Baseline Optimization of CIDF Arrays for accurate DOA estimation

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Direction finding (DF) systems are now being widely adopted in many applications, such as radio navigation, transmitter identification, and mobile device tracking. These DF systems usually use antenna arrays to estimate radio source directions by comparing amplitude differences and phase delays of the received array signals. Therefore, the baseline, which is a term indicating a line that is chosen for amplitude and phase comparisons, should be carefully determined for accurate direction of arrival (DOA) estimation. For instance, a long baseline of greater than a half wavelength improves estimation resolutions but simultaneously generates grating lobes that lower the estimation accuracy in the system. On the other hand, a short baseline of roughly less than 0.1 wavelengths, usually in a lower frequency band, may results in amplitude and phase differences between received signals that might be too ambiguous to distinguish from each other. This ambiguity becomes even more significant when the antenna elements are mounted on a huge platform, since the amplitude and phase of the incoming signals are distorted by wave scattering and coupling effects due to the platform. For this reason, a great deal of effort has been made for DF algorithms (e.g., Bartlett's beamformer and eigenspace-based algorithms). However, these methods generally require high computational load and relatively long processing time for accurate DOA estimation. Thus, the simple DF algorithm of the correlative interferometer (CIDF) is still widely used in many applications because of its low computational load and fast processing time.

In this paper, we propose an optimization method for the baselines of CIDF arrays that will allow accurate DOA estimation over a wide frequency range. In our approach, we will include the entire aircraft geometry to take into account the actual antenna characteristics, such as radiation patterns and mutual coupling, as well as possible platform effects. The CIDF array will be assumed to consist of nine omni-directional antenna elements operating at the VHF/UHF band, and then the combinations of its baselines will be optimized using a genetic algorithm in conjunction with the FEKO EM simulator developed by EM Software and Systems. DOAs will be estimated with a conventional CIDF algorithm, and the average root mean square error for all angles of interest will be averaged to evaluate each baseline combination. Based on the results obtained, the optimized baselines will also be evaluated using various standpoints to verify the suitability of the optimization method proposed in this paper.

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