Receive-Beamforming-Enhanced Qualitative Inverse Scattering

Matthew J. Burfeindt*(1) and Hatim F. Alqadah(1)
(1) US Naval Research Laboratory, Washington, DC, 20375

The Linear Sampling Method (LSM) is a qualitative inverse scattering algorithm for reconstructing the support of an unknown target. It has several beneficial qualities that motivate study. Unlike traditional radar imaging approaches, it does not make any linear scattering assumptions, and thus has potential for higher fidelity image results. Unlike many quantitative inverse scattering approaches that reconstruct target dielectric properties as well as shape, it does not require nonlinear optimization, and instead only involves solving systems of linear equations.

The major challenge for practical LSM imaging is its need for dense wide-angle spatial sampling in both the transmit and receive apertures, which may not be achievable in some practical scenarios. In this presentation, we present a focal receive beamforming enhancement to the LSM to allow for imaging in scenarios with a densely sampled receive aperture and a sparsely sampled transmit aperture. This scenario results in a highly overdetermined system of linear equations to be solved via conventional LSM, which typically results in highly aberrant imagery. By applying the receive beamforming enhancement, we convert the highly overdetermined LSM linear system to a modestly underdetermined system which may be more easily solved via conventional Tikhonov regularization.

Previous work has investigated beamforming enhancements for quantitative inverse scattering approaches. A focal beamforming approach (Burfeindt et al, *IEEE Trans. Ant. Prop.*, 2013) was developed to improve the performance of the reconstruction against noise. A non-focal approach (Abubakar et al, *IEEE Trans. Ant. Prop.,* 2012) was also developed to reduce the size of the system to be solved at each algorithm iteration. Our technique is distinct in that it is applied to qualitative inverse scattering imaging for the purpose of overcoming the challenge of sparse apertures.

In our presentation, we detail the mathematical development and implementation of the proposed technique. We then demonstrate effective imaging via several examples from simulated data. Lastly, we discuss potential application of the beamforming enhanced technique to hybrid quantitative-qualitative approaches.