Course Syllabus

Time and venue: Tu,Th 3:55–5:15 pm, Bolz Hall 0436

Instructor: C. Emre Koksal, Dreese 712, koksal@ece.osu.edu

Web page: Class material will be posted on Carmen

Office Hours: Thursday 2:30–3:30 pm or by appointment

Content: Stochasic processes, detection and estimation theory arise in most applications of communication systems, signal processing and system theory.

The first half of this course studies detection and estimation. Topics include: Bayes, Minimax and Neyman-Pearson hypothesis testing; composite hypothesis tests; generalized likelihood tests; signal detection in noise; Bayesian parameter estimation; estimator properties; maximum-likelihood parameter estimation. It also introduces timely topics, including message passing and belief propagation.

The second half of this course deals with basic concepts of stochastic processes. Stochastic processes are used to represent uncertainty due to noise or due to some unknown characteristic of the system such as an unknown frequency in a sinusoid. This course is concerned with modeling such signals and building tools for analyzing the effects of processing these signals.

Prerequisites: Fluency in dealing with random vectors, and functions of random vectors (ECE 804, ECE 6001, or equivalent). Linear systems theory and linear algebra. Some exposure to MATLAB. Mathematical maturity.

Homework assignments: Approximately once every two weeks. Assigned on Tuesdays due the following Tuesday. Some questions will require the use of MATLAB. Since the primary purpose of the homeworks is to help you solidify your understanding of course material, discussions on assigned problems are encouraged. However, all written work turned in must be your own.

Text: *Signal Detection and Estimation, Second Edition*, H. Vincent Poor, Springer, 1994. Further handouts from various textbooks.

Other References:

- *Probability, Random Processes and Estimation Theory for Engineers*, H. Stark and J. W. Woods, Prentice-Hall, 2002.
- *Detection, Estimation, and Modulation Theory*, Van Trees (Wiley: 1971)
- *Stochastic Processes: Theory for Applications*, Robert G. Gallager, available on-line at http://www.rle.mit.edu/rgallager/notes.htm
- *Quickest Detection*, Poor and Hadjiliadis (Cambridge University Press: 2008)
- *An Introduction to Probability and Its Applications - Vols. I (and II)*, Feller.
- *An Exploration of Random Processes for Engineers*, B. Hajek, available on-line at http://www.ifp.illinois.edu/∼hajek/Papers/randomprocesses.html
- *Statistical Signal Processing, Detection and Estimation Theory*, Scharf (Addison-Wesley:1990)
- *Probability and Random Processes*, 3rd Edition, G. Grimmett and D. Stirzaker, Oxford University Press, 2004.
- *Probability, Random Variables and Stochastic Processes*, A. Papoulis and S. U. Pillai, McGraw-Hill, 4th Ed., 2002.
- *Theory of Point Estimation*, Lehmann (Wiley: 1983)
- *Abstract Inference*, Grenander (Wiley: 1981)
- *Statistical Theory of Signal Detection*, 2nd ed., Helstrom (Pergamon: 1968)
- *Elements of Signal Detection and Estimation*, Helstrom (Prentice-Hall: 1995)

Grading (*tentative*):

Homework	15%
Midterm 1	25%
Midterm 2	25%
Final	35%
Participation	5%

Attendance: Attendance is not mandatory. However the student is responsible for all assignments, changes of assignments, announcements, lecture notes, etc. I will also be posting the assignments, main announcements, and my lecture notes on Carmen.

Topical Outline of the Course

- Elements of Hypothesis Testing and Signal Detection (8–9 lectures)
  - Bayesian hypothesis testing
  - Neyman-Pearson hypothesis testing
  - Composite hypothesis testing
  - Colored noise and signal design
  - Performance analysis
  - Sequential detection
- Elements of Parameter Estimation (8–9 lectures)
  - Bayesian parameter estimation
  - Iterative estimation and Kalman filtering
  - Non-random parameter estimation
  - Properties of estimators, performance bounds
  - Maximum-likelihood parameter estimation
- Message Passing and Belief Propagation (2–3 lectures)
  - Factor graphs
  - Message passing, calculation of posterior pdfs and likelihood ratios
- Stochastic Processes (10–11 lectures)
  - Characterization of stochastic processes
  - Mean-square calculus
  - Brownian motion and white noise
  - Karhunen-Loeve expansion and detection of continuous sighals
  - Stationarity and ergodicity
  - Frequency domain characterization and power spectral density
  - Gaussian and Markov processes
  - (*time permitting*) Stochastic processes through linear systems
  - (*time permitting*) Spectral factorization and whitening filters
  - (*time permitting*) Estimation of waveforms and Wiener filters