Syllabus: Intermediate Statistics, 36-705 (Fall 2018)

1 Overview

This course covers the fundamentals of theoretical statistics. Topics include: concentration of measure, basic empirical process theory, convergence, point and interval estimation, maximum likelihood, hypothesis testing, Bayesian inference, nonparametric statistics and bootstrap resampling. This course is excellent preparation for advanced work in Statistics and Machine Learning. See below for a detailed schedule.

Some course objectives for students in machine learning include: (1) Predict which kinds of existing machine learning algorithms will be most suitable for which sorts of tasks, based on formal properties and experimental results. (2) Evaluate and analyze existing learning algorithms.

There are several textbooks that we will use material from. The main textbook for the course will be Larry Wasserman's "All of Statistics". We will cover Chapters 1-12 from the text plus some supplementary material. There are several other useful references:

1. Casella, G. and Berger, R. L. (2002). Statistical Inference, 2nd ed.
2. Rice, J. A. (1977). Mathematical Statistics and Data Analysis, Second Edition.
3. **(Advanced)** van der Vaart, A. (2000). Asymptotic Statistics
4. **(Advanced)** Bickel, P. J. and Doksum, K. A. (1977). Mathematical Statistics.

We will closely follow Larry Wasserman's version of this course, and you can find lecture notes and even lecture videos online at `www.stat.cmu.edu/~larry/=705`.

2 Background and Prerequisites

I assume that you are familiar with basic probability and mathematical statistics. You should already know the following concepts: probability, distribution functions, density functions, moments, transformation of variables, and moments generating functions.

2.1 Is This The Right Course For You? 36-705 versus 36-700

We have another course, 36-700, that covers similar material but assumes less background. In 705 I assume you are already familiar with basic probability. **This course moves extremely fast.** If you want a course that requires less background, you should take 36-700 instead.

3 Grading

- 25% : Test I (Friday September 21st)
- 25% : Test II (Friday November 2nd)
- 30% : Final Exam (Date set by the University)
- 20% : Homework

3.1 Exams

All exams are closed book. Do NOT buy a plane ticket until the final exam has been scheduled.

3.2 Homework

Homework assignments will be posted (roughly weekly) on the web. You should submit your HW via Canvas before 3pm Thursday. If you need an extension due to illness, email me BEFORE the homework deadline.

We will frequently re-use material including old homework assignments. The homeworks are meant for you to practice solving problems, do not search for HW solutions online (they are quite easy to find).

3.3 Reading and Class Notes

Class notes will be posted on the web regularly. The notes are not meant to be a substitute for the book and hence are generally quite terse. Read both the notes and the text before lecture. Sometimes I will cover topics from other sources.

3.4 Group Work

You are encouraged to work with others on the homework. But write-up your final solutions on your own. Please credit the students that you work with clearly.

4 More important information

4.1 Course Information

All course material, including assignments and lecture notes will be posted on the website:

`www.stat.cmu.edu/~siva/705/main.html`

4.2 Piazza

We will use Piazza to answer questions. Please sign-up at the following website:

`https://piazza.com/cmu/fall2018/36705/home`

4.3 Office Hours

1. **Instructor Office Hours:** Monday 1:30-2:30pm, BH 132K.
2. **Ilmun Kim (Head TA):** TBA.
3. **Boyan Duan:** TBA.
4. **Benjamin LeRoy:** TBA.

5 Accommodations for Students with Disabilities

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

6 Statement of Support

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, 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. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is almost always helpful.

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 reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

1. CaPS: 412-268-2922
2. Re:solve Crisis Network: 888-796-8226
3. If the situation is life threatening, call the police. On campus: CMU Police: 412-268-2323. Off campus: 911

If you have questions about this or your coursework, please let me know. Thank you, and have a great semester.

7 Calendar

This is a tentative list of topics.

Date	Lecture Topic
August 27th	Review
August 29th	Concentration Inequalities
August 31st	Concentration Inequalities
September 3rd	**No Class (Labor Day)**
September 5th	Convergence
September 7th	Convergence
September 10th	Central Limit Theorem
September 12th	Uniform Laws and Empirical Process Theory
September 14th	Uniform Laws and Empirical Process Theory
September 17th	Uniform Laws and Empirical Process Theory
September 19th	Review
September 21st	**EXAM 1**
September 24th	Likelihood and Sufficiency
September 26th	Point Estimation (MLE)
September 28th	Point Estimation (Method of Moments, Bayes)
October 1st	Decision Theory
October 3rd	Decision Theory
October 5th	Asymptotic Theory for MLE
October 8th	Asymptotic Theory for MLE
October 10th	Hypothesis Testing
October 12th	Hypothesis Testing
October 15th	Goodness-of-fit, two-sample, independence
October 17th	Multiple testing
October 19th	**No Class (Mid-Semester Break)**
October 22nd	Multiple testing
October 24th	Confidence Intervals
October 26th	**No Class (Inauguration)**
October 29th	Confidence Intervals
October 31st	Review
November 2nd	**EXAM 2**
November 5th	Bootstrap
November 7th	Bootstrap
November 9th	Bayesian Inference
November 12th	Bayesian Inference
November 14th	Linear Regression
November 16th	Non-parametric Regression
November 19th	Minimax Lower Bounds
November 21st	**No Class (Thanksgiving Break)**
November 23rd	**No Class (Thanksgiving Break)**
November 26th	Minimax Lower Bounds
November 28th	High-dimensional Statistics
November 30th	High-dimensional Statistics
December 3rd	Model Selection
December 5th	Causal Inference
December 7th	Causal Inference

Some additional topics we may cover include metrics on distributions and a more detailed treatment of exponential families.