Fast shear wavevector estimator for real-time elasticity map reconstruction

Background, Motivation and Objective

Shear-wave elastography is a technique used to calculate the viscoelasticity and other mechanical properties of soft tissues. The computational costs associated with calculating the wavenumber of the propagating waves using spatiotemporal Fourier transforms are remarkably high. This work outlines a straightforward algorithm to find the wavenumber by combining angular spectrum process and a local phase gradient estimator. Therefore, it presents a low complexity and can be implemented in real-time applications.

Statement of Contribution/Methods

The proposed algorithm consists of four steps. Firstly, the angular spectrum of tissue shear-wave displacements is filtered in a directional and bandpass manner. Then, the frequency spectrum is analyzed to find the central frequency. Next, the gradient of the harmonic displacement phase map is calculated to locally estimate the wavenumber and, finally, the phase velocity map at selected frequency is obtained. Pseudo-spectral time-domain simulations and experiments using a CIRS-049 elasticity phantom and a 7.5-MHz 128-elements linear array were performed to validate the method. In addition, results were compared with a spectral wavenumber estimator for local phase velocity imaging [IEEE Trans Ultrason Ferroelectr Freq Control, 67(3) 526-537, 2020].

Results/Discussion

Results show that the proposed method is capable of accurately reconstructing viscoelasticity maps. Furthermore, elasticity maps show a strong similarity with those obtained by state-of-the-art techniques, Figs. (a, b). We also found the key parameters for correct reconstruction of the velocity map, e.g., the central frequency, and established its selecting criteria. This is important in viscoelastic media, where the shear wave phase velocity depends on the frequency. Experimental results show that the values of 2.50±0.03 m/s and 4.23±0.07 m/s for the background and inclusion, respectively, prove a good agreement with the manufacturer's values of 2.45 m/s and 4.50 m/s, with relative errors ranging from 2-5%. In the last step of our analysis, we compared the computational time of our proposed method with that of the local wavenumber method for different map sizes, Fig. (c). This approach presents lower computational complexity and, therefore, it may be suitable for real-time elastography applications.

