Dynamic Metasurface Antennas as an Enabling Platform for Alternative Synthetic Aperture Radar (SAR) Modalities

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Synthetic aperture radar (SAR) systems conventionally use mechanically-actuated reflector dishes or large phased arrays to generate the steerable, directive beams necessary for spotlight mode SAR. While these systems have yielded high-resolution images from far distances, the disadvantages of considerable weight and cost, substantial power consumption, and moving parts are particularly relevant to spaceborne systems. Meanwhile, metasurface antennas have emerged as a capable hardware platform for state-of-the-art microwave imaging applications. These apertures can generate and switch between a multitude of desired radiation profiles at high speeds while maintaining a low-cost, lightweight, and planar form factor. These apertures consist of an electrically-large waveguide loaded with subwavelength radiators, which each selectively leak energy from the guided wave into free space. By tuning each radiating element, we can modulate the aperture's radiation to generate desired patterns, such as steered directive beams, without moving parts or phase shifters.

In addition to their hardware benefits, dynamic metasurfaces can offer alternative SAR modalities for improved performance and added flexibility. In this work, we will briefly discuss how dynamic metasurfaces can conduct existing SAR modalities, e.g. spotlight and stripmap, with performance similar to conventional systems. We will then discuss two additional modalities, enhanced resolution stripmap and diverse pattern stripmap, which may achieve improved performance. These modalities offer the ability to circumvent the trade-off between resolution and region-of-interest size that exists within traditional stripmap and spotlight by using unorthodox radiation profiles in place of conventional, steered beams. Imaging results with a simulated metasurface antenna verify the impact on resolution and region-of-interest in these modalities. Additionally, we discuss the necessary considerations for implementing these methods and analyze how these methods are affected by noise relative to other modalities. Ultimately, the hardware gains coupled with the additional performance modalities made possible by dynamic metasurface antennas have poised them to propel the SAR field forward and open the door to exciting opportunities.