Calibration algorithm for gain-phase and mutual coupling errors in uniform linear array

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Abstract

The effect of gain-phase perturbations and mutual coupling between antennas significantly degrades the performance of digital array radar (DAR). This paper concerns about array calibration in the scenario where the true azimuths of auxiliary sources deviate from nominal values but the angle intervals between them are known. Making use of the special structure of gain-phase matrix and mutual coupling matrix (MCM) in uniform linear array (ULA), a simplified form of distortion matrix is developed. It is utilized in the algorithm to obtain the least-square estimation of distortion matrix based on the orthogonal characteristic between signal subspace and noise subspace. The algorithm achieves considerable improvement in estimation accuracy due to the reduction of unknown parameters and rarely suffers from ambiguous problems. It requires only one auxiliary source with the help of rotation platforms. Simulation results demonstrate the validity, robustness and high performance of the proposed algorithm. Finally, experiments are carried out by an S-band DAR test-bed with eight antenna elements. The expected results of measured data show that the proposed algorithm is practical and effective in actual circumstance.

Introduction

Digital array radar (DAR) employs a full digital beam-forming (DBF) architecture in receiving and transmitting system. It has the potential of forming multiple simultaneous beams while proving improved dynamic range and anti-interference ability. In the last decades, it has attracted considerable attention and is widely used in space surveillance. 1-2 Most array signal processing algorithms such as DBF and direction of arrival (DOA) relay crucially on the assumption that the array manifold is perfectly known. In actual systems, the array manifold is inevitably affected by gain-phase perturbations and mutual coupling effects, which will seriously degrade the performance of DAR. 3

Traditional way to obtain calibration information is to carry out measurements using computational electromagnetic solvers. It has been applied in some actual radar systems for channel calibration. 4-5 The algorithm is useful for initial calibration, but it is time consuming and has high demands for environments. As a result, it may be impractical during the operation of array systems.

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References

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