DBP – Image Guided Prostate Interventions

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Engineering Teams:
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Current Clinical Teams:
(1) National Institutes of Health
(2) Princess Margaret Hospital, Toronto
(3) Brigham and Women’s Hospital, Boston

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(1 more years, will submit competitive renewal)
Transrectal Prostate Biopsy in MRI
Results in multiple clinical trials

- From concept to trials in 22 month
- 38 biopsies and seed placements
- Accuracy ~3 mm
- No severe adverse events

Example #1

Target (red dot)
Needle void on target
Needle tract on target

Example #2

Krieger et al. IEEE TMBE, 2005
G. Fichtinger, 2007
Current Projects

1. Interactive User Interface
2. Registration/Segmentation
(1) Interactive User Interface

Challenge:
Make 3D Slicer fully applicable in this application
Current status: VTK/ITK based application
Preliminary Results – 1\textsuperscript{st} patient
(2) Registration/Segmentation

Pre-op planning MRI/MRS - supine

Intra-op intervention MRI - prone
Problems of MR prostate registration

• Fusion of pre-op information for improving intra-op execution, under the circumstances:
  – Completely different patient positions $\rightarrow$ large anatomical misalignment
  – Different imaging parameters
  – Different coils
  – Local deformation and surrounding tissue deformation $\rightarrow$ significant shape change $\rightarrow$ Non-rigid registration
Problems of MR prostate segmentation

- Localize prostate within scanned volume
- Critical: accuracy of segmentation → registration accuracy
- **Challenges**
  - Extreme detail in MRI/MRS → internal structures → too many edges near true boundary
  - No reliable region homogeneity or texture
  - Actual total gland (TG) boundary blends into surrounding tissues
  - Large variation in shapes
  - Variable edge profile within slice and across slices
  - Variable imaging sequence across datasets
Our approach

Pre-op scan → Segmentation → Pre-op segmented prostate → Rigid registration → Pre-op rigid-registered prostate → Deformable registration → Registered and deformed Pre-op prostate

Intra-op scan → Segmentation → Intra-op segmented prostate
Segmentation

User: Prostate center, expected coil radius

A-priori knowledge: size, shape

Speckle suppression and edge enhancement

Integrate a-priori information

Slice: Central slice
Initial estimate: shape model

Canny edge

A-priori knowledge-based false-edge removal

Fill missing information

Fit closed spline to get final contour estimate for current slice

All slices segmented? Yes

Present to user

No

Initial estimate = last final contour

Pre-op scan
Pre-op segmented prostate
Rigid registration
Pre-op rigid-registered prostate
Deformable registration
Intra-op rigid-registered prostate
Registered and deformed Pre-op prostate

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Preliminary results (1)

a) Original image  b) Contrast enhance  c) Canny edge  d) Narrow search

e) Correct orientation  f) Clear overlaps  g) Fill information  h) Spline fit
Preliminary results (2)
Problems of MR prostate tracking

• Prostate deforms and changes location after targeting and collecting sample
• Critical: detect and warn against such situation
• Challenges
  – RT imaging is restricted to slices
  – How we track a volume based on single slices?
  – The usual stuff:
    • No reliable region homogeneity or texture
    • Actual total gland (TG) boundary blends into surrounding tissues
    • Large variation in shapes
    • Variable edge profile within slice and across slices
Problems of MR needle/seed/device tracking

Examples of susceptibility artifacts imaged using Single Shot Fast Spin Echo (SSFSE) and Fast Gradient Recalled Echo (FGRE) sequences, with needles perpendicular to B0, and immersed in a NiCl solution. Dashed lines and crosses are actual needle shaft and tip, while dotted lines and circles indicate detected artifact.