AN OPTIMIZATION APPROACH TO ELASTIC INVERSE PROBLEMS

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Abstract

Imaging the elastic modulus distributions of soft tissues requires the solution of an elastic inverse problem. A typical approach to formulating this inverse problem is as an optimization problem. We consider in particular formulating this inverse problem as a constrained optimization problem.

Background and Motivation

• Elasticity imaging or elastography is a technique which uses imaging modalities to measure and image relative displacements within tissue microstructures. Its main goal is to map the elastic modulus (stiffness) of soft tissues. Tissue stiffness or elastic modulus distribution is believed to be clinically significant and may be correlated to tumor and other tissue pathologies.

• In collaboration with MedBED, and a host of researchers nationally and internationally, we have demonstrated the ability to reconstruct elastic modulus distributions from image data. We have worked with simulated images, images of phantoms, excised tissues, and in vivo (clinical) data, and we have worked with ultrasound and x-ray modalities.

• Stabilization techniques as [5, 6] have been developed to overcome problems that produce numerical solutions when some stability conditions are violated. However, these techniques only work when the corresponding continuous problem is mathematically well posed.

State of the Art

• We continue to lead the field of elasticity imaging in terms of quantitative elasticity imaging.

• The elastic modulus reconstructions shown in Figures 3b and 5b show clearly the stiffer inclusion and the linear distribution of the shear modulus, respectively. These solutions were obtained assuming a homogeneous distribution for μ in the initial guess. The GILS term employed in these reconstructions helped to reduce the effect of any spurious discrete solutions.

Discussion

• The elastic modulus reconstructions shown in Figures 3b and 5b show clearly the stiffer inclusion and the linear distribution of the shear modulus. These solutions were obtained assuming a homogeneous distribution for μ as the initial guess. The GILS term employed in these reconstructions helped to reduce the effect of any spurious discrete solutions. Figure 3b shows the reconstruction for the pure shear case without GILS. The spurious solutions are present in these reconstructions.

• From the theoretical point of view, we can demonstrate that the inverse problem, as formulated in this work, is well posed regarding displacement but not for the strain image inaccessible case. This is true only when

Future Work

• We plan to prove convergence and stability analytically for the plane strain and 3D elasticity inverse problems. In doing that we have to identify the correct norm to minimize and the form of the regularization terms to be used.

• Further analysis will be done to determine a good approximation for the stabilization parameter v such that we guarantee optimal performance.

Opportunities for technology transfer

• In the context of elastography, by imaging in vivo distributions of the biomechanical properties of soft tissues, we expect this research to enable clinical applications in the diagnosis and treatment of breast, prostate cancer and other soft tissue pathologies. In the context of computational methods, we will develop an accurate, efficient and stable method for solving the inverse problems.

Collaborators

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References


