Using morphological binary images operations for automate rotation fill-in estimation in Ultrasound Elastography medical Imaging

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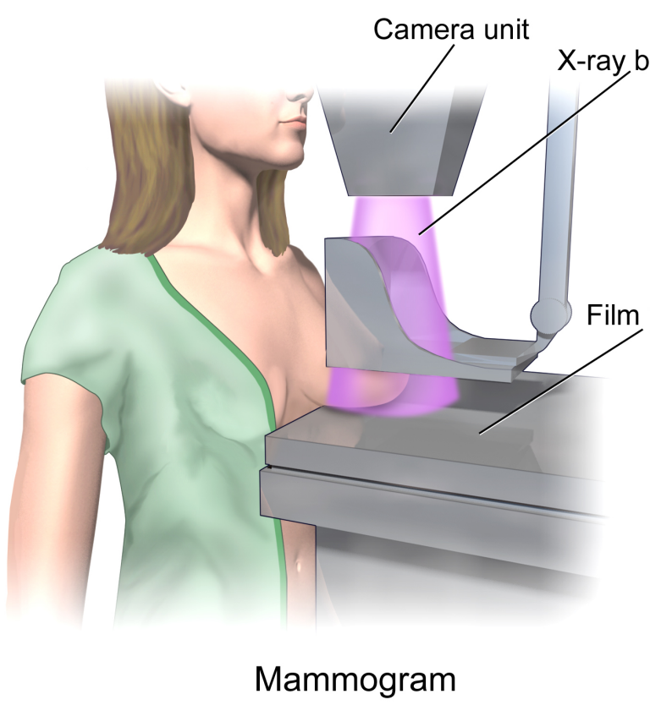
Motivation

Breast Cancer is the most common cancer among women worldwide and the second most common cancer overall.
The most common method of breast cancer diagnosis is mammography, which use doses of ionizing radiation to create images.
Ultrasound Imaging is often utilized to complement mammography as an useful, real-time, low-cost and non-invasive imaging modality in the detection of suspicious masses.



Introduction

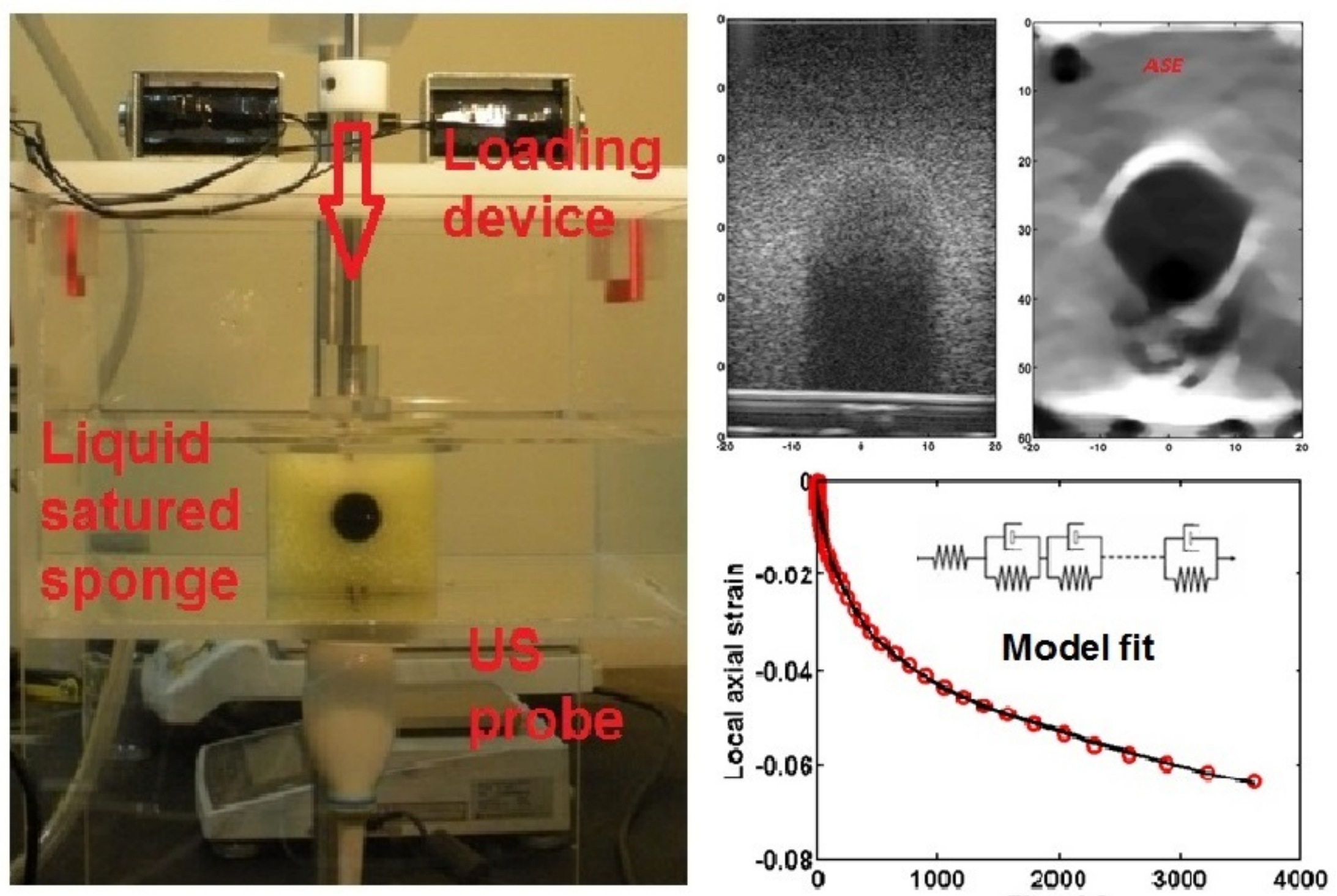
Rotation fill-in is a sliding feature present in Ultrasound Elastography (UE) imaging modalities called Rotation Elastogram (RE) and Axial-Shear Strain Elastogram (ASSE) [1,2]. It came from the bonding condition at the interface between the tumor and host tissue and may be used as non-invasive breast tumor classification tool to reduce the number of unnecessary benign biopsies [1,2].

The goal of the present work is to automatically identify the tumor area in ASSE images for the calculation of rotation fill-in.

The method aims to reducing the manual selection of lesion, which is operator dependent and cannot be used in real-time UE scanning.

Image Filtering Method

Automate Rotation fill-in estimation method is based on morphological binary image operations applied to Axial Strain Elastogram (ASE, Figure 1a). The method consists in selecting the inside region of the inclusion (tumor model) in the ASSE image (Figure 1e).
Firstly, the total ASE image area is reduced by deleting the edges, then turns the ASE into a binary image with a threshold of 50% (Figure 1b) and reduces the selected areas applying morphological operations producing its disconnection.
A size filter is then used to select the biggest area (inclusion) which is then returned to its original size (Figure 1c).
Finally, the ASSE values inside the lesion are compared with external values obtaining a relative measurement of rotation fill-in (Figure 1e and f).

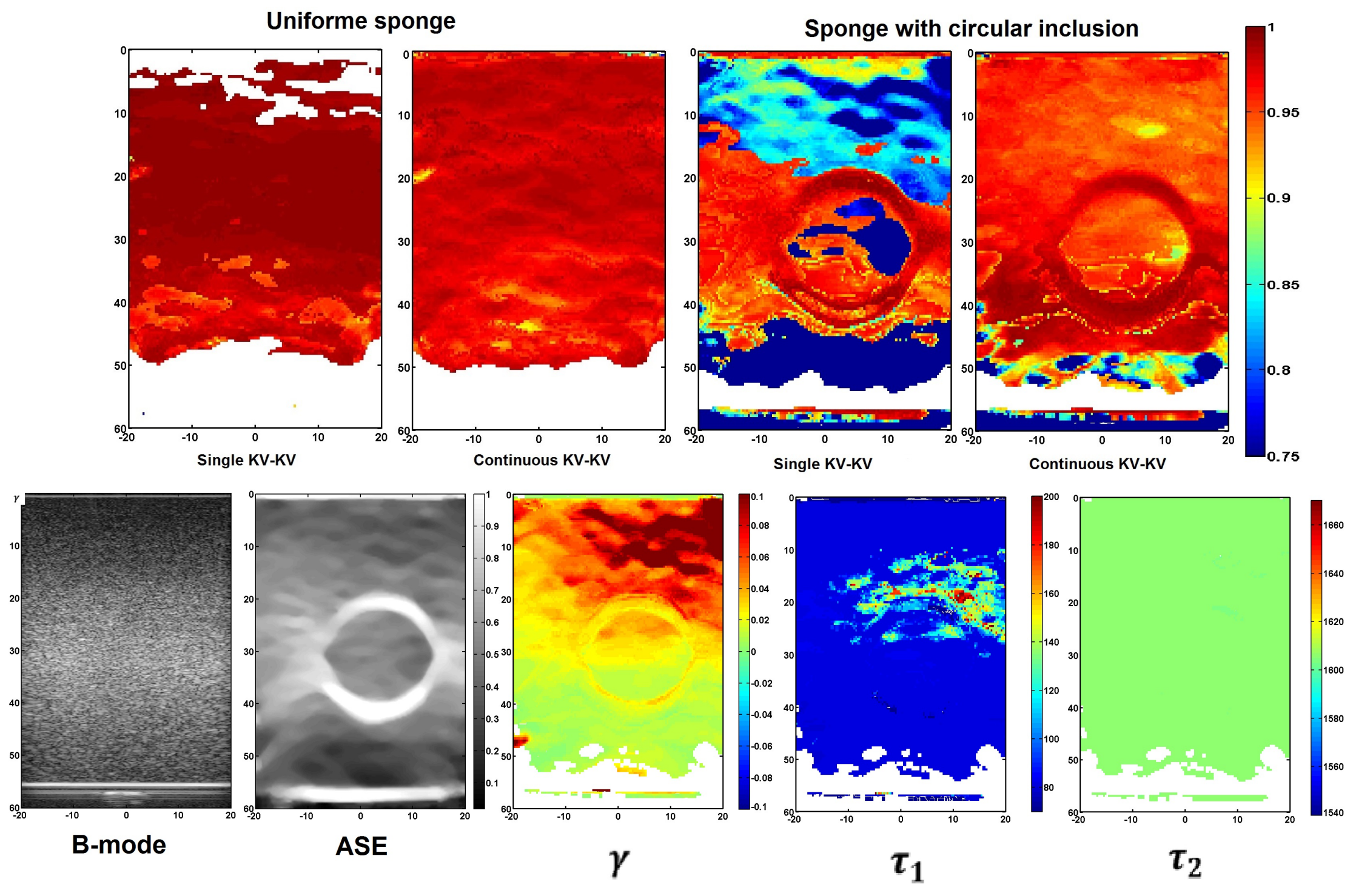


Finite Elements Analysis

The proposed method is first tested using Finite Elements Analysis (FEA, ANSYS) and then validated using tissue-mimicking gelatin-glass-beads phantom. The 2D FEA simulations are performed in multi-deformation fashion for isotropic elastic soft materials and the contact manager is used to emulate different bonding conditions of the inclusion (Figure 1d). The simulations were performed for different ultrasound-probe angles (α) to evaluate the robustness of the proposed method.

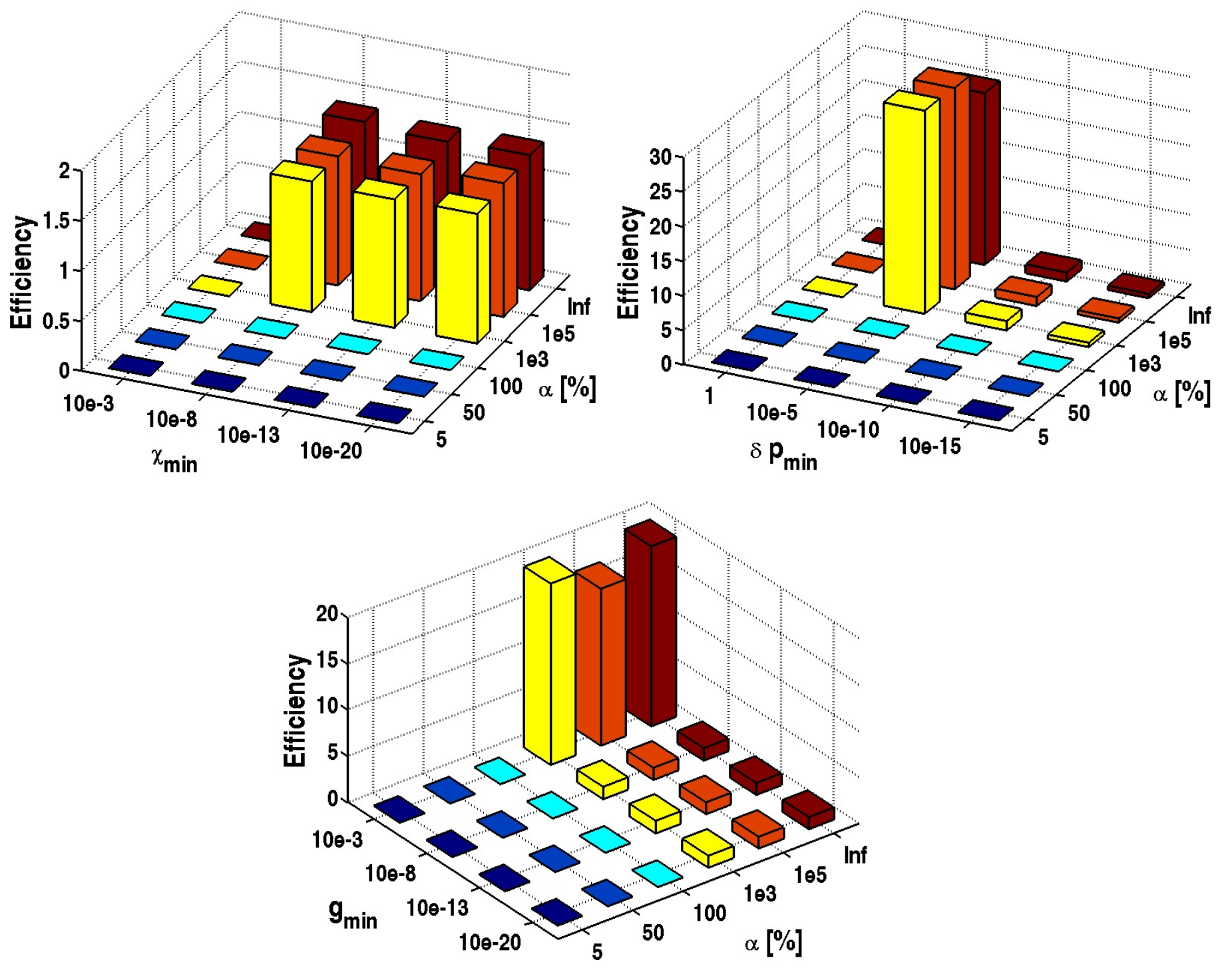
In-Vitro Analysis

The Figure 2(a) shows the experimental setup, where the ultrasound linear array probe (Terason 12L5-V) is used to axially compress the tissue-mimicking phantom at different angles α. The ultrasound machine Terason T3000 Advanced controlled in Matlab ambiance is used to acquiring the rf-raw data in quasi-static fashion in synchronism with the axial compression ϵ_0 for each angle α. The elastographic images (ASE and ASSE, Figure 2b-e) are obtained from rf-raw data using a multilevel 2D block-matching algorithm described in [3]. On the Figure 2e, the fill-in value is shown (~100%) for a loosely bounded inclusion, which is consistent with previous studies [1,2].



Experimental Setup

ASSE images are obtained from a gelatin glass-beads phantom.



References

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Conclusion

- The proposed method for automate rotation fill-in estimation is validated by in-vitro experiments.
- Method shows to be robust to elastographic images distortions introduced by the ultrasound probe angle.

Future Research

- Further in-vivo studies will be necessary to fully validate this method.
- Real-time implementation for in-vivo applications (collaboration from software engineering or computer science area).