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IMPROVING ULTRASONIC IMAGING USING NOVEL CODED EXCITATION TECHNIQUES

BY

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DISSERTATION

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ABSTRACT

In ultrasound imaging, the axial resolution depends on the source bandwidth. Recently, a novel coded excitation and pulse compression technique, known as Resolution Enhancement Compression (REC), was developed. REC enhances the -6 dB bandwidth of an ultrasonic imaging system. In this dissertation, the limitations of the REC technique were explored and specific imaging applications were examined.

Several factors that could limit the improvements in ultrasonic imaging afforded by REC were assessed. First, it was hypothesized that a Wiener filter could adversely affect the compression performance of coded excitation because it had the potential to boost the harmonics due to nonlinear distortion. When the Wiener filter operated near an inverse filter the harmonics were boosted, resulting in increased sidelobes. Pre-filtering of the harmonics was found to solve this problem. Second, it was hypothesized that the larger the bandwidth boost desired, the smaller the voltage that could be applied at the center frequency. When doubling the bandwidth, the center frequency voltage was 6 dB below the band edges of the pre-enhanced chirp. Finally, the effects of attenuation were evaluated. Because of the attenuation, a larger shift in the center frequency due to the larger bandwidth was identified.

Several applications for the REC technique in biomedical imaging were explored. It was hypothesized that the variance of the speckle could be reduced further when using frequency compounding and REC. By using the bandwidth enhancement delivered by REC, the trade off between improved contrast and axial resolution was extended. Similarly, REC was combined with quantitative ultrasound (QUS) techniques to improve parametric images of estimated scatterer diameter. Larger bandwidths were observed to lead to a smaller variance in spectral estimates, thereby improving QUS image contrast.

Finally, novel techniques for improving the compression of codes in ultrasonic imag-

ing were developed and assessed. The effects of the spatially varying nature of a transducer's impulse response and echo signal-to-noise ratio (eSNR) throughout the depth of field of the source were evaluated. Significant improvements in image quality were realized through the use of Wiener filters that accounted for the spatially varying eSNR.

To my wife Mary Ann, my dogs Smudge and Jaxx,
my family, and my friends,
who kept my poles inside the unit circle.

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