Detection and Estimation
EE 6343

This course introduces students with the principles of detection and estimation theory. In particular, detection of known signals as well as signals with random parameters in the face of noise is discussed. Various detection criteria, such as Bayes, minimax, Neyman-Pearson, and minimum probability of error are introduced. Furthermore, maximum a posteriori (MAP), maximum-likelihood (ML), Bayes criteria for deterministic and random parameter estimation as well as minimum mean square estimators (MMSE) and best linear unbiased estimators (BLUE) are thoroughly discussed. Current topics in the field, such as RAKE receivers for diversity reception wireless receivers and a large class of closed-loop phase, frequency, and time synchronizers are discussed.

Course Outline:

1. Hypothesis Testing
    a. Bayes Criterion
    b. Minimum Probability of Error Criterion
    c. Neyman-Pearson Criterion
    d. Minimax Criterion
    e. Multiple Measurements
    f. Composite Hypothesis Testing
    g. Unknown A Priori Information
    h. Receiver Operating Characteristic
2. Detection of Known Signals in Noise
    a. The Likelihood Functions
    b. A White Gaussian Noise Channel
    c. Matched Filters
    d. Binary and M-ary Communication Systems
    e. Digital Approach
3. Detection of Signals with Random Parameters in Noise
    a. Detection of Signals with Random Phase
    b. Noncoherent Communication Systems
    c. The Quadratic Receivers
    d. Detection of Signals with Random Phase and Amplitude Signals
    e. Detection of Signals with Random Time of Arrival
    f. Digital Approach

4. Detection of Signals in Colored Gaussian Noise
   a. Karhunen-Loeve Expansion
   b. Detection of Known Signals
   c. Receiver Performance
   d. Optimum Signal Waveform
   e. The Likelihood Function
   f. Detection of Signals with Random Parameters in the Face of Colored Gaussian Noise
5. Estimation Theory (Introduction)
   a. Least-Square Estimate
   b. Filtering, Smoothing, and Prediction
6. Random Parameter Estimation
   a. Bayes Estimator
   b. Minium Mean Square Estimator (MMSE)
   c. Maximum A Posteriori (MAP) Estimators
   d. Maximum-Likelihood (ML) Estimators (MAP)
   e. Properties of Estimators
      - Efficient Estimators
      - Unbiased Estimators
      - Consistent Estimators
      - Sufficient Estimators
   f. Best Linear Unbiased Estimators (BLUE)
   g. Properties of Cost Function
7. Real Parameter Estimators
   a. Minimum Variance Estimators
   b. Maximum-Likelihood (ML) Estimators
8. Cramer-Rao Bound for
   a. ML Estimator and its Properties
   b. MAP Estimators and its Properties
9. Multiple Parameter Estimation
   a. Random Parameters Estimation (MAP)
   b. Deterministic Parameters Estimation (ML)
   c. Bounds on Estimation Error
10. Estimation of Signal Parameters in the Face of an AWGN
   a. Estimation of Amplitude
   b. Estimation of Phase

c. Estimation of Time of Arrival
  - Baseband Signals
  - Narrowband Signals

d. Joint ML Estimator of Frequency and Time of Arrival

11. Estimation of Signal Parameters in the Face of Colored Gaussian Noise
  a. Estimation of Phase
  b. Estimation of Phase
  c. Estimation of Time of Arrival
    - Baseband Signals
    - Narrowband Signals

12. Generalized Likelihood Function (Detection & Estimation)
  a. Unknown Phase
  b. Unknown Phase and Frequency
  c. Unknown Phase, Frequency, and Amplitude
  d. Unknown Phase, Frequency, Amplitude, and Time Arrival

Instructor: *Dr. Kamran Kiasaleh, EC 4.914, (214) 690–2990.*
Prerequisite: EE6349 (or equivalent) and knowledge of basic communications systems.

Required

Texts:

1. *Detection, Estimation, and Modulation Theory Vol I by Harry L. Van Trees, Wiley.*
2. *Detection of Signal in Noise by A. Whalen, Academic Press, Inc.*

Recommended

Texts:

1. *Statistical Signal Processing, Detection, Estimation, and Time Series Analysis by L. L. Scharf, Addison Wesley.*
2. *Optimal Filtering by Anderson and Moore, Prentice Hall.*
3. *Selected IEEE Journals.*

Homework: Assigned biweekly (no late homework accepted)

Tentative Grading Policy:

HW	15%
Exam 1	35%
Final Exam	50%