Feasibility of Two-Dimensional Quantitative Sonoelastographic Imaging

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***Abstract*—In this paper, a two-dimensional (2D) quantitative sonoelastographic technique for estimating local shear wave speeds from slowly propagating shear wave interference patterns (termed crawling waves) is presented. Homogeneous tissue-mimicking phantom results demonstrate the ability of quantitative sonoelastographic imaging to accurately reconstruct the true underlying shear wave speed distribution as verified using mechanical measurements. From heterogeneous phantoms containing a 5 or 10 mm stiff inclusion, results indicate that increasing the estimator kernel size increases the transition zone length about boundaries. Contrast-to-noise ratio (CNR) values from quantitative sonoelastograms obtained in heterogeneous phantoms reveal that the 2D quantitative sonoelastographic imaging technique outperforms the one-dimensional (1D) precursor in terms of image noise minimization and contrast enhancement. Experimental results from an embedded porcine liver specimen with an induced radiofrequency ablation (RFA) lesion validate 2D quantitative sonoelastographic imaging in tissue. Overall, 2D quantitative sonoelastography was shown to be a promising new imaging method to characterizing the shear wave speed distribution in elastic materials.**

Keywords-crawling waves; elasticity imaging; shear wave speed

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technique that estimates the vibrational response of soft tissue to forced harmonic oscillation [4]. Regarding this particular qualitative method, high and low vibrational amplitudes are surrogates for soft and hard tissue regions, respectively [5]. With the advent of slowly propagating shear wave interference patterns (termed crawling waves) that are generated using two opposing mechanical sources vibrating at slightly offset frequencies [6], the potential for quantitative sonoelastography was established. Owing to the spatial properties of crawling wave patterns, analysis of such provides a local estimate of the underlying tissue elastic properties, namely shear wave speed distributions [7].

Recently, a one-dimensional (1D) autocorrelation-based sonoelastographic method was developed for local shear wave speed estimation and imaging [8]. For an opposing source pair and assuming plane wave conditions, crawling waves propagate across the image plane and spatial information is confined to the lateral dimension, which validate use of the 1D quantitative sonoelastographic estimator. However, tissue heterogeneities and shear wavefront distortions can produce deviations from the plane wave assumption. Therefore, a two-dimensional (2D) quantitative sonoelastographic technique incorporating both local axial and lateral data in the estimation process may prove more accurate and robust under these conditions. In this paper, we address this hypothesis by introducing a 2D quantitative sonoelastographic imaging te-0030hn are integer values denoting axial and lateral

coordinates, respectively, α denotes the shear wave attenuation coefficient, is the distance between opposing mechanical sources,

denotes the -axis spatial sampling interval, and S and Δ S denote the shear wave number and difference, respectively. Given the crawling wave displacement field described by (1), the shear wave speed in 1D space can be kernel consists of