EC419: Adaptive Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Adaptive Signal Processing	3	0	2	NIL

Course Objective: Adaptive signal processing involves development of various adaptation algorithms and assessing them in terms of convergence rate, computational complexity, robustness against noisy data, hardware complexity, numerical stability etc. This course demonstrates the design of important class of adaptive filters, LMS, RLS and Kalman filters.

Course Outcomes:

CO1: Apply linear and non-linear adaptive filters to solve signal processing and filtering problems.

CO2: Analyze stationary processes, stochastic models, and correlation matrices for process characterization.

CO3: Demonstrate Wiener filter concepts, including minimum mean squared error and channel equalization.

CO4: Evaluate LMS and RLS algorithms for adaptive filtering and their stability in dynamic systems.

CO5:Implement Kalman filter techniques for recursive state estimation and filtering in real-time systems.

S. No.	Content	Contact Hours
Unit 1	**INTRODUCTION:** The filtering problem, Adaptive filters, linear filter structures, approaches to the development of linear adaptive filter algorithms, real and complex forms of adaptive filters, non-linear adaptive filters, Applications. **STATIONARY PROCESSES AND MODELS:** Partial characterization of a discrete time stochastic process, mean ergodic theorem, correlation matrix, correlation matrix of sine wave plus noise, stochastic models, wold decomposition, asymptotic stationarity of an auto regressive process. Complex Gaussian process.	8
Unit 2	**WIENER FILTERS:** Linear optimum filtering problem statement, principle of orthogonality,	8

	minimum mean squared error, Wiener hopf equations, error performance surface. Channel equalization. Linearly constrained minimum variance filter, generalized side lobe cancellers.	
Unit 3	**LINEAR PREDICTION:** Forward Linear Prediction, backward Linear Prediction, Levinson-Durbin algorithm, properties of prediction error filters, Schur-Cohntest, auto regressive modeling of a stationary stochastic process, Cholesky factorization, lattice predictors, joint process estimation, block estimation. **Method of steepest descent:** Steepest descent algorithm, stability of the Steepest descent algorithm.	8
Unit 4	**LEAST MEAN SQUARE (LMS) ALGORITHM:** Overview of the structure and operation of the Least Mean square Algorithm, Least Mean square adaptation Algorithm, stability and performance analysis of the LMS algorithm. Normalized Least Mean Square (NLMS) Algorithm, Concept of method of least squares. **RECURSIVE LEAST SQUARES (RLS) ALGORITHM:** The matrix inversion lemma, the exponentially weighted RLS algorithm, update recursion for the sum of weighted error squares. Convergence analysis of the RLS algorithm.	10
Unit 5	**KALMAN FILTERS:** Recursive minimum mean square estimation for scalar random variables, statement of the Kalman filtering problem, the innovations process, estimation of the state using the innovations process, filtering, initial conditions, variants of the Kalman filter, extended Kalman filtering.	8
	Total	42

Books:-

S. No	Name of Books/Authors/Publisher
1	S. Haykin, Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001.
2	Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.
3	B. Farhang-Boroujen, Adaptive Filters: Theory and Applications, John Wiley and Sons, 2013.
4	Manolakis D. G., V. K. Ingle, and S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, Inc., 2000.
5	John G. Proakis, Dimitris G.Manolakis, Digital Signal Processing, Principles, Algorithms and Applications , Pearson Education / PHI, 2007.