Phased Array Antenna Design Based on Swarm Aperture

Junming Diao* and Yuanxun E. Wang
Department of Electrical Engineering
University of California, Los Angeles, CA, USA
diaojunming@gmail.com, ywang@ee.ucla.edu

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.

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 is assumed to be 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. Since the ideal isotropic source is not exist for practical application, an antenna with near isotropic radiation pattern are design and fabricated. The approximate isotropic scanned phased array can be implemented by tiling each non-isotropic element with an optimized angle.

Swarm aperture provides a mobile platform for the phased array design, where the antennas carried by fast moving UAVs can be considered as a time-varying system. The mainlobe of array radiation pattern keeps constant by the real-time beamforming calibration, while the time-average sidelobe level for the array radiation pattern can be largely reduced due to the fast moving of UAVs. A rotational circular-polarized patch array antenna with a large element spacing in wavelength has been designed and fabricated to experimentally demonstrate the time-varying array antenna for interference mitigation. Compared to the time-modulated arrays based on fast switches, the mechanical rotational array shows the advantages of low loss, high aperture efficiency, simple system architecture and wide bandwidth.