NONLINEAR ELASTICITY IMAGING

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Mechanical properties of soft tissue can change with tissue pathology. For example, it is observed that the elastic (shear) modulus of malignant breast masses is typically an order of magnitude higher than the background of normal soft tissue. In addition with increasing applied strain their stiffness increases more rapidly than the background.

Elasticity imaging makes use of conventional imaging techniques such as ultrasound imaging, MRI and PET to generate images of mechanical properties. This is made possible by (1) imaging the tissue with a conventional imaging technique in an undeformed state, (2) deforming the tissue and imaging it once again, (3) registering the underformed and deformed images to estimate the displacement field and (4) reconstructing the spatial variation of mechanical properties from the displacement field by assuming an appropriate mechanical model and then evaluating the parameters in this model by solving an inverse problem.

In this talk I will describe a new algorithm for solving the inverse elasticity problem when the tissue is modeled as a hyperelastic material undergoing quasi-static finite deformation. The problem is posed as the minimization of a cost function representing the difference between the measured and predicted displacement fields. The cost function is minimized with respect to the spatial distribution of material properties using a gradient based optimization approach. The gradient is calculated efficiently using the adjoint method and a continuation strategy in the material properties.

I will present numerical examples (1) with synthetic data that demonstrate the feasibility and efficiency of the proposed algorithm, and (2) with clinical data the demonstrate its usefulness in the diagnosis of breast cancer.