36-710: Advanced Statistical Theory II
Fall 2019

Instructors:

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Lectures:

Monday and Wednesday, 9:00am - 10:20am, PH 226A.

Class Website:

http://www.stat.cmu.edu/~arinaldo/Teaching/36710/F19/

Please check the website on a regular basis.

Prerequisites:

- 36-709: Advanced Statistical Theory I

Topics:

This is the second of two semester-long core Ph.D. courses in theoretical statistics. We will cover a selection of modern topics in mathematical statistics, with a focus on high-dimensional statistical models and non-parametric statistical models. One of the main goals of this course is to provide you with some theoretical background and mathematical tools to read and understand the current statistical literature on high-dimensional models.

The tentative list of topics for the first half of the class include:

- VC theory;

- Gaussian processes;

- Chaining;

- Local Rademcher complexities and applications to non-parametric least squares.

The second half of the course will be devoted to techniques for establishing minimax lower bounds.

Class material:

Much of the course material come from the book "High-dimensional statistics: A non-asymptotic viewpoint", by M. Wainwright. Further eading material and notes will be posted on the webiste.

Other recommended textbooks are:

1. *High-Dimensional Probability, An Introduction with Applications in Data Science,* by R. Vershynin, 2018+, available here

2. *Probability in High Dimension*, 2016, lecture notes by R. VCan Handel, available here

Course Grading:
Your assessment and grades will be determined as follows:

- Homework assignments (70%).

- Scribe duties (10%).

- Attendance and class participation (5%).

- Final Exam/Project (15%).

Any failure to turn in any assignment, to fulfill the scribe duties and to miss a significant number of lectures without informing me of your absence or without a reasonable excuse will result in a lower grade.

Scribe duties:
Each student will take turn in transcribing the notes of every lecture in electronic format using the latex template available at `http://www.stat.cmu.edu/~arinaldo/Teaching/36710/F19/schedule.html`. The scribe has to attend class, take good and accurate notes, check for mistakes and inconsistencies, write them up in latex, add references and expand the material if appropriate and after consulting with me. The resulting pdf and latex files have to be submitted for my approval within one week. The pdf files containing the lecture notes will be posted on the class website.

Homework:
The problems on your homework assignemnts will be mostly of theoretical nature and will for the jost part be proofs.

There is a great value in discussing problems and sharing knowledge with your classmate, so you are encouraged to engage in group work. However, you should attempt to solve homework problems by yourself and only afterwards meet and compare with others.

Attendance and Involvment:
It is important that you attend class, as the selection and organization of the topics will be on occasion different from the notes and textbooks. If you know you will be absent for few consecutive lectures, please let me know.

Come and see me any time you are confused or stuck and don't be shy in class: the more questions you ask and the more feedback I receive from you, the better I will be able to tailor the lectures to your specific needs.

Final Project:

The final project involves picking a topic of interest, reading the relevant results in the area and then writing a short paper (8-12 pages) summarizing the key ideas in the area. You may focus on a single paper if you prefer. Your are NOT required to do new research, but you are welcome to. The paper should include background, statement of important results, and brief proof outlines for the results. If appropriate, you should also include numerical experiments are an application with real data.

- You may work by yourself or in teams of two.

- The goals are (i) to summarize key results in literature on a particular topic and (ii) present a summary of the theoretical analysis (results and proof sketch) of the methods (iii) implement some of the main methods. You may develop new theory if you like but it is not required.

- You will provide: (i) a proposal, (ii) a progress report and (iii) and final report.

- The reports should be well-written.

Proposal. <u>Due October 9.</u> A one page proposal. It should contain the following information: (1) project title, (2) team members, (3) precise description of the problem you are studying, (4) anticipated scope of the project, and (5) reading list. (Papers you will need to read).

Progress Report. Due <u>November 6.</u> Three pages. Include: (i) a high quality introduction, (ii) what have you done so far, (iii) what remains to be done and (iv) a clear description of the division of work among teammates, if applicable.

Final Report. Due <u>December 13.</u> The paper should be in NeurIPS format[1]. (pdf only). Minimum 8 pages, maximum 12 pages. No appendix is allowed. You should submit a pdf file electronically. It should have the following format:

1. Introduction. Motivation and a quick summary of the area. 2. Notation and Assumptions.

2. Key Results.

3. Proof outlines for the results.

4. Implementation (simulations or real data example.)

5. Conclusion. This includes comments on the meaning of the results and open questions.

Wellness:

Course work at this level can be intense, and we encourage you to take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, socializing, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. If you are having any problems or concerns, do not hesitate to come speak with either of us. There are also many resources available on campus that can provide help and support. Asking for support sooner rather than later is almost always

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[1]The NuerIPS 2019 style files can be found here: https://neurips.cc/Conferences/2019/PaperInformation/StyleFiles

a good idea. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider also reaching out to a friend, faculty member, or family member you trust to help get you the support you need.

Disability Resources

If you require a special accommodation, such as needing more time to finish exams, please visit the Office of Disability Resources to obtain appropriate documentation. See http://www.cmu.edu/hr/eos/disability/students/