



NA-MIC

National Alliance for Medical Image Computing

<http://na-mic.org>

Training & Validation Update

Sonia Pujol, PhD
NA-MIC Training Core P.I.



NA-MIC Training Core Effort

Our mission:

- **Teaching effort** to accelerate the transfer of NA-MIC technology to the community
- **Validation effort** to investigate the comparative performances of algorithms



2011 NA-MIC Training Workshops

12 workshops at 11 different national & international venues

- Harvard Medical School, Boston, MA. Feb-March, 2011
- Johns Hopkins, Baltimore, MD. April 2011
- SCI Institute, Utah. April 2011
- University of Western Ontario, London, Canada. June 2011
- OHBM 2012, Quebec City, Canada. June 2011
- AAPM meeting, Vancouver, Canada. August 2011
- UBC workshop, Vancouver, Canada. August 2011
- MICCAI 2011, Toronto, Canada. Sept. 2011
- Cranio-Maxillo Facial workshop, Cleveland. Nov. 2011
- SfN 2011, Washington, DC. Nov. 2011
- RSNA 2011, Chicago, IL. Dec. 2011



NA-MIC Workshops



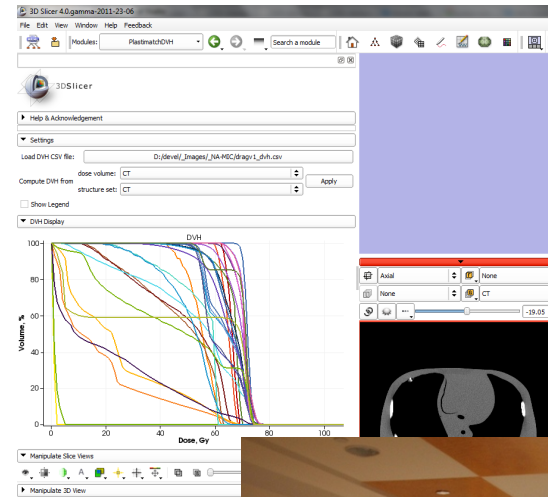
Hands-on workshops tailored for clinicians, clinical researchers, and scientists at national events, invited seminars, and international conferences (MICCAI, RSNA, SfN...)





AAPM 2011, Vancouver

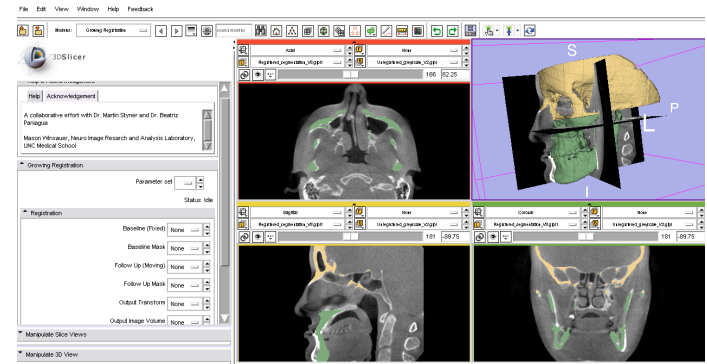
- Theme: 3DSlicer for radiotherapy research
- Gregory Sharp, MGH, Andras Lasso, Queen's University
- 20 participants





2011 Cranio-Maxillo Facial Workshop, Cleveland

- Theme: Slicer development in Orthodontics
- Beatriz Paniagua, UNC
Tung Nguyen, UNC
Lucia Cevidanes, U.Michigan



Joint Cephalometric Experts Group 2011 - 20 participants

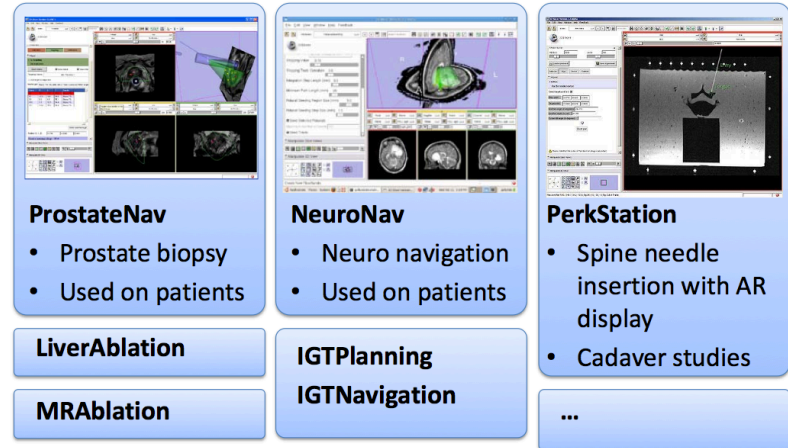




UBC 2011, Vancouver

- Theme: 3D Slicer for image-guided therapy research
- Andras Lasso and Tamas Ungi, Queen's University
- 21 participants


Image-guided therapy applications in Slicer 3.6







SfN 2011 DTI workshop

- Full day event on DTI analysis
- Lectures & hands-on sessions on acquisition, analysis and interpretation of DT-MRI data
- 23 neuroscientists



 **Society for Neuroscience**
Neuroscience 2011 Meeting, Nov. 12-16, Washington, DC
Satellite Workshop



White Matter Exploration with Diffusion Tensor Imaging: Fundamentals and Perspectives

A Hands-On Workshop by the National Alliance for Medical Imaging Computing (NA-MIC)


The workshop will guide participants through the fundamentals of the acquisition, analysis and interpretation of DT-MRI data through a series of lectures and hands-on sessions with the participants running DT-MRI analysis on their own laptops, to provide a conceptual understanding of the underlying theory of Diffusion Imaging, and a practical experience of extracting relevant clinical information from DT-MRI data.

Friday November 11, 2011
9:00 am – 5:30 pm

Room 159A, Walter E. Washington Convention Center
Washington, DC

Workshop Faculty
Sonia Pujol, PhD, Harvard Medical School
Randy Gollub, MD, PhD, Harvard Medical School
Anastasia Yendiki, PhD, Harvard Medical School
Ipek Oguz, PhD, University of North Carolina

For registration and detailed agenda, please see:
http://wiki.na-mic.org/Wiki/index.php/SFN2011_Diffusion_Tensor_Imaging_Analysis_Workshop





Johns Hopkins Workshop

- Local Host: Prof. Rai Winslow, Director, Institute for Computational Medicine, JHU
- ICM Distinguished Seminar Series: Ron Kikinis, MD. “3DSlicer”
- Full-day workshop
 - Basics of DTI
 - White matter tractography for neurosurgical planning
 - OpenIGTLink

NATIONAL ALLIANCE FOR MEDICAL IMAGE COMPUTING

Neuroimage Analysis Workshop

Tuesday April 5, 2011
8:00 am – 5:00 pm

Johns Hopkins University
Baltimore, MD

Workshop Faculty

Ron Kikinis, M.D., Harvard University
Sonia Pujol, Ph.D., Harvard University
Nicole Auzoin, MSc, Harvard University

3DSlicer

Clinical Goal

The goal of this tutorial is to explore white matter fibers surrounding a tumor using Diffusion Tensor Imaging (DTI) Tractography.

White Matter tracts
Tumor
Ventricles

White Matter Exploration for Neurosurgical Planning
Sonia Pujol, Ph.D. – Ron Kikinis, M.D.
© NA-MIC ARR 2011

INSTITUTE for COMPUTATIONAL MEDICINE

Johns Hopkins Institute for Computational Medicine (ICM), a remarkable collaboration between Johns Hopkins School of Medicine and Whiting School of Engineering, is using powerful computational tools to transform the practice of medicine.

[More about our mission](#)



Univ. Western Ontario, Canada

- Local Host: Prof. Terry Peters,
Director, Robarts Imaging Institute
- Image Registration, Programming
OpenIGTLink
- BIRC Lecture: “Open Source
Platforms for Collaborative
Research Examples from 3DSlicer.”
Ron Kikinis, MD
- 63 participants





Slicer booths

- **OHBM 2011** June 2011
- **BWH 2011 Resident Fair**
Nov 2011
- **RSNA 2011 Slicer Booth**
Nov 27-Dec 2, 2011



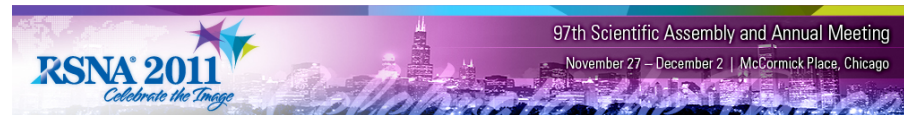
HBM 2011 Quebec City, Canada

17th Annual Meeting
of the Organization on Human Brain Mapping
Centre des Congrès de Québec
June 20-26, 2011



**BRIGHAM AND
WOMEN'S HOSPITAL**

A Teaching Affiliate of Harvard Medical School





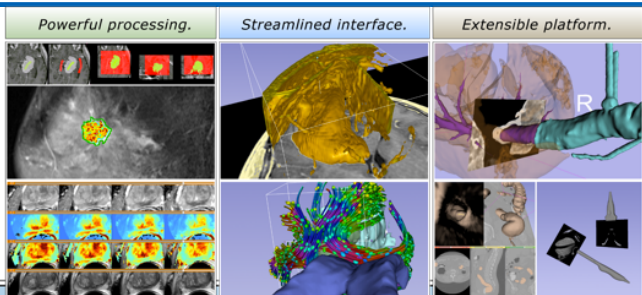
RSNA 2011

- Largest medical conference in the world - 60,000 participants
- NA-MIC presence:
 - 2 hands-on courses
 - 54 hours demos at the 3DSlicer Booth
 - paper presentation on SPL Brain Atlas





Slicer4 Premiere at RSNA 2011



NA-MIC and NAC at RSNA

Agenda

[edit]

[edit]

Sunday, November 27	Monday, November 28	Tuesday, November 29	Wednesday, November 30	Thursday, December 1	Friday, December 2
<p>8:00am-11:00am. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>11:00am-12:30pm. RSNA Refresher Course: Quantitative Medical Imaging for Clinical Research and Practice Exhibit. Room S401CD</p> <p>-----</p> <p>12:30pm-6:00 pm. 3D Slicer Exhibit Exhibit Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p>8:00am-11:00am. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>11:15am-11:45am. QIRR Theater Presentation Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>12:15pm-1:15pm. Meet-The-Experts Session Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>1:15pm-6:00 pm. 3D Slicer Exhibit Exhibit, Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p>8:00am-11:00am. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>12:30pm-2:00pm. RSNA Refresher Course: 3D Visualization for radiological applications Exhibit. Room S401CD</p> <p>-----</p> <p>12:30pm-6:00 pm. 3D Slicer Exhibit Exhibit, Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p>8:00am-12:15pm. 3D Slicer Exhibit Exhibit Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>12:15pm-1:15pm. Meet-The-Experts Session Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>1:15pm-6:00 pm. 3D Slicer Exhibit Exhibit, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>4:30pm-6:00pm. RSNA Refresher Course: Lifecycle of an Imaging Biomarker: From Validation to Dissemination Exhibit Room S501ABC</p>	<p>8:00am-12:15pm. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>Session starts at 10:30 am - Talk at 11:10am-11:20am. RSNA Paper presentation: Publicly Available RadLex-linked Anatomy Atlases for Image Analysis, Informatics and Education Exhibit Room S402AB</p> <p>-----</p> <p>12:15pm-1:15pm. Meet-The-Experts Session Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p>1:15pm-6:00pm. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p>	<p>8:00am-12:45pm. 3D Slicer Exhibit Exhibit, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p>



3D Slicer

version 4.0

www.slicer.org



Slicer4 Premiere at RSNA – Behind the scenes

- July 19, 2011
'Slicer4 review and Programming Sprint'
- RSNA 2011 targeted objectives and deadline for the first release of Slicer4

Events:Slicer4-Review-07-2011

Contents [hide]

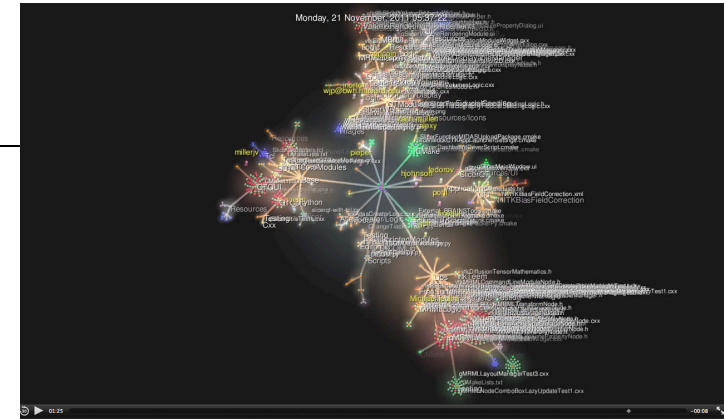
- 1 RSNA 2011 Targeted Objectives
 - 1.1 UI
 - 1.2 Under the hood
 - 1.3 Infrastructure
 - 1.4 Beginning Of The Rest
- 2 What
- 3 When
- 4 Who
- 5 Where
- 6 Why
- 7 Work on
 - 7.1 Full List
 - 7.1.1 UI
 - 7.1.2 Under the hood
 - 7.1.3 Infrastructure
 - 7.1.4 Completion
- 8 Agenda
- 9 Attending

RSNA 2011 Targeted Objectives

- ▀ Roadmap for the Slicer 4 release for the series of demos at the RSNA 3DSlicer Booth
- ▀ Most tasks need to be ready by end of September, to leave time to update tutorials, test and debug.
- ▀ List of open Mantis issues with RSNA Target

UI

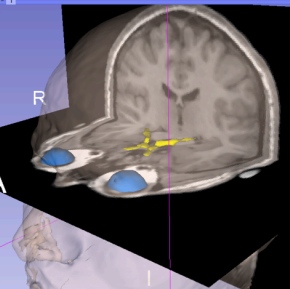
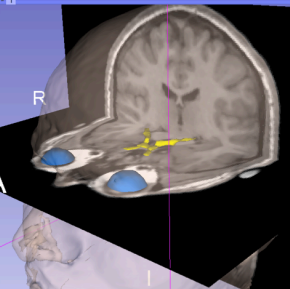
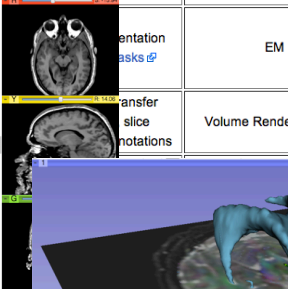
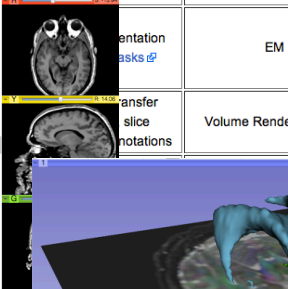
- ▀ Main GUI Cosmetics
 - ▀ % face lift for the Slice viewers: reduce permanent non-image components. Reduce the number and depth of submenus. (J2) **done**
 - ▀ % Main Gui 3D viewers should have similar appearance to slice viewers (J2) **done**
 - ▀ % scenview and screenshot icons move to the icon bar at the top of the main gui. (J2-> Nicole) **done**
- ▀ Module Cosmetics
 - ▀ % Volume Rendering of (J2) (in progress)
 - ▀ % Models module of (J2) **done**
 - ▀ % Editor of, see picture to the right (Steve) (Done)
 - ▀ % Welcome Module of (Wendy)



Slicer
visual blog
(S.Pieper)



RSNA 2011: Slicer Booth

Nb	DEMO	Datasets	Notes	Tools	Slicer Modules
1	Data Loading and Visualization	Slicer3Visualization Data	Slicer3Visualization Tutorial	Compare View, Clipping, Save, Restore, Scene Views, Dicom studies sorting, Dicom networking (?)	Data, Volumes, Models, Scene Views
2	MRI-based topographic parcellation of human brain		Parcellation tasks	EM Segmenter	EMSegmenter
3	Volume Render #1 Head		Transfer slice annotations	Volume Rendering and Annotations	Volume Rendering, Annotations, Scene Views
4	Volume Render #2 Abdomen				Volume Rendering, Annotations, Scene Views
5	Volume Render #3 Thorax				Volume Rendering, Annotations, Scene Views
6	Traumatic Brain Injury Case Analysis	TBI Demo Data (UCLA)			BC Segmentation, Model Maker, Editor, Annotations, Scene Views
7	Radiotherapy	Plastimatch Dose Warping Data (MGH)			Plastimatch Extension: DICOM/DICOM-RT Import, DICOM/DICOM-Export, B-Spine Deformable Registration, XFORMWARP Warping with transform Transforms,
8	White matter exploration for neurosurgical planning	White Matter Exploration dataset	New		Volumes, Editor, Fiducials, Diffusion Tensor Estimation, Diffusion Tensor Tractography Fiducial
9	Longitudinal analysis of meningioma growth	Change Tracker Data are part of the tutorial	Change Tracker	Crosshairs, BRAINSFit	Volume
10	Image-guided prostate interventions	Prostate Data updated for Slicer4, in progress Can load RSNA2010 demo scene, mostly working, see [1]	Pre-op/Intra-op registration; Use Case Demo Prostate Data	Linked Viewing	Volume
11	Brain Atlas	NAC Multi-modality MRI-based Atlas of the Brain	Work in progress - atlases are being updated	Linked Viewing	Volume
12	Abdomen Atlas	Knee Atlas	Work in progress - atlases are being updated	Linked Viewing	Volume
13	Knee Atlas Atlas	Abdominal Atlas	Work in progress - atlases are being updated	Linked Viewing	Data, Volumes, Models, Scene Views

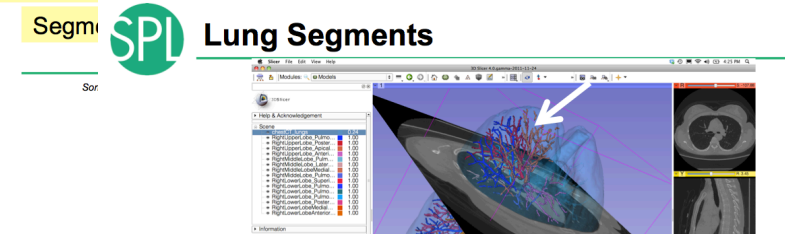
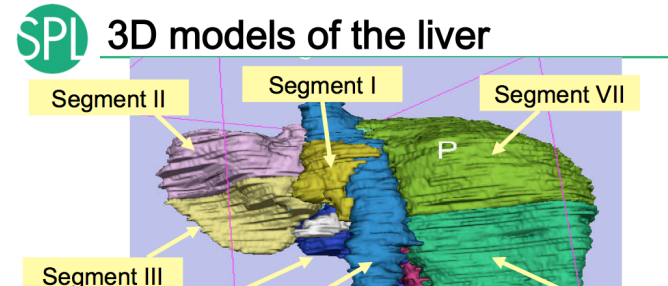
- 13 hands-on demos with pre-computed datasets
- ~10-20 visitors per day

“The 3D Slicer open source software platform for segmentation, registration, quantitative analysis and 3D visualization of biomedical image data”



RSNA 3D Visualization Course

- 3D interactive visualization of liver & lung segments
- In Collaboration with Dr. Kitt Shaffer, Vice Chairman for Radiology Research, BU Medical Center
- 105 international attendees

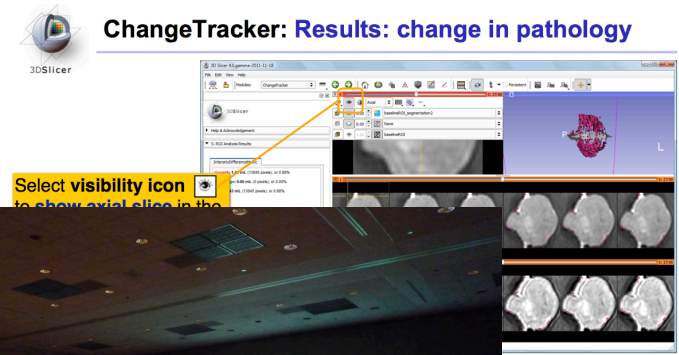
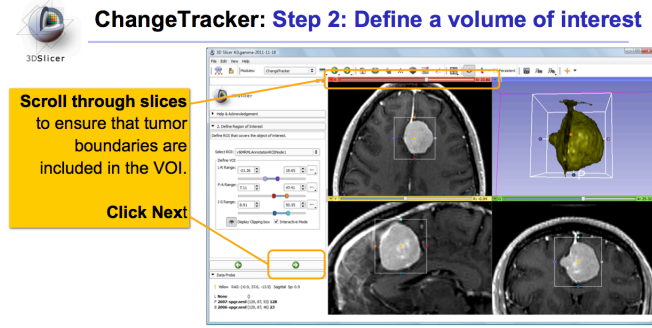


Slide 98



RSNA Quantitative Imaging Course

- Slicer4minute, Change Tracker& PET/CT Fusion
- In Collaboration with Harvard Catalyst
- 120 participants

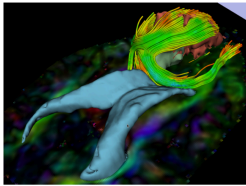




Slicer Training Compendium

Image Analysis Pipeline

The image analysis pipeline



Sonia Pujol, Ph.D. — Ron Kikinis, M.D.

described in this
different algorithm
algorithm for segmenting
tumor parts, the
algorithm for surface
and the single tract
streamline tract
for tract generation

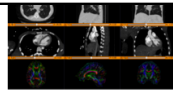
Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

Sonia Pujol, Ph.D.
Ron Kikinis, M.D.

Surgical Planning Laboratory
Harvard University

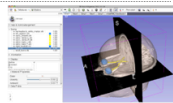
- New Slicer4 Compendium
- Development of new tutorials based on Clinical workflow: e.g., “White matter exploration for neurosurgical planning”
- Slicer tutorial contest

- The SlicerWelcome tutorial is an introduction to Slicer based on the Welcome module.
- Audience: First time users who want a general introduction to the software.



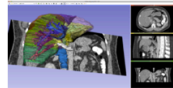
SLICER4MINUTE TUTORIAL

- The Slicer4Minute tutorial is a brief introduction to the advanced 3D visualization capabilities of Slicer4.0.
- Audience: First time users who want to discover Slicer in 4 minutes.
- The Slicer4Minute dataset contains an MR scan of the brain and 3D reconstructions of the anatomy.



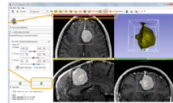
SLICER4 3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGY APPLICATIONS

- The Slicer4RSNA course guides through 3D data loading and visualization of DICOM images for Radiology Applications in Slicer4.
- Audience: Radiologists and users of Slicer who need a more comprehensive overview over Slicer4 visualization capabilities.
- The Slicer4RSNAAdataset1 and Slicer4RSNAAdataset2 contain a series of MR and CT scans, and 3D models of the brain, lung and liver.



SLICER4 QUANTITATIVE IMAGING TUTORIAL

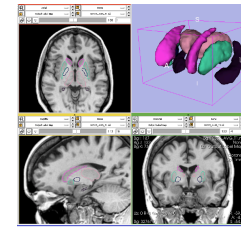
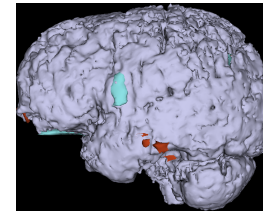
- The Slicer4 Quantitative Imaging tutorial guides through the use for Slicer for quantifying small volumetric changes in slow-growing tumors, and for calculating Standardized Uptake Value (SUV) from PET/CT data.
- Audience: Radiologists and users of Slicer who need a more comprehensive overview over Slicer4 quantitative imaging capabilities.
- The PETCTFusion and Change Tracker datasets contain a series of MR, CT and PET data.





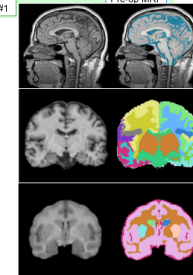
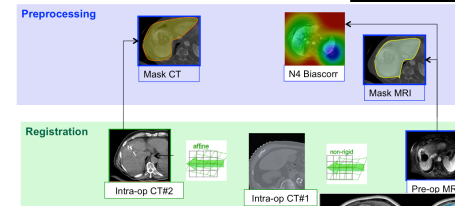
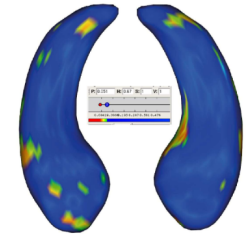
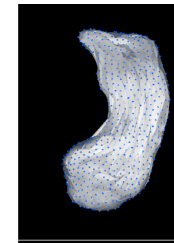
Summer 2011 Tutorial Contest

- 8 tutorial submissions
- First prize winner: 'Automated Segmentation of TBI cases using ABC Segmentation' (Andrei Irima, Jack Van Horn, UCLA)



BRAINSCut Output example for sub-cortical structures

Select	Status	Name	Category	Description	HomePage
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ABC			
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ARCTIC	Cortical Thickness	ARCTIC is an e	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	EMFiberClusteringModule	Tractography	An EM approa	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ExampleCommandLine	Examples	An example of	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ExampleLoadableGuiLessModule	Examples	An example of	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	HammerRegistration	Work in Progress	HammerRegist	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	LabelDiameterEstimation	Statistics		
<input type="checkbox"/>	<input checked="" type="checkbox"/>	platform-slicer			
<input type="checkbox"/>	<input checked="" type="checkbox"/>	PythonGpuImageScriptedModule	Developer Tools	This is an exa	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	TofIsmarkScriptedModule	Developer Tools	This is an exa	



```

Left DNI Diffusion:
baseLineOfNumber: 1
numberOfSlices: 23
gradientOfNumber: 1
0 [ 0.00000 0.00000 0.00000 ] 1
1 [ -0.48150 -0.11050 0.00000 ] 1
2 [ -0.48872 -0.73550 -0.14738 ] 1
3 [ -0.26568 -0.94151 -0.24181 ] 1
4 [ 0.09583 0.62494 0.05728 ] 1
5 [ -0.27708 0.52617 -0.44897 ] 1
6 [ -0.48594 -0.17957 -0.39241 ] 1
7 [ 0.73828 0.18209 0.05207 ] 1
8 [ 0.47739 0.73349 -0.29741 ] 1
9 [ -0.33829 -0.94159 -0.18917 ] 1
10 [ -0.37444 -0.53845 -0.78833 ] 1
11 [ -0.08009 -0.52179 0.05202 ] 1
12 [ 0.97183 0.18124 -0.18756 ] 1
13 [ 0.00000 0.18129 -0.49726 ] 1
14 [ -0.08128 0.73359 -0.05366 ] 1
15 [ -0.08665 0.94202 -0.33611 ] 1
16 [ 0.46157 -0.51867 -0.05847 ] 1
17 [ 0.22899 -0.51887 -0.79848 ] 1
18 [ 0.28824 -0.17423 0.05764 ] 1
19 [ -0.62183 0.70788 -0.28728 ] 1
20 [ 0.30288 -0.94854 -0.18986 ] 1
21 [ 0.15878 -0.94932 -0.25473 ] 1
22 [ 0.07626 -0.17089 0.45833 ] 1
23 [ 0.97822 -0.17246 0.89921 ] 1
=====
QC result summary:
=====
Image information check: PASS
Diffusion information check: PASS
File name check: PASS
Index name check: PASS
Gradient name check: PASS
  
```

→ Next Tutorial Contest: NA-MIC Summer Project Week 2012



Slicer QA effort

2011 Summer Project Week Automated GUI Testing

[Contents \[hide\]](#)

- 1 Key Investigators
 - 1.1 Objective
 - 1.2 Approach, Plan
 - 1.3 Progress

Key Investigators

- Brigham and Women's Hospital: Sonia Pujol
- Isomics Inc: Steve Pieper
- Kitware: Jean-Christophe Fillon-Robin
- OE: Xiaodong Tao

Objective	Approach, Plan	Progress
The objective is to explore different solutions for automated GUI testing.	We'll generate automated tests using the Slicer3minute tutorial. <ul style="list-style-type: none">SikuliQtTesting librariesDirectly calling GUI via PythonQt	<ul style="list-style-type: none">We have developed a sikuli script that runs automatically the different steps of the Slicer3minute tutorial using Slicer4: automated test exampleWe reviewed the needs for the integrated test recording framework in VTKIG/Python (about 80% done, but is no the slicer4-to-do list)

2012 Project Week:AutomatedTesting

[Contents \[hide\]](#)

- 1 Key Investigators=
 - 1.1 Objective
 - 1.2 Approach, Plan
 - 1.3 Progress

Key Investigators=

- Brigham and Women's Hospital: Sonia Pujol
- Isomics Inc: Steve Pieper
- Kitware: Jean-Christophe Fillon-Robin, Benjamin Long

Objective	Approach, Plan
The objective is to implement automated GUI testing in Slicer4 based on QtTesting, to be able to perform nightly automated tutorial testing.	We'll generate automated tests for the Slicer4minute tutorial, and define associated metrics to measure the outcomes.

- Automated GUI testing of Slicer4
- First implementation at 2011 Summer Project Week using Sikuli
- On-going development with Kitware using QtTesting (JC, Benjamin Long)

Development of nightly automated tutorial testing



Dissemination Update

12th Project Week: Salt Lake City, Utah, Winter 2011

- 106 attendees: 20 academic institutions, 9 companies
- 59 Projects: Segmentation, Registration, IGT, Radiotherapy, Informatics, DTI, Engineering

13th Project Week: MIT, Summer 2011

- 101 attendees: 17 academic institutions, 8 companies
- 61 Projects: TBI, Radiation Therapy, Huntington's Disease, Atrial Fibrillation, IGT, Segmentation, Registration, Tractography, Vessels, Engineering



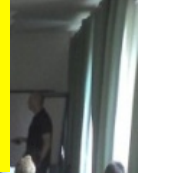
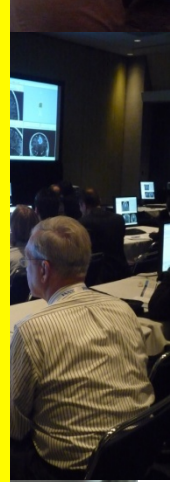


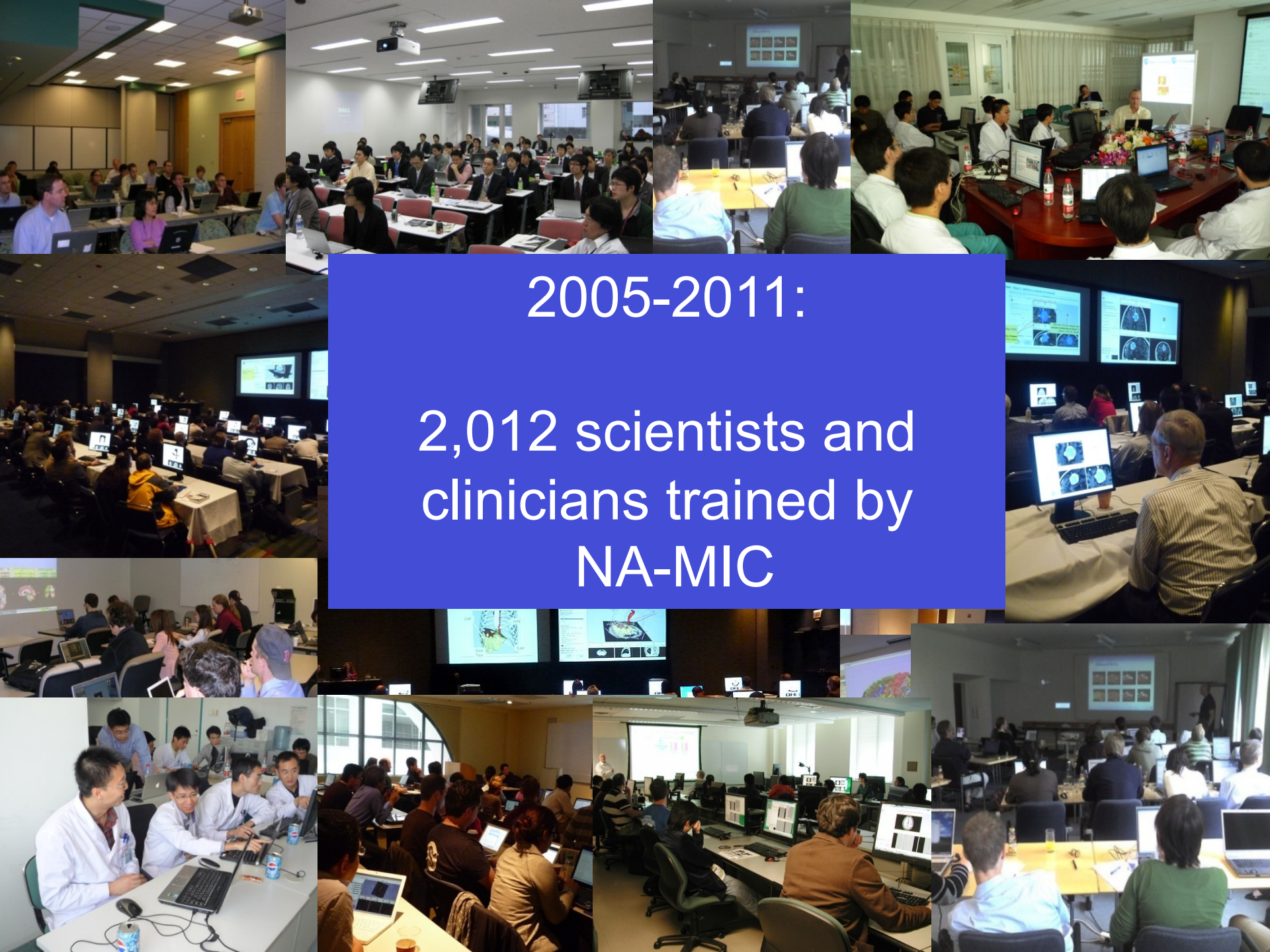
2011 outreach events:

12 workshops

457 NA-MIC training workshop participants

207 NA-MIC project week participants





2005-2011:

2,012 scientists and
clinicians trained by
NA-MIC



NA-MIC

National Alliance for Medical Image Computing

<http://na-mic.org>

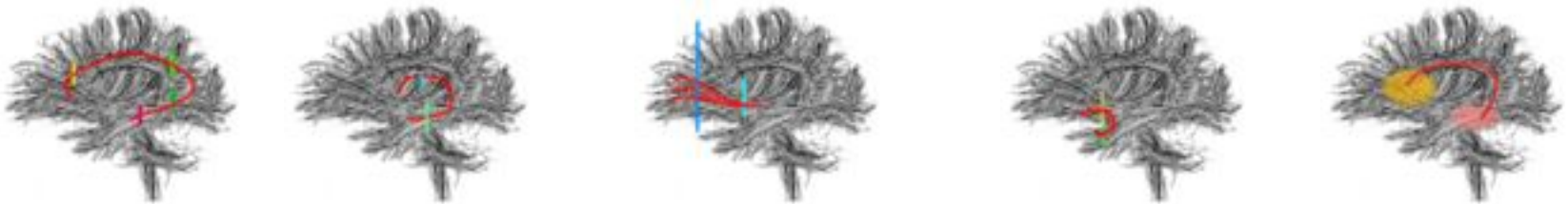
DTI Validation Update:

Challenges in clinical transfer of DTI tractography



NA-MIC pilot initiative

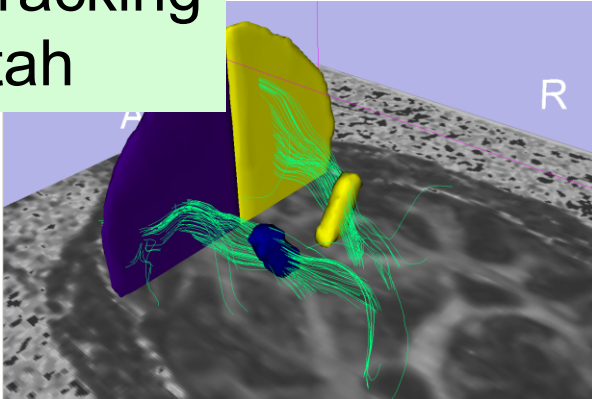
- Exploratory work on validation of DTI tractography
- Cross-comparison of tractography algorithms on major white matter fascicles



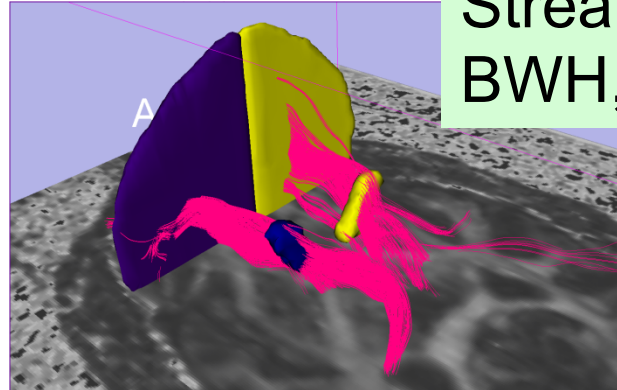


Early Implementation

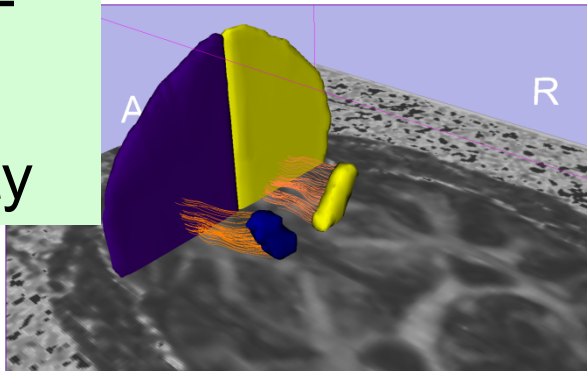
Fiber Tracking
SCI, Utah



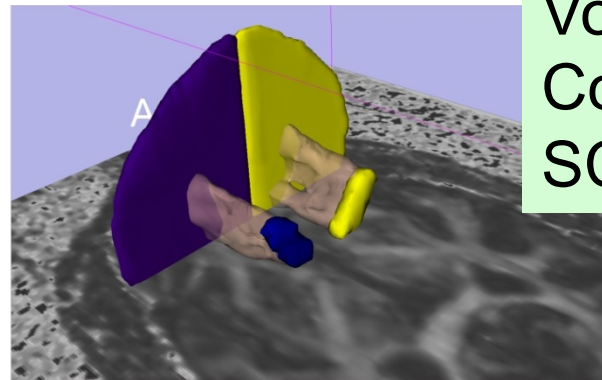
Streamline
BWH, Harvard



GTRACT
Iowa
University



Volumetric
Connectivity
SCI, Utah

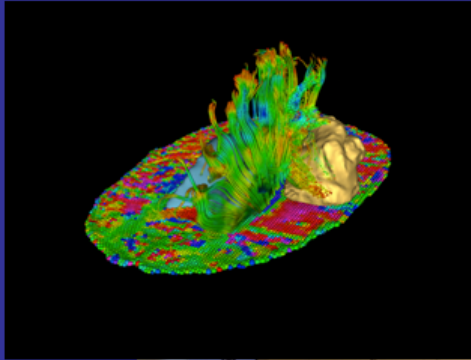


Pujol et al. ISMRM 2009

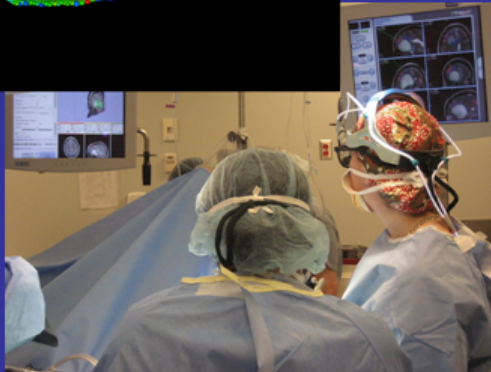


MICCAI 2011 DTI Challenge

14th International Conference on Medical Image Computing and Computer Assisted Intervention



DTI Tractography for Neurosurgical Planning: A Grand Challenge



MICCAI 2011 Workshop
Sunday September 18, 9am-6pm
Westin Harbour Castle
Toronto, Canada

Workshop Faculty

Sonia Pujol, PhD, Surgical Planning Laboratory, Harvard Medical School
Ron Kikinis, MD, Surgical Planning Laboratory, Harvard Medical School
Alexandra Golby, MD, Brigham and Women's Hospital, Harvard Medical School
Guido Gerig, PhD, The Scientific Computing and Imaging Institute, University of Utah
Martin Styner, PhD, Neuroimage Research and Analysis Laboratory, University of North Carolina
William Wells, PhD, Surgical Planning Laboratory, Harvard Medical School
Carl-Fredrik Westin, PhD, Laboratory of Mathematics in Imaging, Harvard Medical School
Sylvain Gouttard, MSc, The Scientific Computing and Imaging Institute, University of Utah

National Alliance for Medical Image Computing

http://www.na-mic.org/Wiki/index.php/Events_DTI_Tractography_Challenge_MICCAI_2011



Workshop Faculty

- Sonia Pujol, BWH
- Ron Kikinis, BWH
- Alexandra Golby, BWH
- Guido Gerig, SCI Utah
- Martin Styner, UNC
- William Wells, BWH
- CF Westin, BWH
- Sylvain Gouttard, SCI Utah
- Arya Nabavi, Kiel Hospital, Germany



Special Thanks

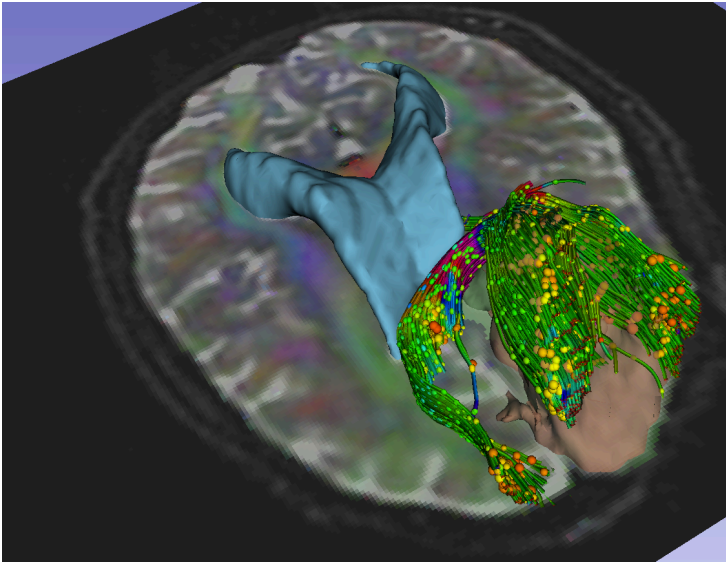
- Hatsuho Mamata, BWH
- Isaiah Norton, BWH



Tractography for neurosurgery

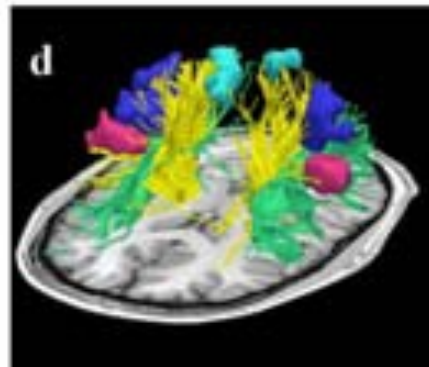
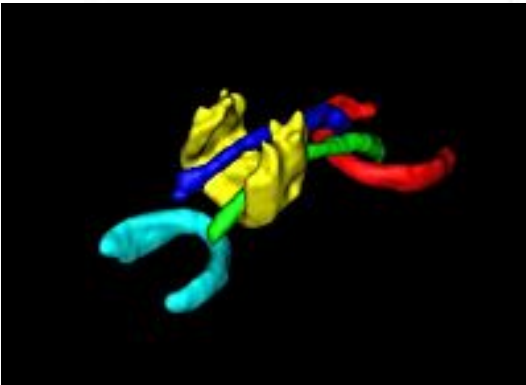
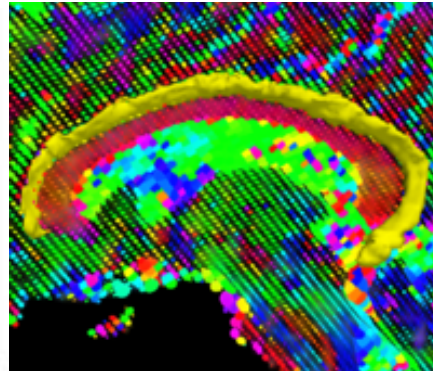
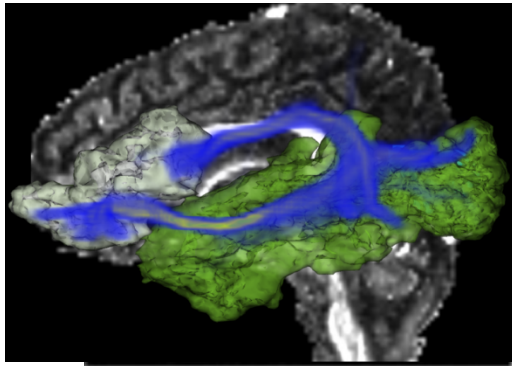
Tractography has the potential to bring valuable information to the neurosurgeon

- Spatial relationship between the tract and the tumor
- Demonstration of tract displacement
- Assessment of tumor infiltration





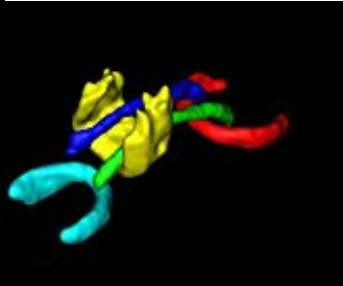
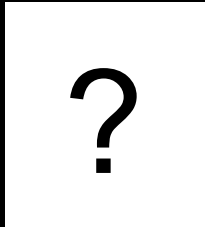
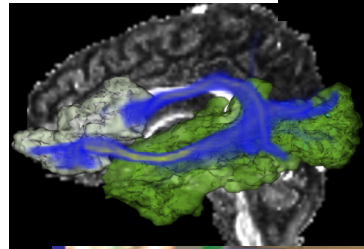
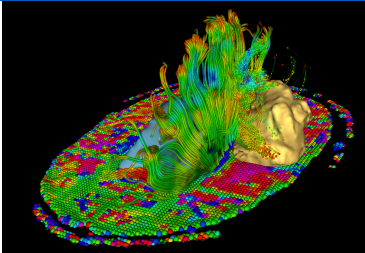
Tractography Algorithms



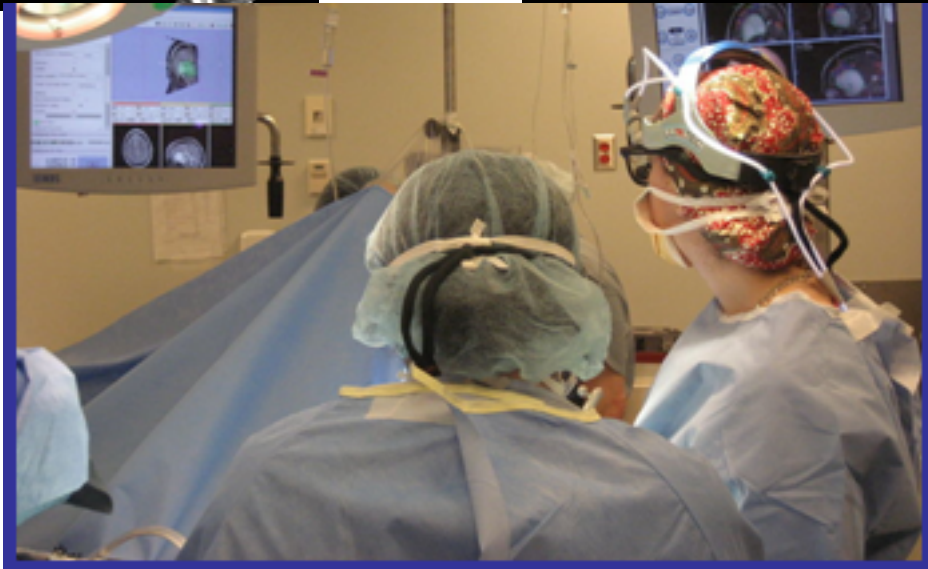
A wide variety of tractography techniques has been developed over the past decade (streamline, stochastic, volumetric, two-tensors...)



How to choose ?



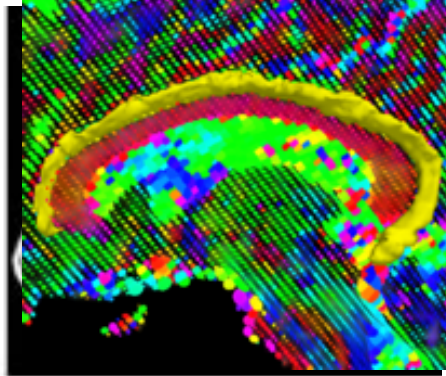
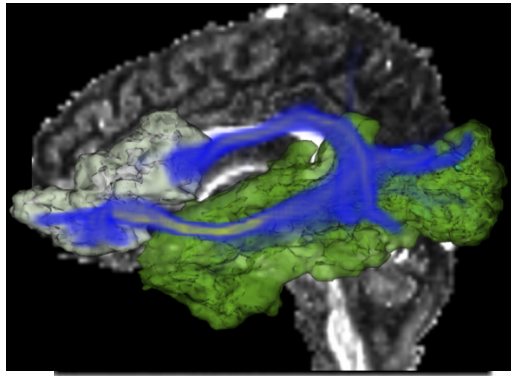
Neurosurgeons face the challenge of selecting the appropriate tractography method



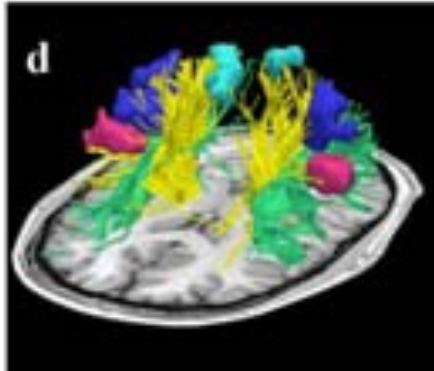
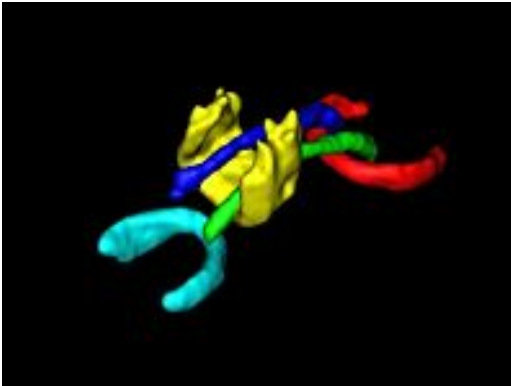
Need for tool comparison



Goal of the workshop

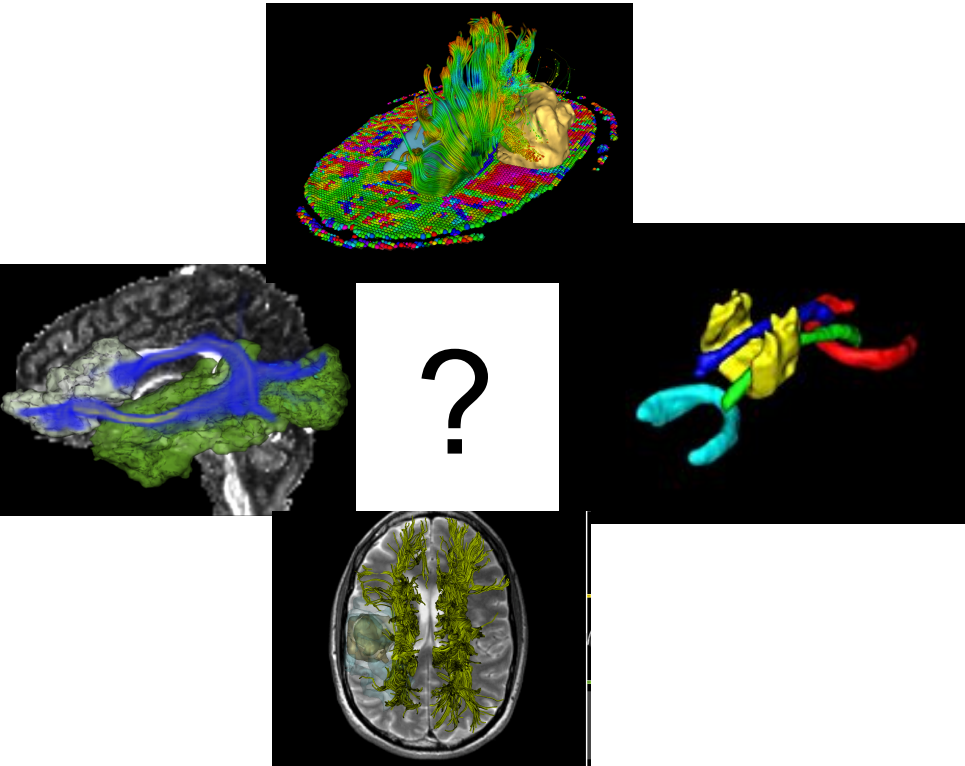


Qualitative and quantitative evaluation of multiple existing tractography algorithms





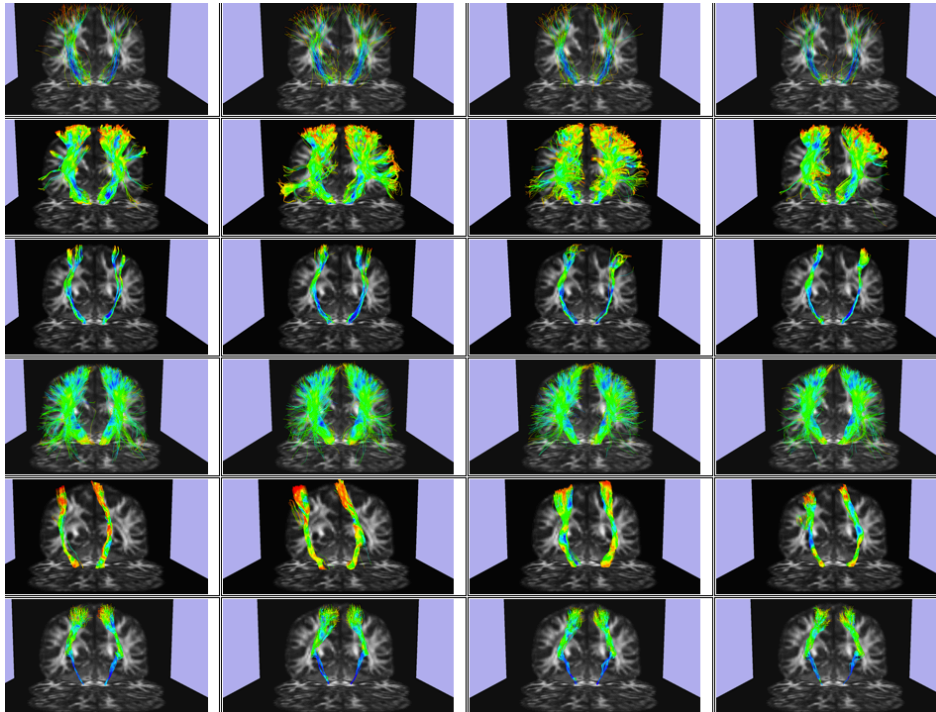
How to compare?



Many degrees of variability
(patient, MR sequence,
tumor location, etc..)



How to compare?



Many degrees of variability

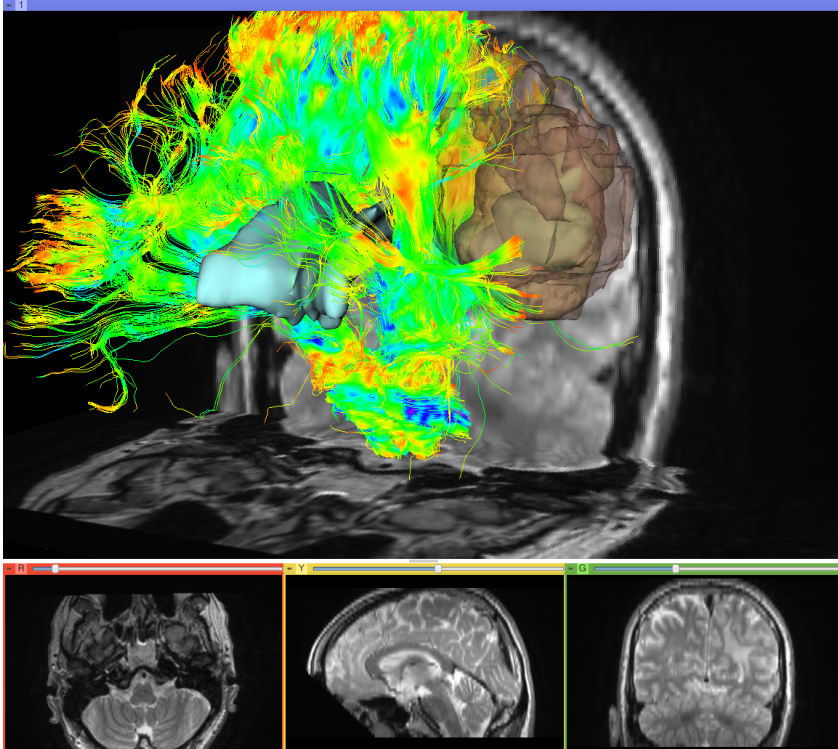
(patient, MR sequence, tumor location, etc..)



**Standardized
evaluation on a
common set of data**



How to compare?



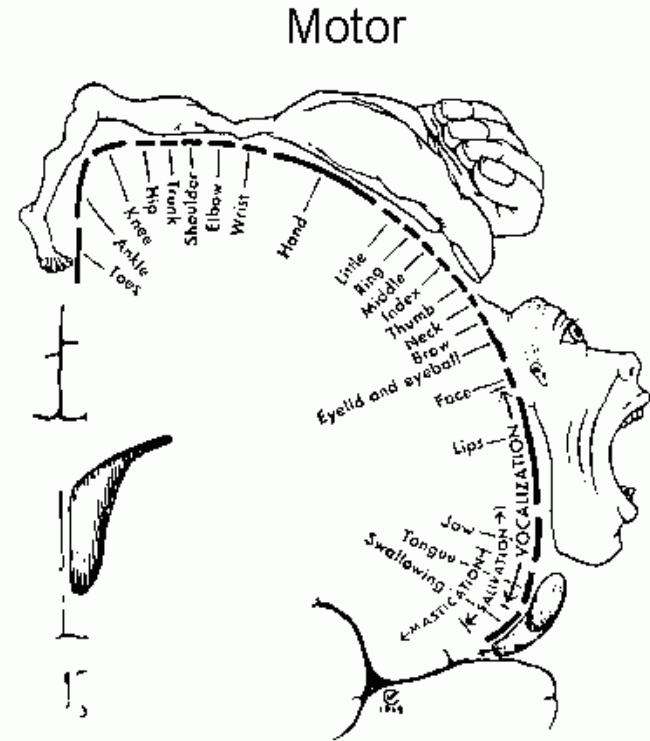
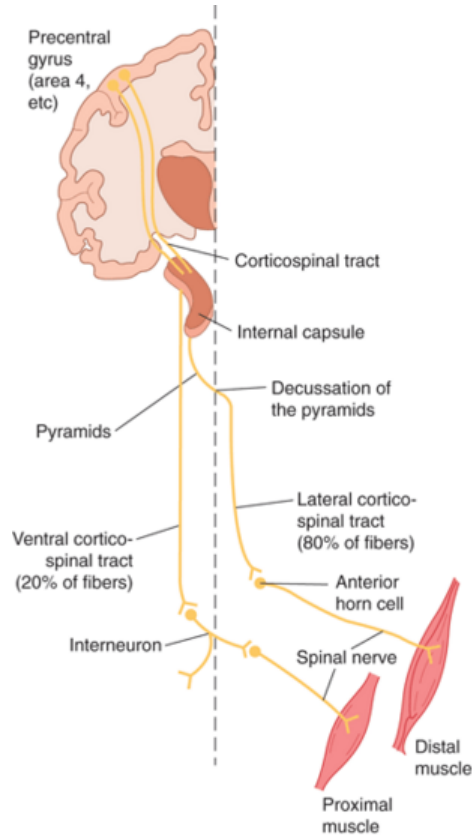
Absence of ground truth



Combination of qualitative and quantitative criteria to get closer to the ground truth



Corticospinal tract



(After W. Penfield and T. Rasmussen, 1950)

Source: Barrett KE, Barman SM, Boitano S, Brooks H: *Ganong's Review of Medical Physiology*, 23rd Edition: <http://www.accessmedicine.com>



Workshop datasets

- Four neurosurgical cases involving the CST
 - Patient1: Residual anaplastic oligoastrocytoma
 - Patient2: Anaplastic oligoastrocytoma
 - Patient3: Anaplastic oligodendroglioma
 - Patient4: Glioblastoma grade 4

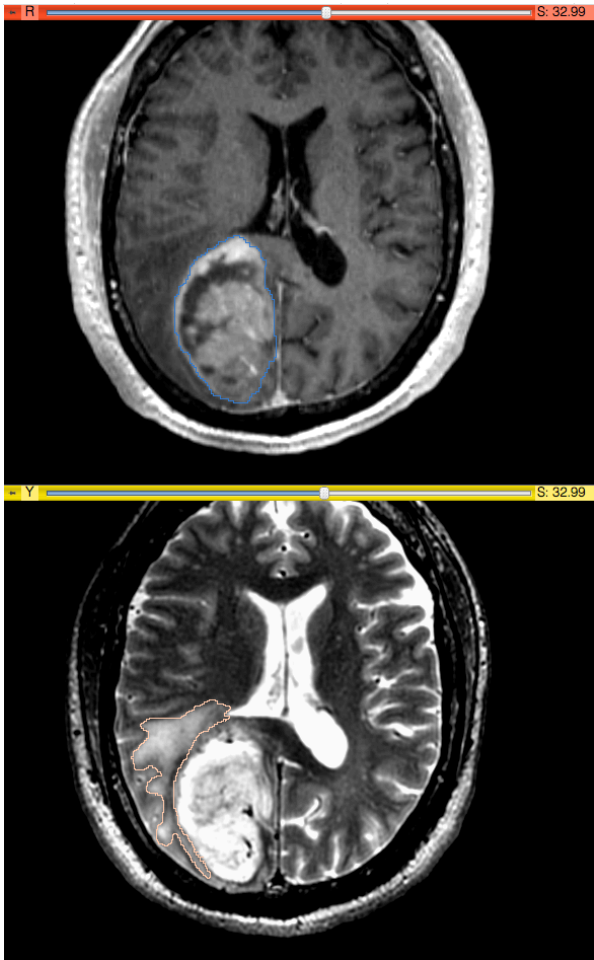
Cases provided by Dr. Alexandra Golby, neurosurgeon, BWH

- Two healthy subjects scanned twice on 5 different scanners

Datasets provided by Guido Gerig, Ph.D, SCI Utah



Workshop Datasets



- Each dataset included T1-weighted, T2-weighted, Pre-op DWI and DTI
- Manual segmentation of tumor and edema on T1 and T2 images
- Review by expert neuroradiologist



Evaluation Criteria

Two sets of metrics

- Qualitative assessment by clinicians and DTI experts
- Quantitative analysis based on five different metrics



Quantitative evaluation

Metric 1: Dice coefficient of overlap

Metric 2: Hausdorff distance

Metric 3: Fiber FA and MD profile along tract

Metric 4: STAPLE sensitivity score

Metric 5: STAPLE specificity score



Clinical Evaluation Criteria

C1: Anatomical correctness of the tract

C2: Presence of false positive-tracts

C3: Presence of false negative-tracts

C4: Correct depiction of the distance between the tract and the lesion

C5: Demonstration of tract displacement

C6: Demonstration of tumor infiltration

→ critical to the neurosurgeon



MICCAI 2011 Workshop

- 8 international teams
- 10-hour long workshop
- 25 participants
- 352 corticospinal tracts generated
- 5,900 visits on challenge webpage



DTI Tractography for Neurosurgical Planning: A Grand Challenge

Welcome to the DTI Tractography for Neurosurgical Planning: A Grand Challenge workshop. The goal of the initiative is to provide neurosurgeons with an overview of the progress in the field of DTI Tractography for Neurosurgical Planning and to provide a platform for the development and validation of a wide range of advanced tractography techniques. DTI Tractography for Neurosurgical Planning: A Grand Challenge workshop will give participants the opportunity to evaluate the performance of their tractography techniques and gain insights on the currently available paradigms for evaluating tractography results in the Operating Room in the absence of ground truth.

Faculty:

- Boris Poon, Ph.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Ben Adams, M.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Alexander Goh, M.D., Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School
- Guohua Gao, Ph.D., The Scientific Computing and Imaging Institute, University of Utah
- Mark Spitzer, Ph.D., NeuroImage Research and Analysis Laboratory, University of North Carolina
- Wilson Velho, Ph.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Christophoros Michos, Ph.D., Laboratory of Radiology and Imaging Informatics, Brigham and Women's Hospital, Harvard Medical School
- Frank Gantner, M.Sc., The Scientific Computing and Imaging Institute, University of Utah
- Paul Mollnes, M.D., Department of Neurosurgery, University Hospital Schleswig-Holstein, Kiel, Germany
- Mathias Marnett, M.D., Ph.D., Department of Radiology, Brigham and Women's Hospital, Harvard Medical School

Timeline Agenda:

- 08:00-09:00: Start of the workshop
- 09:00-09:30: Welcome remarks
- 09:30-10:00: DTI Tractography and Neurosurgical Planning
- 10:00-10:30: Presentation of the challenge
- 10:30-10:45: Coffee break
- 10:45-12:15: Tractography Demos
- 12:15-12:30: Lunch break
- 12:30-12:45: Inviting remarks
- 12:45-1:15: Roundtable discussion
- 1:15-1:30: A. Volumental Appl.



http://www.na-mic.org/Wiki/index.php/Events:_DTI_Tractography_Challenge_MICCAI_2011



Challenge participants

- UPenn, Philadelphia, USA
- INRIA Rennes, France
- Robarts Research Institute, Toronto, Canada
- Scientific Computing and Imaging Institute, Salt Lake City, USA
- University of Florida, USA
- Laboratory of Mathematics in Imaging, Boston, USA
- German Cancer Research Centre, Heidelberg, Germany
- UNC Chapell Hill, USA



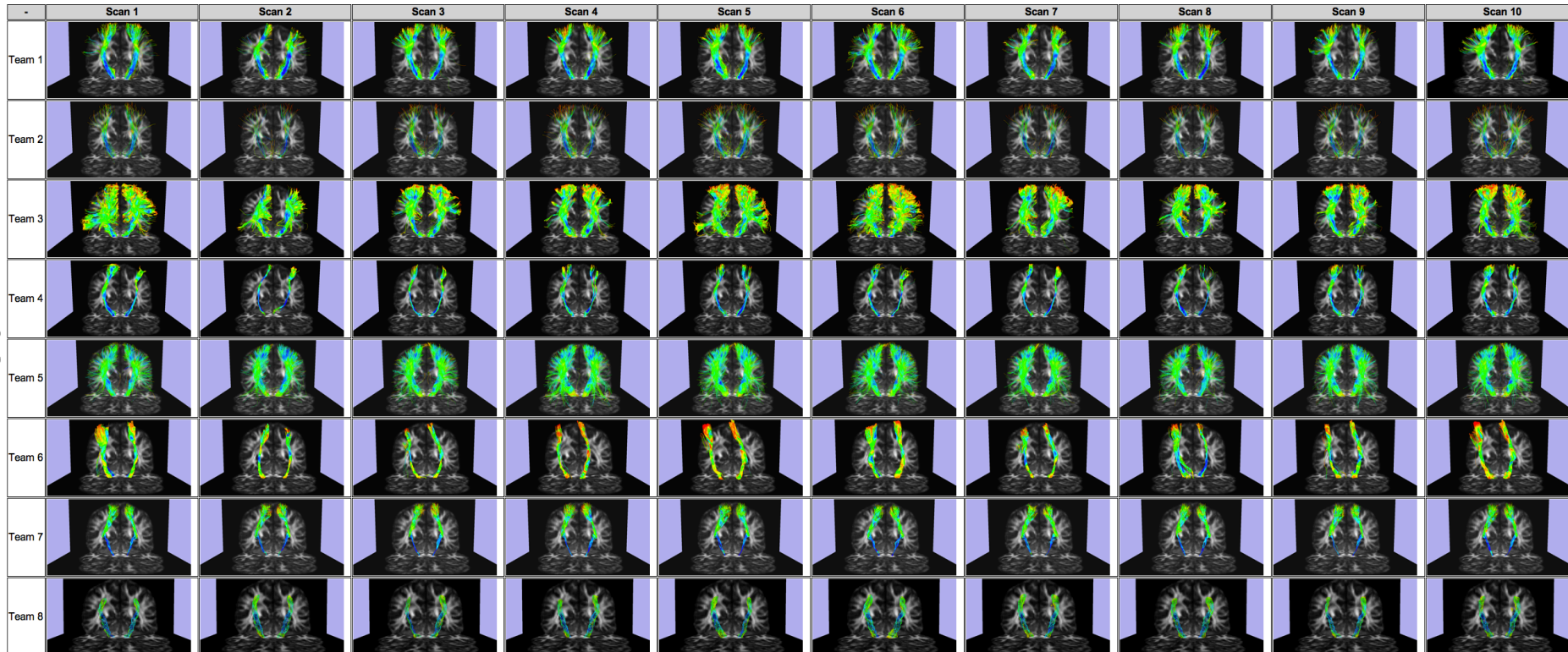
Tractography Algorithms

1. Intrinsic Unscented Kalman Filter
2. Global Fiber tracking based on Finsler Distance
3. Automated Atlas-Based Seeding
4. Machine Learning & Particle Mass based tractography
5. Streamline tractography based on a multi-compartment model
6. Filtered Multi-tensor tractography
7. Volumetric Tractography
8. MITK Global Tractography



Healthy subjects Results

Scan



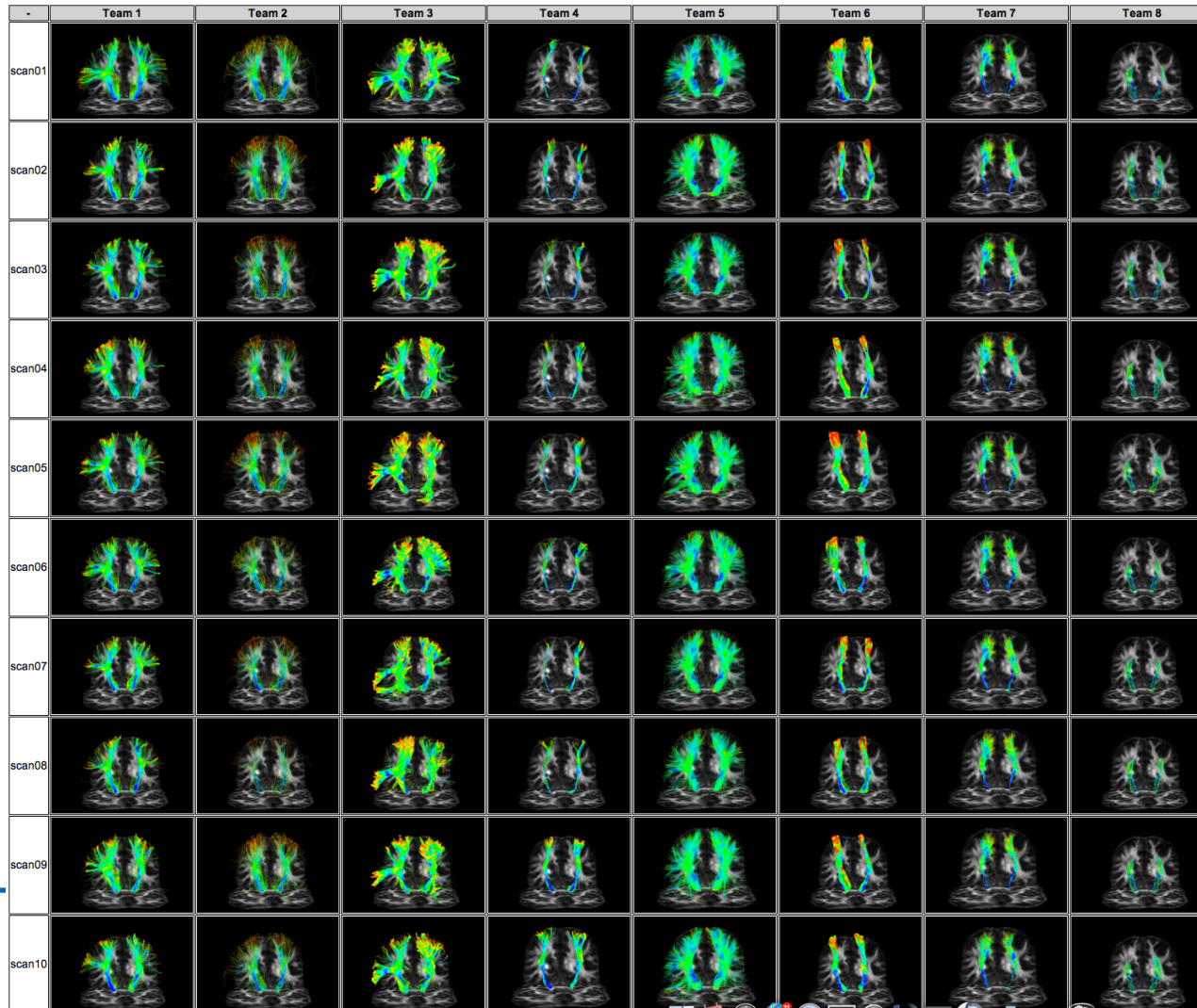


Healthy subjects Results

Team

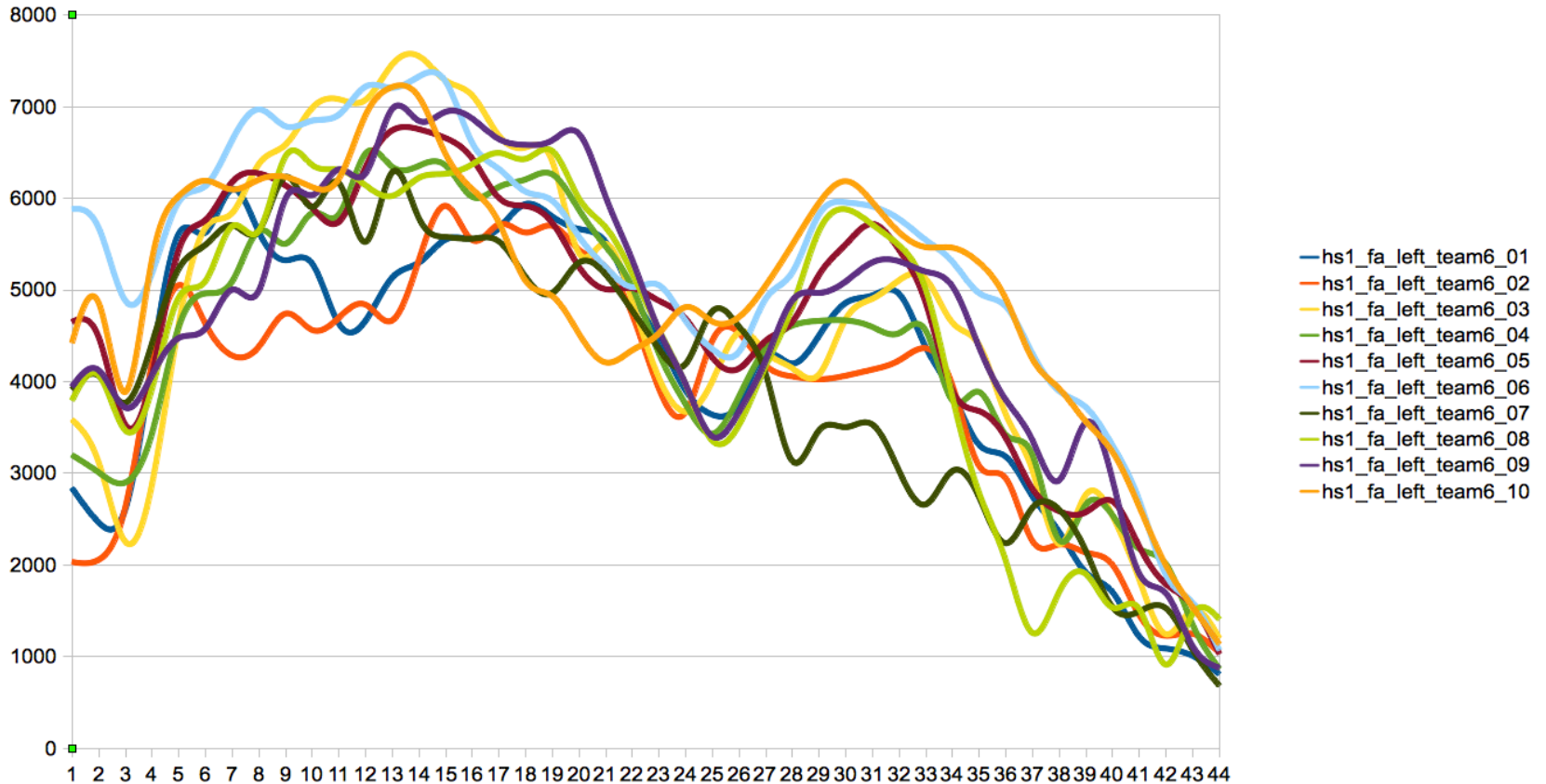
Healthy Subject 1 (For each scan, the images show the comparison across teams.)

Scan





FA profile example



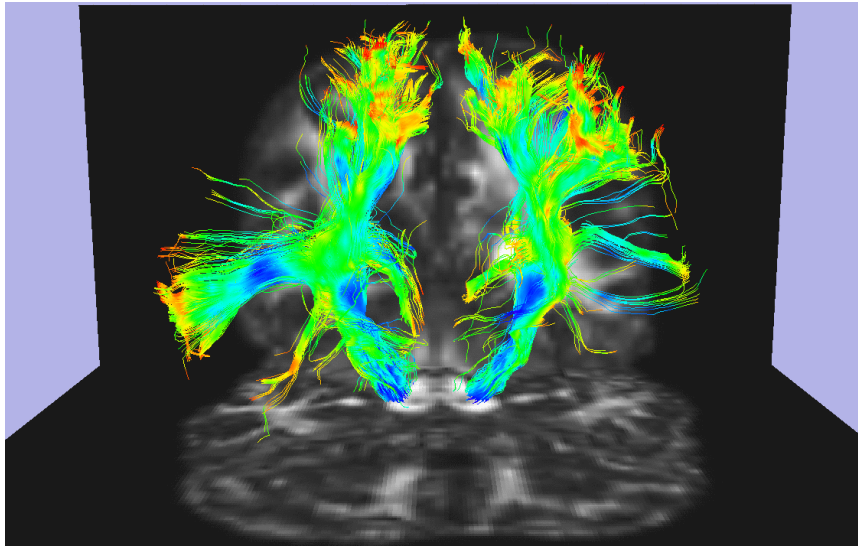


Results

Mean(STD)	Healthy Subject 1	Healthy Subject 2
Dice's coefficient	0.45(0.17)	0.40(0.27)
Hausdorff Distance	1.95(0.97) mm	2.7(2.10) mm
STAPLE sensitivity	0.45(0.09)	0.42(0.08)



Workshop Outcomes

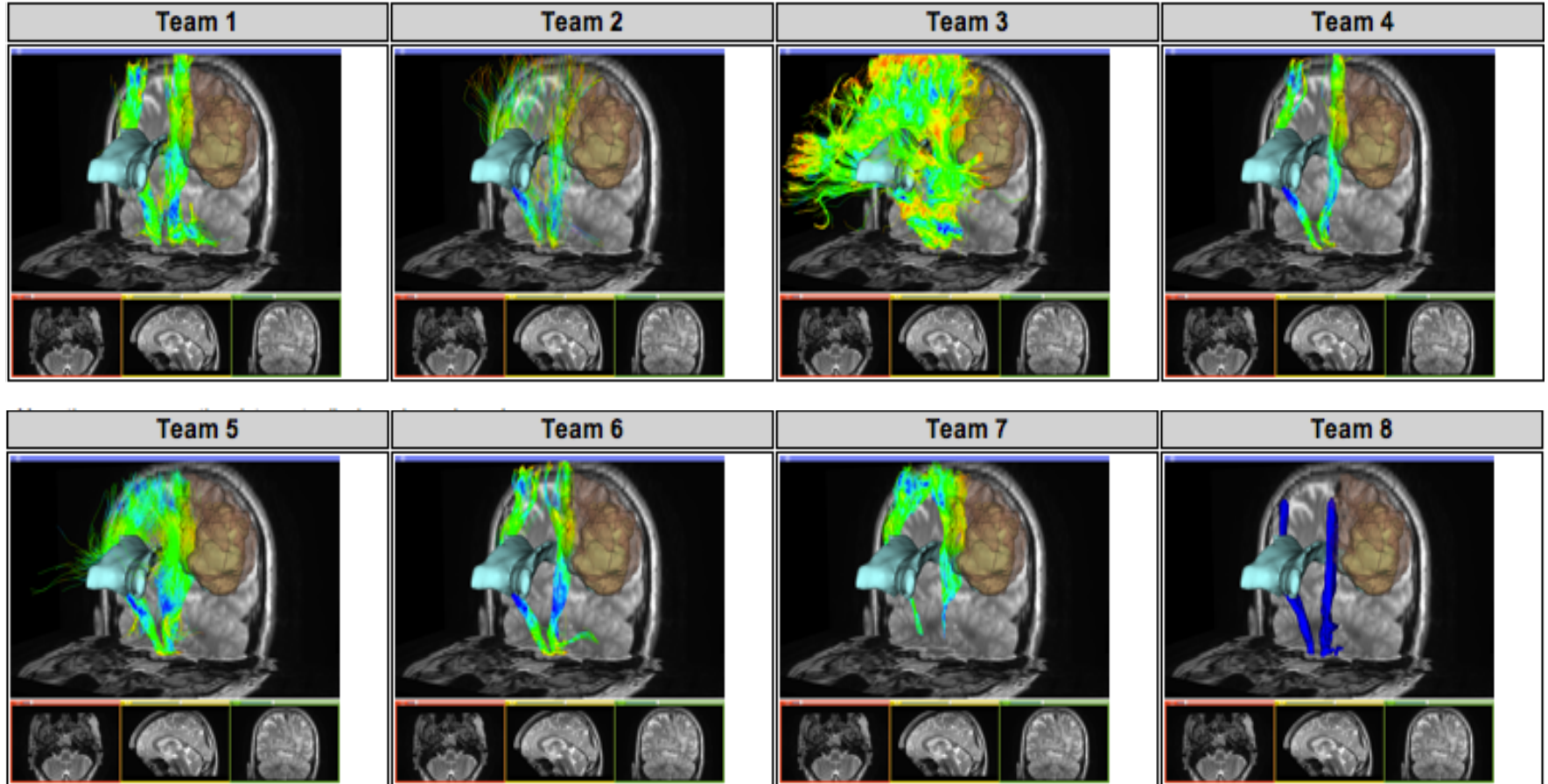


Healthy subject study

→ large **intra-
algorithm** variability

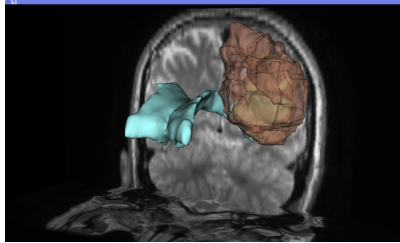


Clinical Cases Results

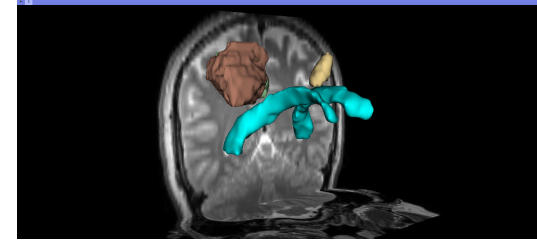
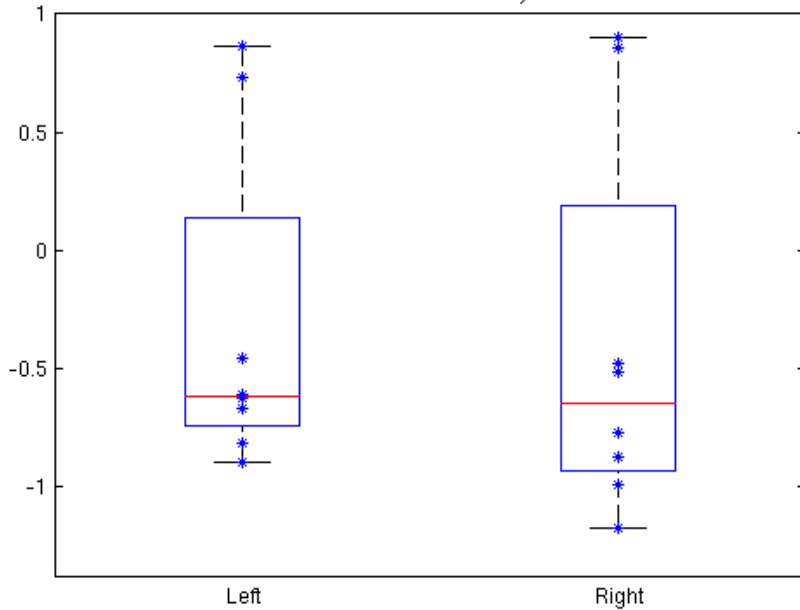




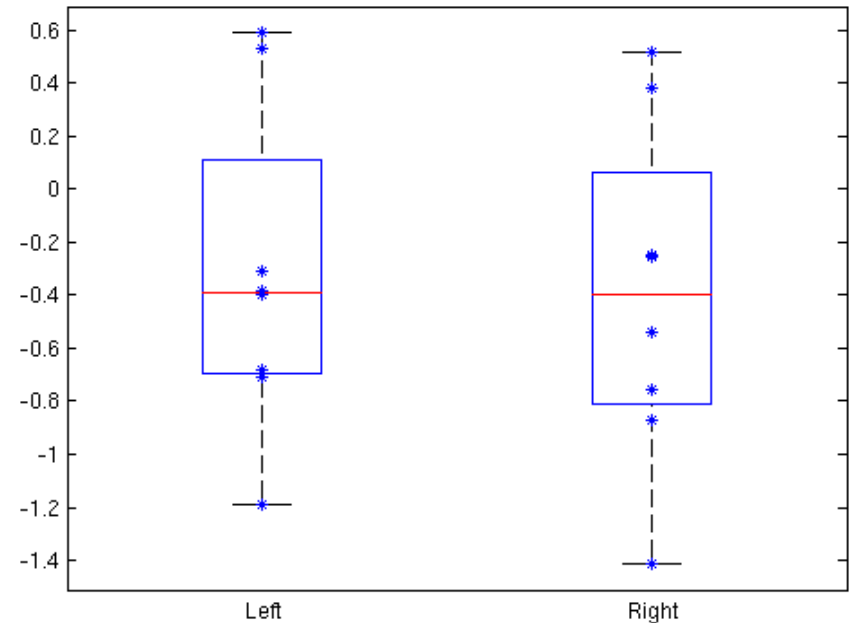
STAPLE results



Patient 1 - Sensitivity



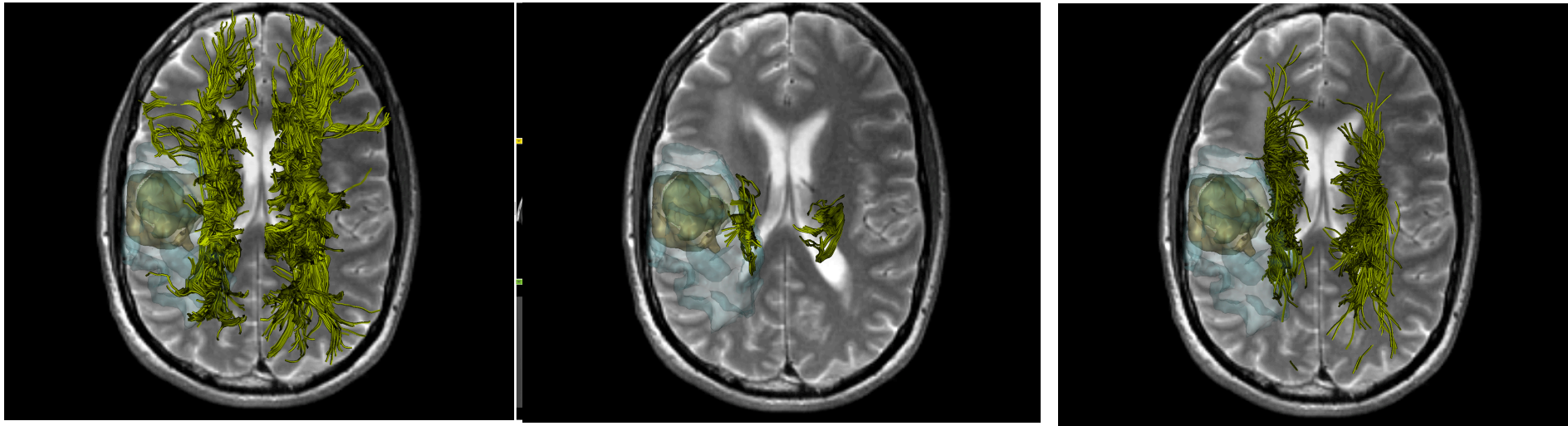
Patient 2 - Sensitivity



Weak agreement, large inter-algorithm variability

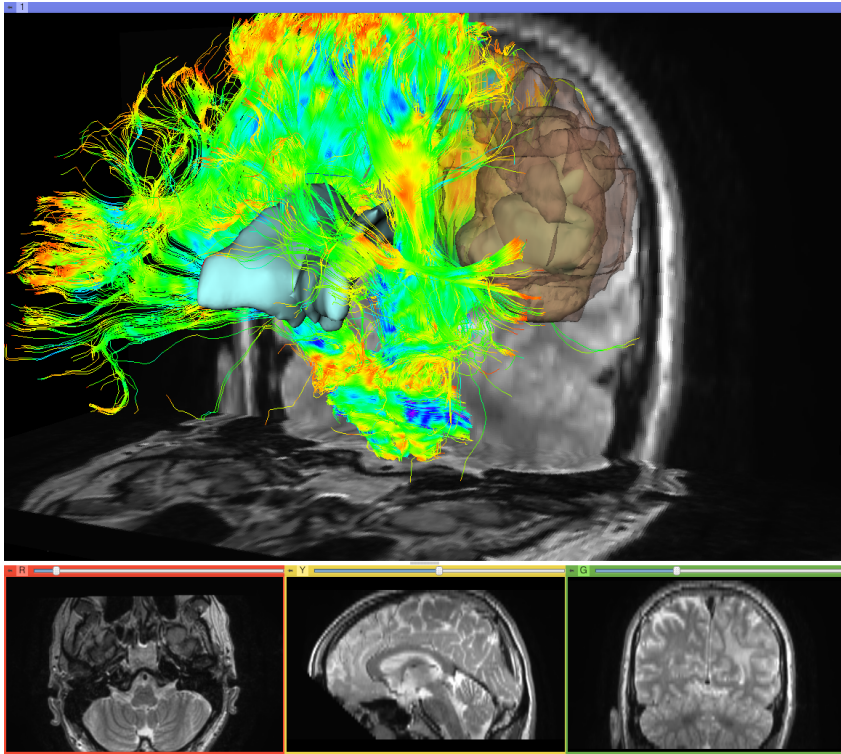


Clinical cases results

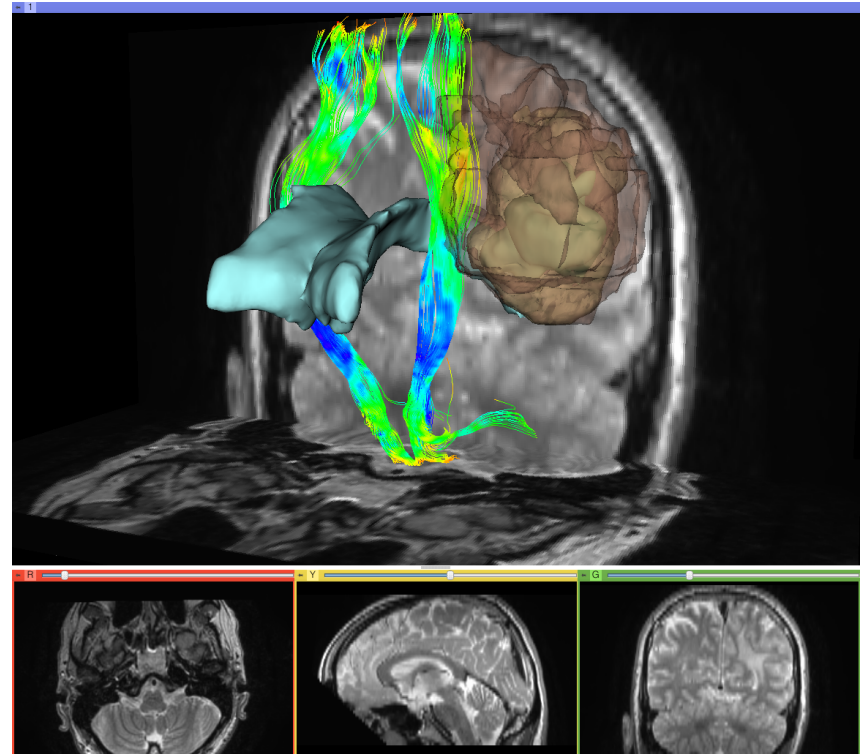




CST reconstructions



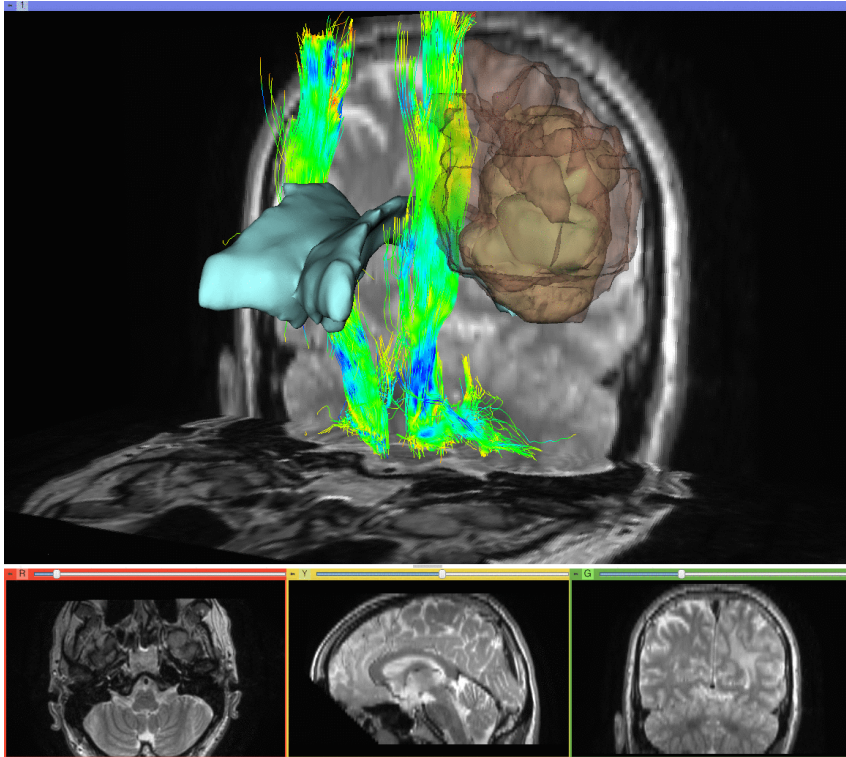
FP



FN



Clinical cases Results



Neurosurgical cases study

→ large **inter-algorithm** variability



Workshop outcomes

- Large variability among tractography methods
- Quantitative metrics selected based on hypothesis of successful targeting of CST
- Opportunity for review and feedback from leading neurosurgeons
- Positive feedback from the MICCAI community



Bridging the gap

- After the challenge, each team received a 14-page document containing the qualitative evaluation by the clinical and DTI experts, and the values of the quantitative metrics
- Participants were invited to re-process the data using the reviewers' feedback



DTI Challenge: Conclusion

- Appropriate reflection of the current state of the art in the field
- Submission to MICCAI 2012
- On-going learning effort for the community

