Syllabus

CS732 Advanced Machine Learning (Spring 2024)

General Information

Course Number: CS732 CRN 15989

Lecture Hours: 1:00 – 3:50 pm, Monday

Lecture Location: Cullimore Hall 110

Instructor

Shuai Zhang, Assistant Professor

Email: sz457@njit.edu

Office Room: GITC 4410

Office Hour: 4:00 pm - 4:40 pm Monday, 1:00 pm -1:40 pm Wednesday

Course Overview

This course aims to enhance your theoretical understanding of the statistical properties of learning algorithms. For instance, it will delve into questions like when and why machine learning algorithms are effective, how to formalize the process of algorithmic learning from data, and how mathematical thinking can be employed to craft improved machine learning techniques. The topics covered generalization bounds through uniform convergence, classical machine learning theory, and recent advancements in deep learning theory.

Prerequisites

Students are expected to have the following background:

- Calculus
- Linear algebra
- Probability
- Machine learning
- Recommended but not required: functional/real analysis, Convex optimization, Matrix analysis

Schedule

DATE	CLASS	PARTIAL LIST OF LECTURE TOPICS	Lecture Notes #
01/22	1	Overview, supervised learning, empirical risk minimization	L1
01/29	2	Asymptotic analysis, uniform convergence	L2, L3
02/05	3	Concentration Inequalities, Sub-Gaussian Distribution	L4
02/12	4	Rademacher Complexity, and generalization bound for linear model	L5
02/19	5	Challenges in deep learning, generalization bound for shallow neural networks, Overparameterized model	L6
02/26	6	Covering number approach, generalization for deep neural networks	L6, L7
03/04	7	Data dependent generalization bound, All-layer margin	L8
03/11		No Class, Spring Break	
03/18	8	Neural Tangent Kernel	L9
03/25	9	Implicit regularization effect of initialization	L10
04/01	10	Implicit regularization effect of noise, Stochastic gradient descent	L11
04/08	11	Unsupervised learning, Spectral Clustering, Introduction to Non-convex Optimization	L12, L13

04/15	12	Paper Review / Project Presentation	
04/22	13	Paper Review / Project Presentation	
04/29	14	Paper Review / Project Presentation	

Textbooks

There will be no required textbooks for the class. Some of the class material, however, will be based on content from the following scribe notes:

- Tengyu Ma, Lecture notes for machine learning theory
  (Link: https://github.com/tengyuma/cs229m_notes/blob/main/master.pdf)

Assignments

There will be **4~6 assigments** throughout the semester. Each assignment consists of several small problems needs to be solved or proved. Each assignment has its own detailed instructions. Each assignment needs to be completed in two weeks days and submitted via Canvas.

Paper Review and Project

- The paper review and project can be carried out by a group of at most 3 students. Each group is required to write a review of one paper and conduct one mini-project.
- You can choose any paper/project for your topics as long as they are related to machine learning.
- Each group is required to give a presentation for one paper and submit a final report for your project.
- Additional details regarding the paper review and project will be announced in a separate document.

Grading Policies

- Lecture attendance (20%)
- Assignments (30%)
- Project (25%)
- Paper presentation (25%)

Grading Scale

- **A**: 90-100,
- **B+**: 80-89,
- **B**: 75-80
- **F**: 0-74.

You will receive an **F** if you miss three lectures without valid reasons, fail to submit any homework on time, do not submit the project, or do not complete the paper review. However, as

long as you attend all the lectures, complete all the homework, the project, and the paper review, you will receive a grade of **B+** or **A**.

Grade Corrections

Check the grades in course work and report errors promptly. Please try and resolve any issue within one week of the grade notification.

Course Policies

Collaboration and External Resources for Assignments

Some homework problems will be challenging. You are advised to first try and solve all the problems on your own. You are also allowed to collaborate with your classmates and search for solutions online. But you should use such solutions only if you understand them completely (admitting that you do not understand something is way better than copying things you do not understand). Also, make sure to give the appropriate credit and citation.

Late Policy

- There will be a 10% penalty of total regular points for every day an assignment is late.
- **Max. late submission is 3 days late.**

Academic Support System

NJIT Academic Calendar:

https://www5.njit.edu/registrar/calendars/ This contains drop/add and other important dates.

Academic Integrity:

Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http:www5.njit.edu*policies*sites*policies*files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. **Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university**. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

Academic Support and Student Affairs:

"From questions about becoming a student at NJIT – to student engagement – to searching for information on career development, the Division of Academic Support and Student Affairs Staff is here to help."

Bookstore: NJIT has a bookstore. Please check its web page how COVID is affecting operations.

Canvas Help Page: Canvas support for students.

Center for Counseling and Psychological Services

"The NJIT Center for Counseling and Psychological Services (C-CAPS) is committed to assisting students in the achievement of their academic goals as well as benefiting from their personal experience on campus. College life can be personally challenging and stressful at times. We believe that the educational process is an important component of the development of the individual as a whole person. Our goal is to optimize the college experience and improve the quality of the lives of our students by promoting their mental health and facilitating students' personal, academic and professional growth."

The Learning Center

"Our mission is to assist students both in the classroom and beyond by providing tutorial services, academic coaching, academic and personal enrichment workshops and staff and peer support so students can meet the demands of their coursework and are prepared for life after graduation."

Robert W. Van Houten Library

"The Van Houten Library offers electronic and print resources essential to the mission of New Jersey's science and technology university, including a core collection of academic books, databases, and journals, as well as research and consultation services."

Student Disability Services

"The Disability Support Services office works in partnership with administrators, faculty and staff to provide reasonable accommodations and support services for students with disabilities that have provided our office with documentation to receive services."

Student Financial Aid Services

"Student Financial Aid Services (SFAS) at NJIT is committed to providing you with every opportunity to obtain funding to support your undergraduate educational costs at NJIT."

Acknowledgement

This course includes materials adapted from Course CS229M by Prof. Tengyu Ma at Stanford University.