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

## Anastasios Kyrillidis

### Spring 2024

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

Web: **https://akyrillidis.github.io/comp414-514/**
E-mail (course): `ricecomp414514@gmail.com`

Office Hours: TBA (over Zoom)
Zoom link for office hours: See Canvas

Classroom & Hours: SEW 301, MWF 11:00 am - 11:50 am
Zoom link for course: See Canvas

## Course Description

The course's primary focus will be smooth optimization techniques with machine learning and artificial intelligence applications. 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

The class has no textbook; the instructor will provide a Notes.pdf with most of the course material scripted. The class will be a collection of lectures and Python notebooks prepared by the instructor. 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.

## Course outcomes

After successful attendance, students are expected to:

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

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

(*vi*) can 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.

The instructor will be available for discussion after an appointment is set up; email communication is also sufficient if the student prefers. You are highly encouraged to attend and participate in class (see Grading and Evaluation), even if you are 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, they will scribe and take notes for a bonus of 5% 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%** scribing of notes - **This is a bonus**.
- **50%** final project or final exam (the latter is recommended for undergrads).
- **50%** 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 make obtaining a specific letter grade easier.

### Scribing notes

The instructor will share a latex template.

### Homeworks

The instructor expects the homework answers to be in latex form and submitted as a .pdf at the course email and/or the Canvas course page.

### Final project logistics

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

- **Literature review.** This includes an in-depth review and analysis of a paper (to be selected from a list of papers provided by the instructor or you after the instructor'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 as soon as possible.

- Submit a one-page description of the project, what it is about, your opinion, what needs to be done (related papers to read), and whether you have any ideas to improve the concepts involved. Describe why they are important or exciting, and provide some appropriate references. If it is original research, provide a plan for the next steps and what needs to be done by the end of the semester to finish the project. Deadline: TBA.

- 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 report should be at least six 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 so that computers will be allowed. 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 in on time. I wouldn't say I like penalties, but you will receive a 10% penalty for each day of delay. No submissions after a two-day grace period. Exceptions will be given to special circumstances, with proper documentation.

## Academic Integrity and Honesty

Students must 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.