A NOVEL APPROACH TO EVALUATING BREAST DENSITY USING ULTRASOUND TOMOGRAPHY

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Degree: Awarded August 2007 by Wayne State University

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Women with high mammographic breast density have a 4- to 5-fold increased breast cancer risk compared to women with fatty breasts. The purpose of this work was to investigate the feasibility of assessing breast density with acoustic velocity measurements, and to compare the results with existing measures of mammographic breast density. First, an anthropomorphic breast tissue phantom was imaged with our computed ultrasound tomography clinical prototype. Strong positive correlations were observed between sound speed and material density, and sound speed and CT number. Next, we investigated a sample of ~100 patients. Whole breast acoustic velocity was determined by creating image stacks and evaluating the sound speed frequency distribution. Acoustic measures of breast density were compared to two mammographic density measures: (1) qualitative estimates determined by a certified radiologist using the BI-RADS Categorical Assessment based on a 1 (fatty) to 4 (dense) scale, and (2) quantitative measurements obtained via digitization and computerized analysis of archival mammograms. We observed significant differences in global sound speed between every BI-RADS compositional category, showing that our technique was consistent with the current standard of care. Quantitatively, a strong correlation between mean acoustic velocity and calculated mammographic percent density was also demonstrated for two mammographic views.

Building on these empirical results, we investigated the use of volumetric ultrasound percent density (USPD) for breast density estimation both *in vitro* and *in vivo*. In the phantom, a comparison between segmented CT scans and corresponding sound speed scans yielded a close correlation in USPD between the two modalities. For the patient sample, USPD was determined by segmenting high sound speed areas from each tomogram using a k-means clustering routine, integrating these results over the entire breast, and dividing by total breast area. A strong positive association between BI-RADS category and USPD was demonstrated. Furthermore, comparing USPD to calculated mammographic density yielded moderate to strong positive associations for two mammographic views. The feasibility of using sound speed texture features (i.e. skewness and fractal dimension) for breast density assessment was also explored.

This work suggests, for the first time, that non-invasive and non-ionizing evaluation of breast density has been made possible by employing ultrasound tomography. Further, global sound speed and USPD appear to be the most promising indicators of breast density. These applications may play an integral role in monitoring treatment changes, tracking chemoprevention response, and identifying high-risk patients. Overall, potential benefits of quantifying a relationship between acoustical properties and breast density introduce a novel application of clinical ultrasound, one that may prove to be significant in breast cancer risk assessment.

A copy of the dissertation can be requested via email.