Detection and Estimation Theory (CT505)
Credit Structure: 3-0-0-3
Instructor: Srimanta Mandal

Objective:
Different problems in signal processing and communication involve detection and processing of the signals to make inference. In practical scenario, the signals could be noisy. The objective of this course is to provide fundamental and theoretical concepts to develop frameworks such that the inference problem can be addressed in those areas.

Contents:

- Foundations
  - Probability: conditional probability, PDFs, Continuous random variable, Functions of random variables, Characteristic Functions, Expectation and Moments, Central Limit Theorem.
  - Linear Vector Spaces, Hilbert Spaces
  - Constrained and unconstrained optimization

- Detection theory
  - Detection in the Presence of Unknowns: Random Parameters, Non-random parameters
  - Detection of Signals in Gaussian Noise: White Gaussian, Colored Gaussian, Spectral detection
  - Detection in the Presence of Uncertainties: Unknown signal and Noise parameters
  - Non-Gaussian Detection Theory: Robust Hypothesis Testing, Non-Parametric Model Evaluation, Partially Known Signals and Noise, Partially Known Signal Waveform, Partially Known Noise Amplitude Distribution, Non-Gaussian Observations

- Estimation theory
  - Terminology in Estimation Theory
  - Minimum variance unbiased estimation: Unbiased estimators, Minimum variance criterion, Existence and search of the minimum variance unbiased estimator, Extension to a vector parameter.
  - Cramer-Rao Lower Bound: Signals in white Gaussian noise, parameter transformation, vector parameter, general Gaussian case, and WSS Gaussian random process.
Parameter Estimation via Bayesian: Bayesian linear model, nuisance parameter, Bayesian Estimation for Deterministic Parameters, Risk Functions, MMSE and MAP Estimator, Sequential Linear MMSE estimators, Wiener Filtering.

Kalman Filtering

Outcome:
After completion of the course, students shall be equipped with different techniques of detection and estimation theory. This will be useful for addressing different research problems in the areas of communications, signal processing, control, etc.

Evaluation Policy:

1st In-semester Exam: 25%
2nd In-semester Exam: 25%
Final Exam: 40%
Transcript Preparation: 10%

References: