DBP – Image Guided Prostate Interventions

PI: Gabor Fichtinger

Engineering Teams:

Queen's University

Johns Hopkins University

Current Clinical Teams:

(1) National Institutes of Health

(2) Princess Margaret Hospital, Toronto

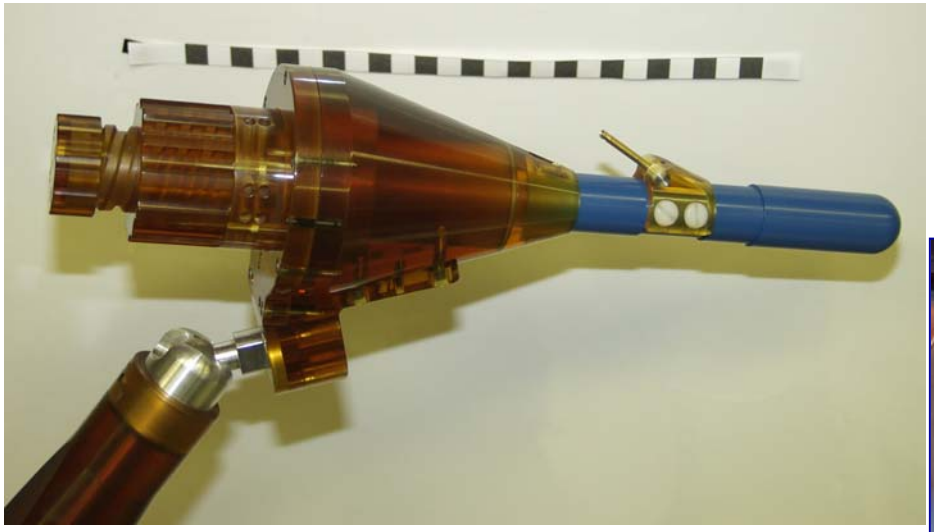
(3) Brigham and Women's Hospital, Boston

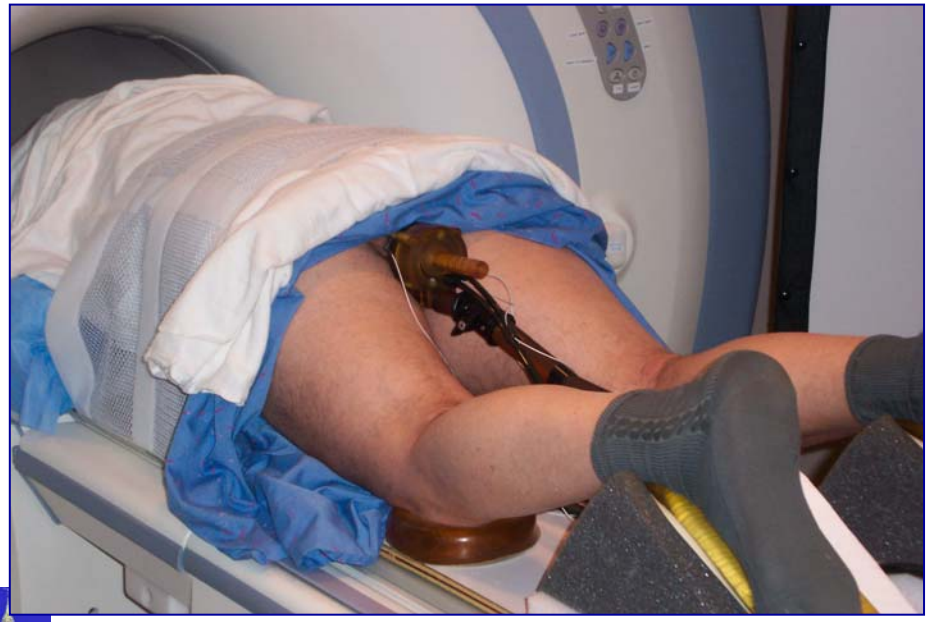
Funding

NIH/NIBIB 1R01EB002963, PI Fichtinger

(1 more years, will submit competitive renewal)

Transrectal Prostate Biopsy in MRI

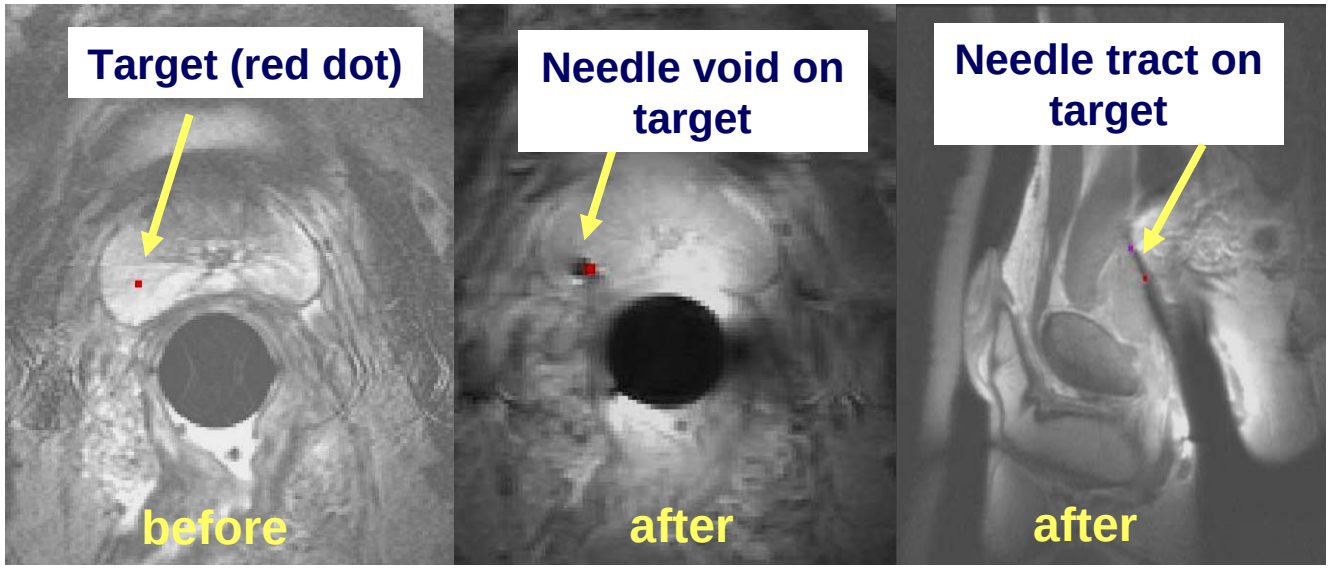




Results in multiple clinical trials

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

Example #1



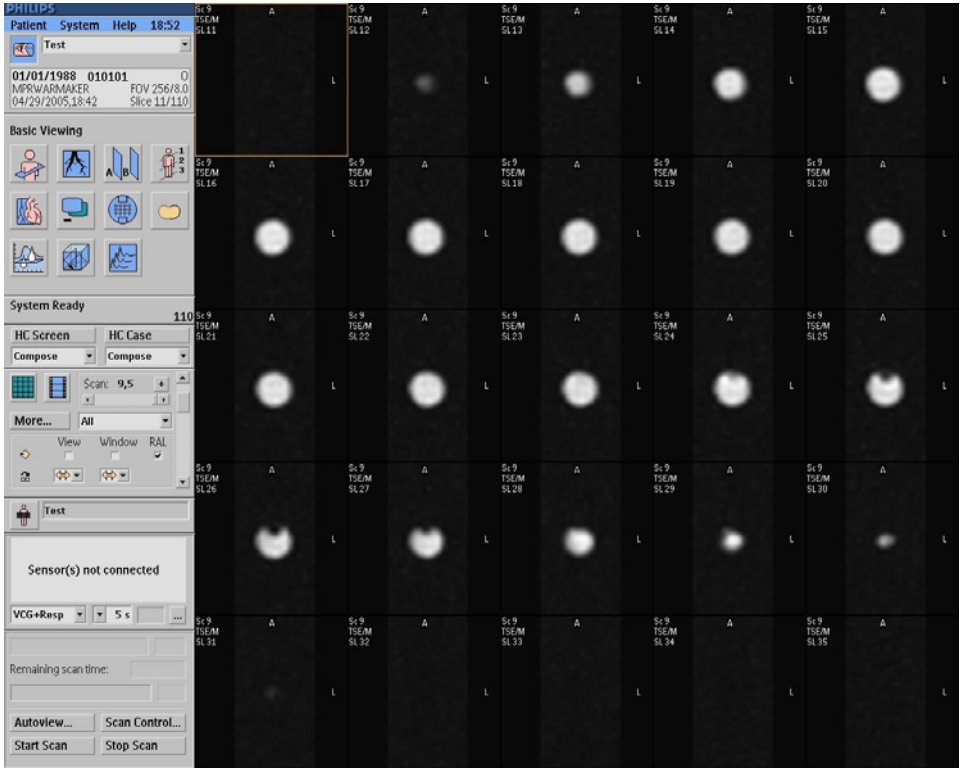
Example #2

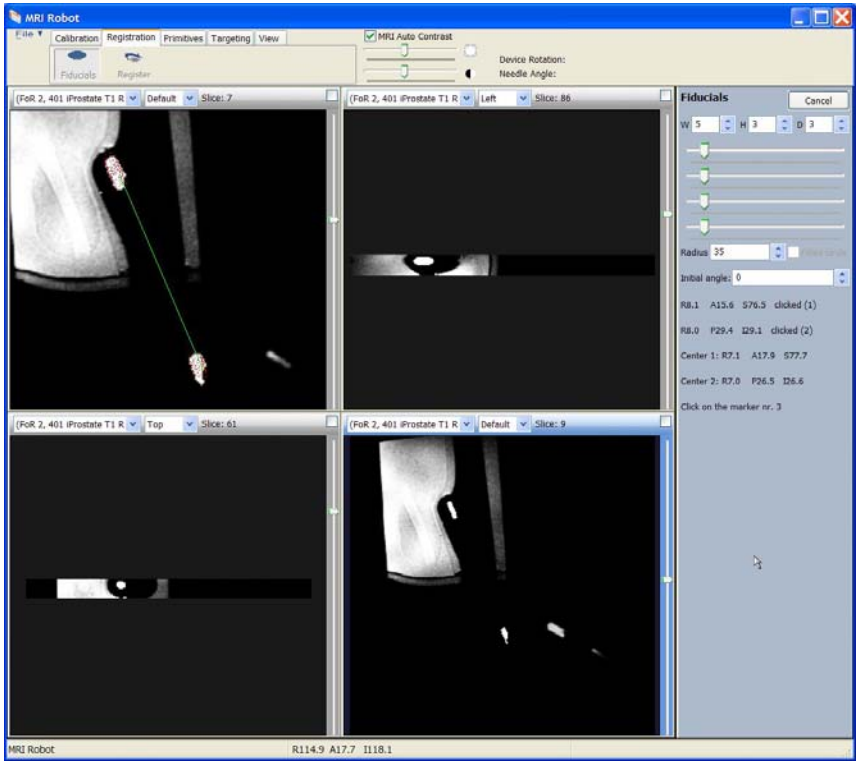
Krieger *et al.* IEEE TMBE, 2005

Current Projects

1. Interactive User Interface
2. Registration/Segmentation

(1) Interactive User Interface



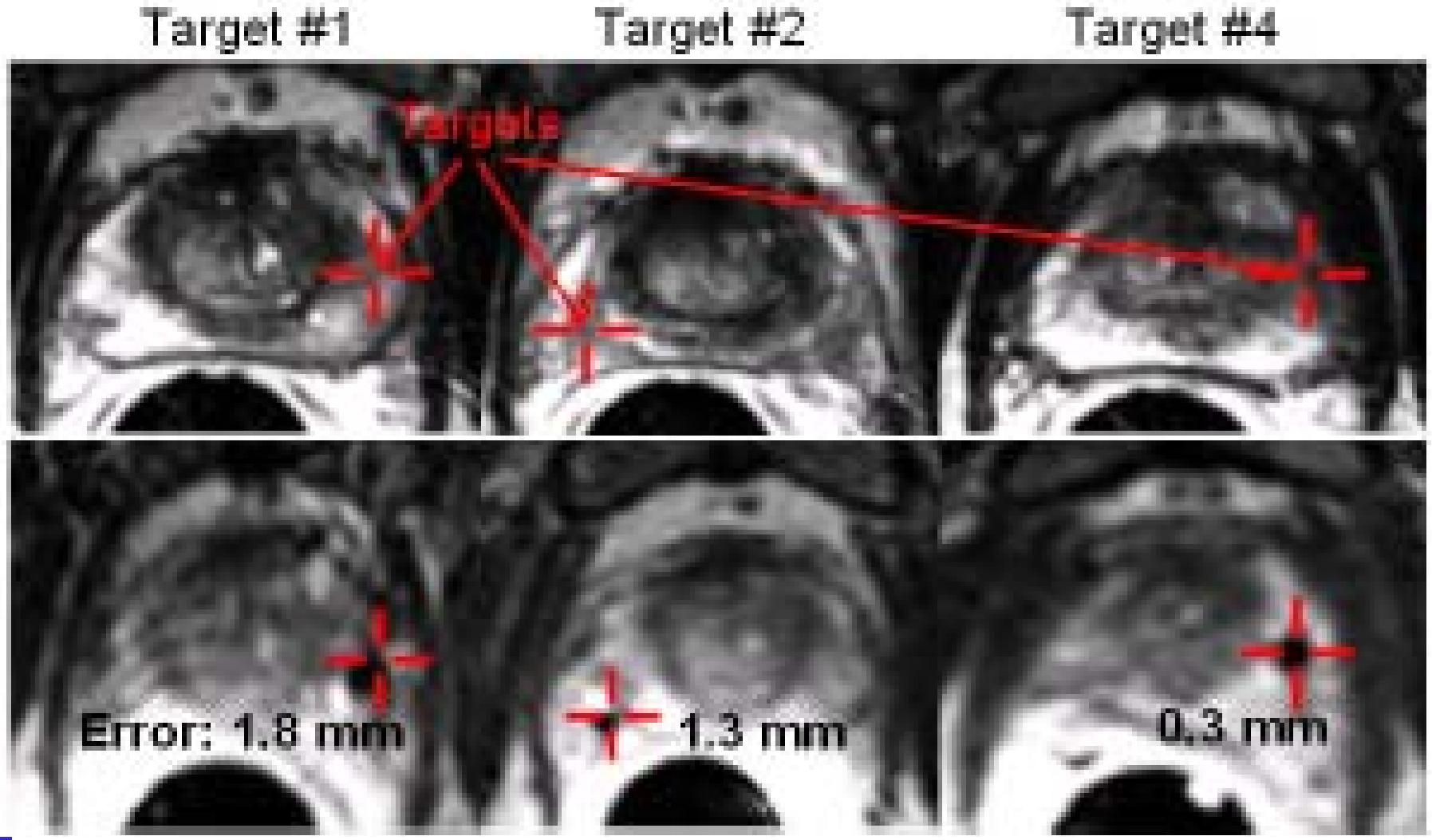


Challenge:

Make 3D Slicer fully applicable in this application

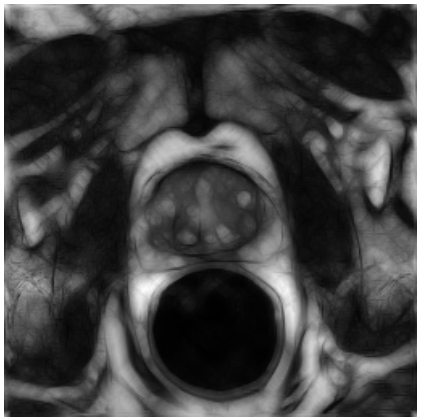
Current status: VTK/ITK based application

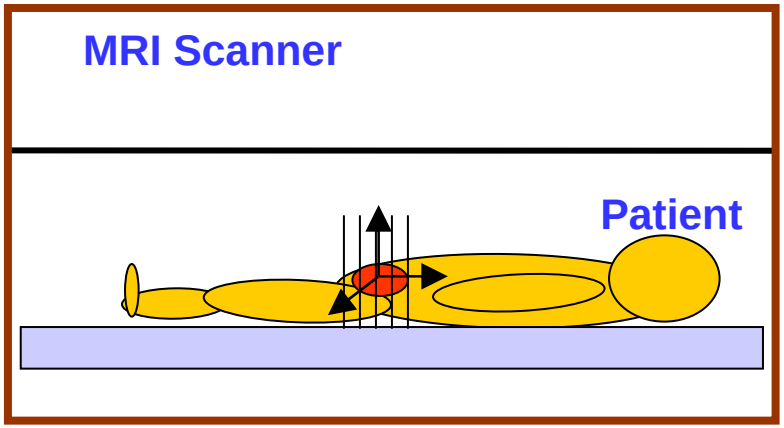
Preliminary Results – 1st patient



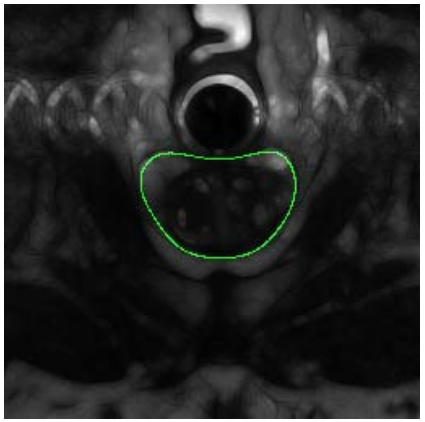
(2) Registration/Segmentation

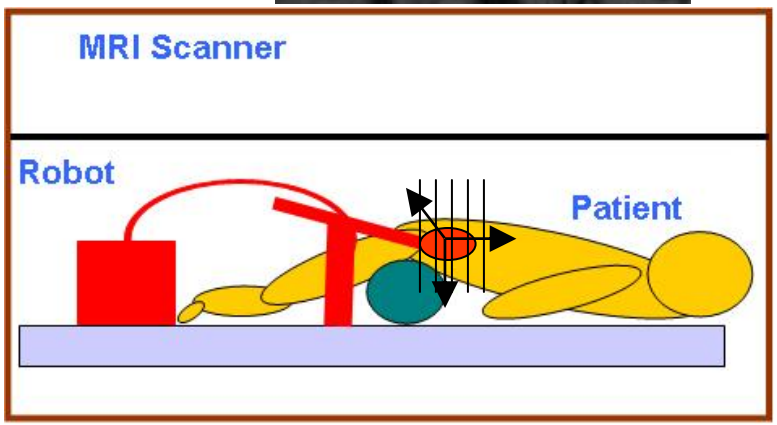
Pre-op planning MRI/MRS - supine





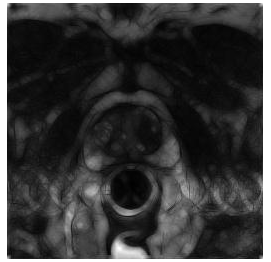
Intra-op intervention MRI - prone

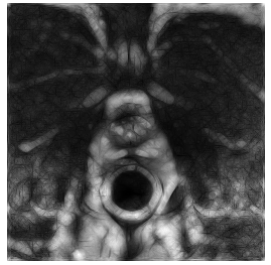


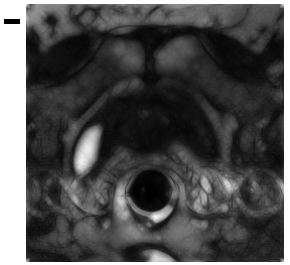


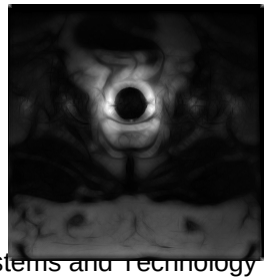
Problems of MR prostate registration

- Fusion of pre-op information for improving intra-op execution, under the circumstances:
  - Completely different patient positions → large anatomical misalignment
  - Different imaging parameters
  - Different coils
  - Local deformation and surrounding tissue deformation → significant shape change → Non-rigid registration



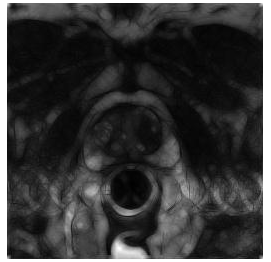
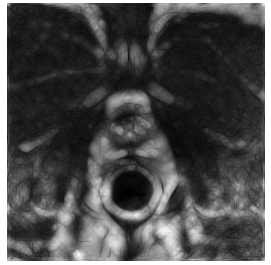
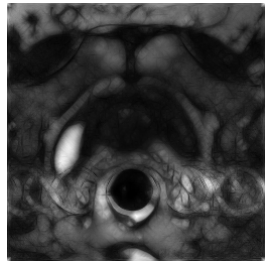
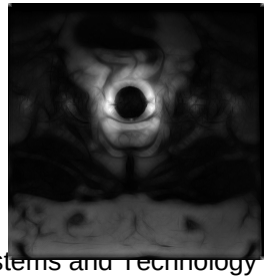




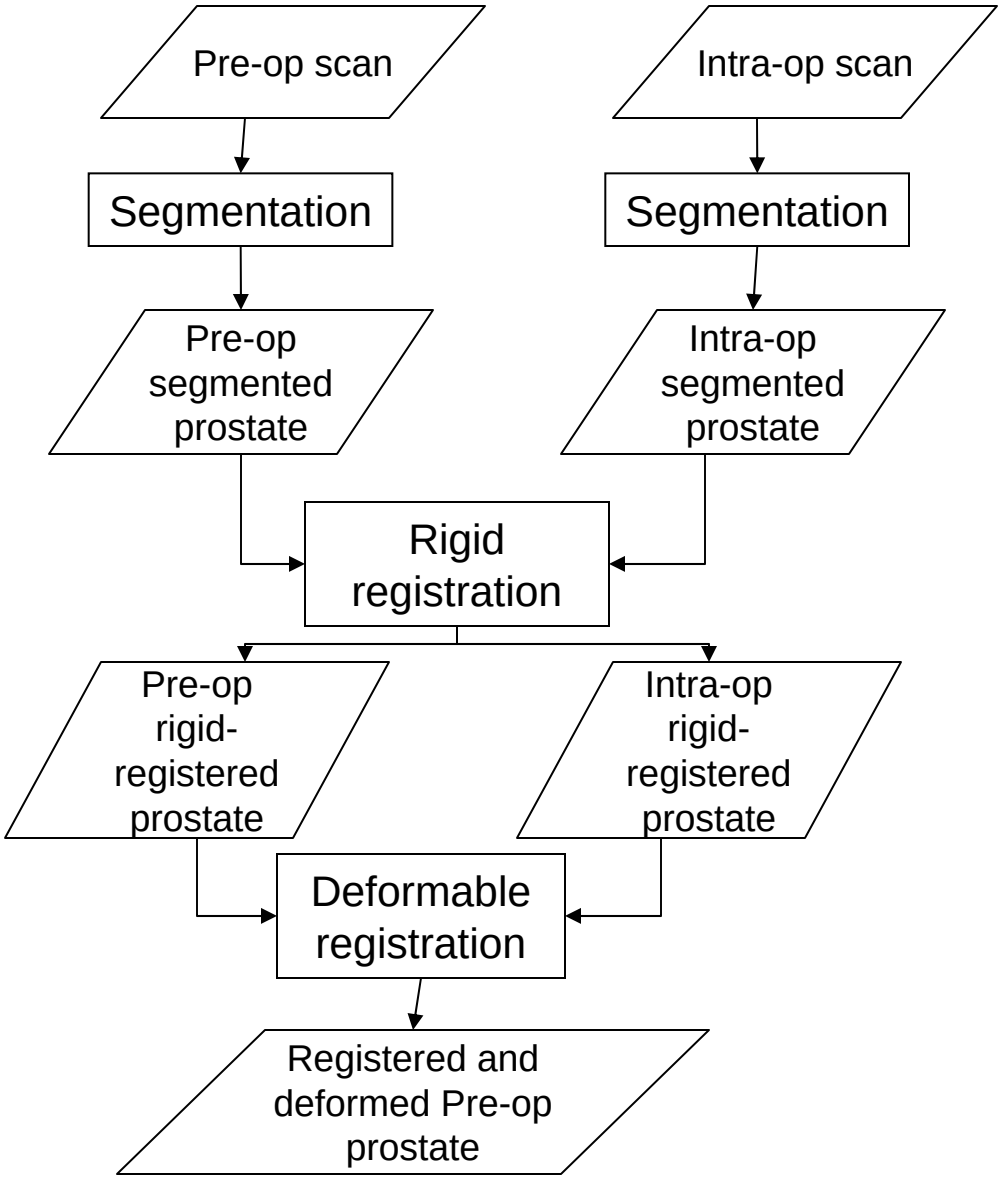


Problems of MR prostate segmentation

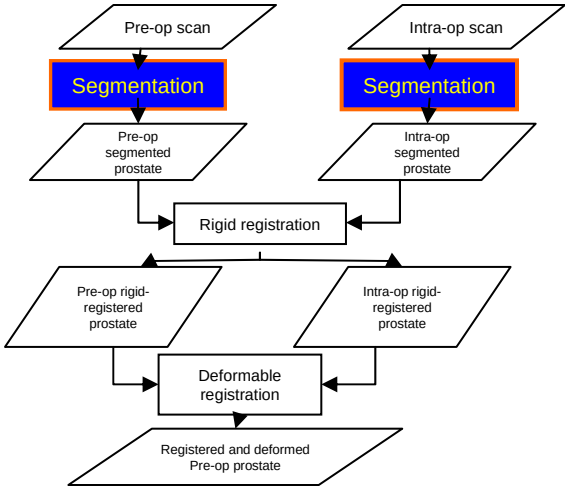
- Localize prostate within scanned volume
- Critical: accuracy of segmentation → registration accuracy
- **Challenges**
  - Extreme detail in MRI/MRS → internal structures → too many edges near true boundary
  - No reliable region homogeneity or texture
  - Actual total gland (TG) boundary blends into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

Our approach



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 ?

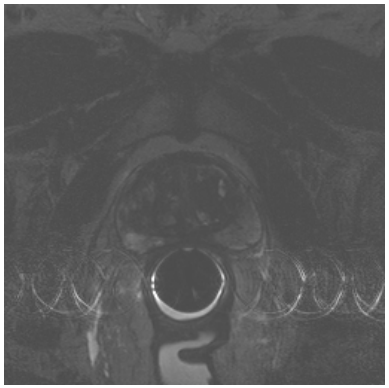
No

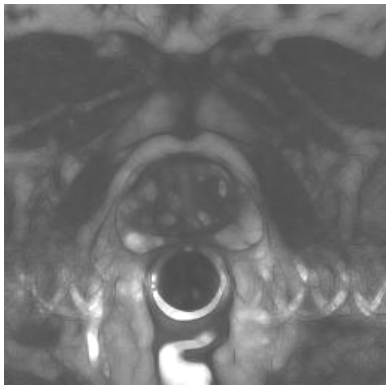
Initial estimate = last *final* contour

Yes

Present to user

Preliminary results (1)


a) Original image


b) Contrast enhance

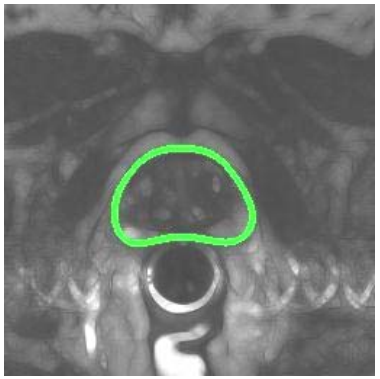

c) Canny edge


d) Narrow search

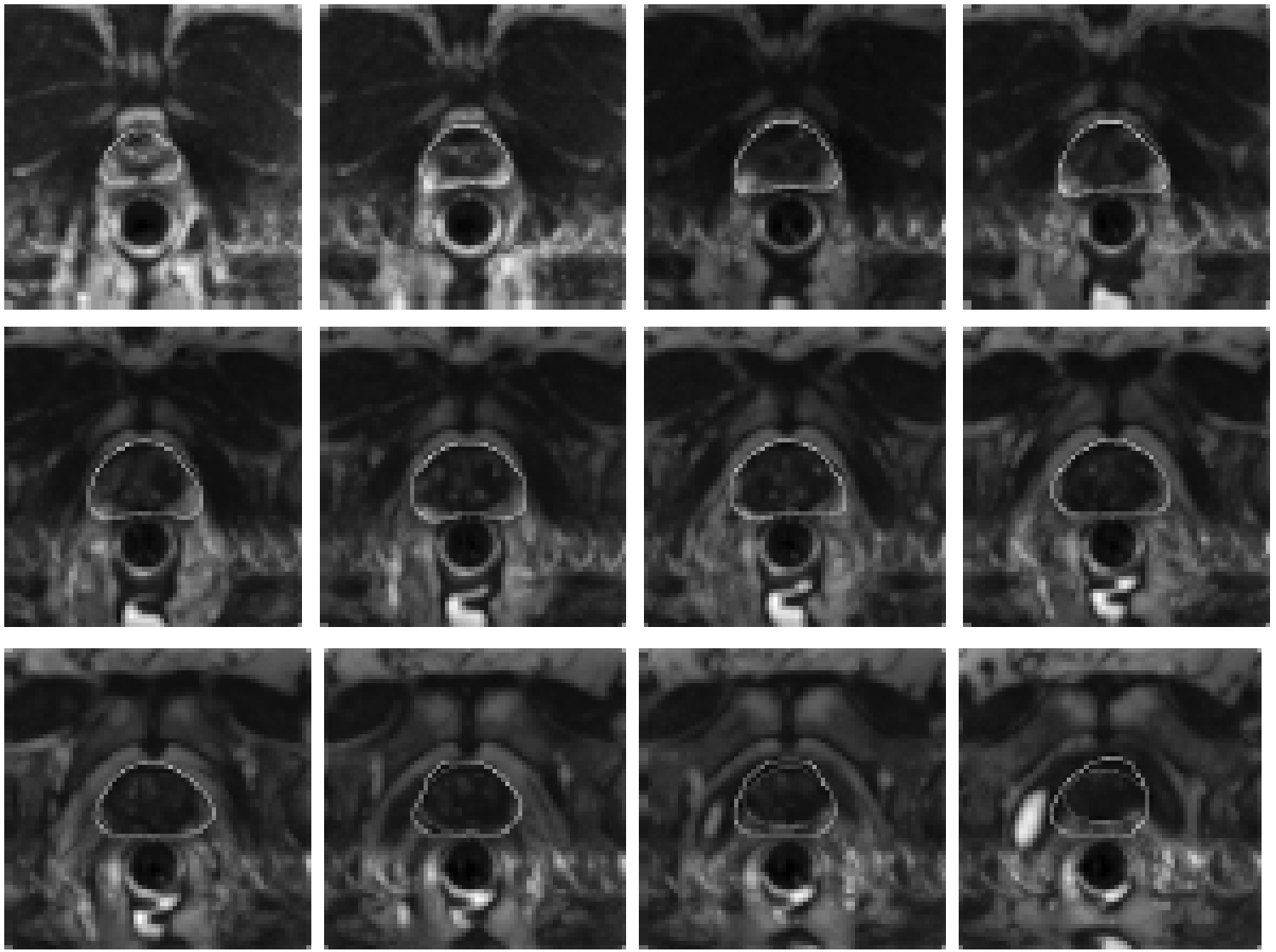

e) Correct orientation


f) Clear overlaps


g) Fill information

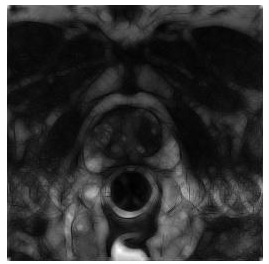

h) Spline fit

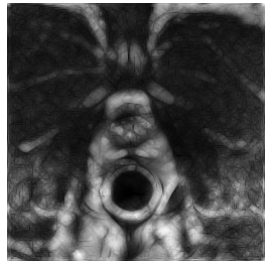
Preliminary results (2)

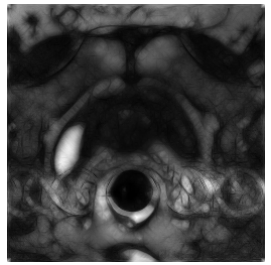


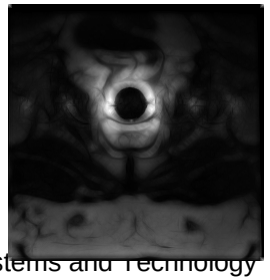
Problems of MR prostate tracking

- 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

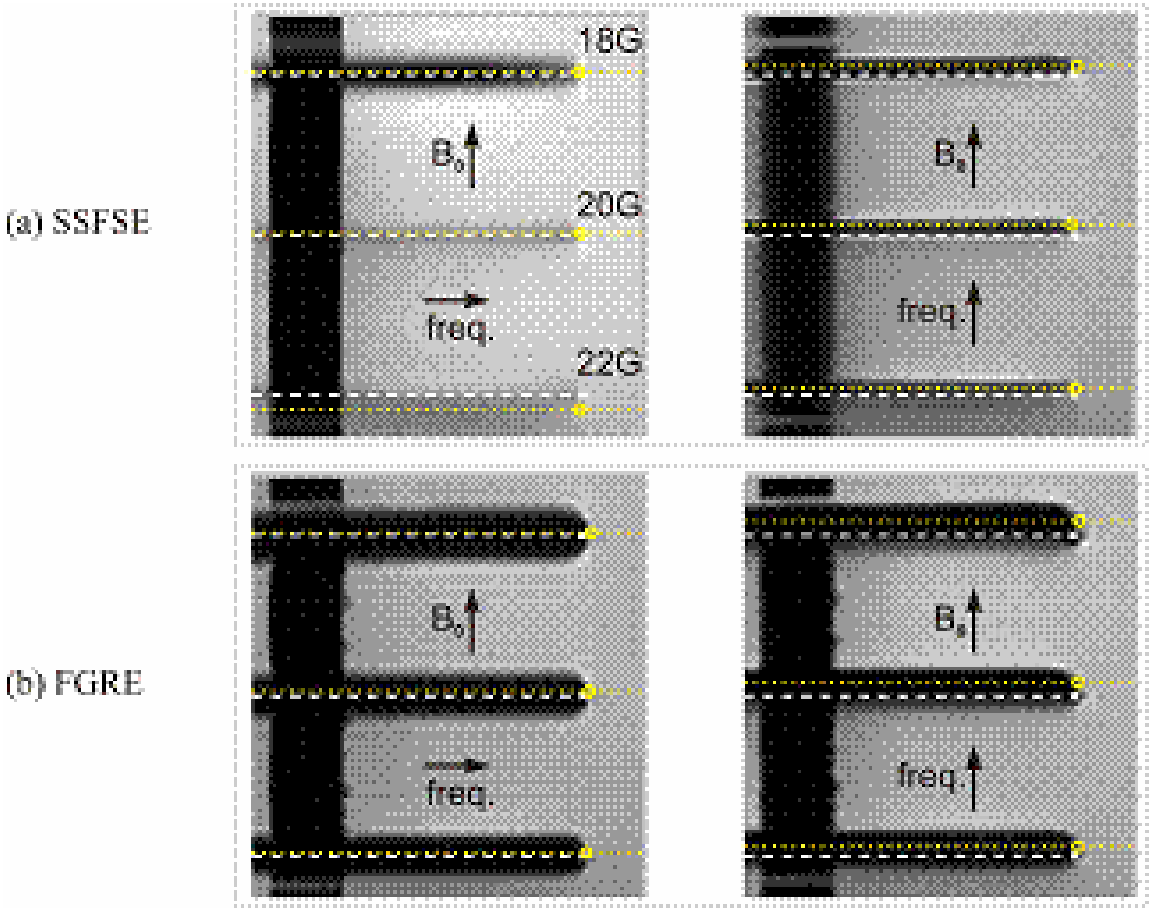








Problems of MR needle/seed/device tracking



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.

*S DiMaio, D Kacher, R Ellis, N Hata, G Zientara, L Panych, G **Fichtinger**, CMC Tempany, R Kikinis, F Jolesz, Needle Artifact Localization in 3T MR Images, Stud Health Technol Inform. 2005;119:120-5.*