University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

MOHAMMED ALBULAYLI

MSc (University of Victoria, 2012)
BSc (King Saud University, 2005)

"Migration-Based Image Reconstruction Methods for Plane-Wave Ultrasound Imaging"

Department of Electrical and Computer Engineering

Monday, July 30, 2018
10:00 A.M.
Engineering Office Wing
Room 430

Supervisory Committee:
Dr. Daler Rakhmatov, Department of Electrical and Computer Engineering, University of Victoria (Supervisor)
Dr. Panajotis Agathoklis, Department of Electrical and Computer Engineering, UVic (Member)
Dr. Daniela Constantinescu, Department of Mechanical Engineering, UVic (Outside Member)

External Examiner:
Dr. Chaitali Chakrabarti, School of Electrical, Computer and Energy Engineering, Arizona State University

Chair of Oral Examination:
Dr. Colin Bradley, Department of Mechanical Engineering, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies

Abstract

Ultrasound imaging plays an important role in biomedical diagnostics due its safety, noninvasive nature, and low cost. Conventional ultrasound systems typically form an image frame by scanning the region of interest line-by-line, using a focused beam during transmission and dynamic focusing during reception. Alternatively, the region of interest can be insonified at once using a plane wave, which allows for ultrafast data acquisition rates but reduces the resulting image quality. The latter can be improved by means of coherent plane-wave compounding (CPWC), whereby multiple plane waves are emitted at different angles to obtain multiple image datasets that are subsequently combined to enhance the final compounded image.

We present two novel Fourier-domain techniques for CPWC image reconstruction from raw linear-array sensor data. In particular, we show how to modify two classic algorithms used for geophysical data processing, namely Stolt's and slant-stack depth migration under zero-offset constant-velocity assumptions, so that their new versions become applicable to plane-wave ultrasound data processing. To demonstrate the merits and limitations of our approach, we provide qualitative and quantitative comparisons with other Fourier-domain methods reported in the ultrasound literature. Our evaluation results are based on the image resolution, contrast, and similarity metrics obtained for several public-domain experimental benchmark datasets.

We also describe another novel Fourier-domain method for CPWC image reconstruction that can be used in situations where the speed of sound varies with depth in a layered propagation medium. Our technique builds on Gazdag's phase-shift migration algorithm that has been modified to handle plane-wave ultrasound data processing. Our simulation results show that the proposed method is capable of accurately imaging point targets in a three-layer medium, mimicking tissue-bone-tissue ultrasound propagation.