Low complexity and high accuracy angle of arrival estimation using eigenvalue decomposition with extension to 2D AOA and power estimation

Saleh O Al-Jazzar1*, Artem Muchkaev2, Ahmad Al-Nimrat3 and Mahmoud Smadi3

Abstract
In this paper, an angle of arrival (AOA) estimator is presented. Accurate AOA estimation is very crucial for many applications such as wireless positioning and signal enhancement using space processing techniques. The proposed estimator is based upon applying the eigenvalue decomposition (EVD) method on the crosscorrelation matrix of the received signals at two sides of the antenna array doublets. The proposed method is named the eigenvalue-decomposition-based AOA (EDBA) estimator. In comparison with the ESPRIT algorithm, the EDBA has less complexity because the decomposition in the EDBA method is performed only once and on a smaller matrix dimension than that in the ESPRIT algorithm where the decomposition is performed twice. The other advantage is that the EDBA method has better performance than the ESPRIT algorithm. The EDBA is also extended to two-dimensional (2D) AOA estimation with automatic pairing in two ways. The first one performs the 2D AOA estimation by considering the eigenvalues of the crosscorrelation matrix to estimate the azimuth angles and their corresponding eigenvectors to estimate their corresponding elevation angles. Thus, the 2D AOA estimation is performed with automatic pairing and without the need for any pairing or searching techniques. The second 2D AOA extension of the EDBA is named the Two-EDBA estimator. This second 2D estimator performs the pairing between the azimuth and elevation angles using the alignment of the eigenvalues’ magnitudes. An additional advantage for the Two-EDBA estimator is the fact that it provides an estimate for the received signal power paired automatically with its corresponding AOA estimate. Simulations of the proposed EDBA method and its 2D extensions with the signals’ power estimation are shown to assess their performance.

1 Introduction
Many applications require accurate estimation of the angle of arrival (AOA) of the received signal. Examples of these applications are signal reception enhancement [1,2] and accurate wireless positioning [3,4]. Many effects cause errors in the AOA estimation. An error in the AOA estimate can cause huge error when locating wireless devices or an increase in the bit error rate when detecting the received signal. Thus, it is of interest to develop techniques to estimate the AOA accurately.

In some cases, it is required to estimate two-dimensional (2D) angles, i.e., the azimuth and elevation angles. Besides the accuracy requirement for estimating both the azimuth and elevation angles, it is of interest to pair them for each of their corresponding source. The complexity of the estimator is another issue that requires the designers of the estimator to take care of. Also, in 2D AOA estimation, the antenna array geometry plays an important role in the estimation procedure. In this paper, we will assume two antenna array geometries and we will provide a 2D estimator, based upon the proposed estimator, for each of these geometries. The first one is the rectangular antenna array shape formulated from two-parallel uniform linear arrays (ULAs). The