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Algebraic Helmholtz inversion in planar magnetic resonance elastography

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Abstract

Magnetic resonance elastography (MRE) is an increasingly used noninvasive modality for diagnosing diseases using the response of soft tissue to harmonic shear waves. We present a study on the algebraic Helmholtz inversion (AHI) applied to planar MRE, demonstrating that the deduced phase speed of shear waves depends strongly on the relative orientations of actuator polarization, motion encoding direction and image plane as well as on the actuator plate size, signal-to-noise ratio and discretization of the wave image. Results from the numerical calculation of harmonic elastic waves due to different excitation directions and simulated plate sizes are compared to experiments on a gel phantom. The results suggest that correct phase speed can be obtained despite these largely uncontrollable influences, if AHI is based on out-of-plane displacements and the actuator is driven at an optimal frequency yielding an optimal pixel per wavelength resolution in the wave image. Assuming plane waves, the required number of pixels per wavelength depends only on the degree of noise.

1. Introduction

Magnetic resonance elastography (MRE) is a noninvasive technique used for assessing the elasticity of *in vivo* soft tissues (Muthupillai *et al* 1996, Plewes *et al* 1995). The technique exploits the motion sensitivity of the MR phase signal to detect the propagation of externally induced harmonic shear vibrations inside the human body. MRE is able to measure three-dimensional internal deformation fields which can be used to deduce elastic constants by solving an appropriate inverse problem. Unlike the far more frequently encountered exterior inverse problem relevant in remote sensing, such as radar, sonar (Colton and Kress 1997) and seismology (Aki and Richards 2002), the inverse problem in MRE is to deduce the desired

