Title: Quantitative Ultrasound Imaging of in vivo breast tumors

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Abstract

The main goal of this dissertation is to perform quantitative ultrasound imaging (QUS) of *in vivo* breast tumors in order to provide new tools to differentiate benign from malignant breast masses. The studies outlined in Chapters 3-4 demonstrate that attenuation and backscatter coefficients (BSC) of phantoms can be estimated from the radiofrequency echo data acquired by a clinical ultrasound imaging system, when a well-calibrated reference phantom is used to account for dependencies of echo signals on system settings and transducer properties. Chapter 5 presents attenuation coefficients and backscatter coefficients for an animal breast tumor model and demonstrates the feasibility of producing accurate QUS parameters regardless of imaging system used. The study in Chapter 5 was validated in Chapter 6 using a phantom that mimics scanning conditions encountered in the animal model study. A least squares method (LSM) for simultaneous attenuation and backscatter coefficient estimation was introduced to account for attenuation over inhomogeneous paths between an ultrasound transducer and region of interest within a mass. The LSM was verified using well-characterized phantoms. Later the LSM was applied in QUS studies of human breast masses. Preliminary data on attenuation coefficients, BSCs, and effective scatterer diameters (ESD) within human breast masses were derived from a subject population undergoing breast biopsy procedures. The total attenuation in the mass was estimated from the product of the attenuation coefficient and antero-posterior (AP) dimension

and was compared to relative acoustic shadowing criteria reported as "posterior echo features" in the ultrasound breast imaging BI-RADS lexicon. The BSC averaged over frequency (ABSC) provides information of the average scattering strength ("echogenicity") of an object. The ABSC was compared to the "echo pattern" descriptor of the BI-RADS descriptors and showed a potential to quantify the echogenicity within masses. A scatter plot of the ABSC and attenuation coefficient showed potential to differentiate between fibroadenomas and carcinomas with a simple linear discriminant. In addition, most human fibroadenomas exhibited a wider distribution of ESD estimates over the ROI than carcinomas. Chapter 9 presents an assessment of accuracy of attenuation measurements by the reference phantom method (RPM) when the tissue sound speed differs from that of the reference. The RPM is convenient for accounting for system factors on echo data. However the speeds of sound in the tissue and reference need to be the same for this method to be most effective. The study also discusses the methods to minimize errors.

These results demonstrate that a great deal of progress has been made in the effort to develop QUS technology to improve breast ultrasound specificity. This thesis also demonstrates that, even with the demonstrated potential provided here, there is more that can be done to significantly improve the state of the art in QUS technology.