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Decomposition of Antenna Array and their Two-way Radiation Characteristics to Enhance ESPRIT Estimation of Angle-of-arrival for Vehicular ADAS Applications

Shih-Kai Ho [(1)], Hsi-Tseng Chou [(1]
(1) National Taiwan University, Taipei, Taiwan; e-mail: f06942018@ ntu.edu.tw; chouht@ntu.edu.tw

Estimating signal parameters via rotational invariance (ESPRIT) is widely employed in the vehicular advanced driver assistant system (ADAS) for high-resolution echo signal detection (determining the signal's direction of arrival (DoA)) from nearby vehicles. The ADAS implements multiple transmitting (TX) and receiving (RX) antennas, which follow the ESPRIT algorithms to produce the basic MIMO mechanisms. The two key factors of ESPRIT for high-resolution estimation are increasing the echo signal strength and forming identical configurations for its two position-offset arrays. The former improves the S/N ratio to increase the correlation matrix's eigenvalues compared to the noises, while the latter is a stringent requirement in the ESPRIT process for DoA estimation. Especially the offset between the two ESPRIT arrays determines the valid range of detection angles. Thus, when the array sizes are increased to enhance the signal strengths, the oversized period will cause grating lobes to bring in the wide-angle alias signals.

This paper presents a new subarray decomposition technique to effectively produce the two ESPRIT arrays such that the signal strengths can be enhanced without causing grating lobes. In particular, the technique is applied to the ESPRIT MIMO mechanisms of creating virtually overlapped subarrays. The decomposition produces the subarrays in spatial and spectral domains with continuous antenna element distribution to fill the gap between the ESPRIT's two antenna arrays and thus avoiding the grating lobes of incurring alias signals.

In this paper, the decomposition procedure is first summarized. Afterward, the radiation characteristics of the TX/RX two-way propagation are demonstrated to show their behaviors in the array signal processing. Particular attention is placed on the gain strength in beam steering to enhance the coverage ranges. The singular-value decomposition (SVD) technique is employed to estimate the effectiveness of ESPRIT beamforming. Numerical simulations will be presented to validate the feasibility of the proposed approach. The reduction of the proposed technique to the angular beam-space ESPRIT algorithms will also be shown to support its theoretical validity.

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