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Laser Speckle Contrast Based Shear Wave Elasticity Tomography: An Anisotropic Phantom Study

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Background, Motivation and Objective

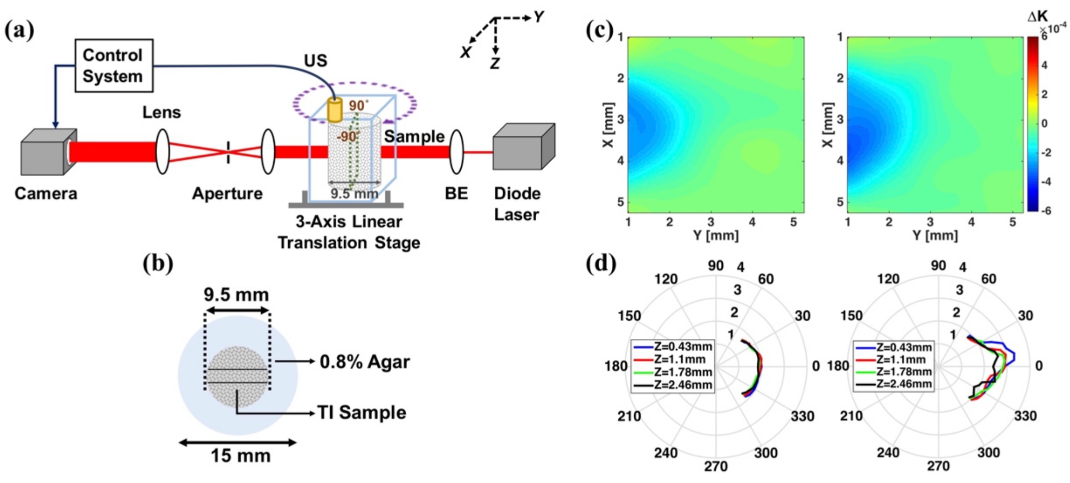
Fiber orientations are known to regulate tissue and organ functions, and abnormality is an indicator of pathological changes. 3D elasticity imaging has been a valuable tool for assessing the inhomogeneities in tissue in applications such as disease characterization and mechanical anisotropy investigation. In our previous study, a 3D laser speckle contrast based shear wave (LSC-SW) tomography system was developed. The system comprises an LSC imaging system and an ultrasound transducer mounted on a rotatory device. 3D visualization of shear wave propagation was achieved by using tomographic reconstruction on the 360^{o} projections of the SW wavefront, and volumetric SW velocity distribution of cylindrically-symmetrical sample can be computed using the time-of-flight algorithm. In this study, a rotatory mount is designed to allow the transducer and the sample to rotate together. We hypothesize that the system can evaluate samples with transversely isotropic (TI) mechanical characteristics, and provide SW velocity estimation with 1^{o} angular resolution from 72 acquisitions.

Statement of Contribution/Methods

The local disturbance induced by shear wave propagation in a semi-turbid sample results in local blurring in the time-integrated speckle image of the sample. Projections of the shear wave wavefront are imaged by rotating the transducer and the sample, computing the speckle contrast defined as $K = \sigma_S/\langle I \rangle$, where σ_S and $\langle I \rangle$ are the standard deviation and mean intensity of pixels within an image region, for each rotation angle. The 3D shear wave wavefront can be reconstructed using the filtered backprojection algorithm, and the shear wave velocities along different propagation angles are calculated using linear regression on the respective spatiotemporal map.

Results/Discussion

The setup of the LSC-SW tomographic imaging system and the TI phantom are illustrated in Fig.1(a), and Fig.1(b). The TI phantom comprises of 4 nylon lines (diameter = 0.1 mm) embedded in 6.5% gelatin. Fig.1(c) shows the SW wavefront (SW propagation time = 0.1 ms) reconstructed using the filtered backprojection method. As shown in Fig.1(d), the shear wave velocity estimated in the direction parallel to the nylon lines (0˚) in the TI phantom is approximately twice the shear wave velocity estimated for the homogeneous phantom (6.5% gelatin). Due to the limited field of view, the complete SW velocity polar plot requires 2 sets of SW tomographic data, with the transducer placed in 0˚ and 90˚ relative to the TI structure. The results demonstrated the feasibility of the proposed approach and will be presented in the full report.



(1a) Schematic of the imaging system and (1b) TI phantom model. (1c) SW wavefront reconstructed (SW propagation time = 0.1 ms), and (1d) SW velocity polar plots of homogeneous and TI phantom.