جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Estimation, Filtering and Detection - EE 252

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	EE 252
Course Title	Estimation, Filtering and Detection
Academic Semester	Spring
Academic Year	2017/2018
Semester Start Date	01/28/2018
Semester End Date	05/24/2018
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Sun Thu

Instructor(s)

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Teaching Assistant(s)

Name	Email
TBA	

Course Information

Comprehensive Course Description	Course Overview EE 252: Estimation, Detection and Filtering This course introduces the basic theory of signal detection and estimation. Signal detection and estimation roughly deals with extraction of information from signals. Since the signals are noisy or corrupted in some unknown manner, detection and estimation is cast in a probabilistic framework. In this sense, estimation and detection falls within the realm of statistical inference. We will cover the following topics: hypothesis testing, signal detection, parameter estimation, and signal estimation. The course will deal with discrete signals. However, depending on the pace of the class and time permitting, we will also cover the previous topics for continuous signals. Applications of estimation theory include any area where inferences and decisions must be made from (noisy) data. These include communications, control, signal processing, biology, computer vision, finance, etc. We will closely follow the required textbook [1], which should be available from the library. We will cover chapters 2, 3, 4, and 5. Time permitting we will also look into chapters 6 and 7. Additional reading materials will be distributed as the class progresses. Prerequisites: We will assume a solid knowledge of probability theory (random variables, distributions, conditional distributions, law of large numbers, etc...). An advanced graduate course on random processes is required (AMCS 241 at KAUST would suffice as a prerequisite). Topics Covered 1. Review of Probability, Bayes Statistical Decision Theory, Bayes Hypothesis Testing 2. Minimax Hypothesis Testing, Neyman-Pearson Hypothesis Testing, ROC curves 3. Composite Hypothesis Testing: Bayes, Uniformly Most Powerful Tests, Locally Optimum Tests 4. Signal Detection: IID Noise Models, Gaussian non-IID Noise Models 5. Signal Detection: Detection of Signals with Random Parameters 6. Evaluation of Signal Detection Procedures: Chernoff Error Bounds, Chernoff-Stein Lemma 7. Sequential Detection: Sequential probability ratio tests, Wald's Identity 8. Parameter Estimation: Bayes Formulation, MMSE, MMAE, MAP estimators 9. Non-Random Parameter Estimation: UMVUE, sufficient and complete statistics, Rao-Blackwell Theorem 10. Information Inequality: Fisher Information, Cramer-Rao Lower Bound 11. Maximum Likelihood Estimation; Asymptotic Properties of MLE: Consistency, Asymptotic effi- ciency, Least squares, Robust Parameter Estimation 12. Recursive Parameter Estimation, EM Algorithm 13. Signal Estimation: Kalman Filter 14. Linear Signal Estimation: Wiener-Hopf equation, Levinson Filter 15. Wiener-Kolmogorov Filter (Non-causal and causal)
Course Description from Program Guide	Estimation: linear and nonlinear minimum mean squared error estimation and other strategies. Linear filtering: Wiener and Kalman filtering. Detection: simple, composite, binary and multiple hypotheses.Neyman- Pearson and Bayesian approaches.
Goals and Objectives	1. Review of Probability, Bayes Statistical Decision Theory, Bayes Hypothesis Testing 1 2. Minimax Hypothesis Testing, Neyman-Pearson Hypothesis Testing, ROC curves 3. Composite Hypothesis Testing: Bayes, Uniformly Most Powerful Tests, Locally Optimum Tests 4. Signal Detection: IID Noise Models, Gaussian non-IID Noise Models 5. Signal Detection: Detection of Signals with Random Parameters 6. Evaluation of Signal Detection Procedures: Chernoff Error Bounds, Chernoff-Stein Lemma 7. Sequential Detection: Sequential probability ratio tests, Wald's Identity 8. Parameter Estimation: Bayes Formulation, MMSE, MMAE, MAP estimators 9. Non-Random Parameter Estimation: UMVUE, sufficient and complete statistics, Rao-Blackwell Theorem 10. Information Inequality: Fisher Information, Cramer-Rao Lower Bound 11. Maximum Likelihood Estimation; Asymptotic Properties of MLE: Consistency, Asymptotic effi- ciency, Least squares, Robust Parameter Estimation 12. Recursive Parameter Estimation, EM Algorithm 13. Signal Estimation: Kalman Filter 14. Linear Signal Estimation: Wiener-Hopf equation, Levinson Filter 15. Wiener-Kolmogorov Filter (Non-causal and causal)
Required Knowledge	We will assume a knowledge of probability theory (random variables, distributions, condi- tional distributions, law of large numbers, etc...) at the graduate level. A graduate level course in random processes is a required prerequisite (a course such as AMCS/EE 241 at KAUST would suffice as a prerequisite).

Reference Texts	H Vincent Poor. An introduction to signal detection and estimation. Springer, 1994.
Method of evaluation	**40.00**% - Final exam **30.00**% - Midterm exam **30.00**% - Homework /Assignments
Nature of the assignments	There will be homework worth 30%, assigned every two weeks.
Course Policies	No late homeworks accepted.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 01/28/2018 Thu 02/01/2018	Review of Probability, Bayes Statistical Decision Theory, Bayes Hypothesis Testing
2	Sun 02/04/2018 Thu 02/08/2018	Minimax Hypothesis Testing
3	Sun 02/11/2018 Thu 02/15/2018	Neyman-Pearson Hypothesis Testing, ROC curves
4	Sun 02/18/2018 Thu 02/22/2018	-Composite Hypothesis Testing: Bayes, Uniformly Most Powerful Tests, Locally Optimum Tests
5	Sun 02/25/2018 Thu 03/01/2018	-Signal Detection: IID Noise Models, Gaussian non-IID Noise Models
6	Sun 03/04/2018 Thu 03/08/2018	-Signal Detection: Detection of Signals with Random Parameters
7	Sun 03/11/2018 Thu 03/15/2018	-Evaluation of Signal Detection Procedures: Chernoff Error Bounds, Chernoff-Stein Lemma
8	Sun 03/18/2018 Thu 03/22/2018	-Sequential Detection: Sequential probability ratio tests, Wald's Identity
9	Sun 03/25/2018 Thu 03/29/2018	-Parameter Estimation: Bayes Formulation, MMSE
10	Sun 04/01/2018 Thu 04/05/2018	-Parameter Estimation: MMAE, MAP estimators
11	Sun 04/08/2018 Thu 04/12/2018	-Non-Random Parameter Estimation: UMVUE, sufficient and complete statistics, Rao-Blackwell The- orem
12	Sun 04/15/2018 Thu 04/19/2018	-Information Inequality: Fisher Information, Cramer-Rao Lower Bound
13	Sun 04/22/2018 Thu 04/26/2018	-Maximum Likelihood Estimation; Asymptotic Properties of MLE: Consistency, Asymptotic effi- ciency
14	Sun 04/29/2018 Thu 05/03/2018	-Least squares, Robust Parameter Estimation
15	Sun 05/06/2018 Thu 05/10/2018	-Recursive Parameter Estimation, EM Algorithm
16	Sun 05/13/2018 Thu 05/17/2018	-Signal Estimation: Kalman Filter
17	Sun 05/20/2018 Thu 05/24/2018	-Linear Signal Estimation: Wiener-Hopf equation, Levinson FilterWiener-Kolmogorov Filter
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Note

The instructor reserves the right to make changes to this syllabus as necessary.