Mechanically Assisted Trans-Rectal Prostate Biopsy

DBP2: Prostate Interventions, Queen’s University and JHU

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Goal for roadmap project

• End-to-end application for MR-guided robotically-assisted trans-rectal prostate biopsy

• Add slicer features relevant to clinical interventional procedures

• Utilize slicer in our diagnostic and therapeutic research programs for prostate cancer
Prostate cancer statistics

• One of every 6 men in the U.S. will be diagnosed
• 230,000 new cases in 2007
• Incidence will double by 2025
• ~1 million needle biopsies per year
• (Add 10% for Canada, and double for Europe)

• **Ultrasound guided biopsy is cheap, but has poor sensitivity. Cancers as large as a sugar cube are routinely missed**
MRI for biopsy guidance

**PROS**
- Sensitivity in detecting soft tissue abnormalities
- Excellent visualization of prostate and normal tissues
- Morphological, functional and molecular imaging

**CONS**
- Expensive, limited availability
- This is gradually changing as clinical efficacy is being proven
Trans-rectal, MR compatible

A. Krieger et al., MICCAI 2007
Implementation plan

• Interactive Slicer module
  – Workflow wizard à la EMSegment module

• Workflow:
  – Pre-op planning (future)
  – Robot pose calibration
  – Intra-op targeting
  – Post-biopsy verification
Calibration of Robot Pose

- Load thin-slab calibration image
- Semi-automatic identification of 4 robot fiducials
- Compute robot pose in scanner coords
Targeting biopsy sites

- Load targeting image
- Identify targets with Slicer fids
- Compute robot rotation, needle trajectory, needle depth
- Physician adjusts robot manually and takes biopsy
Verification after biopsy

• Scan after each biopsy (slice or thin slab)

• Compare needle void with planned target
Registration needs

• MR to MR registration
  – Currently, targets are manually placed on intra-op scan based on the pre-op plan
  – Better: pre-op to intra-op registration
  – Must be deformable registration
    • Prone vs. supine, robot in rectum

• MR to US highly desired for future
  – Compare MR to current TRUS procedures
Robot communication needs

• This is a “manual” robot
  – Positioned by hand, no motors
  – Robot joints have encoders, readouts must be displayed to the operator
  – Slicer IGT demon can be used

• Motorized version is forthcoming!
Display needs

• Dual-display required
  #1: display by scanner console
  #2: in-room for interventionalist

• In-room display properties:
  – Full-screen of one Slicer view
  – No interaction, just display
Data-handling needs

• Read DICOM oblique orientations
  – Needed for intervention in general
  – Use Slicer’s IJK to RAS

• RAS to LPS conversion
  – Planning, targeting is always LPS
  – Scanner consoles are LPS
“Frame of Reference”

- Each procedure can involve several “frames of reference” (FORs)
  - i.e. motion occurs: calibration repeated
  - Need FOR identifier tags for data sets and fiducial lists
  - Data sets with different FORs must not be allowed to be overlaid or compared: very real risk to the patient
Feature Summary

• From NA-MIC
  – Workflow GUI infrastructure
  – Oriented images set from DICOM header
  – Registration

• From Queens/JHU
  – End-to-end application
  – Secondary full-screen display
  – Prostate-specific registration

• Shared
  – Multiple Frame-of-Reference in Slicer