ECE 440 - Introduction to Random Processes

Syllabus - Fall 2024

Time: Mondays and Wednesdays, 4:50-6:05 pm. **Place:** Gavett Hall 202. **Class website:** http://www.hajim.rochester.edu/ece/sites/gmateos/ECE440.html

Instructor: Gonzalo Mateos (gmateosb@ece.rochester.edu). Office hours: Tuesdays 10:30 am, 726 Computer Studies Building. Teaching assistant: Hamed Ajorlou (hajorlou@ur.rochester.edu). TA office hours: Fridays 2:30 pm to 3:30 pm, 701 Computer Studies Building.

Textbook: We will use lecture slides to cover the material. Good general reference John A. Gubner, *"Probability and Random Processes for Electrical and Computer Engineers,"* Cambridge University Press.

Available online from the University of Rochester library.

Additional reading:

Sheldon M. Ross, *"Introduction to Probability Models,"* 13th. edition, Academic Press. (Earlier editions are fine.)

Both books are on reserve for the class in Carlson Library.

Prerequisites: Useful to have good background in Probability Theory (of which we will do a fast-paced review the first five lectures), as well as Calculus and Linear Algebra (i.e., integrals, limits, infinite series, differential equations, vector/matrix notation, systems of linear equations, eigendecomposition). For homework assignments we will use Matlab.

Credit distribution: Homework assignments (10, 28 points), in-class midterm (Oct. 30, 36 points), take-home final (Dec. 15-17, 36 points).

Grading: At least 60 points are required for passing (C grade), a B requires at least 75 points, and an A at least 92. There is no curve. Undergraduate (ECE 271) students are expected to complete the same assignments and exams, but will be awarded extra 10 points counting towards the final grade.

Academic dishonesty: Academic dishonesty will be dealt with according to the University of Rochester's Academic Honesty Policy.

Class description: Introduction to Random Processes (ECE 440) is an entry-level

graduate class that explores stochastic systems. The latter could be very loosely defined as anything random that changes in time, and the evolution of such systems is mathematically described by a random process. Stochastic systems are at the core of a number of disciplines in engineering, for example communication systems and machine learning. They also find application elsewhere, including social systems, markets, molecular biology and epidemiology, just to name a few.

Class objectives: The goal of the class is to learn how to model, analyze and simulate stochastic systems. With respect to analysis we distinguish between what we could call theoretical and experimental analysis. By theoretical analysis we refer to a set of tools which let us discover and understand properties of the system. Naturally, probability theory plays a key role as the mathematical language that allows us to quantify uncertainty. The theory can only take us so far and is usually complemented with numerical analysis of experimental outcomes. Although we use the word experiment more often than not we simulate the stochastic system in a computer and analyze the outcomes of these virtual experiments.

Topic outline: The topics covered in ECE 440 can be split into five thematic blocks

- 1) Introduction (1 lecture)
- 2) Probability review (5 lectures)
- 3) Discrete-time Markov chains (6 lectures)
- 4) Continuous-time Markov chains (7 lectures)
- 5) Gaussian, Markov, and stationary random processes (8 lectures)

Application domains we will explore to illustrate the usefulness of the theory include

- 1) Web search and Google's PageRank[©]
- 2) Optimal decision making and reinforcement learning
- 3) Queuing systems
- 4) Predator-prey population dynamics
- 5) Arbitrages and stock options pricing
- 6) Radar
- 7) Principal component analysis

For a detailed description of the contents including a lecture-by-lecture schedule, see the class website http://www.hajim.rochester.edu/ece/sites/gmateos/ECE440.html.

Mon. 8/26 Introductions, class organization, motivating example Wed. 8/28 Probability spaces, conditional probability, independence Mon. 9/2 Labor day - No class Wed. 9/4 Random variables, discrete and continuous, expectations HW1 due Mon. 9/9 Multiple RVs, joint distribution, expectations HW1 due Wed. 9/11 Bounds, convergence notions and limit theorems HW2 due Wed. 9/18 Markov chains, examples, Chapman-Kolmogorov equations HW3 due Wed. 9/18 Gambler's ruin problem, discrete-time queuing models HW3 due Wed. 9/25 Classes of states, irreducible Markov chains HW3 due Mon. 9/30 Limiting distributions HW4 due Mon. 10/2 Ergodicity HW4 due Mon. 10/7 Ranking of nodes in graphs HW5 due Wed. 10/6 Poisson processes, interarrival times, definitions, examples HW5 due Mon. 10/14 Fall term break - No class HW6 due Fri. 10/25 Mon. 10/23 Transition probability function, Kolmogorov's equations HW6 due Fri. 10/25 Midterm review lecture HW6 due Mon. 10/24 Trasmition probability function, Kolmogorov's equations </th <th>Date</th> <th>Description</th> <th>Homework</th>	Date	Description	Homework
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