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

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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.

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Bryan Hall, Room 305
Host: Arye Nehorai

Bio: Christ D. Richmond received his a B.S. in Electrical Engineering from the University of Maryland in College Park, and a B.S. in Mathematics from Bowie State University. He received his S.M., E.E., and Ph.D. degrees in electrical engineering from the Massachusetts Institute of Technology (MIT), Cambridge.

He is currently a member of the technical research staff at MIT Lincoln Laboratory, Lexington. His research interests include detection and parameter estimation theory, sensor array and multichannel signal processing, statistical signal processing, random matrix theory, radar/sonar signal processing, multivariate statistical analysis, information theory, multiantenna detection, multi-input multi-output (MIMO) systems, and wireless communications.

Dr. Richmond is the recipient of the Office of Naval Research Graduate Fellowship Award 1990-1994, the Alan Berman Research Publications Award March 1994 (Naval Research Laboratory), and the IEEE Signal Processing Society 1999 Young Author Best Paper Award in area of Sensor Array and Multi-channel (SAM) Signal Processing.