Development of an open-source system for prostate biopsy training in Senegal

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Methods

Introduction

• Prostate cancer is the second most common type of cancer diagnosed in men
• In sub-Saharan Africa, the high number of cases has led to a recent increase in referrals to trans-rectal ultrasound (TRUS) guided prostate biopsy [1]
• This procedure requires training to become proficient in locating and targeting the four prostate zones using only TRUS as a visual aid [2]
• We have partnered with an international aid program, “Train the Trainers”, to develop a feasible prostate biopsy training system for use in Senegal [3]
• To produce a beneficial learning process, the training program teaches users to identify zones on TRUS and perform proper zonal sampling
• This research presents the implementation of imaging simulator for an open-source prostate biopsy training tool, highlighting the critical component of zonal anatomy overlay on TRUS

Methods

Dataset Generation

• Prostate zonal overlay enables the zonal identification step and allows users’ performance to be evaluated
• We acquired anonymized TRUS volumes and prostate zonal segmentations from sources which made data available for research purposes [4], [5]
• We overlaid the zonal segmentations onto the TRUS volumes through deformable fiducial registration (Figure 1)
• Generated a dataset of 10 patients

Figure 1: Prostate ultrasound image (left) with labelled zonal anatomy registered and overlaid (right).

Training Module Implementation

• Python scripted module implemented in 3D Slicer, an open-source medical imaging and visualization platform [6]
• Simulation scene includes 3D view with TRUS and probe, and 2D sagittal view of the corresponding TRUS slice (Figure 2)
• Also consists of a copy of the prostate zones and a transform hierarchy to facilitate the ultrasound simulation
• Training interface:
  1. Load 1 of 10 patient TRUS and zonal overlay
  2. Scan TRUS using buttons or keyboard arrow keys
  3. Toggle zonal overlay visibility
  4. Train identification of zones by placing fiducials on a blank TRUS in the correct regions
  5. Save progress

Figure 2: Screen shot consisting of 3D view with movable TRUS probe and corresponding 2D sagittal US slice (left). Corresponding 2D slice with visible zonal overlay (right).

Proposed Physical System Components:

• Mock TRUS probe
• ArUco Markers
• Mock rectum
• Laptop running 3D Slicer
• Webcam

Figure 3: TRUS biopsy simulator design.

Methods Continued

Evaluation of zonal anatomy overlay

• Performed through a two-part survey to evaluate our overlay as suitable for training prostate zone identification:
  1. Evaluate ten TRUS images overlaid with registered zonal anatomy on a 5-point Likert scale (Figure 1)
  2. Label a specified TRUS region as one of the 4 prostate zones (Figure 4). These labels are compared to our zonal overlay.
• Seven urologists responded based on their interpretation of the zones for each TRUS image

Figure 4: Example from the zone labelling section of the questionnaire.

Results

• On average, the experts rated the accuracy of the zonal overlay at 4 on a 5-point scale
• 7 out of 7 experts labelled the peripheral, anterior, and transitional zones equivalently to our overlay, and 5 out of 7 labelled the central zone equivalently to our overlay (Figure 5)
• Labelling inconsistency for the central zone could be attributed to the challenges of identifying both the central and transitional zone border and any zonal enlargements

Figure 5: Results from the labelling questionnaire.

Conclusion

• We designed and implemented the prototype of a TRUS biopsy imaging simulator in open-source software
• A vital training component, zonal overlay, was generated using publicly accessible image data and was validated by expert urologists.
• We confirm the concept of an educational and open-source prostate biopsy training tool based on clinical patient data

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References