Spatio-Temporal Spectral Analysis by Eigenvalue Decomposition of a Signal AOA Matrix

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Summary

In this paper we investigate the estimation of the angles of arrival and the center frequencies of multiple narrowband sources. The simplest case, in which all the sources with a known common center frequency are located in the same plane as the sensor array, can be viewed as a one-dimensional (1-D) spectral problem. But, generally speaking, the sources have unknown and different center frequencies, and the sources are not located in the same plane as the sensor array so that the angle of arrival (AOA) of an incident source is a vector, $\boldsymbol{\theta} = (\alpha, \beta)$. Thus, this problem of the simultaneous estimation of AOA's and center frequencies of multiple narrowband sources can be regarded as a three-dimensional (3-D) spectral estimation problem. In recent years, many multi-dimensional spectral estimation methods have been proposed. Most of these methods have to carry out multi-dimensional searches to get the "peaks" of the spectrum; this requires too many computations to be used in practice. This paper presents a new high resolution method for solving this 3-D problem. We first formulate the signal model for a rectangular sensor array with delay taps. Then we form auto-covariance and cross-covariance matrices by using the sampled data from the rectangular sensor array and its delay taps. A signal AOA matrix is defined by the cross-covariance matrix and the largest eigenvalues and corresponding eigenvectors of the signal matrix. Without any searches, this method is very effective in computation. Computer simulation results are given to illustrate the performance of the method.

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