Faculty of Science

BERN04, Computational Science: Introduction to Artificial Neural Networks and Deep Learning, 7.5 credits

Beräkningsvetenskap: Introduktion till artificiella neuronnätverk och djupinlärning, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2023-05-31 to be valid from 2023-05-31, spring semester 2024.

General Information

The course is an elective course at second cycle level for a degree of Master of Science (120 credits) in Computational Science or Applied Computational Science

The course is a compulsory second-cycle course for a degree of Master of Science (120 credits) in Applied Computational Science with a specialisation in Physical Geography

The course may be included as optional course in a bachelor's or master's degree in Science(120 credits).

Language of instruction: English

Main field of studies	*Depth of study relative to the degree requirements*
Computational Science	A1N, Second cycle, has only first-cycle course/s as entry requirements
Applied Computational Science	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The gene,ral aim of the course is that the students should acquire basic knowledge about artificial neural networks and deep learning, both theoretical knowledge and practical experiences in usage for typical problems in machine learning and data mining.

Knowledge and understanding

On completion of the course, the students shall be able to:

- in detail give an account of the function and the training of small artificial neural networks,
- explain the meaning of over-training and in detail describe different methods that can be used to avoid over-training,
- on a general level describe different types of deep neural networks.

Competence and skills

On completion of the course, the students shall be able to:

- independently formulate mathematical functions and equations that describe simple artificial neural networks,
- independently implement artificial neural networks to solve simple classification- or regression problems,
- systematically optimise data-based training of artificial neural networks to achieve good generalisation,
- use and modify deep networks for advanced data analysis.

Judgement and approach

On completion of the course, the students shall be able to:

- critically review a data analysis with artificial neural networks and identify potential gaps that can influence its reproducibility.

Course content

The course covers the most common models in the area of artificial neural networks with a focus on the multi-layer perceptron. Furthermore, the course provides students with an introduction to deep learning. Especially is treated:

- Feedforward networks: the simple and the multi-layer perceptron; choice of appropriate error functions and technologies to minimise these; over-training and how this can be discovered and avoided; committees of neural networks and technologies to create committees.
- feedback networks: its use in time series analysis and as associative memories (Hopfield model).
- Convolution network: applications in image processing.
- Auto-encoder: methods for non-linear dimensional reduction; pre-training.
- Generating network: variational auto-encoder and GAN for synthetic data generation.
- Transformer modules: its use in language models; training with self attention.

Course design

The teaching consists of lectures, exercises and compulsory computer exercises

Assessment

Examination takes place in the form of a written exam at the end of the course, and written reports to the computer exercises during the course.

Students who fail the ordinary examination, are offered a resit examination shortly

thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.
For a pass grade on the whole course, the student must have Pass grades on the written exam and on the written reports to the computer exercises.

The grading scale for the computer exercise reports is Fail or Passed, while the written examination is graded by the grading scale Fail, Passed, Passed with distinction.

The final grade is decided through a weighted evaluation of the results in the components of the examination, where the written exam contributes with 95 % and other components be given weight 5%.

Entry requirements

Admission to the course requires general entry requirements, English 6/B and knowledge equivalent to 90 credits in natural sciences of which at least 45 credits mathematics.

Further information

The course replaces FYTN14, Theoretical physics: introduction to artificial neural networks and deep learning, 7.5 credits, and cannot be included in a degree together with this course.

The course is coordinated with EXTQ40, 7,5 credits, that is a course given for students at the Faculty of Engeneering, Lund University.

The examination of the course is scheduled in accordance with the examination timetable of the Faculty of Sciences.

The course is offered at the Centre for Environmental an Climate Science, Lund University

Subcourses in BERN04, Computational Science: Introduction to Artificial Neural Networks and Deep Learning

Applies from V24

2401 Written Exam, 6,0 hp
Grading scale: Fail, Pass, Pass with distinction
2402 Computer Excercises, 1,5 hp
Grading scale: Fail, Pass