Mathematics of Data Science

MATH 5750-001/6880-001, Fall 2023

Credit Hours: Three

Meeting Time: TuTh 12:25pm - 1:45pm, FASB 250

Homepage:
Math 5750: https://utah.instructure.com/courses/890139
Math 6880: https://utah.instructure.com/courses/891566

Instructor: Bao Wang

Office Hours: TuTh 3:00pm - 4:30pm.

Office: WEB 4652.

Email: bwang@math.utah.edu

Textbook: No specific textbook is required, and we will send out course lecture notes.

References:
Zhang et al., Dive into Deep Learning
Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning: From Theory to Algorithms
Christopher Bishop, Pattern Recognition and Machine Intelligence
Yuxin Chen, Large-Scale Optimization for Data Science (ELE 522)
A. S. Bandeira, A. Singer, T. Strohmer, Mathematics of Data Science, Preprint.

Contents

1 COURSE DESCRIPTION

Three credits. Prerequisites: calculus, linear algebra, probability, ordinary differential equation, and Python programming.

2 COURSE DETAILS

- **Course Type:** In person.
- **Location & Meeting Times:** TuTh 12:25 pm - 1:45 am, FASB 250.
- **Attendance & Punctuality:** It is strongly recommended that students attend the class at the scheduled class time. Attendance will be taken.
- **Course Materials:** No textbook is required. Course materials will be available on line at the course webpage and in canvas.

  Additional software/computing requirements: students will be asked to perform some Python programming, knowledge about Python programming is required.
- **Syllabus subject to change:** This syllabus is meant to serve as an outline and guide for our course. Please note that I may modify it with reasonable notice to you. I may also modify the Course Schedule to accommodate the needs of our class. Any changes will be announced in class and posted on Canvas.

3 CONTENT OVERVIEW

Topics include statistical machine learning and deep learning models, e.g. linear models for regression and classification, kernel methods, clustering, dimension reduction, compressed sensing, convolutional neural networks, recurrent neural networks, graph neural networks, and transformers; optimization algorithms for machine learning, e.g. gradient descent, subgradient methods, proximal gradient methods, heavy-ball and Nesterov acceleration, stochastic gradient descent, and Adam; and some theoretical analysis of machine learning models. We will also briefly discuss causal inference if time permits.

4 COURSE EXPECTED LEARNING OUTCOMES

Upon successful completion of this course, a student should be able to:

- Understand popular statistical machine learning and deep learning models, and can implement them.
- Understand first-order optimization algorithms for machine learning.
- Know theoretical performance bound of popular machine learning and deep learning models.
- Know how to find the literature of advances of machine learning and foster interest in data science.

5 COURSE DESIGN

Material will be presented in lectures and read from the text and internet sources. Any supplementary materials will also be made available in canvas at least by 5:00 pm the day before lecture. The course contains several projects and one final project proposed by students themselves. We encourage students to form teams with each team contains three to five members.

6 EVALUATION METHODS AND GRADING

- **Lecture notes scribe 40%:** We will present the lecture using slides and each team needs to scribe each lecture and submit one copy of the lecture notes in PDF along with the latex source. We will provide a latex template. Please submit at least scribes of five lectures.
- **Course projects 60%:** There will be three projects in total and the lowest score will be dropped. For each project, you will need to write a report and submit it along with the source code.
- **Course grade:**

P	90	85	80	77	70	68	66	50	45	40
Grade	A	A-	B+	B	B-	C+	C	C-	D+	D

7 CLASS SCHEDULE and IMPORTANT DATES

- Class meets at TuTh from 12:25pm - 1:45pm in person starting Aug 20 and ending Dec 7.
- Last day to add, drop (delete), elect CR/NC, or audit classes: Sep 1.
- Last day to withdraw from classes: Oct 20.

Holidays: There will be no class on Sep 4 (Labor Day), Oct 8-15 (Fall break), Nov 23-26 (Thanksgiving).