COMP 414/514: Optimization - Algorithms, Complexity & Approximations

Anastasios Kyrillidis

Fall 2019

E-mail (instructor): anastasios@rice.edu

Web: https://akyrillidis.github.io/comp414-514/
E-mail (course): ricecomp414@gmail.com

Office Hours: By appointment
Office: DH 3119

Class Hours: FR 2:00pm - 4:30pm
Class Room: HRZ 212

Course Description

The main focus of the course will be on smooth optimization techniques, with applications in machine learning and artificial intelligence. The course will introduce the basics of algorithms on continuous optimization, starting from the classical gradient descent algorithm in convex optimization, towards more sophisticated approaches in non-convex scenarios. The course will explore the fundamental theory, algorithms, complexity and approximations in nonlinear optimization.

Textbook

There is no textbook for the class; the instructor will provide a Notes.pdf with most of the material of the course scripted. The class will be a collection of lectures, prepared by the instructor, as well as Python notebooks. During the class, some of the lectures will be given in .pdf/presentation form, while others will be handwritten on an iPad (the distinction is on purpose for pedagogical reasons by the instructor) Links to resources will be provided during the course.

Prerequisites

The prerequisites are linear algebra, multivariate calculus, probability and statistics. AI/Machine learning courses are not necessary but highly recommended.

During the first class, a quiz will be given to the students to assess their background; this quiz is going to be used for course content assessment (edits in the syllabus will possibly occur).

Course outcomes

After successful attendance, students are expected to:

(i) have a good understanding of theory involved in optimization, via machine learning/AI applications.

(*ii*) understand the differences of and the reasoning/logic behind optimization algorithms, such as SGD, adaptive methods (Adam, RMSProp, Adagrad, etc), and second order methods..

(*iii*) have a good understanding of standard convex optimization techniques, both in theory and practice..

(*iv*) have a good understanding of the differences / difficulties of convex and non-convex optimization.

(*v*) have a good comprehension how optimization plays a key role in different areas of ML/AI/SP.

(*vi*) be able to read and review advanced papers on similar subjects.

Registration / Communication / Attendance

Please send an email to the course email address to set up a time to meet and discuss your taking the course (after the quiz is preferable).

The instructor will be available for discussion after an appointment is set up; email communication is sufficient also, if preferable by the student. You are highly encouraged to attend and participate in class (see Grading and Evaluation), even if you are just auditing.

Course Format and Structure

There will be a traditionally formatted series of lectures. For each lecture, a chapter in .pdf will be created by the instructor; if a student (or set of students collaboratively) is interested in improving the notes, he/she will scribe and take notes, for a bonus 10% towards the final grade. During lectures, participation with questions / comments is encouraged.

Class Structure (tentative)

See course website: **https://akyrillidis.github.io/comp414-514/schedule/**

Grading Policy

The grade is based on the following factors:

- **5%** participation and attendance.
- **10%** scribing of notes - **This is a bonus**.
- **50%** final project or final exam (the latter is recommended for undergrads).
- **45%** Homeworks.

The instructor reserves the right to curve the scale dependent on overall class scores at the end of the semester. Any curve will only ever make it easier to obtain a certain letter grade.

Scribing notes

A latex template will be shared by the instructor.

Homeworks

The instructor highly recommends writing down the homework answers in latex form and submit a .pdf to the course email.

Final project logistics

The course project can be categorized as a literature review, as original research, or as a literature review that ends up as original research (there is flexibility to that).

- **Literature review.** This includes depth review and analysis of a paper (to be selected from a list of papers, provided by the instructor or by you, after instroctor's approval). The review should provide an in-depth summary, exposition and discussion of the paper (which will often include reading other related papers on that subject).
- **Original research.** You are strongly encouraged to combine your current research with the course project. Otherwise, the instructor will provide some ideas to follow. It can be either theoretical or experimental.

Milestones

- Pick a project the sooner possible.
- Submit a one-page description of the project, what is it about, your opinion, what needs to be done (related papers to read) and whether you have any ideas to improve the ideas involved. Describe why they are important or interesting, and provide some appropriate references. If it is original research, provide a plan on what are the next steps and what needs to be done till the end of the semester to finish the project. Deadline: October 4th.
- We will probably have in-class presentations towards the end of the semester. These will be spotlight talks (5mins). Prepare an oral presentation with slides. Focus on high-level ideas, and leave most technical details to your report.
- A written report. A LaTeX template will be provided (most probably in ICML format). The length of the report should be at least 6 pages (excluding references). Deadline: End of the semester. Note that the project can continue beyond the end of the semester, if it deserves publication.

Course Policies

During Class

The electronic recording of notes will be important for class and so computers will be allowed in class. Please refrain from using computers for anything but activities related to the class. Drinking (coffee, tea, water) is allowed in class. Try not to eat your lunch in class as the classes are typically active.

Policies on Late Assignments

Assignments (scribing, reviews, project) should be turned on time. I don't like penalties but you will receive a 10% penalty for each day of delay. No submissions after a 2 day grace period. Exceptions will be given to special circumstances, with proper documentations.

Academic Integrity and Honesty

Students are required to comply with the university policy on academic integrity found in the Honor System Handbook http://honor.rice.edu/honor-system-handbook/.

Accommodations for Disabilities

If you have a documented disability that may affect academic performance, you should: 1) make sure this documentation is on file with Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) meet with me to discuss your accommodation needs.