PP-13

Rigid and non-rigid prostate image registration of ARFI and MRI image volumes to whole-mount histology

T. Polascik[1], E. Kulbacki[2], J. Madden[2], K. Nightingale[3], S. Lipman[3], M. Palmeri[3], S. Rosenzweig[3], K. Garcia-Reyes[4], C. Kauffman[5], R. Gupta[5], A. Lark[2], A. Buck[2]

[1] *Department of Urology, Duke University Medical Center, Durham, NC, USA*

[2] *Department of Pathology, Duke University Medical Center, Durham, NC, USA*

[3] *Department of Biomedical Engineering, Duke University, Durham, NC, USA*

[4] *Duke University Medical Center, Durham, NC, USA*

[5] *Department of Radiology, Duke University Medical Center, Durham, NC, USA*

Purpose: Prostate cancer (PCa) diagnosis is currently performed through needle biopsy guided by B-mode ultrasound (US). However, the anatomic and pathologic prostatic structures have poor acoustic contrast, so the biopsy is done by systematic sampling, rather than targeting of suspicious regions. Acoustic Radiation Force Impulse (ARFI) imaging is an ultrasonic elasticity imaging technique that is being developed to differentiate between prostatic tissues based upon their mechanical properties. Magnetic Resonance (MR) imaging is also becoming an important prostatic imaging modality because it can use multiple sequences to delineate structures and characterize regions of disease. We are developing image registration techniques that facilitate correlation of pathology delineated in whole mount histology data after prostate resection with in vivo ARFI, B-mode US, and MR images obtained prior to surgery.

Methods: US and ARFI imaging sequences were acquired pre-operatively using a side-fire ER7B endorectal US probe on a Siemens ACUSON SC2000 scanner and a custom transducer rotation stage. Pre-operative standard T1 and T2 MR images were also obtained, along with Diffusion Weighted Imaging (DWI), Apparent Diffusion Coefficient (ADC), and perfusion MR imaging sequences. Segmentation of the pathology and internal prostatic structures was performed using itk-Snap in order to create 3D models of the prostate for each imaging modality. Non-rigid 3D registration of the different models was performed using mutual information and cross correlation based diffeomorphic methods in the Advanced Normalization Tools (ANTs) software package, and the registered images were evaluated for concordance of confirmed pathology with regions of suspicion in all imaging modalities.

Results: In vivo ARFI images delineate anatomic zones of the prostate with higher contrast than the B-mode US images. Additionally, many cancers have been identified as asymmetrical stiffer regions in coronal/axial prostate ARFI imaging planes, which have shown correlation with histologic regions of cancer. Higher Gleason score shows correlation with a decrease in intensity in MR-ADC maps. Atrophy of prostate tissue has also been shown to be a confounding factor for both ARFI and MR images in identifying regions of suspicion for cancer.

Conclusion: Confirmed PCa pathology was found to align with similarly suspicious regions in both ARFI and MR images by using diffeomorphic image registration methods. Focal therapy treatments can be facilitated with improved preoperative localization of PCa using both MR and ARFI imaging. ARFI imaging also holds promise for providing targeted image guidance of needle biopsy, due to its improved anatomical visualization over traditional B-mode imaging.