Evaluation of a pressure sensing array for use with ultrasound strain imaging

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Mechanical in vitro tests and in vivo elasticity imaging have shown differences between breast tissue types in their nonlinear stress/strain behavior. This information could be utilized to differentiate between benign and malignant lesions potentially reducing the benign biopsy rate. Stress and strain measurements are required for absolute measures of this non-linear behavior in vivo. A capacitive pressure sensing array was investigated for measurement of surface stress in conjunction with ultrasound strain imaging.

A variety of experiments were performed with a prototype pressure sensor array to gauge its stability, minimum detectable pressure and noise level in reference to its application in ultrasound elastography. A method of calibration was also developed. Measurements of the surface pressure during deformations of phantoms were taken and compared to results from simulations. In addition, data was collected from patients undergoing ultrasound elasticity imaging at the University of Wisconsin Breast Center.

The experiments demonstrated that the pressure sensor array was stable in an ultrasound imaging environment, though it exhibited a significant warm-up period. A measurement dependence on the stress history was also characterized. A reliable calibration technique was developed, which demonstrates reproducibility to within 5% for most elements. Experiments also show a wide disparity in the minimum detectable pressure among elements. The most sensitive elements are capable of detecting pressure as low as about 100 Pa. The most sensitive elements make the array capable of detecting initial contact and measuring the contact force during a deformation of the breast--a critical task for quantifying stress/strain nonlinearities. The clinical trial confirmed this prediction. However, surface pressure distribution measurements on phantoms have shown only modest agreement with FEA simulations. Geometric uncertainties on the surface of the sensor as well as the variability of the absolute calibration make the array ill suited to measure accurate maps of the surface pressure distribution which might limit its utility for stress distribution measurements and elastic modulus reconstructions