ZJU-UIUC INSTITUTE
Zhejiang University-University of Illinois Urbana-Champaign Institute
浙江大学伊利诺伊大学厄巴纳香槟校区联合学院

ECE 314: Probability in Engineering Lab
Spring 2024
Course Syllabus

Meeting Times

Days	Time	Location
Wednesdays	18:00–20:00	LTN-A 325/401

Attendance is mandatory only on quiz dates and the quizzes are 25 minutes in length, i.e., you do not have to attend the whole 2-hour block on quiz dates. You will complete the laboratory exercises on your own schedule using a Python environment installed on your personal computer. Please contact a TA or instructor if you have any issues with installing a Python environment.

The tentative quiz dates are: 2/28, 3/13, 3/27, 4/10, 4/24, 5/8, 5/22

Course Management

This term we will be using Blackboard for all class lab reports, quizzes, announcements, and discussions.

Instructor

Prof. Piao Chen (piaochen@intl.zju.edu.cn)

Office hours: Contact me to book an appointment.

Teaching Assistants

- Kejun Wu (kejun.20@intl.zju.edu.cn)

Course Material

Jupyter notebook files distributed on the course Blackboard site.

Course Information

Designed to be taken concurrently with ECE 313, Probability in Engineering Systems, to strengthen the students' understanding of the concepts in ECE 313 and their applications, through computer simulation and computation using the Python programming language. Topics include sequential hypothesis testing, parameter estimation, confidence intervals, Bloom filters, min hashing, load balancing, inference for Markov chains, PageRank algorithm, vector Gaussian distribution, contagion in networks, principle component method and linear regression for data analysis, investment portfolio analysis.

Prerequisite: Concurrent enrollment in ECE 313

Course Goals

Show students how to solve problems involving uncertainty through reasoning and computer programming.

Enhance student effectiveness in using a scientific programming language such as Python to solve problems.

At the end of this course, the student will be able to apply the knowledge of probability and statistic and Python programming gained in this course to several different types of problems in engineering.

1. Given a network of hosts that communicate with each other over links that are prone to failure, the student will be able to compute the probability that there exists a viable communication path between any two nodes in the network. (1) The student will also be able to model failure modes for systems composed of several subsystems as a network problem, and to solve such problems. (1)
2. The student will be able to formulate engineering decision-making problems as hypothesis testing schemes that compare likelihood ratios to thresholds. (1, 2) The student will be able to calculate the thresholds required to meet design specifications such as maximum false-alarm probabilities or detection probabilities in radar decision problems, including for sequential hypothesis testing (1,6) The student will be able to design tests using Bayesian methods for the purpose of minimizing the average probability of error. (1,2)
3. The student will be able to specify maximum-likelihood estimates for system parameters. (1,2,6) The student will be able to estimate confidence intervals for parameters for any specified confidence level. (1)
4. The student will be able to compute probability distributions for the parameters of various systems, to estimate average values and variances of these parameters, and to estimate the probabilities that various design specifications are met. (1,6)

As indicated above, the course satisfies Student Outcomes 1, 2, and 6:

Student Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Student Outcome 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Student Outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Laboratory Schedule

Lab	Date	Concepts	Reading
1	1/17	Introduction to Python and discrete random variables	See video on probability mass functions: [pmfmean]
2	1/24	Plotting histograms, exploring law of large numbers, simulating games	Example 1.4.3 in the ECE 313 notes and related videos: [PokerIntro], [PokerFH2P]; also Problem 1.10 and its solution
3	2/28	Bernoulli processes, Poisson distribution	Section 2.6 on Bernoulli processes, [SAQ 2.6]; Section 2.7 on Poisson distribution, [SAQ 2.7]
4	3/6	Standardized random variables, parameter estimation, confidence intervals	This lab is directly related to the ECE 313 concepts listed, covered in Sections 2.2, 2.8, and 2.9 of the course notes. Two relevant SAQs: [SAQ 2.8] and [SAQ 2.9]
5	3/13	Bloom filter/hashing, min hashing	For a description of min hashing see: [SimdocIntro, Simdoc-Minhash1]
6	3/20	Random processes and variations of a random walk	No reading in advance is needed for this lab
7	3/27	Introduction to Markov chains and random graphs	If necessary it'd be good for you to review basic linear algebra, especially matrix multiplication. It would be helpful (but not necessary) for you to read a little about Markov chains on Wikipedia
8	4/3	Applications of Markov chains: page rank, inference, and cache replacement policies	Builds on previous lab. For background you could read about PageRank and Cache algorithms on Wikipedia. You could also see Problem 2.9 in the course notes about the Zipf distribution.

Lab	Date	Concepts	Reading
9	4/10	Binary hypothesis testing, sequential hypothesis testing, and gambler's ruin	Not much advance preparation is needed, but it would be helpful for you to review (i) Section 2.11.1 on the maximum likelihood decision rule and (ii) Problem 2.18. You might also briefly review Lab 6.
10	4/17	Central limit theorem, change detection, multidimensional Gaussian distribution.	Change detection is achieved by using the idea of sequential hypothesis testing explored in Lab 9. While not critical, it would be helpful for you to review the central limit theorem in Section 3.6.3 (revisited in Section 4.10) and to read about the joint Gaussian distribution in Section 4.11.
11	4/24	ODEs, failure rates, and evolutionary games	It would help for you to briefly review failure rate functions in Section 3.9 and the area rule for expectation in Section 3.8.3. This lab gives a brief glimpse of game theory, and how it can be used to model the dynamics of interacting populations of individuals. A nice introduction to this topic is given in Chapter 7 of [Easley and Kleinberg *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*].
12	5/1	Epidemics, or the spread of viruses	You would probably find it useful to spend ten or twenty minutes before the lab reading about "SIR model" and "spread of diseases" on the Internet. For more information, an advanced but fairly readable analysis is given in [M. Draief, A. Ganesh, and L. Massoulié, "Thresholds for virus spread on networks," Ann. Appl. Probab. 18:2 (2008), pp. 359-378].

Lab	Date	Concepts	Reading
13	5/8	Linear regression	It would be helpful to study up on linear minimum means square error estimators in Section 4.9.3 in preparation of this lab. That covers what is called simple linear regression (estimation of a one-dimensional variable from another). The lab goes into multiple linear regression as well (estimation of a one-dimensional variable from a set of other variables), which is discussed in the [ECE 534 notes], Section 3.3.2.
14	5/15	Principal component analysis, and clustering	It would be helpful for you were to spend half an hour before the lab reading about principal component analysis (PCA) on Wikipedia or other websites. The eigen decomposition behind PCA is briefly discussed in the [ECE 534 notes], Section 3.1.

Some adjustments to the laboratory schedule may occur as the semester progresses.

Quizzes

The quizzes will be 25 minutes in length and cover material from the previous two labs. Students reading the pre-lab material listed on the course syllabus page for each lab and thoughtfully doing the labs should have no problem with the quizzes without additional studying for them.

Grading Policy

Final grades for ECE 314 will be weighted as shown below to determine your total score, which in turn, will determine your grade.

	Proportion
Lab assignments	80%
Quizzes	20%

The lowest lab assignment score and lowest quiz score will be dropped.

Other Policies

- Submit your completed Jupyter notebook to the ECE 314 course Blackboard page (https://learn.intl.zju.edu.cn). It is your responsibility to ensure that the file has been uploaded successfully.
- Laboratory assignments will generally be due on Wednesdays at 23:59, 7 days after the first session of a given laboratory unless otherwise stated.

- Students are encouraged to discuss the laboratory exercises but, ultimately, all work you submit **must be your own**.
- Laboratory assignments submitted after the deadline, but no more than 1 week late, **will receive a 50% penalty. Laboratory assignments will not be accepted if submitted beyond 1 week of the deadline.**

Academic Integrity

Academic integrity is essential for maintaining the quality of scholarship in the Institute and for protecting those who depend on the results of research work performed by faculty and students in the Institute. The faculty of the Zhejiang University/University of Illinois at Urbana-Champaign Institute expects all students to maintain academic integrity at all times in the classroom and the research laboratory and to conduct their academic work in accordance with the highest ethical standards of the engineering profession. Students are expected to maintain academic integrity by refraining from academic dishonesty, and by refraining from conduct which aids others in academic dishonesty or which leads to suspicion of academic dishonesty. Violations of academic integrity will result in disciplinary actions ranging from failing grades on assignments and courses to probation, suspension or dismissal from the Institute.