Ref: 28/4

THREE-DIMENSIONAL TISSUE VELOCITY ESTIMATION USING ULTRASOUND FEATURE LOCATION AND SHAPE CORRELATION (FLASH CORRELATION)

by

Ahmed A. Morsy

Department of Biomedical Engineering
Duke University

Date: Sept 8, 1998

Approved:

Olaf T. von Ramm, Supervisor

Stephen W. Smith

Patrick D. Wolf

Jeffrey L. Krolik

Thomas Ryan

Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biomedical Engineering in the Graduate School of Duke University

1998

Abstract

Measurement of tissue and blood velocity is of great clinical importance as it can help differentiate functional abnormalities. Current motion tracking methods, including Doppler and correlation search, have many limitations that compromise the accuracy and usefulness of these methods. It is hypothesized that combining the concepts of feature tracking and correlation search may result in a more accurate and computationally efficient motion quantification method. This new method is called feature location and shape correlation, or simply FLASH correlation. It is an angle-independent method that can measure three dimensional (3D) tissue motion with computational efficiency that permits real-time implementation.

In vitro experiments using a piston transducer to image a tissue phantom showed that using the FLASH Correlation method to track motion in volumetric ultrasound scans can be both accurate and computationally efficient. These experiments involved tracking axial translations of up to 1.54 mm and lateral translations of up to 2.0 mm. It was also demonstrated that a kernel size of one resolution volume was enough to obtain satisfactory tracking performance. The FLASH correlation method was then tested using an ultrasound real-time clinical

volumetric scanner. The results of axial and lateral tracking of a tissue mimicking material demonstrated good tracking performance. Tracking errors were less than 3% for axial translations up to 1.8 mm and less than 10% for lateral translations up to 1.0 mm. The FLASH correlation method was then calibrated using a speckle-generating string phantom moving at a constant velocity and an oscillating sponge moving at a known velocity. After calibration, three dimensional (3D) color velocity maps were generated for a heart phantom and human hearts. *In vivo* 3D color velocity maps of human hearts generated by the FLASH correlation method were in agreement with various events in the cardiac cycle.

In summary, FLASH correlation is an angle-independent method for measurement of 3D tissue velocity. It is well-suited for real-time implementation in hardware. Generation of 3D color velocity maps using the FLASH correlation method will add a useful diagnostic tool to the field of clinical ultrasound.