ECE4260 Course Syllabus

ECE4260

Random Signals and Applications (3-0-0-3)

CMPE Degree
This course is Elective for the CMPE degree.

EE Degree
This course is Elective for the EE degree.

Lab Hours
0 supervised lab hours and 0 unsupervised lab hours

Course Coordinator
Moore II,Elliot

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

Corequisites
None

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

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

Course Outcomes
Upon successful completion of this course, students should be able to:

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 (contiuous 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 (contiuous 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 (contiuous 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.

Student Outcomes

In the parentheses for each Student Outcome:
"P" for primary indicates the outcome is a major focus of the entire course.
“M” for moderate indicates the outcome is the focus of at least one component of the course, but not majority of course material.
“LN” for “little to none” indicates that the course does not contribute significantly to this outcome.

1. (P) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. (LN) 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
3. (LN) An ability to communicate effectively with a range of audiences
4. (LN) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. (LN) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. (M) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. (M) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Topical Outline

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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 dens
   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

4.      Continuous-time random signals
   a.   Poisson processes
   b.   digital modulation
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   c. Brownian motion
   d. Markov processes
   e. wide-sense stationary processes, the autocorrelation functi
   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 te