods - to solve complex machine learning automation tasks, atypical tasks and tasks containing a research component

Social competences

K2st_K1: understands that in the field of IT with particular emphasis on machine learning automation, some elements of the knowledge and skills quickly become obsolete

K2st_K2: understands the importance of using the latest knowledge in the field of machine learning automation in solving research and practical problems

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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 maximum number of points results in a postitive grade.

b) laboratories: assessment of the results of laboratory exercises, written responses (saved as comments in Jupyter Notebook files) and reports prepared partly during the course, and partly after their completion (as the homework).

Programme content

The problem of tuning hyperparameters of machine learning algorithms as a special kind of optimisation problems. Conditional hyperparameter configuration spaces. The trade-off problem between exploration and exploitation in tuning hyperparameters. The problem of difference between the objective function inherent in the training set and the objective function inherent in the validation/test set. Automating the optimization of hyperparameters of machine learning algorithms with traditional algorithms that do not require surrogative modeling (grid search, random search). Hyperparameters' independence and the superiority of random search over grid search. Limited applicability of direct search optimization algorithms (e.g., compass search) to hyperparameter optimisation. Bayesian optimization. The specificity of regression for surrogative modeling in Bayesian optimization - the combined prediction of the expected value and the variance. Regression with Gaussian processes. Efficient Regression for Bayesian Optimization. Acquisition function. The specificity of hyperparameter optimization as a special class of optimization problems without gradient availability. Automatic feature synthesis algorithms for machine learning. Relational data models for automatic feature synthesis. "Traditional" automation of tuning hyperparameters of ML pipelines limited to tuning hyperparameters of model training algorithms. Extended automation of tuning hyperparameters of processing pipelines for "end-to-end" machine learning. Combined tuning of relational data modeling algorithms, feature synthesis algorithms, feature selection algorithms and so-called training the model. Multi-fidelity optimization algorithms: succesive halving, HyperBand, BOHB and DEHB. The approach to the problem of automating the tuning of hyperparameters of machine learning algorithms taking into account the total computational cost and its components: computational cost of obtaining the value of the objective function and computational cost of the optimization algorithm, i.e. the determination of successive points in the space of the objective function domain.

Teaching methods

Lectures: slideshow presentation accompanied by examples given on the blackboard.

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

Bibliography

Basic

1. Russell, S.&Norvig, P. (2016). Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA.

2. Rudolf Kruse, Christian Borgelt, Frank Klawonn, Christian Moewes, Matthias Steinbrecher, „Computational Intelligence", 2013

Additional

1. Richard S. Sutton and Andrew G. Barto, „Reinforcement Learning: An Introduction", 2018 (online: http://incompleteideas.net/book/the-book.html)

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	125	5,0
Classes requiring direct contact with the teacher	60	2,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	65	2,5

[1] delete or add other activities as appropriate