Advanced Topics in Statistical Learning: Spring 2023 Stat 241B / CS 281B

Instructor: Ryan Tibshirani, ryantibs@berkeley.edu

GSI: Seunghoon Paik, shpaik@berkeley.edu

Course website: https://www.stat.berkeley.edu/~ryantibs/statlearn-s23/

(See course website for lecture times, room, office hours, etc.)

In Advanced Topics in Statistical Learning, we will take a guided tour of both basic and advanced methods in statistical and machine learning, and the accompanying analysis tools that enable us to understand them theoretically. Theorems are presented together with practical aspects of methodology and intuition to help students develop a broad sense of the rationale (pros and cons) behind choosing to use a given method/approach in a particular problem setting. Topics to be covered will most likely include: high-dimensional estimation, nonparametric regression and testing, uncertainty quantification, overparametrization and interpolation, among others (see below for a more detailed list).

Prerequisites

While there are no formal pre-requisites, this course will proceed at a fast pace and assume a good degree of mathematical sophistication. We will also assume that familiarity with introductory graduate-level material on probability theory, statistical theory, and statistical methodology, including:

- Notions of convergence (almost sure, in probability, in distribution)
- Law of large numbers, CLT, Glivenko-Cantelli theorem
- Basic concentration inequalities (Markov, Hoeffding, etc.)
- Maximum likelihood, GLMs, regression, classification
- Basic concepts in regularization (e.g., ℓ_1 and ℓ_2 penalties)
- Asymptotic notation and statements $(O(\cdot), O_P(\cdot), \text{ etc.})$
- Fundamentals of calculus, linear algebra, optimization

Topics

In more detail, the topics that we will cover will likely include:

- Nonparametric regression
- Nonparametric classification

- Nonparametric testing
- Minimax theory
- Lasso
- Ridge
- Overparametrization
- Boosting and slow learning
- Implicit regularization
- Conformal prediction
- Model aggregation
- Forecasting theory
- Sequential decision making

Evaluation

Evaluation will be based on be four homeworks and one course project. The project will be done in a small group, and will culminate in a 10-or-so page writeup on a topic of the groups choosing. The grading breakdown is as follows (each homework assignment is worth an equal amount):

- Homeworks: 60%
- Project: 40%

Details on the due dates for the homework, and more details on the project, will be provided on the course website.

Homework

The homeworks are structured to give you experience in written mathematical exercises, and to a lesser extent, programming exercises. As we may reuse problems from other, similar courses that have been taught in the past, you **must not to copy, refer to, or look at** previous solutions in preparing your answers.

Also, while it is completely acceptable for you to collaborate with other students in order to solve the homework problems, we assume that you will be taking **full responsibility in terms of writing up your own solutions and implementing your own code**. You must indicate on each homework the students with whom you collaborated.

In general, late homework will not be accepted. In the case you are busy preparing for a conference deadline or something like that, you must give us at least 5 days notice if you are requesting an extension, and we can give you +2 or +3 days. In the case of an emergency (sudden sickness, family problems, etc.), no notice is needed, and we can work with you to give you a reasonable extension. But we emphasize that this is reserved for true emergencies.

Take care of yourself

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, getting enough sleep, and taking some time to relax. This will probably help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many help-ful resources available on campus. You can find these linked from the Academic Accomodations Hub https://evcp.berkeley.edu/programs-resources/academic-accommodations-hub.