Optimization for Learning

Course Responsible – Pontus Giselsson

Past

- PhD, LTH, Dept. of Automatic Control (2012)
- Postdoc, Stanford, S. Boyd (2013 – 2014)
- Faculty member, LTH, Dept. of Automatic Control (2015 –)

Research interests

- Large-scale optimization and its application (3 PhDs, 1 postdoc)

This course

- First given in 2019, updated (improved?) last year, also this year
- Why I developed this course
  - optimization useful tool in many fields (machine learning)
  - wanted to teach course that reflect my research interests

TAs

Hamed Sadeghi

Manu Upadhyaya

Covid-19 Precautions

- Department of Automatic Control general rules[1] say
  - No physical lectures
  - Can have physical exercise sessions, but keep distance
  - No drop-ins at the department for asking questions
  - Most likely on-site exam
- FRTN50:
  - Video lectures online in different formats
  - Online and on-site exercise sessions

[1] http://www.control.lth.se/education/covid-19-teaching-policy-at-automatic-control-fall-2021/

Course Scope

Course topics:

- Convex analysis
- Supervised learning from an optimization perspective
- Algorithms suitable for large training problems

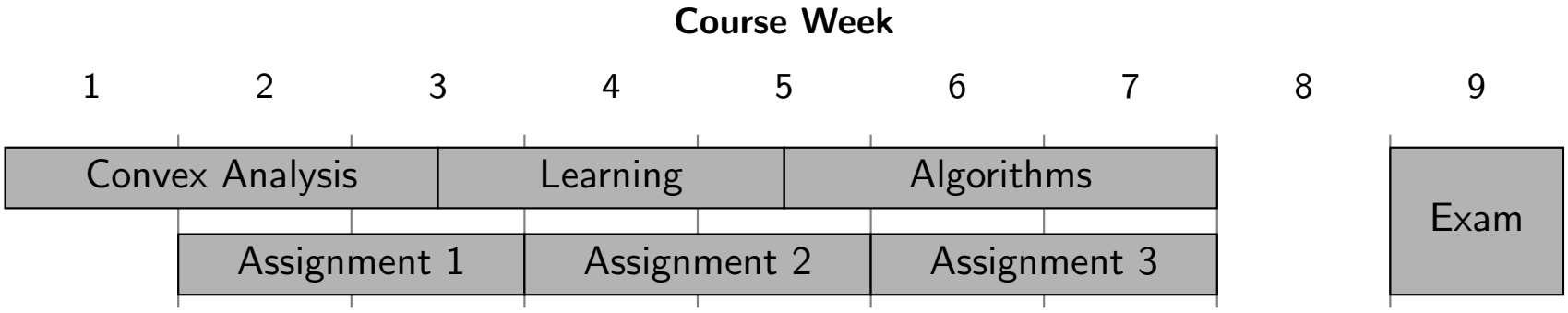
The course is:

- a math oriented course
- focusing on optimization that is key component in learning

The course is not:

- a machine learning course

Course Details



- Convex analysis
  - Convex sets, convex functions, subdifferentials, proximal operators, conjugate functions, duality, proximal gradient method
- Supervised learning
  - Least squares, logistic regression, support vector machines (SVM), deep learning
- Algorithms
  - 2020: Convergence, proximal gradient method, stochastic gradient descent, coordinate gradient descent, (quasi)-Newton methods

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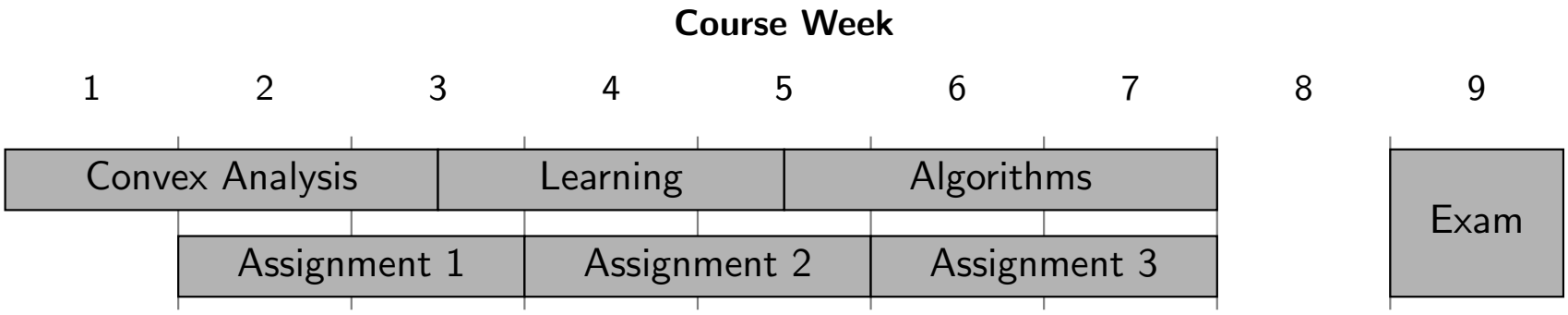

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- Supervised learning
  - Least squares, logistic regression, support vector machines (SVM), deep learning
- Algorithms
  - 2021: proximal gradient method, stochastic gradient descent, less convergence analysis, more implicit regularization

Prerequisites

- Recommended: A (convex) optimization course
- If not: convex analysis part can be tough
- We have general math prerequisites document, read this week!

Literature

- No official course literature, only slides and videos (on webpage)
- Recommend: *Convex Optimization* by Boyd and Vandenberghe (free download, google)
  - Sec. 1: optimization overview
  - App. A: general mathematics (complements our math prereq.)
  - Sec. 2 and 3: complement slides on convex analysis (especially if you have not taken optimization course before)

Lectures

Two different formats, everything online

- "Flipped classroom"
  - 5-10 short pre-recorded short videos[1] for each sub-topic in lecture
  - active listening: skip back (forward), change playback speed, etc
  - online discussion session at lecture time (watch all videos before)
  - first five lectures in this style
- "Nominal lecture style"
  - live or pre-recorded more standard type lecture
  - read through slides before lecture

[1] https://www.control.lth.se/fileadmin/control/Education/EngineeringProgram/FRTN50/VideoPlatform/VideoLecturePlatform.html?lec=1

Exercise Sessions

- Two on-site and online exercise sessions every week
- Manu and Hamed have one online and one on-site session each
- For asking questions

Discussion Forum

- We use the Canvas discussion forum
- Teachers will reply to questions
- Please, also help each other by answering questions!

Examination Format

- Three mandatory hand-ins
- A written exam
  - The result on the exam decides the grade (3-5)
  - Most likely on-site

Handins

- Are done in groups of two and are graded pass or fail
- Involves coding in Julia (julialang.org)
  - Julia is a (new) scientific computing programming language
  - Designed to be as fast as c but as high-level as Matlab/Python
  - Get started via `Introduction to Julia` this week
- Are submitted and returned via Canvas
- Need to pass all handins to pass the course
- First handin: two resubmissions, second-third: one

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- 2nd and 3rd hand-ins may be replaced from 2020
  - to reflect updates to last part of course
  - will focus on implicit regularization and loss landscape
  - coding in Python in Jupyter notebook (1st uses Julia)

Schedule

- We will use the same time slots as in time edit
- Lectures (online)
  - Mondays 13-15 Pontus Giselsson
  - Wednesdays 13-15 Pontus Giselsson
- Exercises
  - Tuesdays 8-10 Hamed Sadeghi (online)
  - Tuesdays 15-17 Manu Upadhyaya (KC:M M1)
  - Thursdays 8-10 Hamed Sadeghi (KC:M M1)
  - Thursdays 15-17 Manu Upadhyaya (online)

Course representative

- We need a course representative
- If you are interested, send me an email or let me know now!

Canvas

- Course webpage

  `https://canvas.education.lu.se/courses/14347/`

  will be updated throughout course
- Course material
- Course program
- Hand-in and correction of submissions
- Discussion forum
- Contact information
- Announcements
- ...

Weekly announcements

- Containing upcoming week's exercises, hand-ins, and lectures
- Other updates

Final comments

- We start in a quite high pace, recommend early start
- Don't hesitate to ask questions and provide feedback
- We hope you will enjoy the course!