Adaptive Signal Processing

Course Information

Course Objective: This course focuses on problems, algorithms, and solutions for processing signals in an manner that is responsive to a changing environment. Adaptive signal processing systems are developed which take advantage of the statistical properties of the received signals. The course analyzes the performance of adaptive filters and considers the application of the theory to a variety of practical problems such as interference and echo cancellation, signal and system identification, and channel equalization. The class is designed as an advanced statistical signal processing course in which students will build a strong foundation in approaching problems in such diverse areas as acoustic, sonar, radar, geophysical, biomedical, and communications signal processing. Understanding of the theoretical foundations of adaptive signal processing theory will be achieved through a combination of theoretical and computer-based homework assignments.

Detailed Course Outline:

PART I: BACKGROUND MATERIAL AND LINEAR OPTIMUM FILTERING

Background Material (Haykin 1-4)

- □ Adaptive filtering: Concepts and applications
- □ Discrete-time signal processing
- □ Stationary processes and models
- □ Spectrum analysis
- □ Linear algebra: Eigenanalysis and matrix decompositions

Wiener Filters (Haykin 5)

- □ Minimum mean square error (MMSE) and the orthogonality principle
- □ Digital Wiener filter and Wiener-Hopf equations
- □ Constrained linear MMSEE
- □ Applications: Minimum variance beamforming

Linear Prediction (Haykin 6)

- □ Forward and backward prediction
- □ Levinson-Durbin algorithm
- □ Lattice filters
- □ Applications: DPCM speech coding

PART II: ADAPTIVE FILTERING METHODS

Stochastic Methods (Haykin 8-10)

- □ Steepest Descent algorithm
- □ Least-Mean-Square (LMS) algorithm
- □ Properties of the LMS
- □ Normalized and frequency-domain LMS
- □ Gradient adaptive lattice methods
- □ Recursive LMS (RLMS) for adaptive IIR filtering
- □ Applications: Active noise control and echo-cancellation

Least Squares Methods (Haykin 11-15)

- □ Least squares and orthogonality
- □ Recursive least squares adaptive algorithms
- □ Properties of RLS
- □ Applications: ADPCM speech encoding

Non-Linear Methods (Haykin 18-20)

- □ Adaptive filters based on higher-order moments
- □ Adaptive filters based on lower-order moments
- □ Applications: Blind channel equalization