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BIOMECHANICAL IMAGING

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PROPOSAL

Certain types of diseases lead to changes in the microstructural organization of tissue. Altered microstructure in turn leads to altered macroscopic tissue properties, which are often easier to infer and quantify than microscopic properties. Thus the measurement of macroscopic properties offers a window into tissue microstructure and health. Consider, for example, the progression of breast cancer during which cancerous cells in the milk duct activate fibroblasts which are responsible for enhanced recruitment of collagen. At the macroscopic level the enhanced collagen manifests itself in the form of a tumor with increased stiffness. By palpating the tissue in and around the tumor, one may then discern that it is stiff and hence infer that it may be cancerous. Similar associations may be developed for the cirrhosis of liver and for atherosclerosis in arteries. In biomechanical imaging (BMI) we aim to utilize this association between macroscopic mechanical properties of tissue and its health by generating images of the mechanical properties and using these to infer tissue pathology.

Broadly speaking BMI involves the following steps:

1. The tissue is continuously imaged using a standard (phase sensitive) imaging technique like ultrasound or MRI.
2. It is deformed while it is being imaged. The deformation may be applied externally or it may be produced internally (by the pressure changes during a cardiac cycle, for example). Further, it may have a desired time dependence (quasi-static, time-harmonic, impulsive, etc.) and a desired amplitude (infinitesimal strain versus finite strain).
3. The images of the tissue during its deformation are used to determine the displacement field within the tissue. For example, when ultrasound is used to image quasi-static deformation of tissue, successive ultrasound images are registered using cross-correlation in order to determine the intervening displacement field.
4. Using the displacement field in conjunction with an appropriate mechanical model, an inverse problem is solved to determine the spatial distribution of the material parameters.

This minisymposium will focus on the mathematical and computational foundations of Biomechanical Imaging. It will include analysis of the well-posedness inverse mechanics problems from observed behavior, analysis of computational formulations suitable for their solution, and algorithms appropriate for their efficient computational solution. An essential part of an accurate inverse solution is an accurate forward model, and so contributions related to forward mathematical modeling of tissue mechanical response are welcome.