Performance Evaluation of Enhanced MUSIC-Based Multi-User DoA Estimation Using Embedded Radiation Patterns for Millimeter-Wave Communication Systems

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Abstract

Integrating radiation patterns into the multiple signal classification (MUSIC) algorithm is a critical advancement for enhancing Direction of Arrival (DoA) estimation. DoA estimation accuracy is essential in modern 5G/6G Base Stations to enable precision beamforming, spatial multiplexing, and high-accuracy localization. Traditional MUSIC algorithms ignore the antenna elements' radiation patterns and mutual coupling. The contribution of this paper is the replacement of the conventional steering vectors (CSV) with the rigorous steering vector for millimeter wave systems. Enhancing MUSIC-based DoA estimation algorithm using embedded radiation elements pattern (ERP) for multiple users is achieved by designing a microstrip antenna array, which operates in millimeter wave at 28 GHz using Rogers RT/Duroid 5880 substrate material, using Ansys electronic desktop. The simulated results evaluate the DoA performance in terms of root mean square error (RMSE) across the range of signal-to-noise ratios SNR∈[-20 dB,10 dB] and different numbers of users, under the assumption of 100 snapshots. Both conventional and rigorous methods for presenting steering vectors achieve competitive DoA estimation for the single-user case. The ERP steering vector (ERPSV) method performs better than CSV for multi-user in noisy environments, with a low SNR value. ERPSV achieves zero RMSE for 9 users simultaneously at the SNR value 10 dB, while CSV fails to distinguish 2 users at the SNR less than 5 dB. The results achieved are presented in more detail in the simulated results section.

Keywords

CSV, Direction of arrival DoA, enhanced MUSIC, ERPSV.