



NA-MIC

National Alliance for Medical Image Computing

<http://na-mic.org>



Coming of age for a NA-MIC DBP

**Gabor Fichtinger, Andras Lasso, Tamas Ungi,
Csaba Pinter, Tomi Heffter, Sid Vikal, David Gobbi,
and Attila Tanacs**

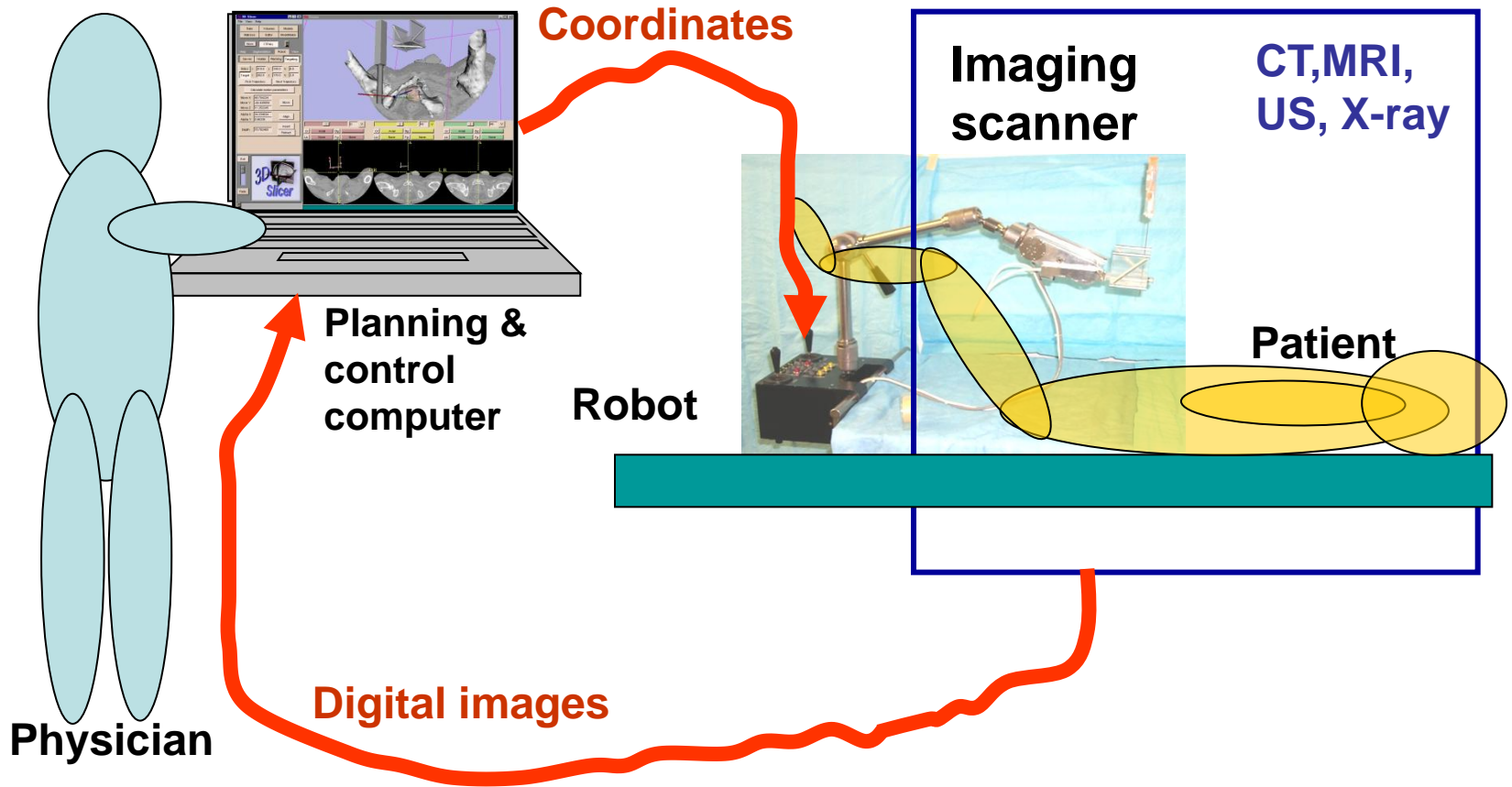
Queen's University, Canada



**Laboratory for
Percutaneous Surgery**



In-situ image-guided surgery





First implementation

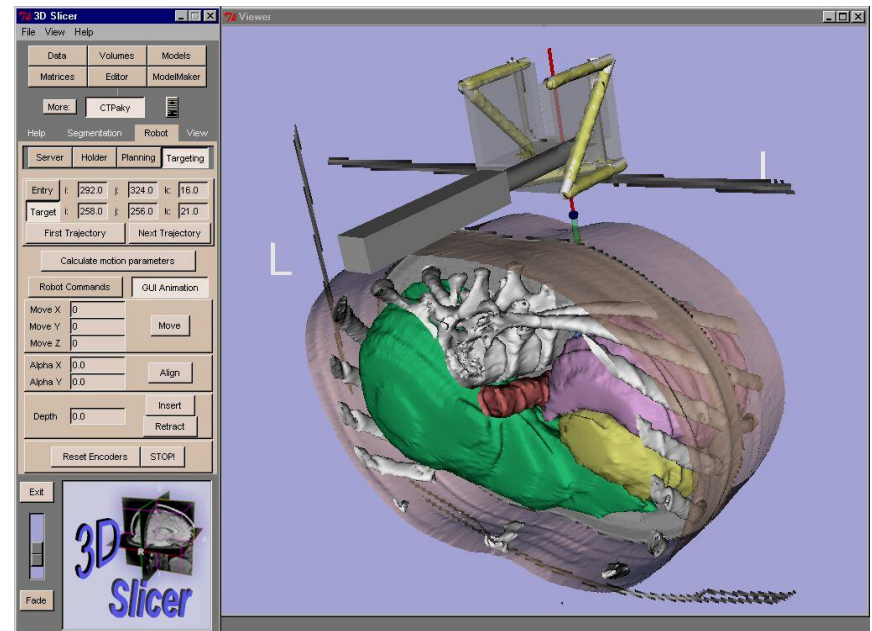
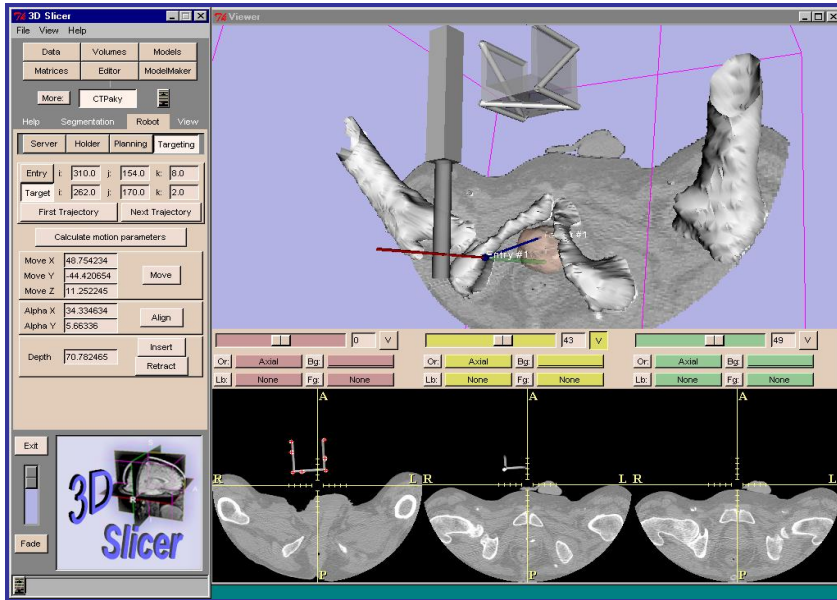


Fichtinger et al. Acad Rad, 2002





First implementation



Tanacs, 2002





Hypothesis

It is possible to architect IGS systems that, to a large extent, are invariant to imaging modalities, scanners, trackers, and surgical devices, and even to anatomical sites and diseases.





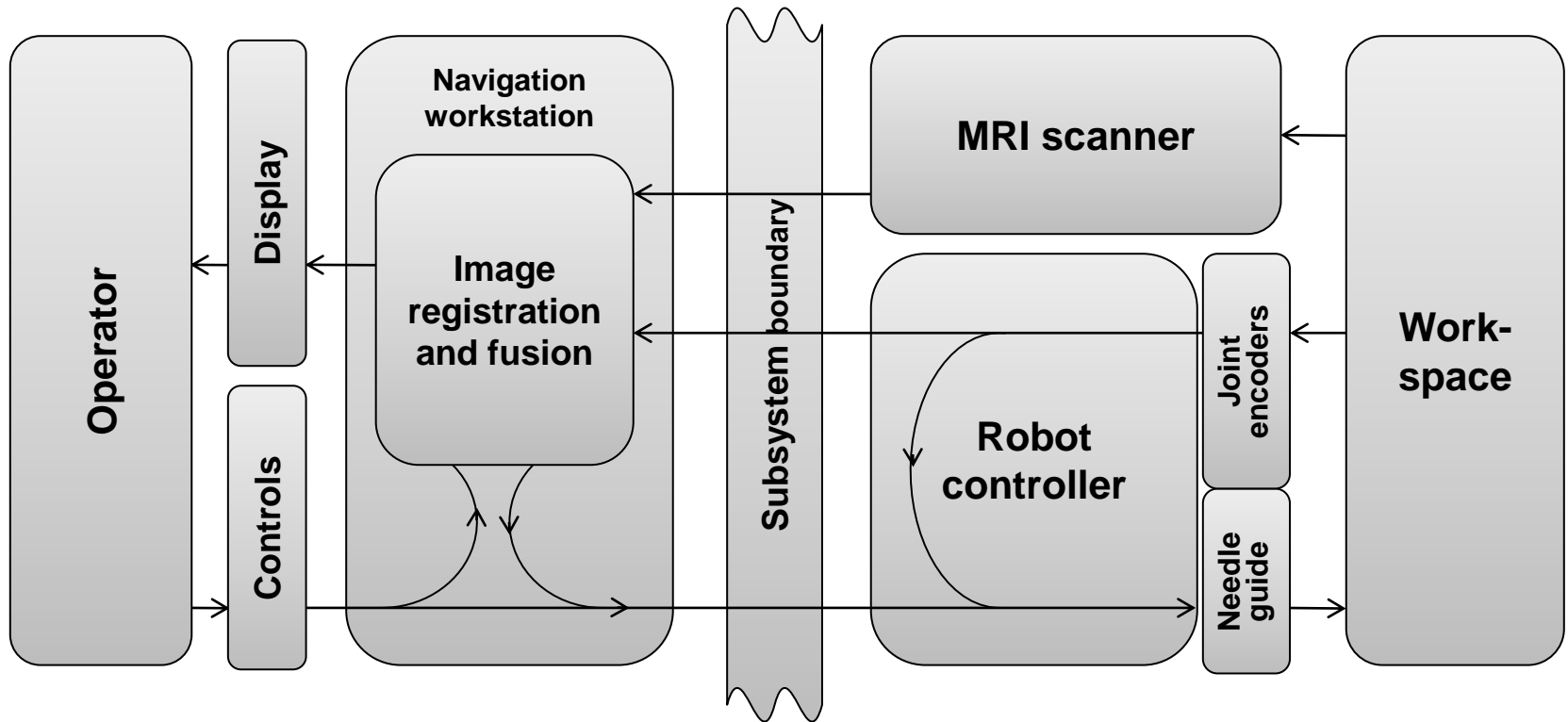
Goals as a NA-MIC DBP

- Develop generic IGS platform on Slicer
- Apply it in image-guided needle surgery
 - Robot-assisted prostate interventions
 - Spinal interventions
- Go clinical





Heterogeneous human supervisory control (HHSC)



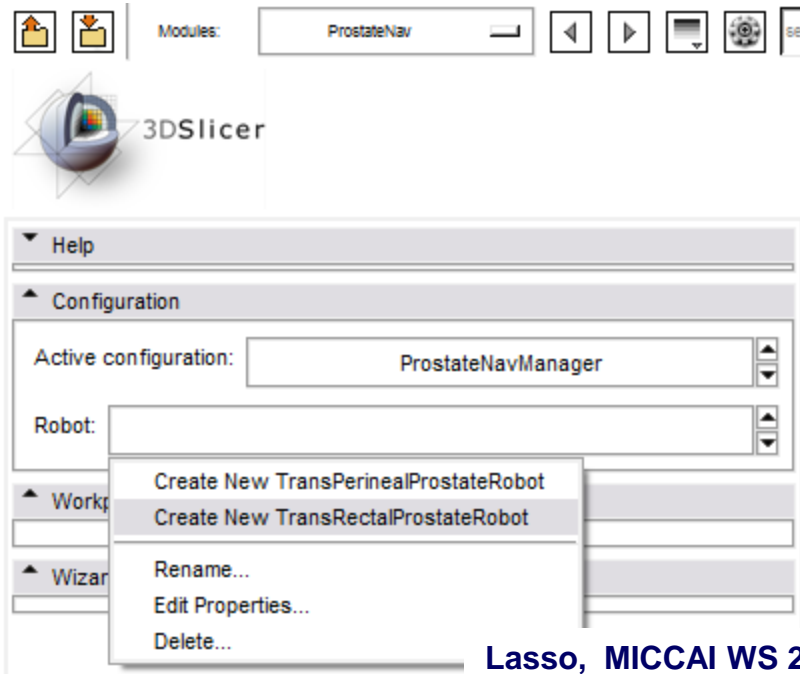
Lasso, 2012





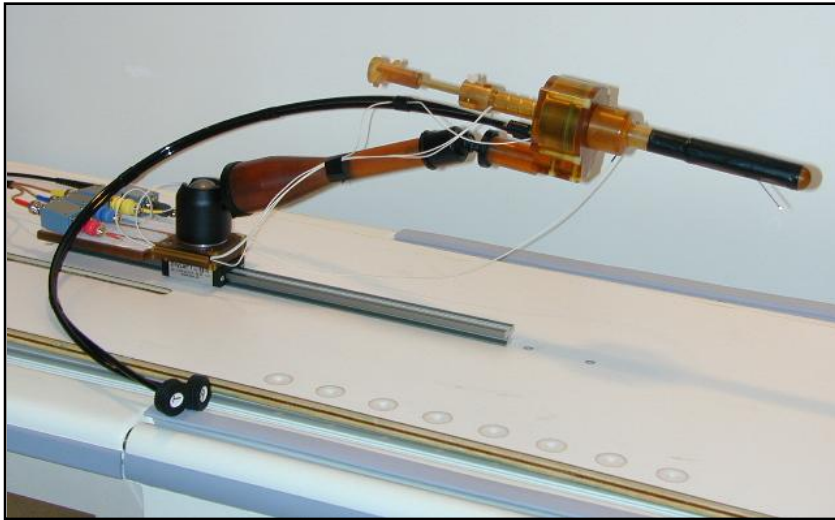
Robotic prostate biopsy in MRI

Configurable to multiple robot systems





Transrectal system at JHU/NIH

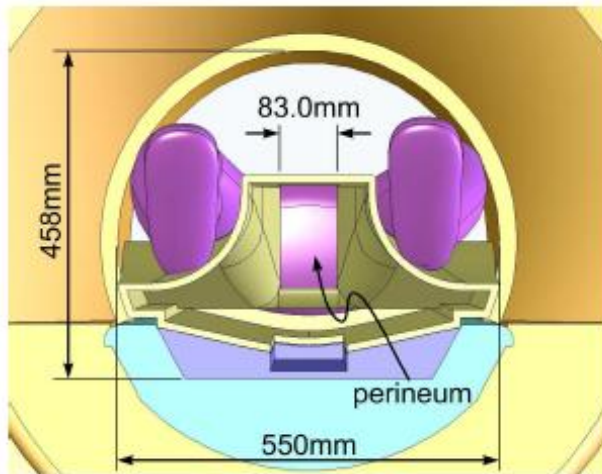
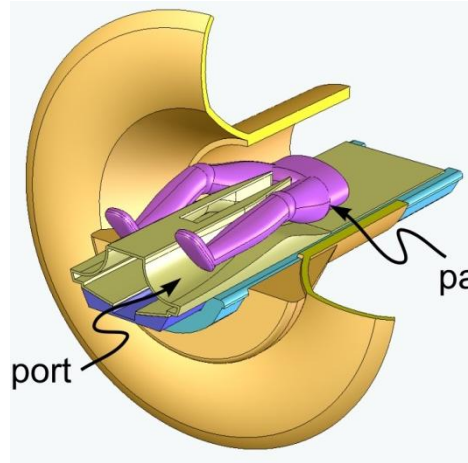


**Krieger *et al.* IEEE TMBE, 2005
(Best paper in 2005-2009)**





Transperineal system at BWH



Fischer *et al.* IEEE ASME, 2007
Song *et al.* IJCARS 2011





Workflow definition

Workflow definition

- Imaging & modeling
- Planning
- Robot registration
- Targeting
- Execution & monitoring
- Verification

3D Slicer Version 3.5 Alpha

File Edit View Window Help Feedback

3DSlicer

Help & Acknowledgement

Workspace Frame

Calibration Segmentation Targeting Verification

Experiment Frame

Wizard

3.4. Targeting

Select targets and prepare for biopsy.

C:\Medicalmag...eb7e69412.dcm

RAS: [] [] []

Needle type: Biopsy

No.	Needle type	RAS location	Reachable	Rotation
1	Biopsy	32.3, 30.2, 3...	Reachable	-23.146052
2	Biopsy	10.2, 28.9, 3...	Reachable	12.730355

Needle type: Biopsy
RAS location: R 10.2, A 28.9, S 36.5
Reachable: Yes
Depth: 11.7 cm
Device rotation: 12.7 deg
Needle angle: 23.3 deg

< Back Next > Help

Manipulate Slice Views

Manipulate 3D View

PerResult TPPFC coverage
None MP_49c2244e2f60412.dcm 13.584

PerResult TPPFC coverage
None MP_49c2244e2f60412.dcm 10.527

PerResult TPPFC coverage
None MP_49c2244e2f60412.dcm 27.096

Biopsy_1
Biopsy_2

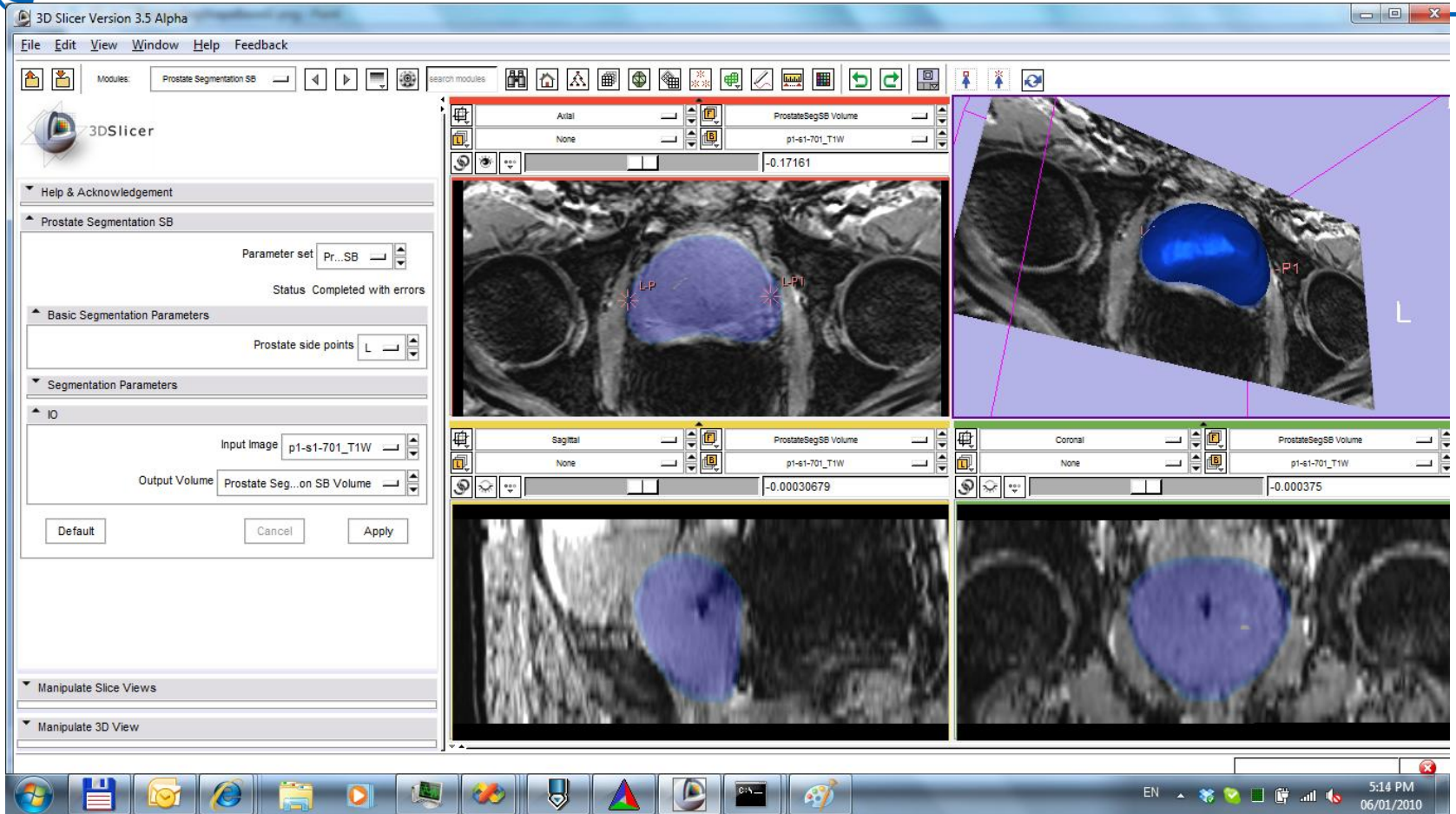
A
S
L

Lasso, MICCAI WS 2009





Modeling and planning



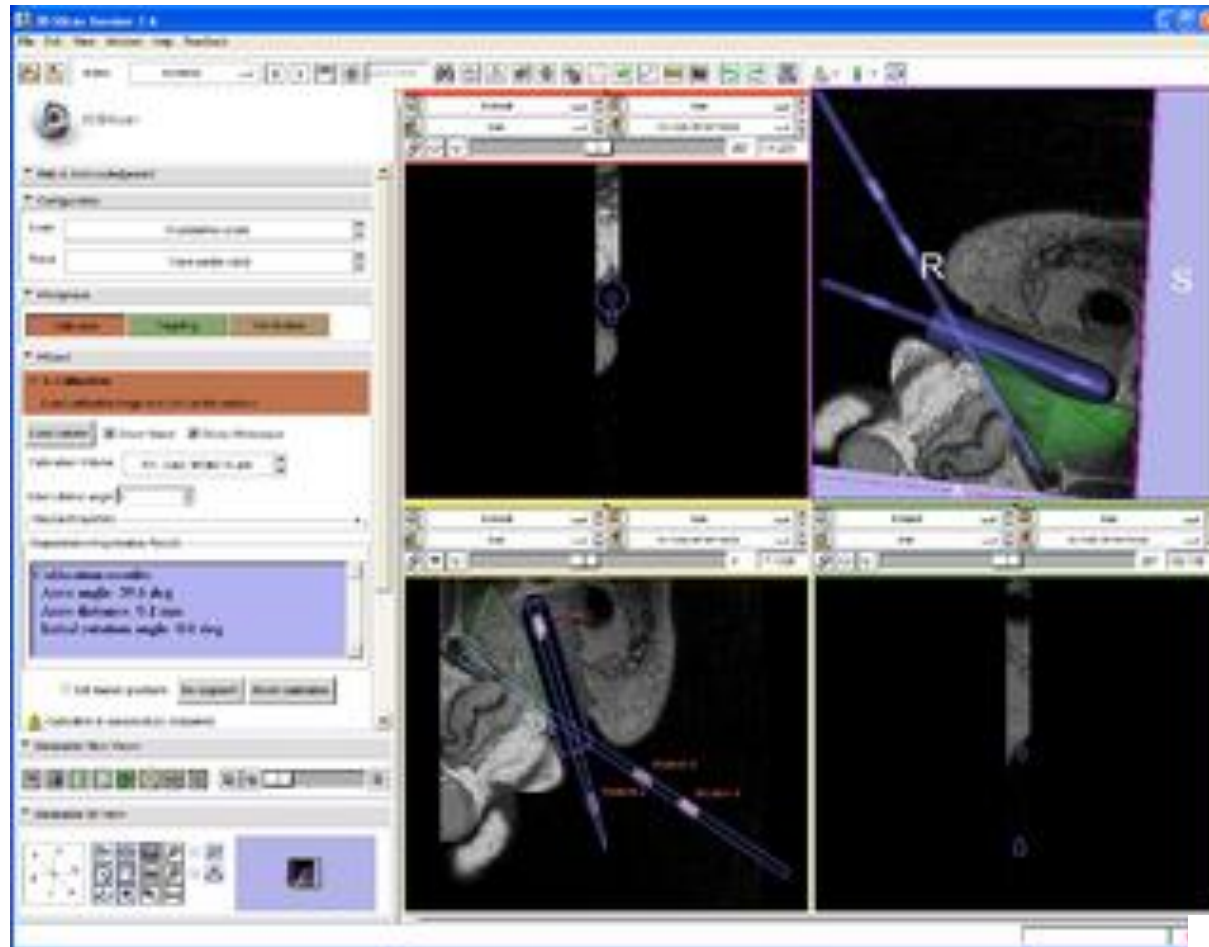
Gao, Tannenbaum *et al.* IEEE TMI 2010



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Robot registration



Lasso ImNO, 2011





Targeting the biopsy sites

3D Slicer Version 3.6

File Edit View Window Help Feedback

Workphase: Calibration Targeting Verification

Wizard: 2 / 3. Targeting

Set target points:

Load volume Show Robot Show Work

Targeting Volume: 801-T2 AXIAL

Add target by image click

Needle type: Seed E-Z-EM 220 (J#H) <S> (0mm overshoot, 150mm length)

Name	R	A	S	Needle
B4	-4.0	-4.9	80.0	Biopsy TSK 14G ...
B5	14.8	-12.2	61.1	Biopsy TSK 14G ...
B6	-18.5	-13.9	63.4	Biopsy TSK 14G ...
S1	11.8	4.6	55.9	Seed E-Z-EM 22...
S2	-14.6	6.3	63.5	Seed E-Z-EM 22...
S3	15.1	-8.4	76.2	Seed E-Z-EM 22...
S4	-15.7	-9.0	78.0	Seed E-Z-EM 22...

Position (X, Y, Z):

Manipulate Slice Views

Manipulate 3D View

801-T2 AXIAL RAS: (81.8, 90.4, 22.3), Bg LK: (-79, -91, 9), Bg: Out of Frame.

Lasso ImNO, 2011





Monitoring in 2nd display

The screenshot displays the 3D Slicer Version 3.5 Alpha interface. The main window shows a 3D model of a prostate with a yellow biopsy needle. The needle is positioned at a depth of 13.3983 cm. The RAS location is R -16.1, A -10.7, S 78.3. The device rotation is 10.126 deg, and the needle angle is 37.1663 deg. The needle type is Generic. The RAS location is R -16.1, A -10.7, S 78.3. The depth is 13.3983 cm. The device rotation is 10.126 deg. The needle angle is 37.1663 deg. The needle type is Generic. The RAS location is R -16.1, A -10.7, S 78.3.

6. Biopsy R 9.7, A 22.8, S 35.4
Rotation: -163.6 deg
Reachable: Yes
Needle angle: 33.1 deg
Depth: 8.9 cm

Encoders not connected

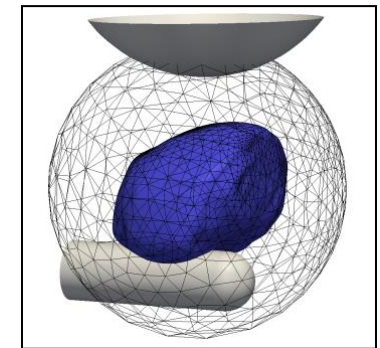
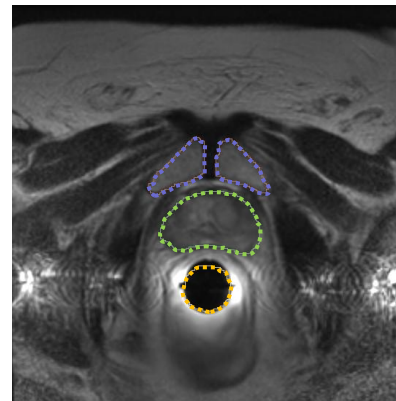
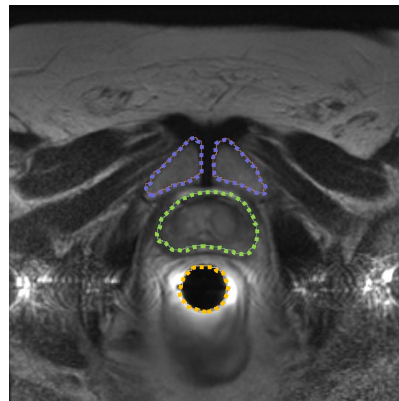
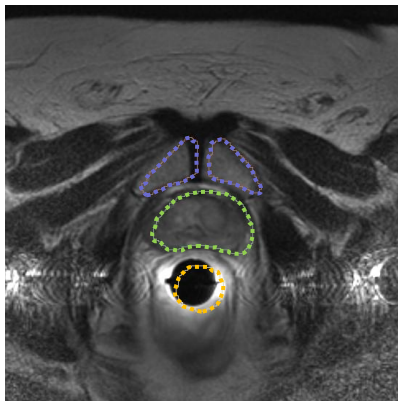
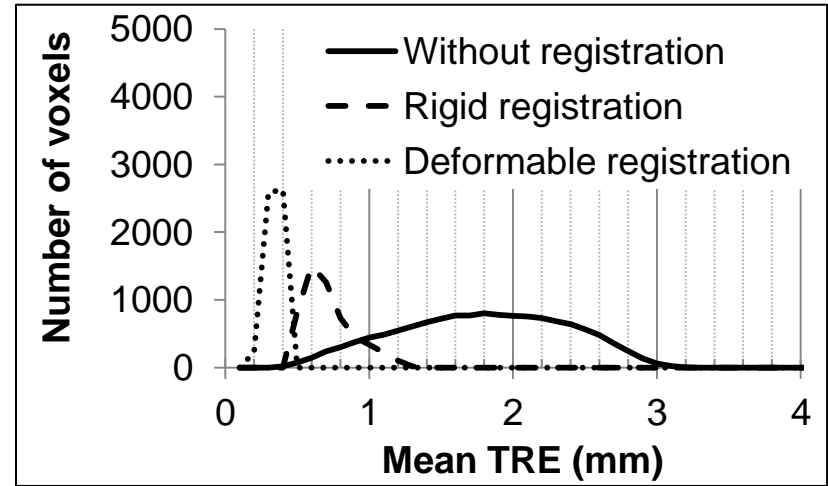
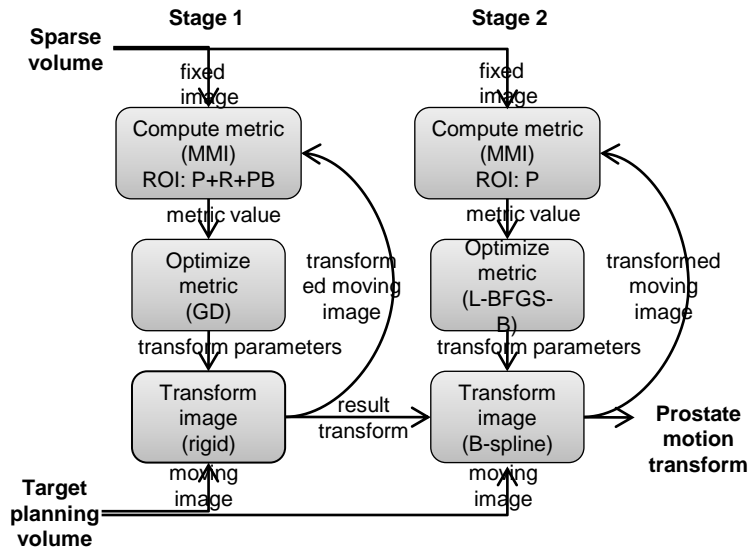
Windows Task Ma... Resource Monitor Slicer3 (Running) - ... Total Commander ... IrfanView 3D Slicer Version 3... EN

Lasso ImNO, 2011





Motion tracking



Tadayyon *et al.* IEEE TBME 2011
Lasso 2012





Verification

3D Slicer Version 3.6 RC3

File Edit View Window Help Feedback

Workphase: Calibration Targeting Verification

Wizard: 3 / 3. Verification

Measure needle distance from target.

Load volume: Show Robot Show Workspace

Verification Volume: 1201-AX SEED CONFIRMATION

Name	R	A	S	Needle	Overall...	PL
B7	-21.4...	-2.98...	90.62	Biops...		
B9	8.585...	4.852...	55.06	Biops...		
B10	7.885...	-12.4...	54.35	Biops...		
B11	-13.4...	-15.6...	56.43	Biops...		
S1	-7.31...	7.482...	84.87	Seed...		
B13	17.50	12.1	82.38	Biops...	0.258237	

Verify target Clear target verification

Select a target, click on 'Verify target' button, then click on two points along the visible needle line.

Manipulate Slice Views

Manipulate 3D View

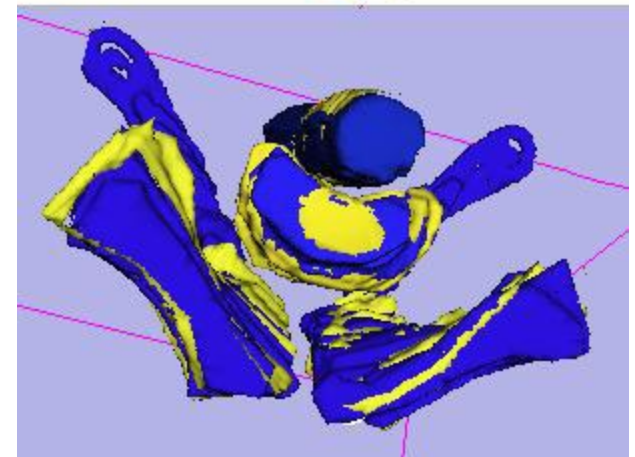
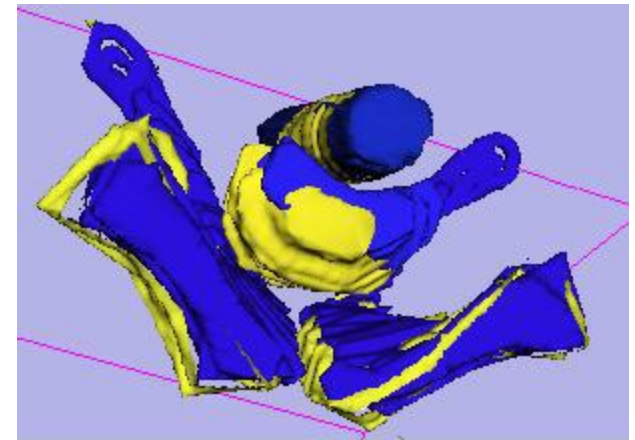
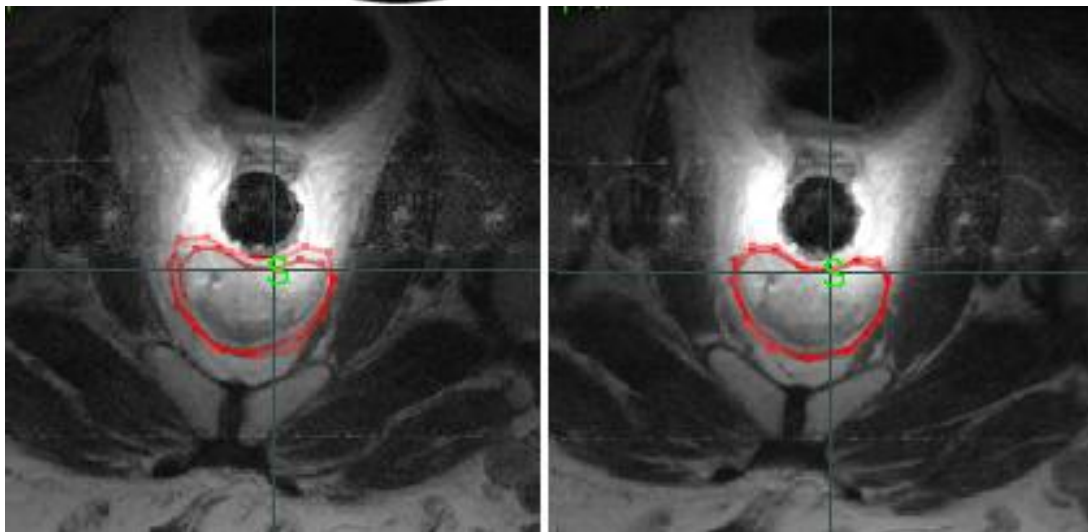
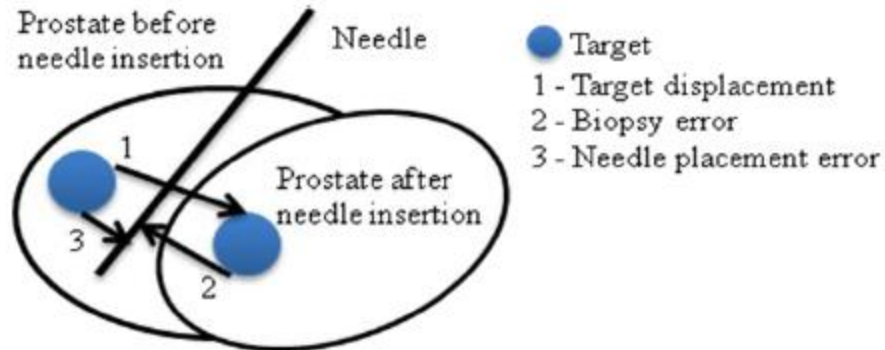
1101-Needle Ax RAS: (-56.7, -125.5, -108.1), B7 Slice not shown,

Lasso ImNO, 2011





Clinical trial analysis

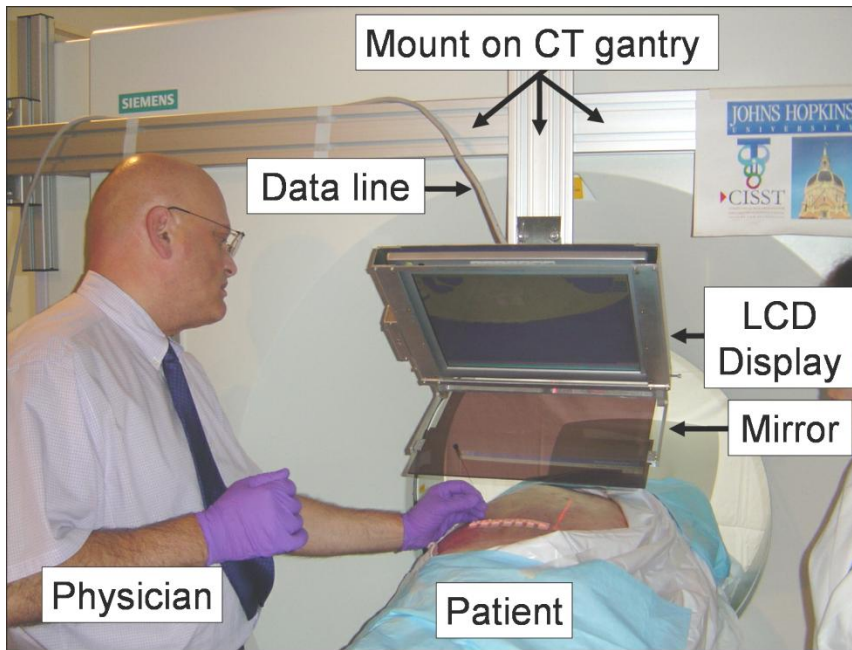


Xu et al. MICCAI, 2010





Augmented reality guidance



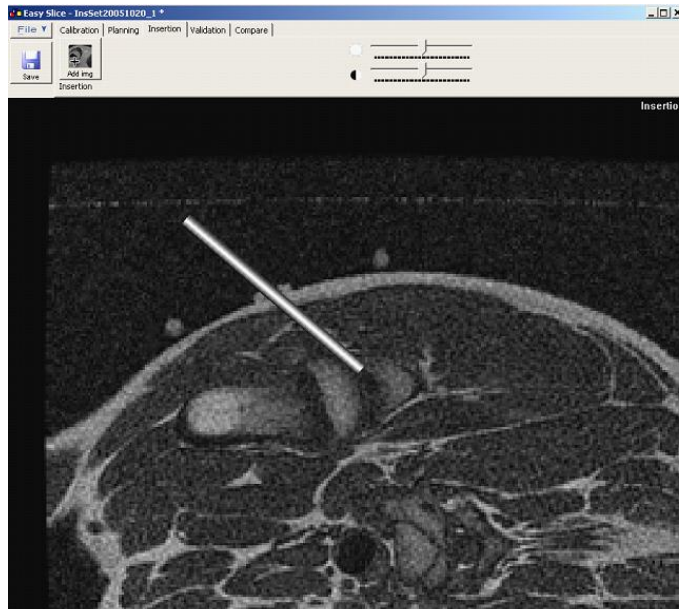
Fichtinger *et al.* IEEE TMBE, 2005

Fischer *et al.* JCAS, 2007

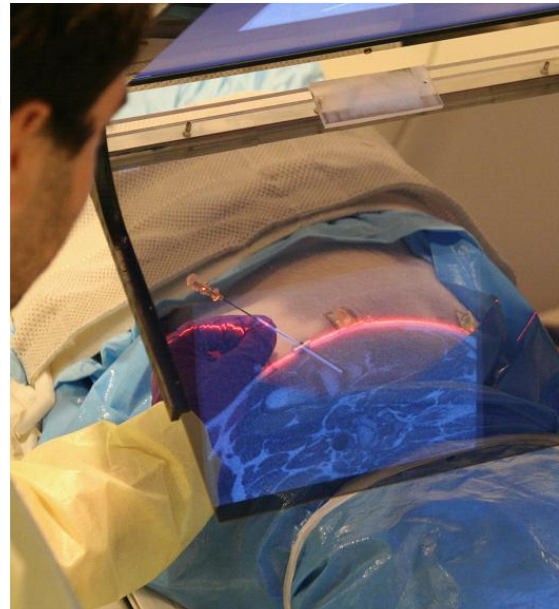




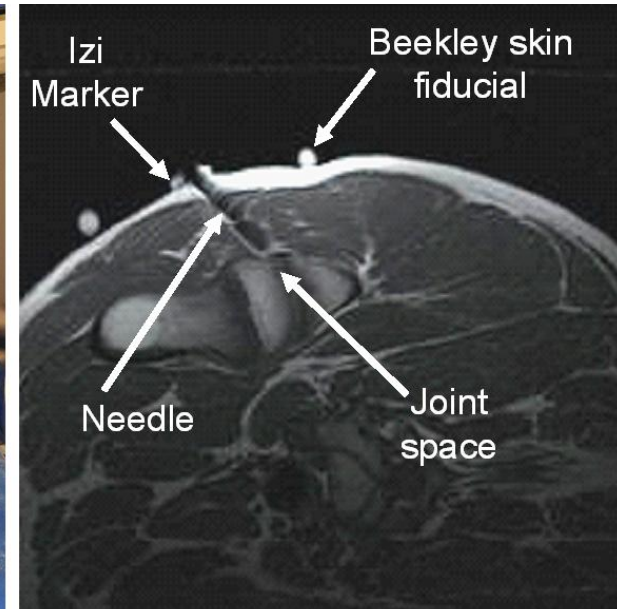
Clinical workflow



Planning



Insertion



Validation

Fischer *et al.* JCAS, 2007





Slicer interface

1. Clicked here to mark Target point

2. RAS coordinates of Target populated

3. Insertion depth, and insertion angle calculated and displayed

4. Needle guide overlaid to mark needle trajectory

5. Press 'Next' to move to next step

3D Slicer Version 3.3 Alpha
File Edit View Window Help Feedback

3D Slicer

Help & Acknowledgment

Mode Frame
Mode: CLINICAL

Work Frame Frame
Collimate Plan Insert Validate Evaluate

Experiment Frame
PRK Parameters: p51 Input Volume: E002_1_Plan
Load experiment Save experiment

2-4 Plan
Plan the needle insertion
Reset plan

Entry point: 55.436 144.98 -87.576
Target point: 21.211 42.454 -87.576
Insertion angle (in degrees): 10.091
Insertion depth (in mm): 108.26

Please note that the order of the clicks on images is important.

< Back Next > Finish Cancel Help

Manipulate Slice Views
Manipulate 3D View

Make Outlin: Pan, Right Button: Zoom

Bg I: 124
Bg J: 138
Bg K: 0

Entry

Target

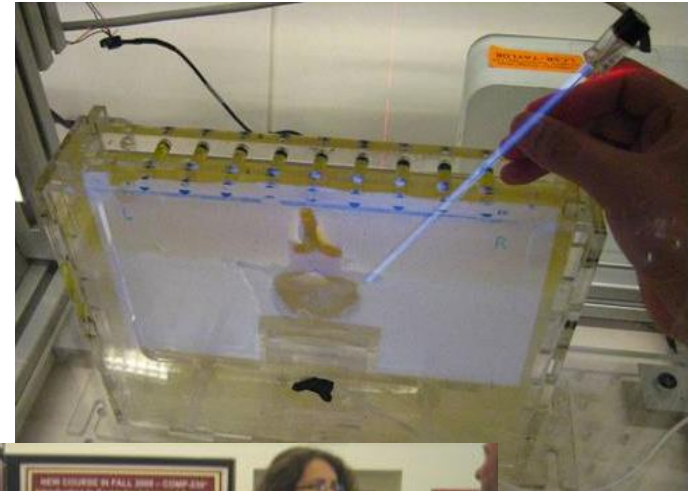
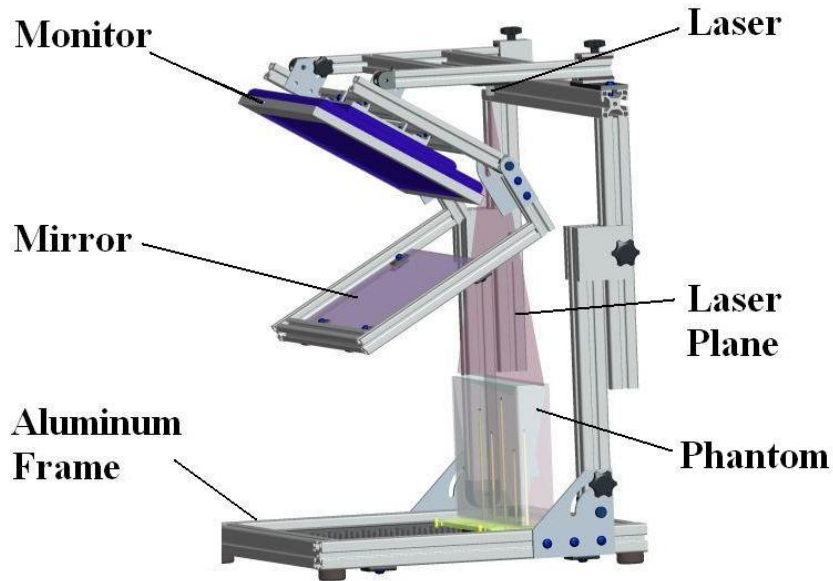
R: 22.2
A: 42.5
S: -87.6

Vikal et al. CMIG, 2009





The Perk Station

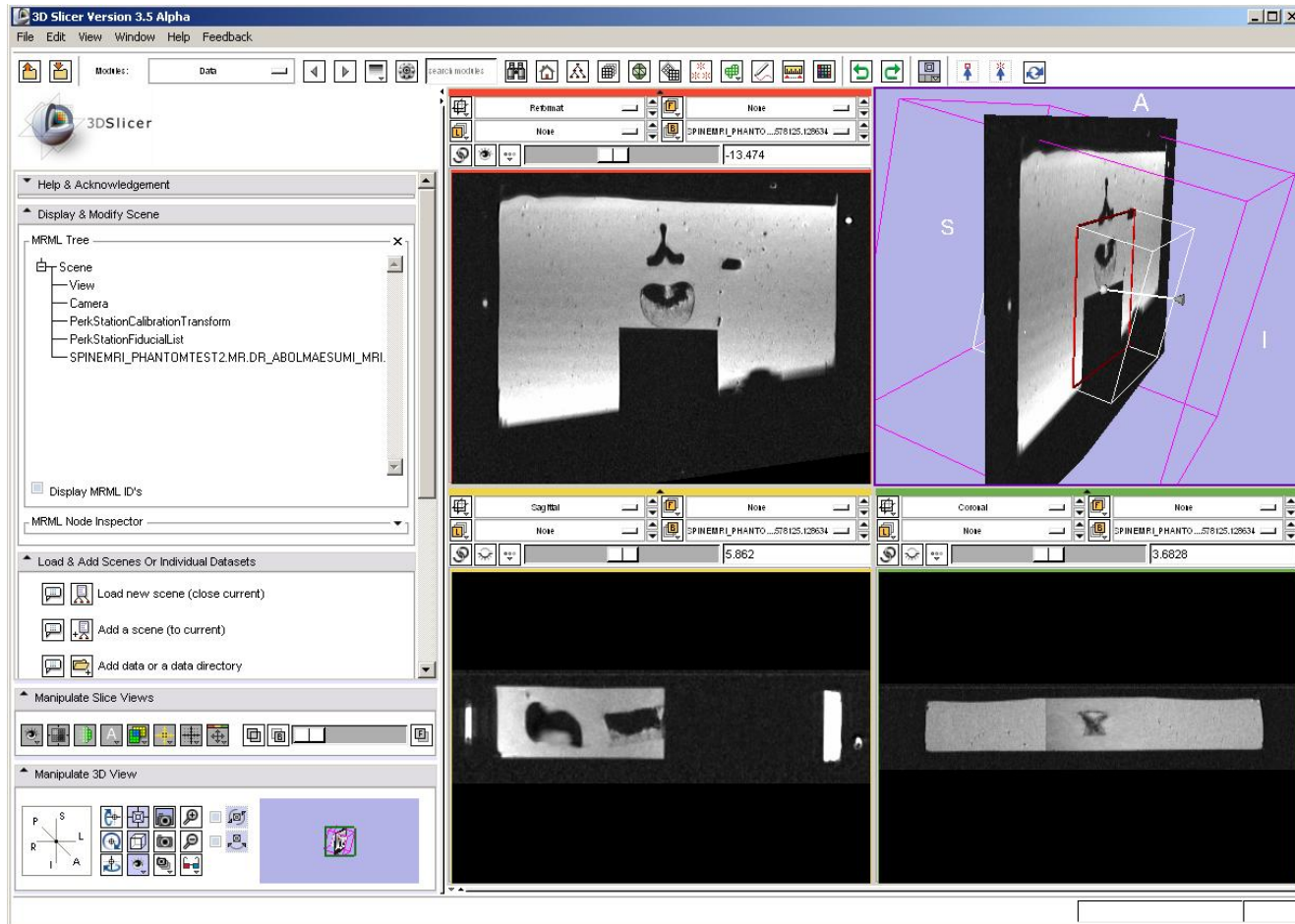


Vikal *et al.* CMIG, 2009





Perk Station interface



Vikal et al. CMIG, 2009





What we learned from NAMIC

- Open source collaborative development pays off in the end only
- It needs people of the same mind, passion and vision – very difficult to come by
- Spending NAMIC funds solely on engineering was a wise and necessary decision
- Work with your friends





Graduation plan

- Form the “Canadian NAMIC”
- Concentrate on IGS and translational clinical engineering
- Work with NAMIC, the older and wiser brother
- Set the rules
- Choose the right partners
- Get funded





SPARKit – Software Platform and Adaptive Radiotherapy Kit



- Affiliated with OCAIRO (Ontario Consortium for Adaptive Interventions in Radiation Oncology) of +20 industry-funded investigators
- Funded by Cancer Care Ontario as a Applied Cancer Research Unit
- Shared, reusable and customizable software infrastructure to assist clinical translation of experimental diagnostic and therapeutic approaches
- The scope of SPARKit is IGRT & associated IGS procedures





SPARKit partners & rules



Partners

- Queen's University, Kingston (Gabor Fichtinger, PI)
- Roberts Research Institute, London (Terry Peters)
- Princess Margaret Hospital, Toronto (David Jaffray)

Rules

- Open to buy-in by other groups (up to our funding limit)
- All money goes to clinical application engineering
- 3D Slicer is mandatory
- Trials, algorithm development etc. must be funded separately





SPARKit engineering staff



Queen's University, Kingston

- **Andras Lasso, Tamas Ungi, Csaba Pinter**

Robarts Research Institute, London

- **Elvis Chen**

Princess Margaret Hospital, Toronto

- **Kevin Wang**
 - **50% SPARKit & 50% other grants**
 - **All present at AHM**





SPARKit projects



- MRI-guided prostate interventions ✓
- MR image overlay guidance ✓
- Slicer Radiation Therapy
- Ultrasound calibration
- Ultrasound-guided needle placements
- Percutaneous needle placement training



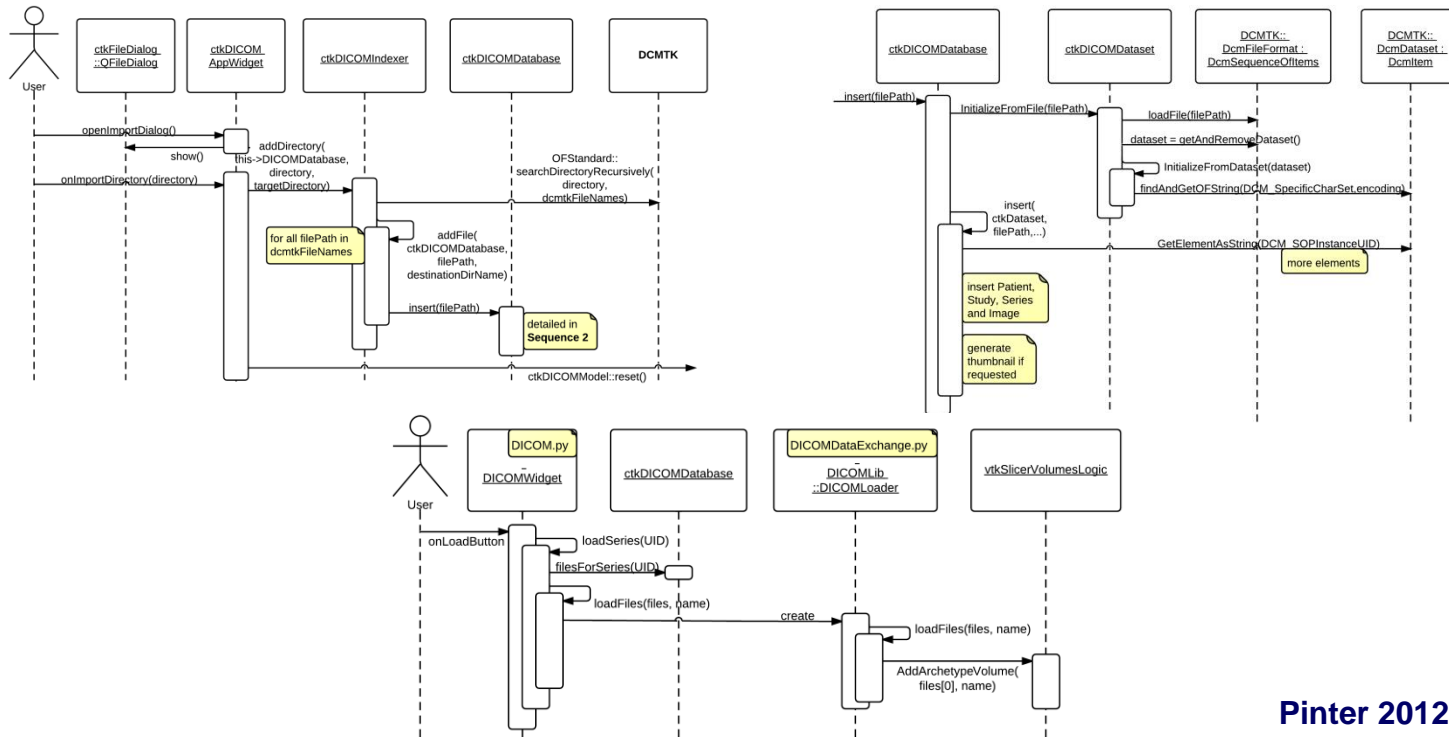


Slicer Radiation Therapy



Csaba Pinter, Andras Lasso, Kevin Wang

- Address common needs of OCAIRO investigators
- DICOM RT I/O in Slicer-4 to provide dose maps, contours, DVH...



Pinter 2012



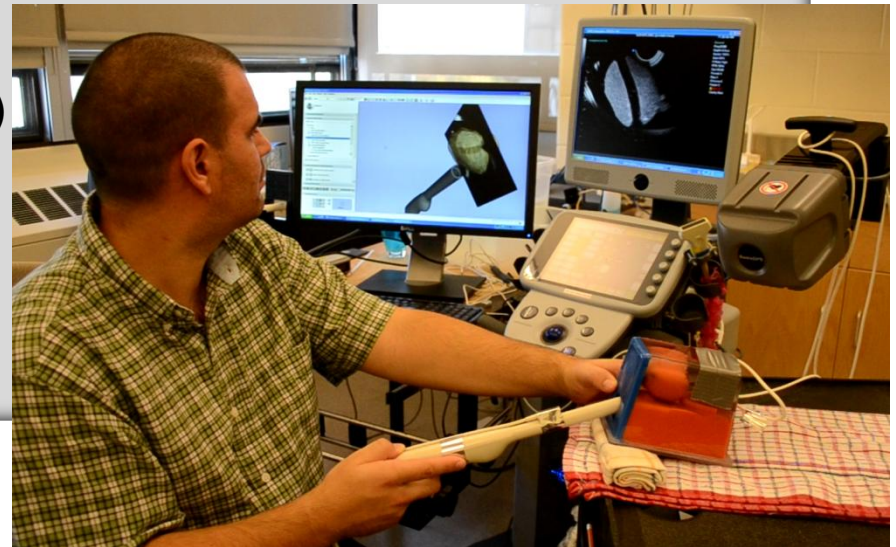


Public Library for Ultrasound



Andras Lasso, Csaba Pinter, Tamas Ungi

- Goal: Facilitate rapid clinical application prototyping of ultrasound-guided interventions
- [Google Scholar on “tracked ultrasound” about 48,000 hits](#)
- Scope: tracked ultrasound calibration, data acquisition, processing, and streaming
- Open-source (since October 2011)
- BSD license, no strings attached
- Users: UBC, Robarts, planned at JHU, BWH, PTI/AMS

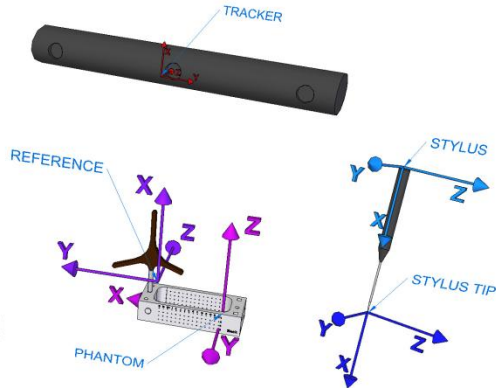
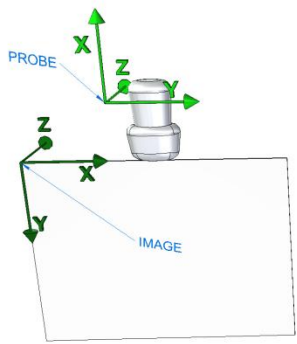


Ungi et al. 2012

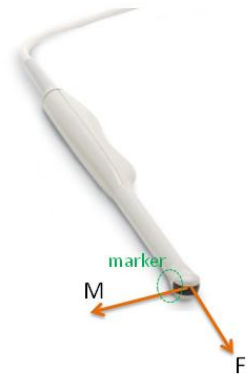




Why is ultrasound difficult?



Transducer axes:
M = marked
U = unmarked = -marked
F = far
N = near = -far



Ablation20100818 L14-5/38-GEN-General 08/18/2010 10:22:49AM

General
Freq 10.0MHz
Depth 6.0cm
Sector 100%
Gain 51%
FR High
FPS 15 Hz
Dyn 80dB
Persist 2
Map 1
Chroma 0
Power 0
MI (?)
Zoom 100%
Clarity Med

Marker symbol (U) is shown at the marked/near corner

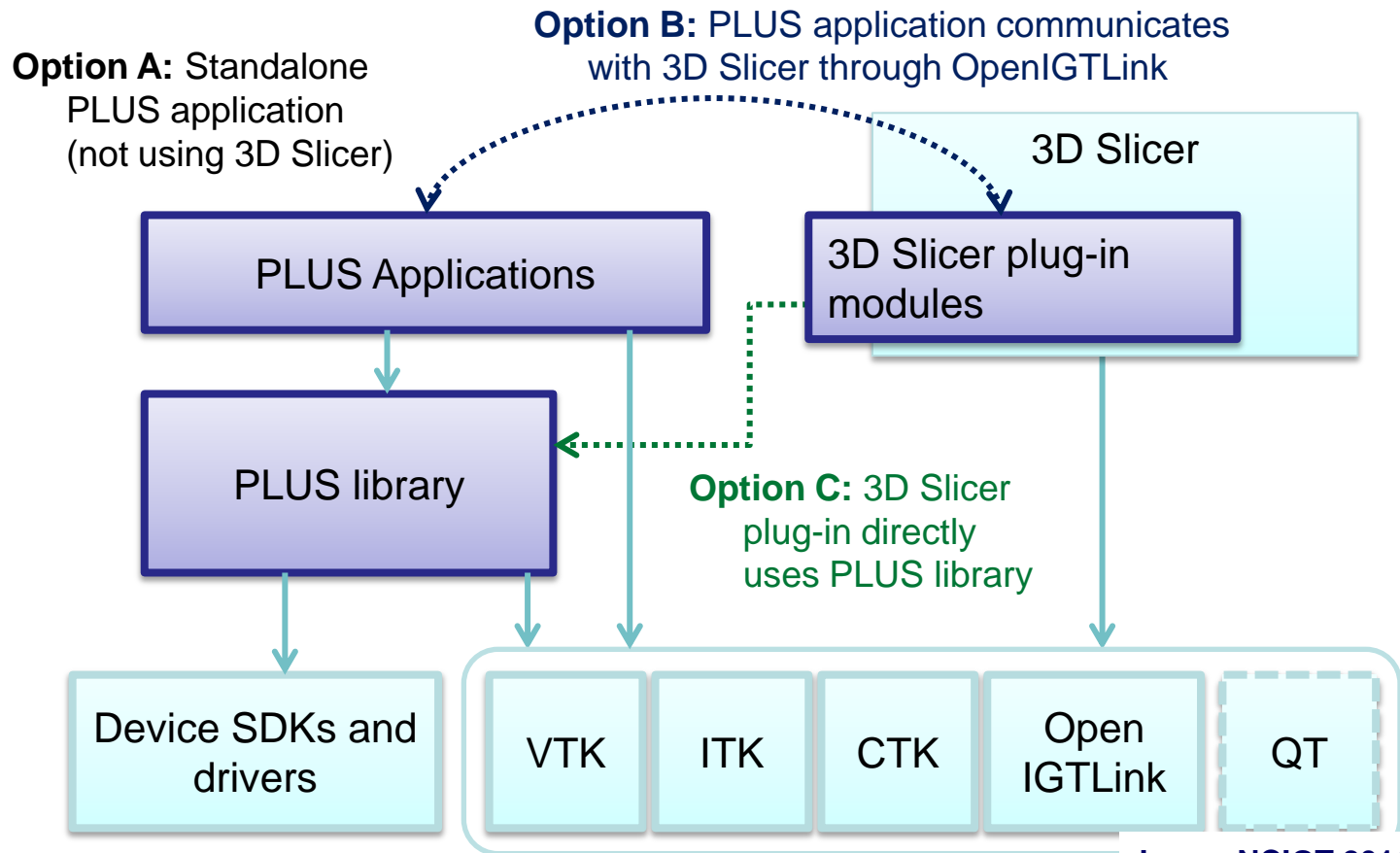
Investigational Use Only
428 / 428 [1 ... 428]

Lasso et al. 2012





PLUS architecture



Lasso NCIGT 2011





Ultrasound navigation



Tamas Ungi, Elvis Chen



Ungi et al. 2012

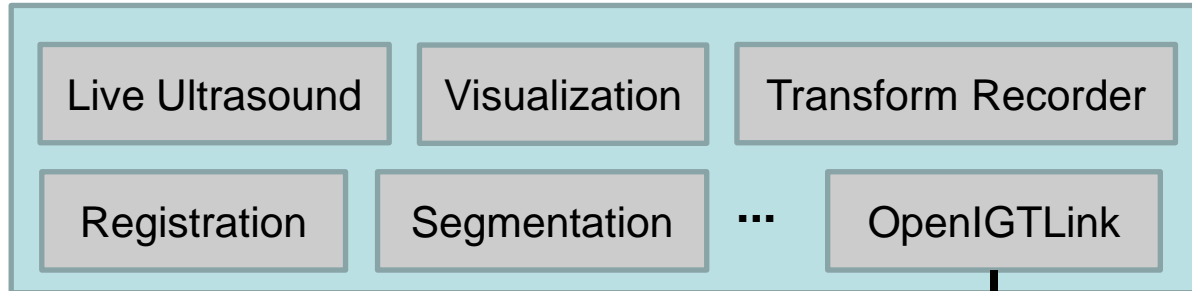




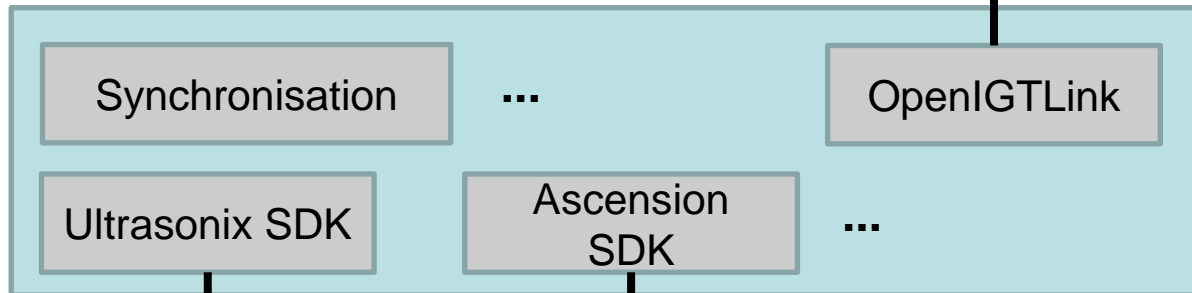
Configurable architecture



3D Slicer



PLUS



Ungi et al. 2012

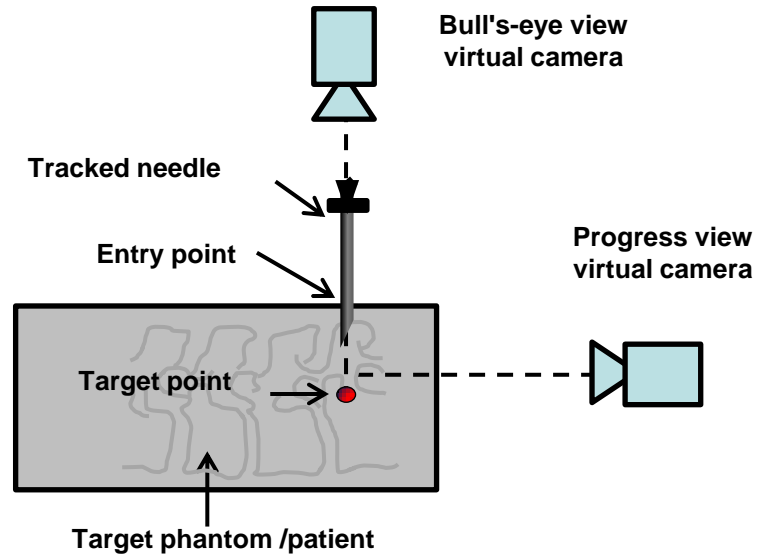
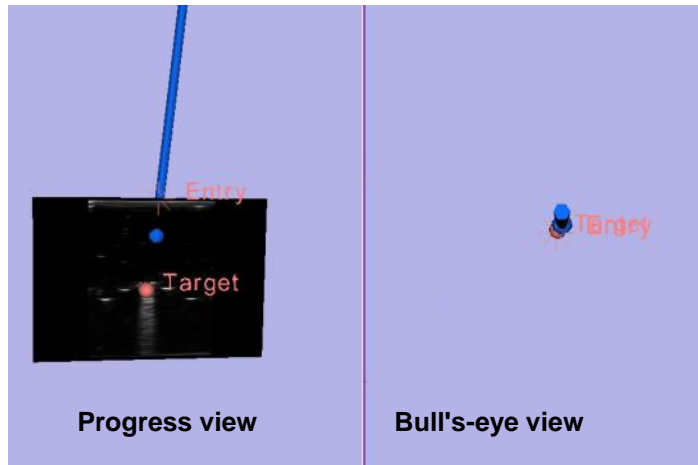




Snapshot ultrasound mode



Dual 3-D layout in 3D Slicer



	Tracked snapshot guidance	Plain ultrasound guidance
Number of insertions	60	60
Success rate (%)	93% *	71%
Insertion time (s)	117 ±19	138 ±34

Ungi et al. 2012





Lessons learned



- Patience
- Leverage other grants
- Stick to the rules
- Choose partners from friends
- Stay in the NAMIC family





Thank you



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<http://na-mic.org>