IMPROVING ULTRASONIC IMAGING USING NOVEL CODED EXCITATION TECHNIQUES

BY

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DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Electrical and Computer Engineering
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2010

Urbana, Illinois

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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.

ACKNOWLEDGMENTS

I would like to thank my PhD adviser Dr. Michael L. Oelze for his tremendous support throughout the last four and a half years of my life. Dr. Oelze taught me a wealth of knowledge from an academic perspective and a significant amount of research skills, which were critical in the completion of my degree. Dr. Oelze always pushed me to strive for the best, which was frustrating at times, but I grew into a better researcher as a result of his actions. I really appreciated how patient he was when reading my manuscripts. It was such a delight to work with him, that I hope we will still collaborate in the future.

I would like to thank the members of my doctoral committee: Dr. Michael Oelze, Dr. Minh N. Do, Dr. Jonathan J. Makela, and Dr. William D. O'Brien Jr. Their comments and suggestions were greatly appreciated, specifically, the ones made to improve the clarity of this dissertation. All four of these individuals are great investigators with an overwhelming amount of knowledge and skills.

I would like to acknowledge the hard work and dedication of Darren Pocci who assisted me with the quantitative ultrasound study, Marko Orescanin who assisted me with the creation of a cone phantom, and Roberto J. Lavarello who helped me significantly during the final stretch of my Ph.D. It was a pleasure for me to work with all the wonderful people from the Bioacoustics Research Laboratory (BRL) at the University of Illinois.

I would like to thank my family for their support. I love you all and hope to spend more time with you.

I would like to thank my wife, Mary Ann. She has been the main support behind this PhD. She was there when I was frustrated, happy, angry, and excited. Most importantly, she was there when I needed her. She is the inspiration in my life. My success belongs

to her.

I would like to thank various organizations for the funding support they provided during my graduate studies: National Institutes of Health and the SURGE Fellowship program at the University of Illinois.

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