Course syllabus

Optimization for Learning
Optimering för maskininlärning

FRTN50, 7.5 credits, A (Second Cycle)

Valid for: 2024/25
Faculty: Faculty of Engineering LTH
Decided by: PLED F/Pi
Date of Decision: 2024-04-15
Effective: 2024-05-08

General Information

Depth of study relative to the degree requirements: Second cycle, in-depth level of the course cannot be classified
Elective for: D5-mai, E4, F5, F5-r, F5-mai, I4-fir, M4, MMSR2, Pi5-ssr
Language of instruction: The course will be given in English

Aim

Learning from data is becoming increasingly important in many different engineering fields. Models for learning often rely heavily on optimization; training a machine is often equivalent solving a specific optimization problem. These problems are typically of large-scale. In this course, we will learn how to solve such problems efficiently. The large-scale nature of the problems renders traditional methods inapplicable. We will provide a unified view of algorithms for large-scale convex optimization and treat algorithms for the nonconvex problem of training deep neural networks.

Learning outcomes

Knowledge and understanding
For a passing grade the student must

- know basic convex analysis
- understand the connection between machine learning and optimization
- have an understanding on the role of regularization in learning from an optimization point of view
- understand unifying framework for large-scale convex optimization

- understand concepts such as nonexpansiveness, and averagedness and their relation to monotone operators and their role for convergence of algorithms
- understand how to derive specific algorithms from the few general ones
- understand methods for avoiding numerical issues in deep neural network training.

Competences and skills
For a passing grade the student must

- be able to describe optimality conditions that are useful for large-scale methods
- be able to describe the building blocks that are the foundations of large-scale optimization algorithms and why they are used
- be able to analyze performance of optimization algorithms
- be able to solve optimization problems numerically using software and own implementations
- be able to present results in writing.

Judgement and approach
For a passing grade the student must

- understand what algorithm that should be used for different machine learning training problems
- be able to participate in the team-work needed to solve the hand-in assignments.

Contents

The course has lectures, exercises, and four hand-in assigments.

The lectures will cover:

convexity, models for learning, unified convex optimization algorithm view, fixed-point iterations, monotone operators, nonexpansive mappings, stochastic methods, reduced variance methods, block-coordinate methods, nonconvex stochastic gradient descent and variations for for deep learning training.

Examination details

Grading scale: TH - (U, 3, 4, 5) - (Fail, Three, Four, Five)
Assessment: Written exam (5 hours), 3 hand-in exercises. In case of less than 5 registered students, the exam may be given in oral form.

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.

Modules
Code: 0121. **Name:** Exam.
Credits: 7.5. **Grading scale:** TH - (U, 3, 4, 5). **Assessment:** Passed exam
Code: 0221. **Name:** Hand-in 1.
Credits: 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in
Code: 0321. **Name:** Hand-in 2.
Credits: 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in
Code: 0421. **Name:** Hand-in 3.
Credits: 0.0. **Grading scale:** UG - (U, G). **Assessment:** Passed hand-in

Admission

Assumed prior knowledge: FMAN61 Optimization
The number of participants is limited to: 90
Selection: Completed university credits within the programme. Priority is given to students enrolled on programmes that include the course in their curriculum.

Reading list

- Lecture slides and notes.

Contact

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Director of studies: Björn Olofsson, bjorn.olofsson@control.lth.se
Course homepage: http://www.control.lth.se/course/FRTN50

Further information

A student who has been offered a seat in the course must confirm his/her participation within a week, or else the seat will be offered to the next student according to the selection criteria.