Signal Processing Seminar

Title: Detection, Estimation, and Beamforming for Adaptive Sensor Arrays: Algorithms and Performance

Speaker: Dr. Christ D. Richmond
MIT Lincoln Laboratory

Date: Wednesday, April 29, 2009
Time: **3**:00 - 4:00 pm
Where: 4269 Beckman Institute

Abstract: A class of adaptive detection and estimation algorithms that exploit the spatial and temporal diversity available from sensor array systems in order to provide robust signal detection and parameter estimation under rather adverse/non-ideal conditions has emerged over the past thirty years. These arrays are often deployed in high multipath environments plagued by limiting interference with unknown statistics. A uniformly most powerful test does not exist for this class of problems. Consequently, optimal detection and estimation rely heavily upon maximum-likelihood (ML) estimates of unknown parameters, including use of data sample covariance matrix. Analyses embracing practicalities such as finite sample support, array response uncertainty/mismatch, nonstationarity, and nonlinear parameter estimation are quintessential for the design of systems requiring precision and robustness, e.g., adaptive radar/sonar systems.

This talk presents an overview analysis of this class of adaptive algorithms, addressing the aforementioned issues of practical interest via the use of random matrix theory. Specifically, the receive operation characteristics are considered for the detector class that includes the adaptive matched filter, Kelly/Khatri's generalized likelihood ratio test, Conte/Scharf's adaptive coherence estimator, and the two-dimensional adaptive sidelobe blanker. The mean squared error (MSE) performance of the signal parameter estimation class that includes the nonlinear ML estimator and the Capon-minimum variance distortionless response beamformer/estimator often used for frequency and/or angle estimation is considered. The MSE performance is considered below threshold where local error performance bounds, like the Cramér-Rao bound, are not useful. Lastly, some discussion of robust sample covariance-based adaptive beamforming is provided and new results/insights on the statistical relationships between conventional and adaptive processing are presented.

Bio: BS, Mathematics, Bowie State University; BS, Electrical Engineering, University of Maryland, College Park; EE, SM, and PhD, Electrical Engineering, Massachusetts Institute of Technology

Dr. Richmond's work consists of theoretical and algorithm development in the general area of detection and parameter estimation theory applied to diverse types of adaptive sensor array systems often deployed in complex (high multipath) environments dominated by limiting interference. His work has been applied to airborne radar, sonar underwater acoustic systems, and multiple-input multiple-output (MIMO) communication systems, and includes signal processing development in space-time adaptive processing (STAP), adaptive beamforming, spectral analysis, performance bounds (Bayesian, non-Bayesian, and non-asymptotic) on parameter estimation (e.g., maximum-likelihood estimation of signal range, Doppler, and/or angle) and receiver operation characteristics (probability of detection vs. false-alarm rate).