CAS Advanced Machine Learning

UNIVERSITÄT BERN

2019-12-12

The Advanced Machine Learning Course is a university study program leading to a "Certificate of Advanced Studies in Advanced Machine Learning" awarded by the University of Bern as laid out in the regulations of the Faculty of Science of the University of Bern for the certificate course Advanced Machine Learning of 2019-12-12.

1. Course objectives

About

In many disciplines, the amount of available data and the computing capacity are growing rapidly. This enables the application of machine learning methods on tasks previously being reserved for humans. Trained machines outperform homo sapiens in more and more cognitive tasks. As with other disruptive technology emergences, the resulting automation potential represents a huge benefit for the human society, but also comes with new challenges and risks. This CAS offers internal and external students, researchers, and employees the opportunity to complement their data science and basic machine learning competences with a formal deepening and broadening of their knowledge and skills on machine learning and artificial intelligence. The format is designed to align with the participants' main study and professional activities. The teaching and learning approaches are team and discussion oriented and designed to develop practical competency.

Competence objectives

The course competences are developed in six modules and a CAS project work. Successful graduates will be (able to):

1. design, tune, train and measure performance of neural networks with advanced deep learning libraries

2. understand the inner mechanisms of neural networks during training

3. familiar with active research in machine learning

4. understand and communicate scientific publications on machine learning and artificial intelligence

5. familiar with the philosophy and ethics of extended and artificial intelligence

6. familiar with one or more applied machine learning domains, the main mathematical methods for data science and machine learning or basic entrepreneurship (elective module)

2. Duration, outcomes and objectives of the modules

Duration and scope

The CAS consists of 18 days of courses (126 hours attendance and 12 ECTS credit points) and a CAS project work (120 hours effort and 4 ECTS credit points). The total expected effort is 480 hours.

Attendance at one information event *Introduction to the CAS Advanced Machine Learning* before course admission is mandatory. Modules 1, 2, 3 and 6 are given in four weekly blocks, Module 4 and 5 over 12 afternoons.

Module 1

Review of Machine Learning, Practical Methodology and Applications

Review of basic principles, concepts, practical methodology and applications in machine learning.

ECTS	2 ECTS credit points (incl. self-study and module work)	**Duration**	6 half days = 21 hours attendance
Assessment	Presentation and computational notebook	**Req. attendance**	80%
Learning outcomes	Graduates • know general concepts and methods of machine learning • can design, tune, and train neural networks • can measure performance of neural networks		
Learning objectives	• Learning Algorithms • Capacity, Over- and Under-Fitting • Hyper-Parameters and Validation Set • Estimators, Bias and Variance • Maximum Likelihood Estimation • Bayesian Statistics • Supervised Learning Algorithms • Unsupervised Learning Algorithms • Stochastic Gradient Descent • Building a Machine Learning Algorithm • Challenges Motivating Deep Learning		
Learning and teaching methods	• Online platform with multimedia material • Inverted classroom with computational notebooks • In-person classes for discussions, feedback and deepening of knowledge • Project work in teams		
Prerequisites	Programming, versioning control systems, linear algebra, calculus, statistics, some machine learning experience (e.g. CAS Applied Data Science or equivalent background)		
Teaching language	English		

Module 2

Deep Networks

Study of established deep network approaches commonly used in industries

ECTS	2 ECTS credit points (incl. self-study and module work)	**Duration**	6 half days = 21 hours attendance
Assessment	Presentation and computational notebook	**Req. attendance**	80%
Learning outcomes	Graduates • know established and commonly used approaches to deep learning • can design, train, tune and regulate deep feedforward, convolutional and recurrent neural networks		
Learning objectives	• Deep feedforward networks • Regularisation for deep learning • Training and optimisation for deep models • Convolutional networks • Sequence modelling and recurrent neural networks		
Learning and teaching methods	• As in Module 1		
Prerequisites	• Module 1		
Teaching language	English		

Module 3 **Deep Learning Research**

Study of new promising, but not yet widely established approaches with deep networks

ECTS	2 ECTS credit points (incl. self-study and module work)	**Duration**	6 half days = 21 hours attendance
Assessment	Presentation and computational notebook	**Req. attendance**	80%
Learning outcomes	Graduates will • know current research topics within the deep learning field • be able to apply newer deep learning approaches to their data		
Learning objectives	May include among other current objectives: • Linear Factor Models • Autoencoders • Representation Learning • Structured Probabilistic Models for Deep Learning • Monte Carlo Methods • Partition Function • Approximate Inference • Deep Generative Models		
Learning and teaching methods	• As in Module 1 and 2		
Prerequisites	• Module 2		
Teaching language	English		

Module 4

Seminar – Selected topics on Machine Learning and Artificial Intelligence

Participants study selected publications on machine learning and artificial intelligence and present them to the others.

ECTS	2 ECTS credit points (incl. self-study)	**Duration**	2x12 seminar lectures
Assessment	Presentation	**Req. attendance**	80%
Learning outcomes	Graduates • are familiar with a wide range of topics in modern machine learning and artificial intelligence research and application • can read, understand and communicate scientific publications on machine learning and artificial intelligence		
Learning objectives	• Current topics of research and applications in machine learning and artificial intelligence		
Learning and teaching methods	• Seminar contributions by participants • Discussions		
Prerequisites	• Module 3		
Teaching language	English		

Module 5 **Philosophy and Ethics of Extended Cognition and Artificial Intelligence**

Artificial Intelligence as a scientific field dates back to the 1950s. This module concerns key philosophical and ethical questions and discussions triggered by the existence of intelligence outside the human brain.

ECTS	2 ECTS credit points (incl. self-study and project)	**Duration**	2x12 lectures
Assessment	Written or oral	**Req. attendance**	80%
Learning outcomes	Graduates • have an overview of the history and the philosophy of artificial intelligence • know philosophical and scientific presuppositions of artificial intelligence • can relate techniques of AI to well-known scientific methods • know the main philosophical discussions on artificial intelligence • know the main moral challenges related to artificial intelligence and can discuss solutions from the perspective of ethics • master best practices for ethics dealing with artificial intelligence		
Learning objectives	• History of computing with a focus on AI • Philosophical conceptions of AI (weak vs. strong AI) • Extended mind hypothesis • Philosophical concepts of data and data analysis • AI and scientific inference • Ethical challenges due to AI in the light of ethical theories • Machine ethics		
Teaching methods	• Lectures, discussions and independent studies		
Prerequisites	• Module 3		
Teaching language	English		

Module 6

Elective Module

One 2 ECTS module on machine learning in an applied domain, mathematical methods for machine learning and data science or entrepreneurship.

ECTS	2 ECTS credit points (incl. self-study and project)	**Duration**	3 days = 21 hours attendance
Assessment	Presentation of project	**Req. attendance**	80%
Learning outcomes and objectives	• Defined by the elective module		
Teaching methods	• Lectures, discussions, inverted classroom with computational notebooks		
Prerequisites	• Defined by the elective module		
Teaching language	English		

CAS Project

CAS Project Work – 4 ECTS (120 hours effort)

In the CAS project module works are combined into a running application for mobile devices, clusters or cloud environments. The application is documented and presented.

Alternatively, the outcome of the CAS project can be a publication ready article on own studies related to module objectives.

Support from module coaches is given and the presentations, codes and articles are assessed with *passed* or *not passed.*

Assessment

3. Performance assessment

The performance assessment for each module includes 80% attendance and a presentation, written or oral exam. Modules are assessed with *passed* or *not passed*.

The CAS project presentation, code and possibly article are jointly assessed with *passed* or *not passed*.

4. Final regulations

Entry into force

The present plan shall enter into force on 2020-01-01.

2019-12-12

Released by the program management represented by:

Prof. Dr. Thomas Wihler

2019-12-12

Adopted by the Faculty of Science, University of Bern

The Dean

Prof. Dr. Zoltan Balogh