Simultaneous Reconstruction of Compressibility and Density Profiles in Multiple–Frequency Acoustic Inverse Scattering

Pedram Mojabi* and Joe LoVetri
Electromagnetic Imaging Lab, Electrical and Computer Engineering Department, University of Manitoba, MB, Canada

In inverse scattering, the goal is to find some properties of the object being imaged from scattered data collected outside the object. Several imaging techniques can be mathematically formulated as inverse scattering problems; e.g., microwave tomography (MWT) and ultrasound tomography (UT). The focus of this paper is on ultrasound tomography. In UT, an appropriate nonlinear inversion algorithm is utilized to determine the compressibility and density profiles of the object being imaged using the scattered pressure data measured outside the object. Having quantitative images of compressibility and density profiles can then be used for several non-destructive imaging applications such as breast cancer imaging (Weiwand et. al., *Inv. Rad.*, 35, 2000).

Several nonlinear inversion algorithms, which have been proposed for MWT, have the potential to be used for UT. For example, the Born iterative method (BIM), originally developed for MWT, has been used for the UT problem (Haynes and Moghaddam, *IEEE Trans. Biomed. Eng.*, 57, 2010). In the work of Haynes and Moghaddam, they have assumed a linear relationship between the compressibility and density profiles of the object being imaged.

In this paper, we present the simultaneous inversion of both compressibility and density profiles using the BIM without imposing prior information about the relationship between these two profiles. Also, we have equipped this BIM with the ability to simultaneously invert multiple-frequency ultrasound data sets. Due to the computational burden of the large-domain multiple-frequency UT problem, we have used a fast regularization technique in conjunction with the inversion algorithm. This regularization technique that has been already used in the MWT problem (Rubæk et. al., *IEEE Trans. Antennas Propag.*, 55, 2007) and (Mojabi and LoVetri, *IEEE Trans. Med. Imag.*, 28, 2009), is a Krylov subspace regularization technique (CGLS), which only requires a few matrix-vector multiplication. This regularization technique is appropriate for the UT problem as it does not require the full storage of the matrix.

Finally, we present some synthetic and experimental results. In the first part, inversion results based on noisy synthetic data will be presented. The objects to be imaged have complex compressibility and density profiles, and are large with respect to the wavelength. In the second part, we show some inversion results from the experimental data collected from the UT system developed in the Electromagnetic Imaging Lab at the University of Manitoba. This system consists of 8 rows of data collection rings, each of which has 32 transducers.