Syllabus for ECE531
Principles of Detection and Estimation Theory
Spring 2013

Instructor: D. Richard Brown III

- Office: Atwater Kent 313
- Office Hours: Mondays 2-4pm.
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Class Meetings

AK219, Tuesdays 6:00pm-8:50pm, Jan 15 – Apr 23 (not March 5 – Spring Break).

Recommended Background:

Students taking ECE531 should have a solid background in probability and random processes (ECE502 or equivalent) and a familiarity with dynamic systems (ECE504 or equivalent; may be taken concurrently). Some familiarity with linear algebra and Matlab may also be useful.

Course Textbooks:

- *Fundamentals of Statistical Signal Processing Volume I: Estimation Theory*, S. Kay
- *Fundamentals of Statistical Signal Processing Volume II: Detection Theory*, S. Kay

Other Potentially Useful References:

There are many potentially useful textbooks on detection and estimation theory. Here are some that I have found helpful.

- *An Introduction to Signal Detection and Estimation*, Second Edition, by H. Vincent Poor
- *Detection of Signals in Noise*, Whalen.
- *Random Signals: Detection, Estimation, and Data Analysis*, Shanmugen.
- *Introduction to Nonparametric Detection with Applications*, Gibson and Melsa.
- *Testings Statistical Hypotheses*, Lehmann.
- *Theory of Point Estimation*, Lehmann.
- *Linear Estimation*, Kailath, Sayed, Hassibi
- *Quickest Detection*, Poor and Hadjiliadis.

Course Description

The subject of signal detection and estimation is concerned with the processing of information-bearing signals for the purpose of making **inferences** about the information that they contain. The purpose of this course is to provide an introduction to the **fundamental theoretical principles** underlying the development and analysis of techniques for such processing. The level of this course is suitable for research students in communications, control, signal processing, and related areas.

Tentative Course Schedule

Date	Topic	Reading
Jan 15	Course introduction, notation, review of joint and conditional probability concepts, review of random variables	Kay vI:1-2
Jan 22	Introduction to non-random parameter estimation, MVU estimators	Kay vI:3
Jan 29	Finding MVU estimators via the Cramer-Rao lower bound	Kay vI:4-5
Feb 5	Finding MVU estimators via linear models and the Rao-Blackwell Lehman Sheffe theorem	Kay vI:7
Feb 12	Maximum likelihood estimation	Kay vI:10-11
Feb 19	General Bayesian Estimation	Kay vI:12
Feb 26	Linear Bayesian Estimation [Kalman filter project assigned]	Kay vI:13
Mar 5	Spring Break.	
Mar 12	Dynamic parameter estimation and the Kalman filter [Kalman filter project due by 6pm]	Kay vII:1, 3.1-3.6
Mar 19	Introduction to detection, Neyman-Pearson detection	Kay vII:3.7-end
Mar 26	Bayesian hypothesis testing	Kay vII:4
Apr 2	Detection of deterministic signals in noise	Kay vII:6
Apr 9	Composite hypothesis testing, GLRT	Kay vII:7
Apr 16	Detection of deterministic signals with unknown parameters	Kay vII:9
Apr 23	Detection of signals in noise with unknown parameters	done!

Quizzes, Project, and Grading

Each week, starting in the second meeting, a 60-minute quiz will be given in the second half of the meeting period. Quizzes are open-book and open-notes. Use of calculators is also permitted during quizzes. No laptop computers, phones, or tablets are permitted.

Here is how it works: At the end of each meeting, students are responsible for watching the screencasts posted to the course website, reading the assigned chapters in the textbook, and working on the suggested problems to reinforce key concepts and test their understanding of the material. The screencasts are not intended to be comprehensive and can be watched before or after reading the assigned chapters in the textbook. Working on the suggested problems collaboratively is encouraged, although it is important that each student learns the material and is capable of taking the quiz without help from other students. Homework is not collected or graded in this course.

Any discussion/questions should be posted to Piazza. Based on the Piazza discussion leading up to the next lecture (and any questions raised in office hours), the instructor will prepare lecture materials and examples for the first half of the class meeting period, prior to the quiz. The quiz will be focused primarily on the reading assignment for the prior week, but may rely on concepts developed in earlier weeks.

For example: At the end of the Jan 15 meeting, students should read Kay vII:1-2, watch the screencasts, and work on the suggested practice problems. The first half of the Jan 22 meeting will be to discuss concepts and work on examples related to Kay vII:1-2 (non-random parameter estimation basics, MVU estimators). The Jan 22 meeting will conclude with a 60-minute quiz on these topics.

Makeup policy: You must notify the instructor and schedule a makeup quiz **in advance** if you are unable to attend class. Failure to schedule a makeup quiz in advance will result in a grade of zero on that quiz.

A Kalman filter MATLAB project will be assigned prior to the Spring break. This project is worth one quiz. The project is due prior to the start of the first class meeting after Spring break.

The grades for this course are based on the average score of the best 12 of 14 quizzes where the Kalman filter project counts as one quiz. The lowest two quiz grades (or the project and the lowest quiz grade) will be dropped.

Class participation bonus: A maximum 5% bonus will be applied to the final grade for students that consistently participate in the class discussions (in the classroom and on Piazza) over the course of the semester. Students are encouraged to answer each other's questions on Piazza.

Course Web Page

The official web page for this course is:

`http://spinlab.wpi.edu/courses/ece531_2013/`

Course materials will be available here. Announcements and Q&A will be posted on Piazza.

END OF SYLLABUS