Elastography: On the Virtual Fields Method
for Mechanical Properties Reconstruction of Biological Tissues.

Supervision: Elisabeth Brusseau and Olivier Basset (Team 3 Ultrasound imaging, CREATIS).

Scientific context

The subject of this internship is in the field of elastography, i.e. imaging techniques that aim at providing information on mechanical properties of biological tissues [1]. Such techniques are of interest for diagnosis since modifications of these mechanical properties can reveal pathological developments [2]. Basically, the medium is subjected to a stress (quasi static load, shear waves) and the response of the medium is imaged (using conventional imaging modalities, e.g. ultrasound) and analyzed to access to the information of interest (e.g. axial strain, shear modulus).

Objectives

At CREATIS, a displacement and strain estimation method is available, already used to provide axial strain images of breast lesions [3]. An example illustrating the capability of this technique to estimate displacement and strain fields is presented below, with a breast phantom (CIRS 059) subjected to slow compression and examined with ultrasound imaging.

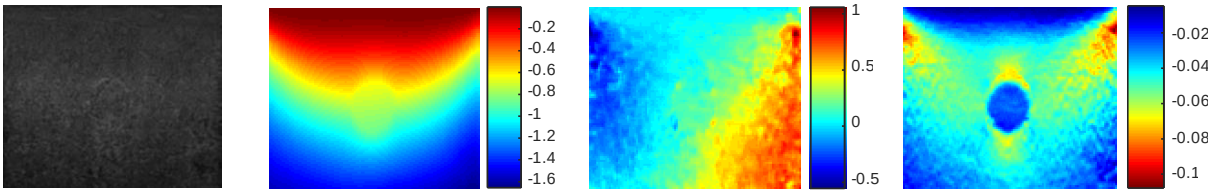

Figure 1: Example of results obtained on a breast mimicking phantom imaged with ultrasound imaging and subjected to slow axial compression. The scanned plane crosses a spherical inclusion that is stiffer than the surrounding material. (a) Conventional ultrasound image, (b) Axial displacement (mm), (c) Lateral displacement (mm) and (d) Axial strain, where the inclusion is clearly brought out compared to the conventional ultrasound image.

The objective of this internship is to investigate the potentiality of a technique called the *Virtual Fields Method (VFM)* to reconstruct mechanical parameters (absolute, relative values) from estimated displacement/strain fields [4]. This technique is based on the virtual work principle and the model of medium considered during these developments will be the linear elastic and isotropic medium.

From the bibliography analysis, a first method will be programmed. This method will be assessed using simulations and experiments with phantoms of known mechanical properties imaged with ultrasound. Note that displacement maps from magnetic resonance elastography can also be processed using the same approach [4].

References:

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[2] A. Itoh, E. Ueno, E. Tohno, H. Kamma, H. Takahashi, T. Shiina, M. Yamakawa, T. Matsumura, “Breast disease: Clinical application of US elastography for diagnosis”, Radiology, vol. 239, pp. 341–350, 2006.

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[4] N. Connesson, E.H. Clayton, P.V. Bayly, F Pierron, « Extension of the optimised virtual fields method to estimate viscoelastic material parameters from 3D dynamic displacement fields”, Strain, vol. 51, pp. 110-134, 2015.