PhD Thesis title: 'ADVANCES IN BIOMEDICAL APPLICATIONS AND ASSESSMENT OF ULTRASOUND NONRIGID IMAGE REGISTRATION**'**

Author: Ganesh Narayanasamy
Email: gnarayan.umich@gmail.com
Institution: University of Michigan
Supervisors: Paul L Carson, J Brian Fowlkes, Bradford Orr, Marilyn A Roubidoux
Graduation Date: Dec 20, 2009
Available on line:
deepblue.lib.umich.edu/bitstream/2027.42/64802/1/gnarayan_1.pdf

ABSTRACT:

Image volume based registration (IVBaR) is the process of determining a one-to-one transformation between points in two images that relates the information in one image to that in the other image quantitatively. IVBaR is done primarily to spatially align the two images in the same coordinate system in order to allow better comparison and visualization of changes. The potential use of IVBaR has been explored in three different contexts.

In a preliminary study on identification of biometric from internal finger structure, semi-automated IVBaR-based study provided a sensitivity and specificity of 0.93 and 1.00 respectively. Visual matching of all image pairs by four readers yielded 96% successful match.

IVBaR could potentially be useful for routine breast cancer screening and diagnosis. Nearly whole breast ultrasound (US) scanning with mammographic-style compression and successful IVBaR were achieved. The image volume was registered off-line with a mutual information cost function and global interpolation based on the non-rigid thin-plate spline deformation. Institutional Review Board approved this study conducted on 10 patients undergoing chemotherapy and 14 patients with a suspicious/unknown mass scheduled to undergo biopsy. IVBaR was successful with mean registration error (MRE) of 5.2±2 mm in 12 of 17 ABU image pairs collected before, during or after 115±14 days of chemotherapy. Semi-automated tumor volume estimation was performed on registered image volumes giving 86±8% mean accuracy compared with a radiologist hand-segmented tumor volume on 7 cases with correlation coefficient of 0.99 ($p<0.001$). In a reader study by 3 radiologists assigned to mark the tumor boundary, significant reduction in the time taken to perform this task ($p<0.03$) was seen due to IVBaR in 6 cases. Three new methods were developed for independent validation of IVBaR based on Doppler US signals.

Non-rigid registration tools were also applied in the field of interventional guidance of medical tools used in minimally invasive surgery. The mean positional error in a CT scanner environment improved from 3.9±1.5 mm to 1.0±0.3 mm ($p<0.0002$).

These results show that 3D image volumes and data can be spatially aligned using non-rigid registration for comparison as well as quantification of changes.

References to author publications that relate specifically to the dissertation:

G Narayanasamy, G LeCarpentier, M Roubidoux, J Fowlkes, P Carson, "Spatial Registration of Temporally Separated Whole Breast 3D Ultrasound Images" *Medical Physics* Vol. 36(9), pp. 4288-4300, Sep 2009.

G Narayanasamy, J Fowlkes, O Kripfgans, J Jacobson, M De Maeseneer, R Schmitt, P Carson, “Ultrasound of the Fingers for Human Identification Using Biometrics” *Ultrasound in Medicine and Biology* Vol. 34, No. 3, pp. 392-399, 2008