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Development of a framework to extract the mechanical properties of breast tissues from ultrasound elastography exams

MEDICAL PHYSICS

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ABSTRACT

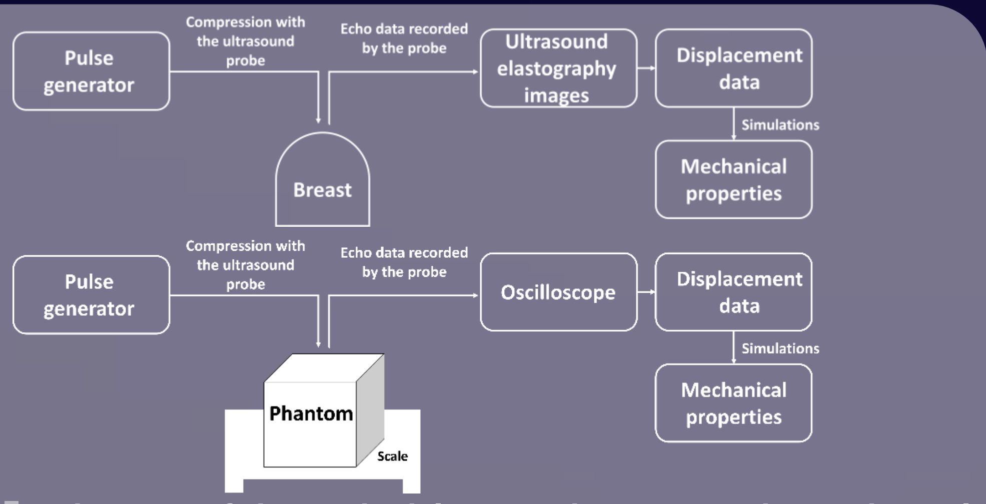
Breast cancer survivors struggle with psychological trauma associated with body image dissatisfaction. Personalized pre-treatment simulations that consider the cosmetic outcome of the treatment may decrease that trauma. The simulated models require accurate mechanical properties. However, the reported properties encompass a wide range of values. Thus, the aim of this work was to extract the mechanical properties of breast tissues from ultrasound elastography exams. We simulated the compression during the examination and obtained the mechanical properties of the tissues by matching the displacement from the simulations to those in the exams. Then, we tested this method on phantoms of different stiffness and obtained their mechanical properties – which were consistent with their stiffness.

METHODOLOGIES

We tracked a feature in the ultrasound elastography exams and retrieved the displacement in each frame by comparing the feature's coordinates to the coordinates of the same feature in the first frame. Then, we simulated the compression and retrieved the mechanical properties (Young's modulus) by obtaining the value that best matched the observed (highest) displacement. We tested this methodology on 3 gelatin phantoms by compressing the phantoms with an ultrasound probe. The phantoms had different stiffness and mimicked medium-density, high-density, and malignant tissues. We obtained the force applied with the ultrasound probe and the corresponding displacement of the phantom. Then, we simulated the compression in COMSOL and extracted the mechanical properties of the gelatin phantoms.

RESULTS

The values of the Young's modulus we extracted agree with the stiffness of each phantom, i.e., the stiffest phantom had the highest Young's modulus. Also, they are consistent with the measurements made by the authors of the phantoms' recipes on a low-density phantom since we obtained higher values.



Schematic of the methodology used to extract the mechanical properties of breast tissues from ultrasound elastography images and from breast-mimicking gelatin phantoms.

DISCUSSION

We will perform compression testing on phantoms made with the same recipes to validate the method. If this framework gives accurate results, we could obtain in-vivo mechanical properties of breast tissues that could be added to computational models to study the cosmetic outcome of cancer treatment.

INSTITUTION

Ciências ULisboa

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INL International Iberian Nanotechnology Laboratory
fct Fundação para a Ciência e a Tecnologia
TEXAS The University of Texas at Austin