USC Viterbi
School of Engineering

EE364: Introduction to Probability and Statistics for Electrical Engineering and Computer Science

Units: 4
Fall 2020

Lecture: Tue. Thu., 12:00-13:50 PM, online (zoom link in Blackboard)
Discussion: Mo, 16:00-16:50, online (zoom link in Blackboard)

Instructor: Andreas Molisch
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Office Hours: Tuesdays, 14:00-15:00; Zoom 99578723332
Thursday 17h30-18h15 Zoom 96287687969
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Course Webpage: https://piazza.com/usc

All assignments, solutions, handouts, announcements, and grades will be posted on Piazza.

Exam Dates:

- **Midterm:** Sept. 30, 12h00-14h00
- **Final Exam:** Nov. 19th, 11h00-13h00 (as set by the university)

Course Description

Probability and statistics form the foundation for a large number of fields and techniques in electrical engineering and computer science – e.g., adaptive signal processing and machine learning, information theory and communications, decision theory, classification, noise modeling and mitigation, etc. Probability uses models to inform us about the outcome of an experiment to be conducted. For example, given a good model, we can determine how probable it is that Seeds will have more than 4 people in line tomorrow at noon. Statistics is concerned with empirical data and informs the design of experiments and the validity of conclusions that can be drawn from experiments. For example, if you are taking a political poll, statistics tells us the relationship between the number of people polled and the accuracy of the poll (e.g., notice how political polls usually have a plus/minus 3% footnote). Statistics and probability are closely connected and rely on one another. In this class, we will begin with probably and develop the basic concepts including set probability, conditional probability, random variables, estimation, and decision making. We will then connect to an introduction to statistics through limit theorems. The approach to teaching this class is to introduce general concepts through problems to foster student self-discovery.

Learning Objectives

Upon successful completion of this course a student will

- Understand probability as a model for uncertainty
- Be able to perform basic set probability relations including conditional probabilities and Bayes' Law
- Understand random variables as models for numerical measurements with uncertainty
- Use the complete statistical characterization of random variables (\eg distribution and density functions) to compute probabilities
- Develop novel probability distributions given a description of a random experiment.
- Interpret the incomplete statistical characterization of random variables, such as mean and variance, to draw qualitative and quantitative conclusions.
- Be able to apply common distributions such as Gaussian, Poisson, Binomial, Exponential and uniform to solve problems as appropriate.
- Utilize joint distributions and joint moments to compute probabilities and make estimates of random variables.
- Understand the Law of Large Numbers and Central Limit Theorem and their relation to statistical analysis.
- Apply basic confidence interval formulas to characterize the accuracy of estimates from experimental data
- Make decisions between a finite set of hypotheses from experimental data
- Perform linear regression to estimate one variable from another using experimental data.

Prerequisite(s): MATH 225 or MATH 245
Co-Requisite(s): none
Concurrent Enrollment: none
Recommended Preparation: programming experience in Matlab

Required Readings Textbook

Charles Boncelet, “Probability, Statistics, and random signals”, Oxford University Press

Recommended Supplementary Textbook

Roy D. Yates and David J. Goodman, Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers, John Wiley & Sons, **Third Edition.**

Additional Material

Robert V. Hogg and Elliot A. Tanis, Probability and Statistical Inference, 8th Ed., Prentice-Hall.

Description and Assessment of Assignments

Homework Policy

- Late HW will not be accepted. A late assignment results in a zero grade. Please have your homework turned in by the beginning of lecture on the date that it is due.
- Homeworks will be assigned on Fridays and collected the next week (11 days later) in class (on Tuesday at the beginning of the lecture)
- Show your work in your homework solution; the correct answer alone is worth only partial credit.
- Homework collaboration is encouraged. This is discussing problems and solution strategies with your classmates, the TA, and/or the instructor and is to be distinguished from copying solutions of others which is **strictly** prohibited.
- For computer-based assignments no code may be shared or copied from the internet. The only exception is code provided to the entire class by the instructor or TA.
- Any resources used, beyond the required readings textbook and notes from class, must be fully referenced. *Using material without referencing is a serious violation of ethical standards and will be sanctioned as such.*

Pop Quiz

- There will be a quiz at the beginning of each lecture testing the knowledge and understanding of the reading assignments

Lecture summary

- Groups of 3 students will present a summary of the previous lecture (rotating assignment).

Exam Policy

- No make-up exams will be given. If you cannot make the above dates due to a class schedule conflict, you must notify me by the last day to add/drop. If I cannot accommodate your schedule, you must drop the class. In the case of a medical emergency, a signed letter from your doctor is required. This letter must include the telephone number of your doctor.
- Exams will be closed book (with a crib sheet allowed).
- All exams are cumulative, but with an emphasis on material presented since the last exam.

Grading Breakdown

- Pop quiz: 10%
- Summary of last lecture 5%
- Class participation: 5%
- Homework: 25 %
- Midterm: 25%
- Finals: 30%

Grading Scale

Final grades will be assigned by a combination of student score distribution (curve) and the discretion of the instructor. **Final grades are nonnegotiable.**

Grading Timeline

Homeworks and exams will be graded within two weeks of collection.

Online teaching and considerations for other timezones:

Specific policies and considerations are explained in the first lecture, see video recordings and slides of the first lecture for details.

Course Outline

1. Foundations of Probability
    - Set Theory
    - Sample Space, Outcomes, Events
    - Probability Law
    - Conditional Probability
    - Total Probability Theorem
    - Bayes' Theorem
    - Independence • Conditional Independence
    - Counting Methods
    - Independent Trials
2. Discrete Random Variables
    - Probability Mass Function (PMF)
    - Cumulative Distribution Function (CDF)
    - Average and Expectation
    - Functions of Discrete Random Variables (RVs) and their Expectations
    - Variance and Standard Deviation
    - Important Families of Discrete RVs
    - Conditioning a Discrete RV by an Event
3. Continuous Random Variables
    - Cumulative Distribution Function (CDF)
    - Probability Density Function (PDF)
    - Expectation of Continuous RVs
    - Functions of Continuous RVs and their Expectations
    - Variance and Standard Deviation
    - Important Families of Continuous RVs
    - Conditioning a Continuous RV by an Event
4. Multiple Random Variables
    - Joint CDFs, PMFs, and PDFs
    - Marginal PMFs and PDFs
    - Conditional PMFs and PDFs
    - Independent RVs
    - Functions of Multiple RVs
    - Covariance and Correlation
    - Jointly Gaussian RVs
    - Orthogonal Random Variables
    - Conditional Expectation
    - Iterated Expectation
5. Detection
    - Binary Hypothesis Testing
    - Maximum Likelihood (ML) Detection
    - Maximum a Priori (MAP) Detection
    - Minimum Mean-Squared Error (MMSE) Estimation
    - Linear Least-Squares Error (LLSE) Estimation
6. Statistics
    - Sample Mean and Variance
    - Law of Large Numbers
    - Central Limit Theorem
    - Confidence Intervals

- Parametric Statistical Testing

7. Intro to Data Science and Machine Learning
   - Random Vectors
   - Linear regression
   - Training and Test Error
   - Basic Classifiers (Nearest Neighbor, Linear)
   - Principal Component Analysis (PCA)
8. Random processes
   - Gaussian random processes
   - Ergodicity and stationarity
   - Correlation

Markov processes Roy D. Yates and David J. Goodman, Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers, John Wiley & Sons, **Third Edition.**

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Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. https://engemannshc.usc.edu/counseling/

National Suicide Prevention Lifeline - 1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. http://www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. https://engemannshc.usc.edu/rsvp/

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: http://sarc.usc.edu/

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. https://equity.usc.edu/

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. https://studentaffairs.usc.edu/bias-assessment-response-support/

The Office of Disability Services and Programs

Provides certification for students with disabilities and helps arrange relevant accommodations. http://dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. https://studentaffairs.usc.edu/ssa/

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. https://diversity.usc.edu/

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, http://emergency.usc.edu

USC Department of Public Safety – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime.
Provides overall safety to USC community. http://dps.usc.edu