A Fast and Efficient MoM Forward Solver for Ultrasound Tomography of Inhomogeneous Compressibility and Density Profiles

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Ultrasound tomography can be mathematically formulated as an inverse scattering problem. The unknowns to be found are the quantitative profiles of the object of interest's compressibility and density. Different iterative nonlinear inversion algorithms, such as the Born iterative method (Haynes and Moghaddam, *IEEE Trans. Biomed. Eng.*, 57, 2010), have been proposed to solve this inverse problem. The main computational burden of these inversion algorithms is the utilized forward scattering solver. This is due to the fact that the size of the object, e.g., human breast, is very large compared to the operating wavelength.

Recently, a forward solver based on the Neumann Series expansion has been proposed for ultrasound tomography (Haynes and Moghaddam, *IEEE Trans. Biomed. Eng.*, 57, 2010). Although this forward solver is computationally efficient, it is not appropriate for high contrast objects. To deal with high contrast and large objects, the method of moments (MoM) forward solver may be used. Most of the MoM algorithms for ultrasound inverse scattering assume a constant density profile for the scatterer (Xu et. al., *IEEE Trans. Ultrason., Ferroelectr., Freq. Control*, 48, 2001). To the best of our knowledge, only a few reports which consider the scattering from objects with both inhomogeneous compressibility and density profiles exist in the literature (Lavarello and Oelze, *J. Acoust. Soc. Am.*, 125, 2009). Herein, we present a fast and efficient MoM solver for solving acoustic scattering from objects with independent inhomogeneous compressibility and density profiles.

The proposed MoM solver has some features which make it appropriate to be used with ultrasound inverse scattering algorithms. First, only one row of the MoM matrix is required to be stored. This is critical for large-domain ultrasound tomography problems where the number of discretized elements is very large. Second, we've implemented this MoM forward solver based on the conjugate gradient algorithm (CG) accelerated using the fast Fourier transform (FFT). Third, we have also implemented the marching-on-source position technique, originally used for microwave tomography (De Zaeytijd, *IEEE Trans. Antennas Propag.*, 55, 2007), for this forward solver so that the initial guess for the CG algorithm becomes closer to the final solution. Based on our implementation, we will compare this forward solver with the Neumann series expansion method, showing that this MoM solver is more appropriate for solving the scattering from high contrast and large objects.