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(G) Toward Accurate Prostate Cancer Diagnosis: Integrating PET Imaging with 3D TRUS Biopsy Techniques

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Prostate cancer (PCa) is the most diagnosed cancer among Canadian men, with an estimated 24,600 new cases in 2022, making up about 21% of new cases and anticipated to cause approximately 4,600 deaths. Prostate biopsy, essential for PCa diagnosis, often uses 2D transrectal ultrasound (TRUS) for tissue extraction but suffers from a high false negative rate of 21-47% due to its inability to directly visualize PCa. This necessitates repeat biopsies and has led to the development of specialized TRUS-guided biopsy devices for precise targeting. Despite high sensitivity in detecting early high-grade PCa, current PET/CT and PET/MRI techniques still yield false negatives. Collaboratively developed with Lakehead University, the novel prostate-specific PET (p-PET) system offers improved sensitivity and resolution, presenting an opportunity to integrate a biopsy approach for accurate early-stage PCa detection. This project aims to develop and integrate a 3D TRUS and PET-guided system for prostate biopsy, including a robotic system for biopsy needle guidance. Objectives include developing a motorized 3D TRUS mechanism with integrated needle guidance, incorporating 3D TRUS software into the PET system for trans-perineal biopsy, and evaluating the system's accuracy using phantom models. The proposed system, adapted the biopsy system from the 3D TRUS with MR prostate fusion biopsy and for gynecological brachytherapy systems developed in our lab, will feature a side-firing ultrasound probe and a needle guidance template on a stabilized, tracked support for precise biopsy control. Custom software will be used to perform needle segmentation from ultrasound and co-register with the p-PET image. Experiments will assess system accuracy and aim to demonstrate a statistically significant improvement in trajectory and needle tip error rates. This p-PET-3D TRUS approach has the potential to significantly improve the identification and targeting of early-stage PCa and promises to increase the accuracy of PCa diagnosis, reducing false negatives and refining biopsy precision.

Keyword-1

Prostate Cancer

Keyword-2

Ultrasound imaging

Keyword-3

Biopsy Techniques

Primary author: KARAGULLEOGLU KUNDURACI, Sule (1. Department of Medical Biophysics, Western University, London, ON, 2. Robarts Research Institute, London, ON)

Co-authors: Dr FENSTER, Aaron (1. Department of Medical Biophysics, Western University, London, ON, 2. Robarts Research Institute, London, ON); Dr TESSIER, David (Robarts Research Institute, London, ON); Dr CUNNINGHAM, Ian (1. Department of Medical Biophysics, Western University, London, ON, 2. Robarts Research Institute, London, ON); Dr BAX, Jeff (Robarts Research Institute, London, ON); GARDI, Lori (Robarts Research Institute, London, ON)

Presenter: AZIZ, Amal (Western University)

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