

Tentative List of Topics - EE602

Statistical Signal Processing

1. Basics of Random Signals and Probability Analysis
2. Introduction to Signal Estimation
 - a. *Parameterized Likelihood Formulation*
 - b. *Optimal Estimation*
 - c. *Mean and Variance Characterization*
3. Scalar Parameter Cramer-Rao Lower Bound
 - a. *CRLB Derivation*
 - b. *CRLB for Gaussian Estimation*
 - c. *Practical Example: Communication Synchronization, CRLB*
4. Vector Parameter Cramer-Rao Lower Bound
 - a. *Vector parameter estimation formulation*
 - b. *Brief introduction to properties of positive definite and semi definite matrices*
 - c. *Vector parameter CRLB derivation*
 - d. *CRLB for Linear estimation in White Gaussian Noise*
 - e. *Practical Example: Image Filtering*
5. Maximum-Likelihood Estimation
 - a. *Optimal estimators for White and Colored Noise*
 - b. *Examples and Applications*
 - c. *MLE for parameter functions*
 - d. *Sequential Least Squares*
 - e. *Expectation-Maximization Algorithm and Examples*
6. Bayesian Estimation
 - a. *Minimum Mean Squared Estimation*
 - b. *Linear MMSE Approximation*
 - c. *Wiener and Optimal MMSE filtering*
 - d. *Bayesian Cramer-Rao Lower Bounds*
 - e. *Maximum A posteriori Estimation*
7. Kalman Filtering
 - a. *Introduction to State-Space Modeling*
 - b. *Introduction to Kalman estimation and tracking*
 - c. *Derivation of the Forward and Backward Scalar Kalman Filter*
 - d. *Extension to vector Kalman filter.*
 - e. *Practical examples from Computer vision, robotics and Wireless Communications*
8. Introduction to Signal Detection

- a. *Formulation of the binary hypothesis testing problem*
- b. *Maximum Likelihood based Optimal Detection*
- c. *Likelihood Ratio Test and Performance*
- d. *Neyman Pearson Criterion for optimal detection*
- e. *Minimum probability of error detector*
- f. *Bayesian minimum risk detector*

9. Detection of Deterministic Signals

- a. *Matched Filter Detector*
- b. *Development of the optimal detector in white and colored Noise*
- c. *Performance of MF detection*
- d. *Multiple Hypothesis testing and asymptotic performance*
- e. *Practical examples: Synchronization, Face detection, Wireless Sensor Networks etc.*

10. Detection of Random Signals

- a. *Introduction of Random Signal Detection*
- b. *Derivation of the energy detector*
- c. *Estimator Correlator for Arbitrary covariance based optimal detection*
- d. *Performance analysis of Random signal detection*
- e. *Practical examples: Cognitive radio scenarios*

11. Signals with unknown Parameters

- a. *Deterministic Signals with unknown parameters*
- b. *Generalized Loglikelihood Ratio Test (GLRT)*
- c. *Bayesian Approach*
- d. *Practical Examples: Sinusoidal Detection*
- e. *GLRT for the Linear Model*
- f. *Asymptotic Performance of Energy Detection*
- g. *Asymptotic performance of GLRT for Linear Model*
- h. *Incompletely known Signal covariance based detection*
- i. *Weak signal detection*

12. Sequential and Model Change Detection

- a. *Sequential Likelihood Ratio Test*
- b. *Average number of Required Observations for Sequential Testing*
- c. *Introduction to Model Change detection*
- d. *Multiple Change time detection*
- e. *Time varying statistics based process detection*