Efficient 3-D Near-Field SAR Imaging for Irregular Scanning Geometries

In this article, we introduce a novel algorithm for efficient near-field synthetic aperture radar (SAR) imaging for irregular scanning geometries. With the emergence of fifth-generation (5G) millimeter-wave (mmWave) devices, near-field SAR imaging is no longer confined to laboratory environments. Recent advances in positioning technology have attracted significant interest for a diverse set of new applications in mmWave imaging. However, many use cases, such as automotive-mounted SAR imaging, unmanned aerial vehicle (UAV) imaging, and freehand imaging with smartphones, are constrained to irregular scanning geometries. Whereas traditional near-field SAR imaging systems and quick personnel security (QPS) scanners employ highly precise motion controllers to create ideal synthetic arrays, emerging applications, mentioned previously, inherently cannot achieve such ideal positioning. In addition, many Internet of Things (IoT) and 5G applications impose strict size and computational complexity limitations that must be considered for edge mmWave imaging technology. In this study, we propose a novel algorithm to leverage the advantages of non-cooperative SAR scanning patterns, small form-factor multiple-input multiple-output (MIMO) radars, and efficient monostatic planar image reconstruction algorithms. We propose a framework to mathematically decompose arbitrary and irregular sampling geometries and a joint solution to mitigate multistatic array imaging artifacts. The proposed algorithm is validated through simulations and an empirical study of arbitrary scanning scenarios. Our algorithm achieves high-resolution and high-efficiency near-field MIMO-SAR imaging, and is an elegant solution to computationally constrained irregularly sampled imaging problems.

**IEEE Access Questions:**

Q: Please add a brief explanation justifying the manuscript type you have chosen. This information will help the Associate Editor and the reviewers during peer review so they evaluate your manuscript with the correct article type in mind.

A:

Our manuscript presents a novel approach to multiple-input-multiple-output synthetic aperture radar (MIMO-SAR) in the near-field for irregular scanning geometries. In this study, we examine existing work on similar problems, develop a new model for decomposing irregular SAR sampling, and propose a novel efficient algorithm to recover high resolution images from dynamic scenarios. Our algorithm is validated in both simulation and empirical studies and compared against existing techniques to yield highly resolved images with low computational complexity.

Q: Please describe how your article fits the scope of IEEE Access. Note, the scope of IEEE Access covers all (but only) IEEE’s fields of interest.

A:

Our manuscript explores novel areas of interest and recent publications in IEEE Access on synthetic aperture radar (SAR) for freehand imaging, irregular scanning geometries, and near-field imaging algorithms and systems. In this study, we pioneer an efficient algorithm for imaging on emerging near-field imaging modalities, for example, drone imaging, freehand imaging, and automotive SAR. Our proposed algorithm is applicable to many 5G and IoT applications in addition to smartphone and automotive SAR imaging.

Q: Please state the unique contributions and advancements your article makes in the related existing literature.

A:

Our manuscript advances near-field synthetic aperture radar (SAR) imaging techniques by offering a joint solution to irregular sampling geometries and multistatic effects to improve the computational complexity over previous techniques. We develop a novel framework to understand and decompose many irregular sampling problems such that a compensation algorithm can be applied to project irregular arrays to virtual regular arrays for efficient image computation. Whereas recent works have promoted system-level design of sub-wavelength localization for irregular near-field SAR, our efficient algorithm enables such mobile smartphone and Internet of Things (IoT) applications through efficient image reconstruction.