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An Improved Adaptive Dot-Shape Beamforming Algorithm Research on Frequency Diverse Array

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Abstract : Frequency diverse array (FDA) beamforming is a technology developed in recent years, and its antenna pattern has a unique angle-distance-dependent characteristic. However, the beam is always required to have strong concentration, high resolution and low sidelobe level to form the point-to-point interference in the concentrated set. In order to eliminate the angle-distance coupling of the traditional FDA and to make the beam energy more concentrated, this paper adopts a multi-carrier FDA structure based on proposed power exponential frequency offset to improve the array structure and frequency offset of the traditional FDA. The simulation results show that the beam pattern of the array can form a dot-shape beam with more concentrated energy, and its resolution and sidelobe level performance are improved. However, the covariance matrix of the signal in the traditional adaptive beamforming algorithm is estimated by the finite-time snapshot data. When the number of snapshots is limited, the algorithm has an underestimation problem, which leads to the estimation error of the covariance matrix to cause beam distortion, so that the output pattern cannot form a dot-shape beam. And it also has main lobe deviation and high sidelobe level problems in the case of limited snapshot. Aiming at these problems, an adaptive beamforming technique based on exponential correction for multi-carrier FDA is proposed to improve beamforming robustness. The steps are as follows: first, the beamforming of the multi-carrier FDA is formed under linear constrained minimum variance (LCMV) criteria. Then the eigenvalue decomposition of the covariance matrix is performed to obtain the diagonal matrix composed of the interference subspace, the noise subspace and the corresponding eigenvalues. Finally, the correction index is introduced to exponentially correct the small eigenvalues of the noise subspace, improve the divergence of small eigenvalues in the noise subspace, and improve the performance of beamforming. The theoretical analysis and simulation results show that the proposed algorithm can make the multi-carrier FDA form a dot-shape beam at limited snapshots, reduce the sidelobe level, improve the robustness of beamforming, and have better performance.

Keywords : adaptive beamforming, correction index, limited snapshot, multi-carrier frequency diverse array, robust
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