Immersion Medium Independent Algorithm for Breast Microwave Imaging

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Biomedical imaging at microwave frequencies has shown potential for breast cancer detection and monitoring. The Universities of Manitoba and Calgary have recently developed an algorithm that combines microwave tomography (MWT) and radar imaging by incorporating radar-derived regional permittivity maps as prior information into a finite element contrast source inversion (FEM-CSI) algorithm (Baran *et. al.*, Pier, 149, 161- 171, 2014). Matching the immersion medium to the dielectric properties of the breast is often regarded as crucial for adequate image reconstruction, however we demonstrate that high quality images are possible in any immersion media when the combined radar/MWT approach is used.

The combined algorithm incorporates prior information into FEM-CSI as a numerical inhomogeneous background. This numerical background allows us to reconstruct the breast's interior in immersion media ranging from air ($\epsilon_b = 1 - j0$) to water ($\epsilon_b = 79 - j4.5$), with varying losses. The quality of the reconstruction depends on the type of prior information used. Including easily obtainable prior information, such as restricting the imaging domain to the breast region and incorporating a user-defined numerical background, helps mitigate the ill-posedness of the inverse problem. Including radar-derived regional permittivity maps eliminates the impact of the immersion medium on the image reconstruction algorithm.

The immersion medium will continue to affect the overall system performance because the obtainable interrogation energy arriving at the receivers from the inside of the breast will depend on the electromagnetic match between the immersion medium and the breast's surface. However, the independence of the reconstruction algorithm to the immersion medium provides us with the flexibility to choose system parameters based on considerations such as the wavelength in the surrounding medium, which affects the size and number of sensors that can occupy the imaging system. Results are presented from synthetic and experimental data that show the consistency in reconstructions using different immersion media. The quality of the reconstructions for varying numbers of antennas and types of prior information are analyzed with metrics to determine the scenarios where this independence holds. Laboratory and numerical experiments are presented using numerical system models for unbounded domains as well as for PEC enclosures.