Analysis of 3-D Phased Arrays Based on Swarm Aperture

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Airborne drones are advancing in technology, being further miniaturized with longer operating hours. Communication and sensing through a swarm of such mobile platforms are emerging technologies that promise significant impact on both commercial and military applications. Compared to the traditional phased array using solid aperture, swarm aperture utilizes UAVs or flying drones as array elements of a phased array which allows the maximization of spatial resource and a dynamic formation of array configurations.

To avoid the collision risky between each UAVs in swarm aperture, the minimum array element spacing for warm-aperture based phased array is usually larger than one half wavelength. Grating lobe becomes a major issue due to large element spacing when the array elements are uniformly distributed. Aperiodic element placement base on random array concept provides a possible way to solve this problem. For the traditional aperiodic arrays, the randomization is implemented on a 2-D plane, where the average element spacing can be larger than one-half wavelength, but the minimal element spacing can be much smaller than that, which largely increases the risk of collision of UAVs. This paper presents a method by adding an additional degree of freedom through a 3-D randomization of the aperiodic array. Compared to the 2-D aperiodic array, the minimum array element spacing can be largely increased for the 3-D aperiodic array while the same radiation performance is maintained.

For the traditional phased array based on solid aperture, the field of view is limited by the array platform effect. Within a limited scan range, the beamwidth of the radiation pattern is increased when it becomes tangential to the array platform. Conformal array techniques could effectively increase the field of view, but the array aperture efficiency is reduced due to the scan blind spot of the subarrays. In this work, we theoretically demonstrated a full-spherical scanned 3-D aperiodic array based on swarm aperture. The UAV-based array element can be considered as an ideal point source in free space and the array element position is optimized for isotropic property during the scan. The array directivity, beamwidth and peak sidelobe level show almost same within the full-spherical field of view.