ECE 4260 Random Signals and Applications

Instructor

Xiaoli Ma

Phone

404-385-7456

Email

xiaoli@gatech.edu

Office Location

Centergy 5181

Office Hours

MW 10:45am-11:45am

Clough Undergraduate Learning Commons 4th floor

Course Overview

Introduction to random signals and processes with emphasis on applications in ECE. Includes basic estimation theory, linear prediction, and statistical modeling.

Course Schedule

Fall 2025 Mon. and Wed. 9:30-10:45am, Clough Undergraduate Learning Commons, Unit 129

Required Text

Stark & Woods, Probability, Statistics, and Random Processes for Engineers (4th edition), Prentice Hall, 2011. ISBN 0132311232, ISBN 978-0132311236 (required)

Pre-requisites

ECE 3084 [min C] and (ECE 3077 or CEE/ISYE/MATH/ 3770)

Course Outcomes

1. Analyze random vectors, their joint statistics, and functions of random vectors
2. Describe random vector properties using linear algebra
3. Optimally estimate random vectors given sets of observations
4. Decorrelate random vectors through transformations
5. Analyze random waveforms, both discrete and continuous observations, using multidimensional probability theory
6. Describe process characteristics in terms of ergodicity and various levels of stationarity (continuous and discrete)
7. Compute autocorrelation, autocovariance, and cross correlation functions for both non-stationary and stationary processes (continuous and discrete)
8. Analyze random signals put through linear filters both in time and frequency (continuous and discrete)
9. Model processes in terms of white noise applied to filters (continuous and discrete)
10. Analyze random walks and Wiener processes
11. Design linear predictors for autoregressive systems (discrete-time only)
12. Analyze short-time stationary processes along with time-dependent ACFs, CCFs, and PSDs (continuous and discrete)
13. Design optimal causal and non-causal Wiener filters
14. Apply state-space descriptions to linear systems and random signals to employ Kalman filters (discrete-time only)

15. Employ Markov chains to model evolving process properties

Course Outline

1. Random Vectors
   a. joint distributions and transformation of random vectors
   b. mean vector and covariance matrix
   c. Gaussian random vectors
   d. estimating the mean vector and covariance matrix
   e. linear estimation and least-squares
   f. minimum mean-square error estimation

2. Discrete-time random signals
   a. Bernoulli trials and random walks
   b. random sequences and discrete-time linear systems
   c. wide-sense stationary sequences and the power spectral density
   d. Markov processes
   e. hidden Markov models

3. Introduction to statistical DSP
   a. discrete-time linear prediction
   b. the Wiener filter
   c. sequences of random vectors, state evolution and the Kalman filter

4. Continuous-time random signals
   a. Poisson processes
   b. digital modulation
   c. Brownian motion
   d. Markov processes
   e. wide-sense stationary processes, the autocorrelation function, and the power spectral density
   f. continuous-time systems with random inputs

5. Further topics
   a. graphical models
   b. Bayesian inference
   c. the expectation-maximization algorithm

Applications will be discussed alongside of general mathematical techniques. Applications will include, but not be limited to, speech processing, tracking, modulation and detection for digital communications, radar, sigma-delta quantization, and financial modeling.

Course Policy

Attendance: Attendance is expected. Students are responsible for all assigned readings, class lectures, as well as material covered in class that is not in the book.

Homework Assignment: Homework is due on CANVAS. No late homework will be accepted since the homework solution will be uploaded to CANVAS on the due date. You may discuss homework problems with other students but all work must be your own. Same homework copies will be considered as cheating and the appropriate action will be taken.

Disability and Special Needs: Any student with a disability or any special need should contact Professor Xiaoli Ma as soon as possible. She has an obligation to accommodate a student's special needs so that the student can participate in the class.

Honor code: http://www.deanofstudents.gatech.edu/Honor/honorcode.txt

Grading policy

Homework: 25%

Midterms: 40%

Attendance quizzes: 10%

Final Exam: 25%

Additional Information

- Lecture notes and handouts will be uploaded to CANVAS
- Homework and solutions will be uploaded to CANVAS