Tissue Mechanics-based Algorithm for Improving Strain Accuracy in Ultrasound Elastography

Amal Aziz[1], Matthew Caius[2], Abbas Samani[1,2,3]

[1]Department of Medical Biophysics, Western University, London, ON, Canada [2]School of Biomedical Engineering, Western University, London, ON, Canada
[3]Department of Electrical and Computer Engineering, Western University, London, ON, Canada

Introduction

BREAST CANCER IS...

THE MOST COMMON CANCER IN CANADIAN WOMEN[1]

THE MOST COMMON CANCER-RELATED DEATH IN WOMEN WORLDWIDE[1]

- Timely diagnosis of breast cancer is one of the largest factors in lowering mortality rates[2]
- Ultrasound Elastography (USE) is one of such diagnostic methods, and uses the fact that tumours are stiffer than surrounding breast tissue for their detection
- USE is used to generate strain images of the breast undergoing mechanical stimulation, which under the tissue stress uniformity assumption, can be used as an estimate of tissue stiffness
- While USE is accessible and inexpensive, the images it produces, especially of lateral strains, are of low quality
- Combination of axial strain images and accurate lateral strain images can be used to produce high quality stiffness images
- The accuracy of strain images can be improved by applying tissue mechanics-based constraints

Objectives

- Our objective was to improve our existing algorithm (STREAL) by expanding on tissue deformation compatibility through including the full set of strain compatibility equations

Methods

Algorithm Development

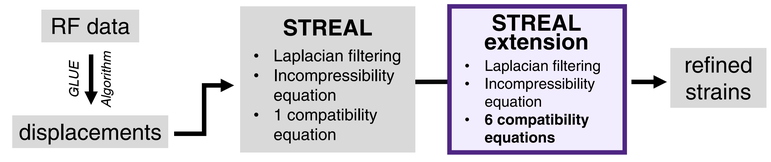

Figure 1. Outline of STREAL algorithm with compatibility equation extension.

Algorithm Validation

- Radio-frequency (RF) data was acquired for:
  1. Breast tissue-mimicking phantom with stiff inclusion
  2. Clinical case for breast cancer
- Strains were refined using algorithm with 1 compatibility equation and then with 6 equations
- SNR and CNR of strain images were calculated

Results

Tissue-mimicking Phantom

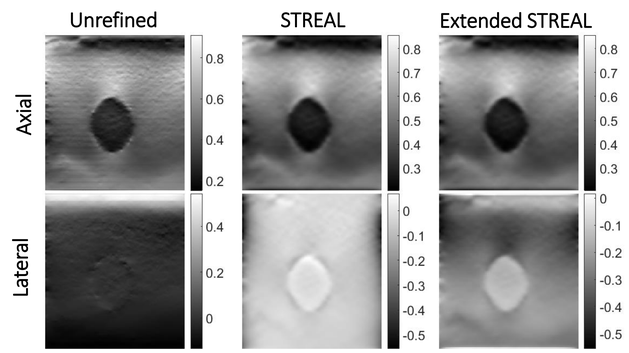

Figure 2. Axial and lateral strains of tissue-mimicking phantom obtained after using 1 and 6 compatibility equations.

Table 1. Absolute values of SNR and CNR of axial and lateral strains obtained using tissue-mimicking phantom.

	Axial		Lateral	
	SNR	CNR	SNR	CNR
1 equation	3.97	3.28	0.89	1.07
6 equations	3.97	3.28	3.43	3.03
Percent Improvement	-	-	285%	183%

Results

Clinical Case

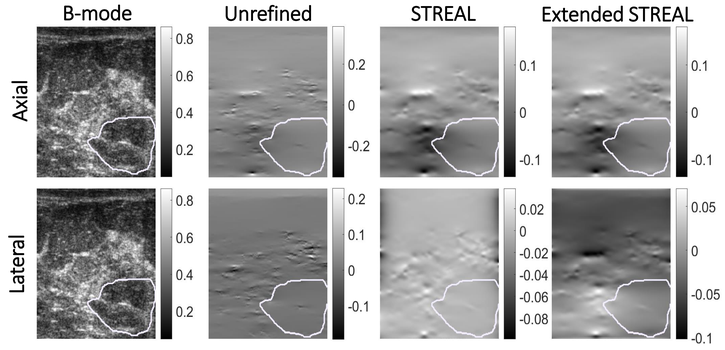

Figure 3. Ultrasound b-mode image, axial strains, and lateral strains of a clinical case obtained after using 1 and 6 compatibility equations with tumour region outlined.

Table 2. Absolute values of SNR and CNR of axial and lateral strains obtained using clinical case.

	Axial		Lateral	
	SNR	CNR	SNR	CNR
1 equation	1.95	11.79	0.60	0.20
6 equations	1.95	11.79	1.93	12.02
Percent Improvement	-	-	222%	5910%

Conclusions

- While axial strains show minimal improvement, tumour regions of lateral strains are much more distinguishable from the background
- CNR and SNR of lateral strains were significantly improved and are more consistent with axial strains
- In summary, the extension provides greater accuracy, especially for lateral strains, and shows potential in producing high quality stiffness images necessary for reliable breast cancer diagnoses

References

[1] Lee, S. (n.d.). *Breast cancer statistics*. Canadian Cancer Society. Retrieved August 9, 2022, from https://cancer.ca/en/cancer-information/cancer-types/breast/statistics
[2] Burton, R., & Bell, R. (2013). The Global Challenge of Reducing Breast Cancer Mortality. *The Oncologist*, *18*(11), 1200–1202. https://doi.org/10.1634/theoncologist.2013-0315