GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3724116
Semester – II
Subject Name: Detection and Estimation Theory

Type of course: Program Core

Prerequisite: Basic knowledge of Signal and Systems

Rationale: The course aims at providing insight into various signal detection and estimation methods. It also aims to explore adaptive filter process for signals with emphasis on signal estimation as these are key issues in signal processing for various communication systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1.	Review of Vector Spaces: Vectors and matrices: notation and properties, orthogonality and linear independence, bases, distance properties, matrix operations, Eigen values and eigenvectors.	**7**
2.	Properties of Symmetric Matrices: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices, principal component analysis (PCA), singular value decomposition.	**8**
3.	Stochastic Processes: Time average and moments, ergodicity, power spectral density, covariance matrices, response of LTI system to random process, cyclo-stationary process, and spectral factorization.	**8**
4.	Detection Theory: Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes‘ criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.	**8**
5.	Estimation Theory: Minimum variance estimators, Cramer-Rao lower bound, examples of linear models, system identification, Markov classification, clustering algorithms.	**6**
6.	Topics in Kalman and Weiner Filtering: Discrete time Wiener-Hopf equation, error variance computation, causal discrete time Wiener filter, discrete Kalman filter, extended	**8**

	Kalman filter, examples. Specialized Topics in Estimation: Spectral estimation methods like MUSIC, ESPIRIT, DOA Estimation.	
Total		45

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks (100)					
R Level	U Level	A Level	N Level	E Level	C Level
10	**30**	**30**	**20**	**5**	**5**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

[1] Steven M. Kay, "Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory", Prentice Hall, 1993
[2] Steven M. Kay, "Fundamentals of Statistical Signal Processing, Volume II: Detection Theory", 1st Edition, Prentice Hall, 1998
[3] Thomas Kailath, BabakHassibi, Ali H. Sayed, "Linear Estimation", Prentice Hall, 2000.
[4] H. Vincent Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer, 1998.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the mathematical background of signal detection and estimation	40%
CO-2	Use classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.	30%
CO-3	Derive and apply filtering methods for parameter estimation.	30%

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List of Experiments / Assignments:

1. Simulate signal and noise models.
2. Simulate spatially separated target Signal in the presence of Additive Correlated White Noise.
3. Simulate spatially separated target Signal in the presence of Additive Uncorrelated White Noise
4. Simulate spatially separated target Signal in the presence of Additive Correlated Colored Noise
5. Detect Constant amplitude Signal in AWGN
6. Detect Time varying Known Signals in AWGN
7. Detect Unknown Signals in AWGN
8. Compare performance comparison of the Estimation techniques - MLE, MMSE, Bayes Estimator, MAP Estimator, Expectation Maximization (EM) algorithm
9. Performance comparison of conventional Energy Detectors and Coherent Matched Filter Techniques

Major Equipment:

Computational lab or facility with the following software or their equivalent:

(1) MATLAB signal processing toolbox
(2) Python

List of Open Source Software/learning website:

(1) NPTEL Video lectures
(2) SciLab