

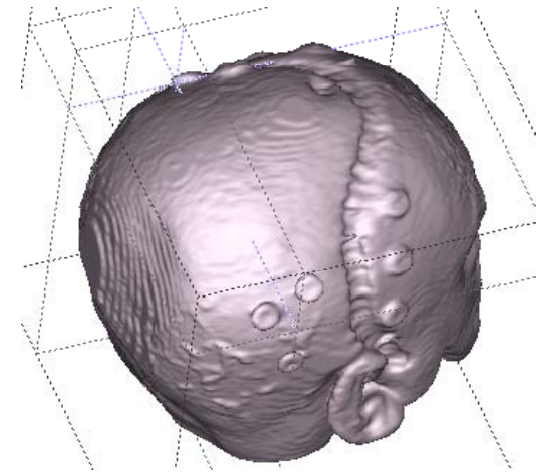


NA-MIC

National Alliance for Medical Image Computing

<http://na-mic.org>

NAMIC DBP UCLA-LONI Traumatic Brain Injury



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University of Utah and SCI Institute

Jack van Horn, A. Toga, P. Vespa, D. Hovda

UCLA LONI, Neurosurgery, Neurology



UCLA TEAM (LONI, Neurosurgery)

- **Jack van Horn**, PhD, LONI, PI NAMIC DBP
- Art Toga, PhD, LONI
- David Hovda, MD (Dept. of Neurosurgery, Director UCLA Brain Injury Research Center:
<http://neurosurgery.ucla.edu/body.cfm?id=657>)
- Paul Vespa, MD (Neurosurgery)
- David McArthur, PhD (Statistics)
- Jeffrey Alger, PhD, Prof. Neurology, MRI/MRS expert,
http://www.stroke.ucla.edu/staff/Alger_JR/,
<http://neurosurgery.ucla.edu/body.cfm?id=648>



Motivation TBI Imaging Research

Discussion D. Hovda

- 1.5 Mio TBI per year, half mild TBI
- 650,000 hospitalizations for longterm brain injury, known as the “silent death”
- 48 billion per year for management and loss of workforce
- 85 clinical trials for therapy, all failed
- No treatment yet, no proven rehabilitation, but management
- Nobody understands neurobiology of brain injury
- Management: 1 Mio\$ per case
- See CDC web-site:
http://www.cdc.gov/TraumaticBrainInjury/tbi_concussion.html



Imaging

1. **First CT:** Emergency imaging:
 - Parameters: mass lesion (subdural, epidural), midline shift, asymmetry, swelling, compression of subarach-noid space, change of ventricles.
2. **Follow-up CT:** 24hrs up to 3 days after injury
3. **After time period: MRI/PET** (only few institutions incl. UCLA)
 - Parameters: more blood, is swelling still active ,
 - T1 scan: how much of brain is sacrificed, blood signature: toxic, midline shift
 - DTI/DWI: Axonal injury, axons become disconnected, stretching, shearing forces, cc
 - PET for blood (oxygenated metabolism (basic rate of oxygen)
4. **Follow-up MRI/PET (+6mo):** Longitudinal assessment, how much is left, change



Key Directions (D. Hovda)

- Towards quantitative measurements with new research tools
 - Multimodal data fusion
 - Longitudinal: change trajectories
 - Degree and change of atrophy, rate of change -> predictor of clinical outcome
 - Axonal damage
- **Home run for Research:** : Rehabilitation experiences that change anatomy, rehabilitation of brain injury
- Flexible image processing framework (“Turbotax for data analysis”)
- User-supervised, efficient, smart, flexible approach
- **Dream:** Dynamic 3D image with multi-variate information over time: Inform clinicians about extent and type of damage and about change over time.



Problems to study

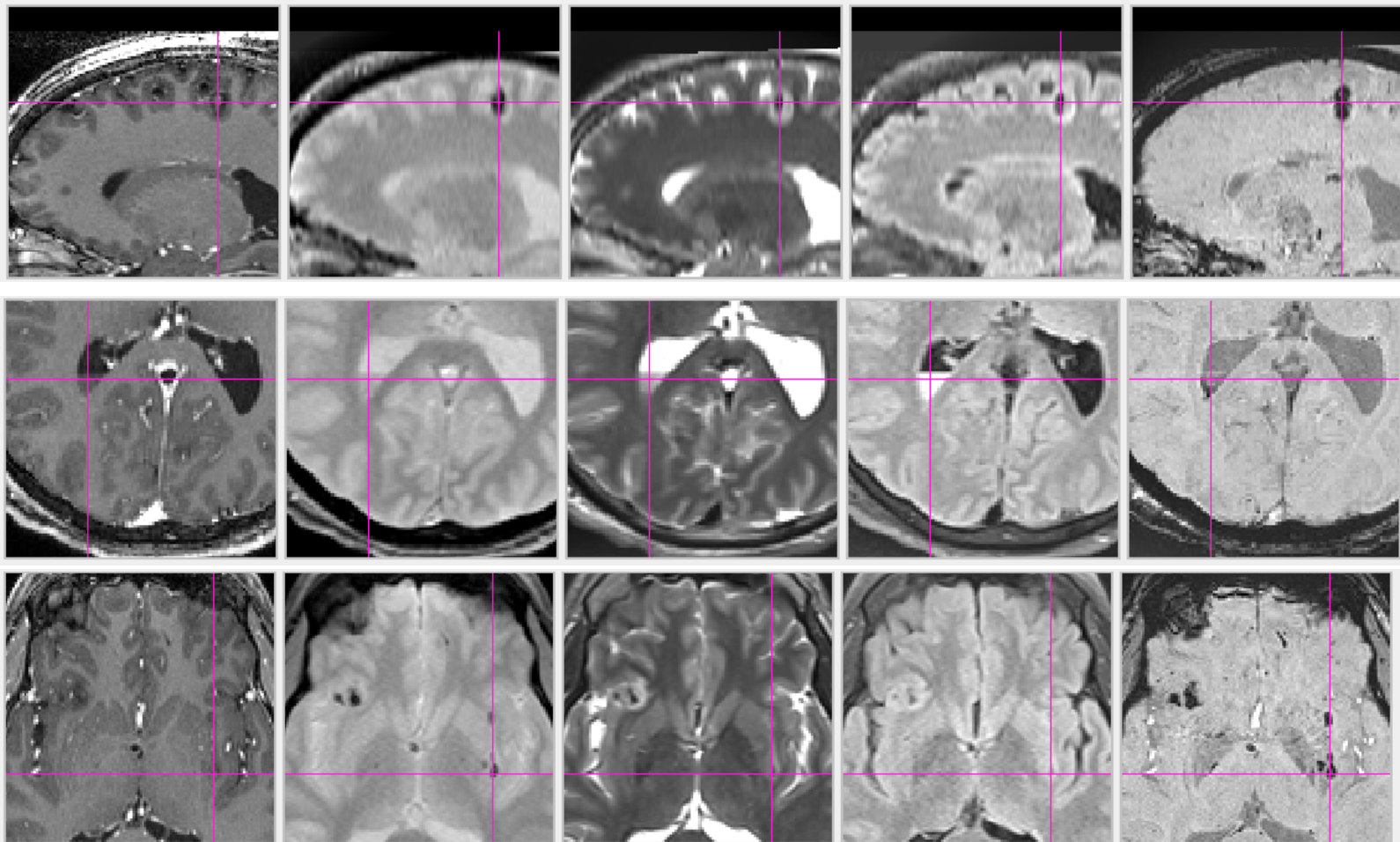
- #1 Problem: Amount of wm involved in injury?
- To learn about degree and change of atrophy and of axonal damage
- Acute and chronic MRI/PET
- Axonal damage

- No tools yet that helps clinicians to analyze and solve problem of quantitative analysis and visualization



Co-Registration of structural MRI with SLICER ABC: Multi-contrast view of tissue & lesions

Mprage postcontrast GRE-bleed TSE FLAIR SWI



TBI case courtesy P. Vespa, J. Alger, J. Horn, UCLA





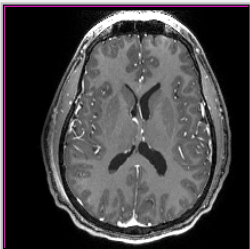
TBI Image Data: Case 3

Name	Matrix	voxel size
Axial TSE	512x512x54	0.46875x0.46875x3 mm ³
Axial GRE bleed	512x512x54	0.46875x0.46875x3 mm ³
Axial FLAIR	512x512x54	0.46875x0.46875x3 mm ³
MP Rage		
postcontrast	256x256x176	1x1x1 mm ³
SWI	192x256x104	0.898x0.898x1.5 mm ³
mIP	192x256x97	0.898x0.898x1.5 mm ³
3T DTI	128x128x54	2x2x3 mm ³
	(20 directions at b = 1000 with 1 b=0)	

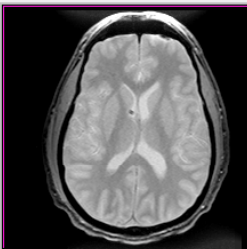


Atlas-Based Classification “ABC” applied to multi-modal MRI of TBI case

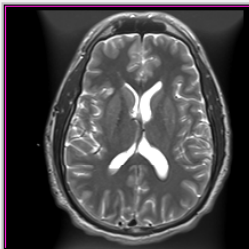
MPrage post



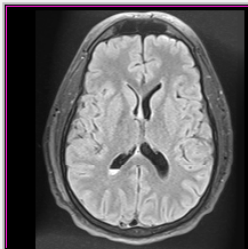
GRE-bleed



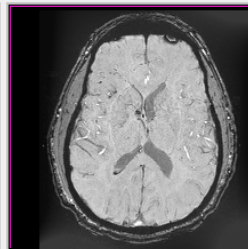
TSE



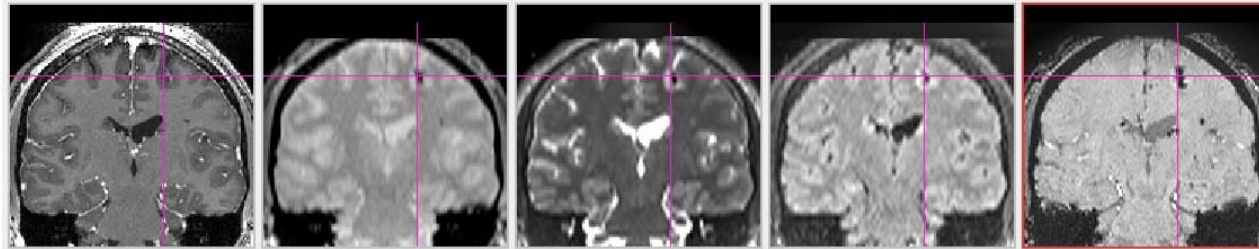
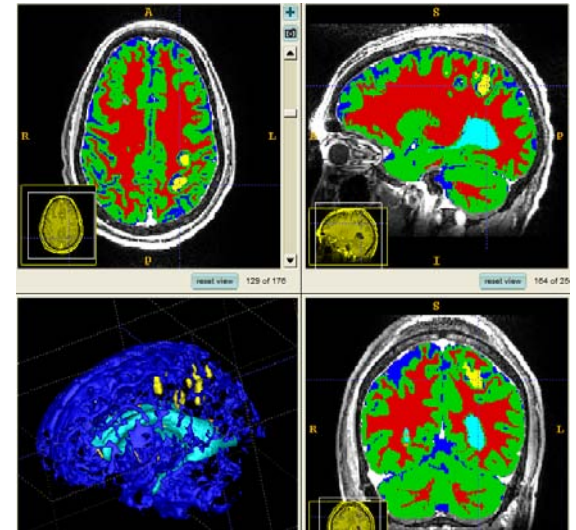
FLAIR



SWI



Brain/csf segmentation



ABC performs co-registration of all input modalities (here 5 MRI channels) and atlas-based segmentation of brain tissue and csf. Bias-correction (all modalities) and brain-stripping is an integrative, automatic part of ABC.

White matter lesions and ventricles were segmented via postprocessing using level-set segmentation. MRI data courtesy of UCLA (P. Vespa, J. Alger and Jack van Horn).



Multimodal fusion: Joint analysis of sMRI and DTI

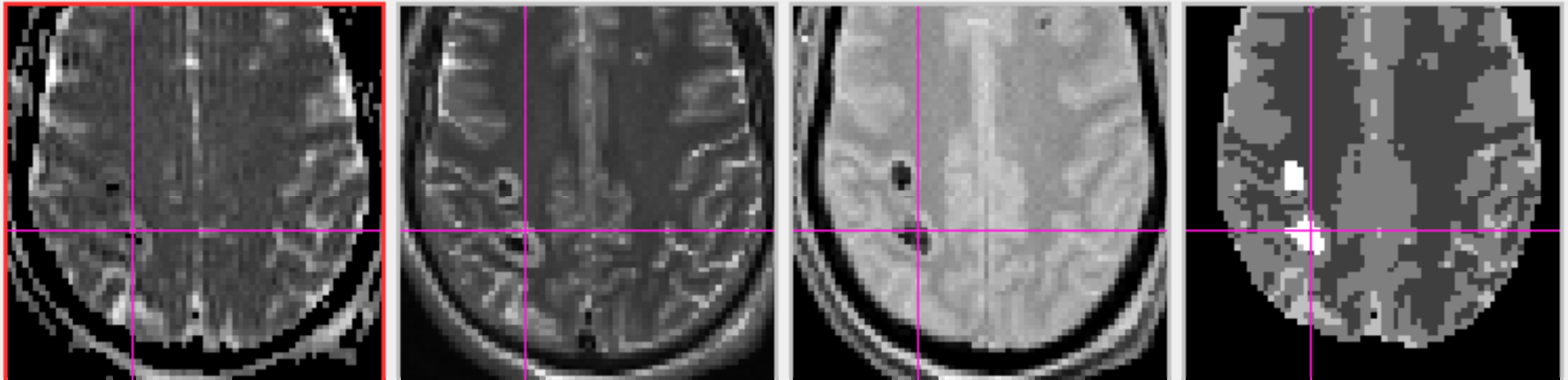
- Co-registration of structural modalities to DTI (baseline image registered to TSE) using ABC.
- DTI tensor field and structural images available in same coordinate system.

DTI (mean diffusivity)

TSE

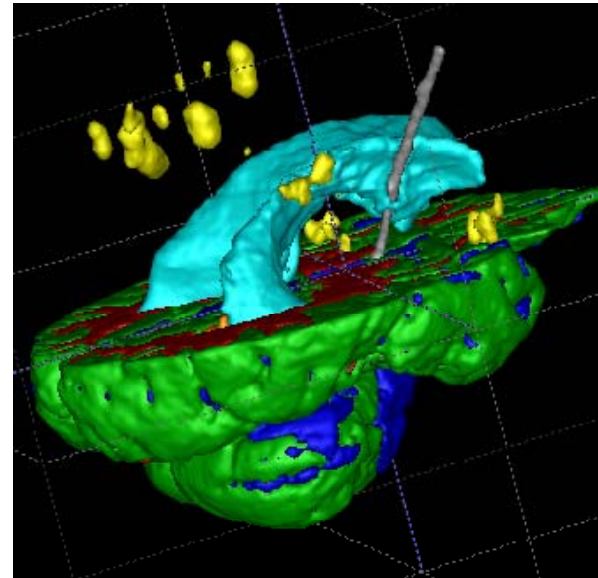
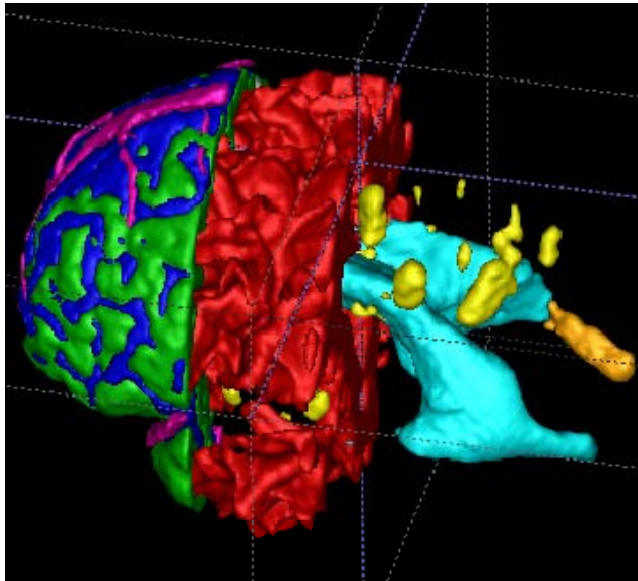
GRE-bleed

Segmentation





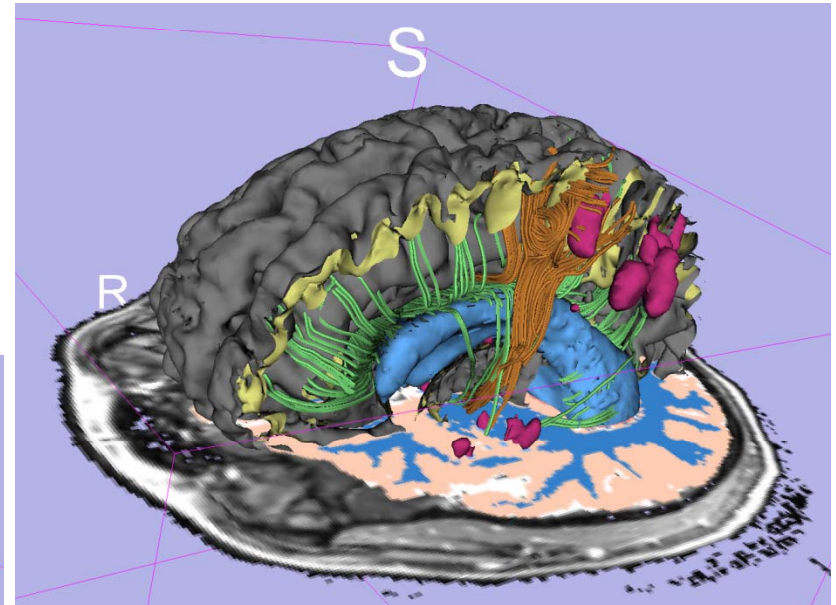
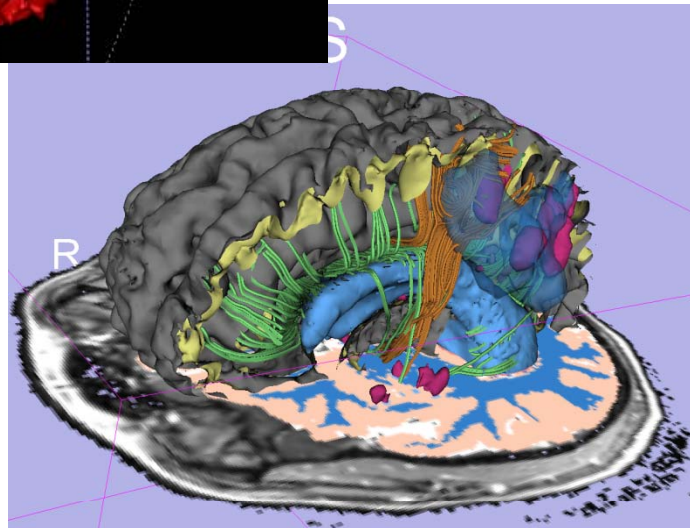
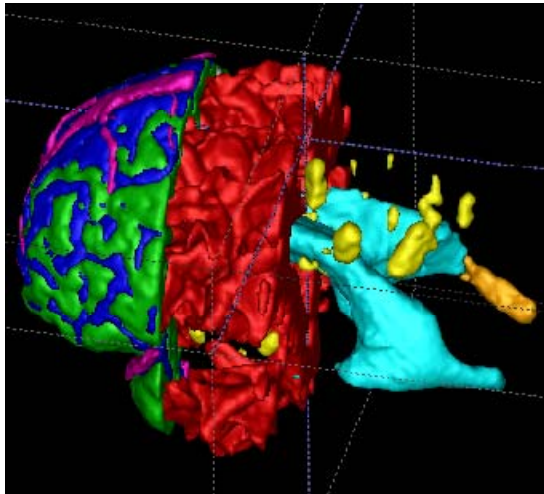
Case 3: Multimodal Aspect



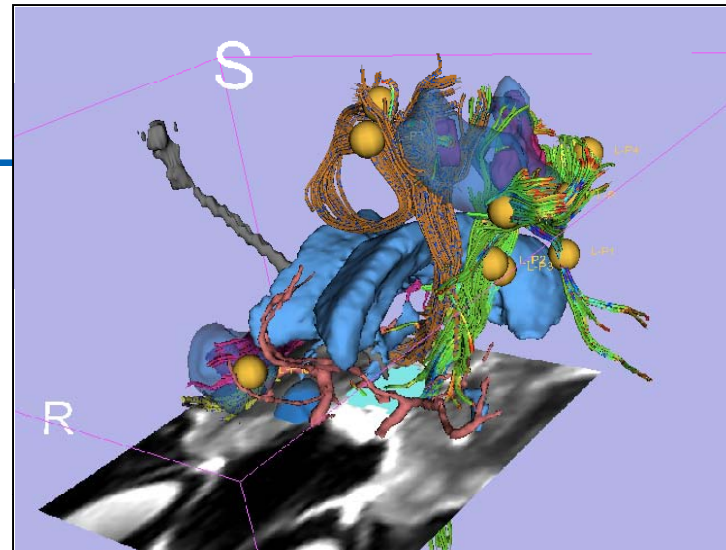
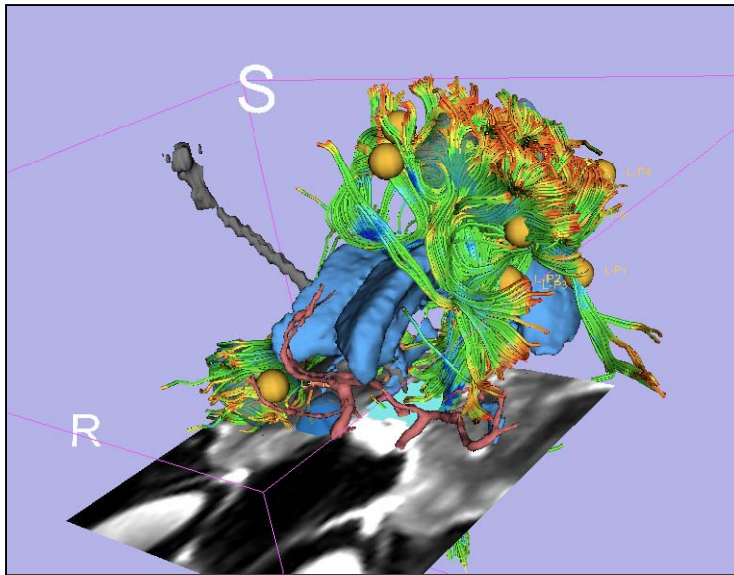
Report by J. Alger: A ventricular shunt is in place on the right. The left frontoparietal area and right frontotemporal junction show contusions (a mixture of black GRE (hemorrhage) and hyperintense FLAIR (edema)). It also looks like some blood is pooling in the posterior horn of the right lateral ventricle. There appears to be some edema on the anteromedial cortex of the right temporal lobe. The SWI shows numerous microhemorrhages in the left and right frontoparietal lobes and the right temporal lobe. I bet this person was seizing.



Slicer-3: Tractography and joint display of segmented objects and MRI



- Tractography, fiber clustering and composition by Ron Kikinis
- Co-registration DTI/sMRI and brain/lesion segmentation by Guido Gerig

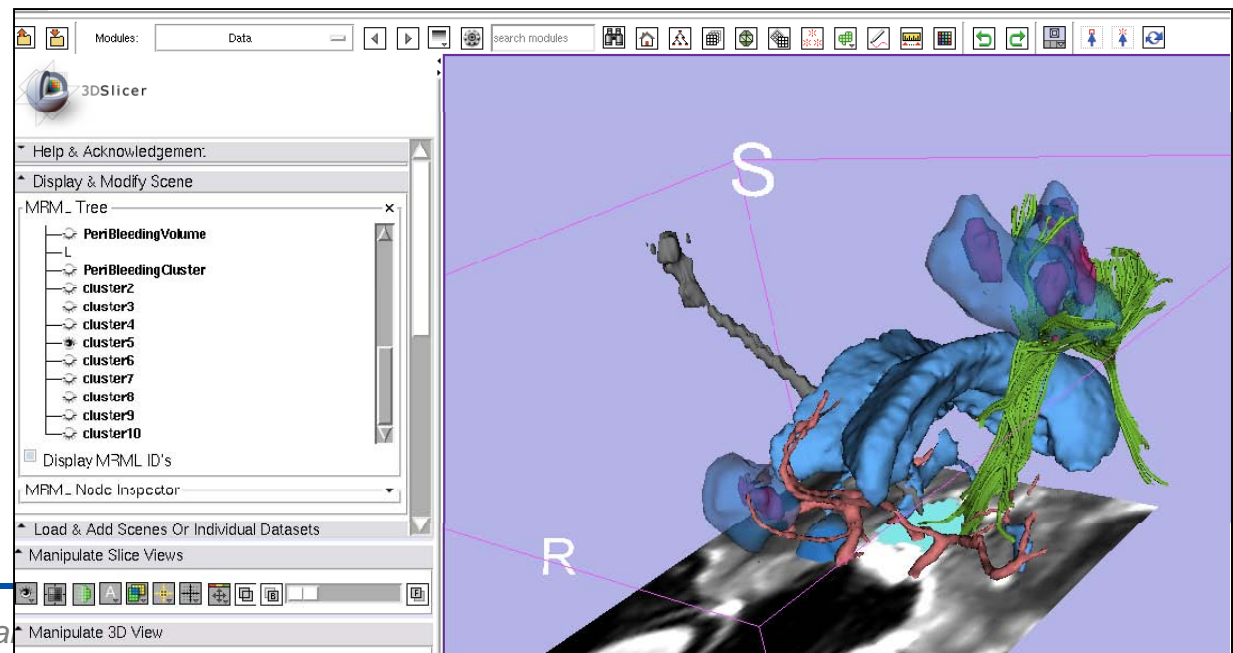


Peri-bleed tract, fiducials for the sub-clusters/tracts, result fiber clustering in relation to lesion.

Ron's comments:

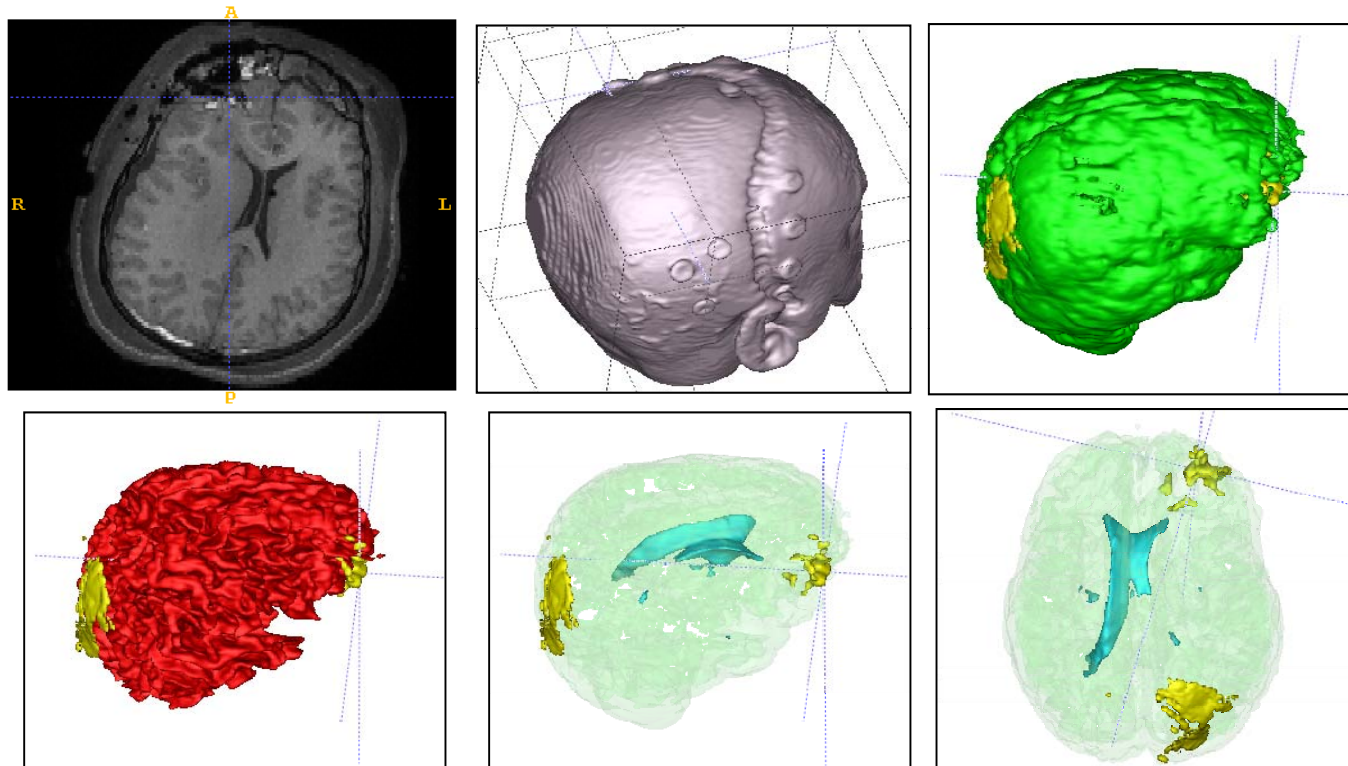
- Proof of capabilities: Visual assessment of multi-modality imaging with 3D tracts and objects.
- Potential identification of specific functions for neurological testing → **deploy tests based on hypothesis from imaging.**
- Future: More principled approach, leads to **quantitative assessments.**

National Alliance for Medical Imaging
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Segmentation Case 1 TBI

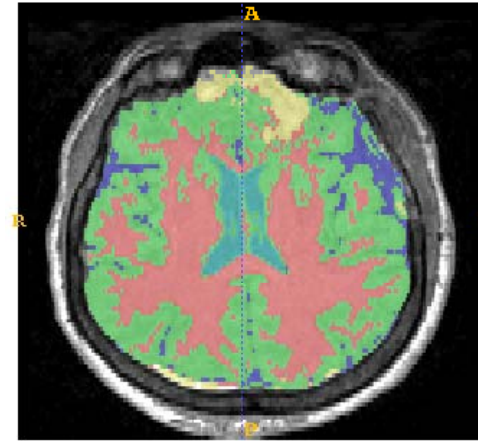
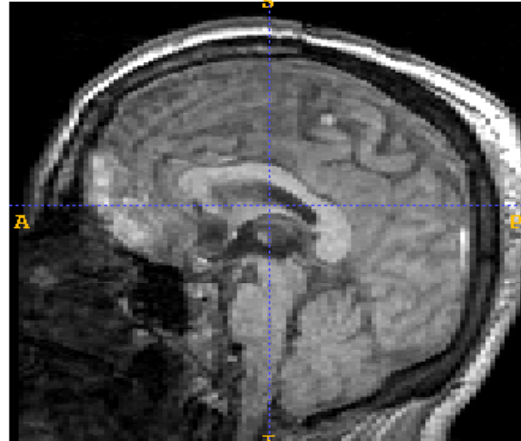
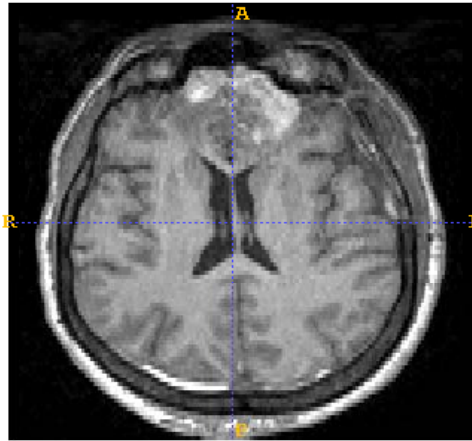


TBI data
courtesy
UCLA (P.
Vespa)

- T1 difficult quality (low contrast, non-isotropic voxels, brain damage)
- Automatic brain segmentation.
- User-supervised level-set segmentation of lesions and ventricles.
- Cursor points to right frontal brain damage, T1 hyperintense lesions shown in yellow.

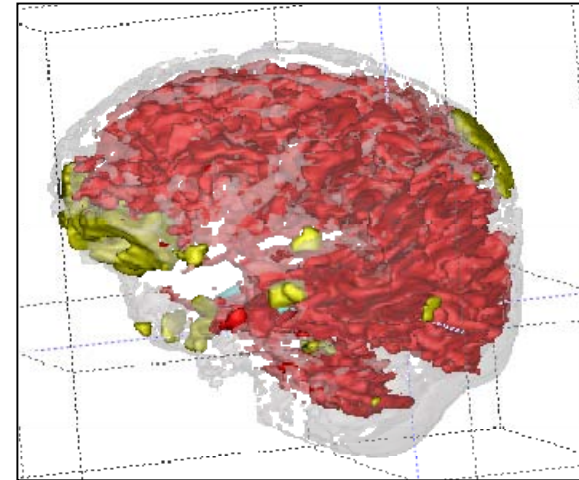
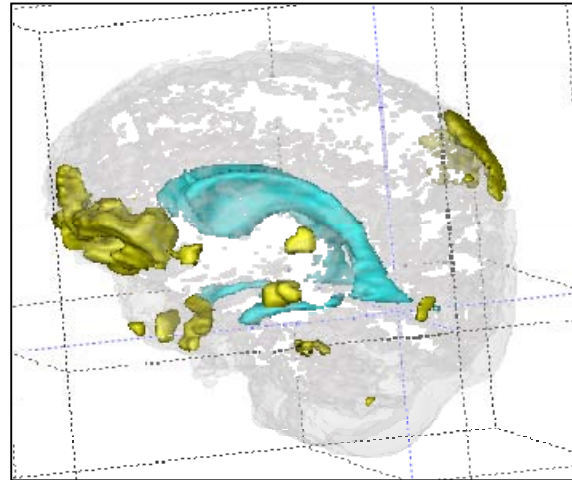


Segmentation Case 2 TBI



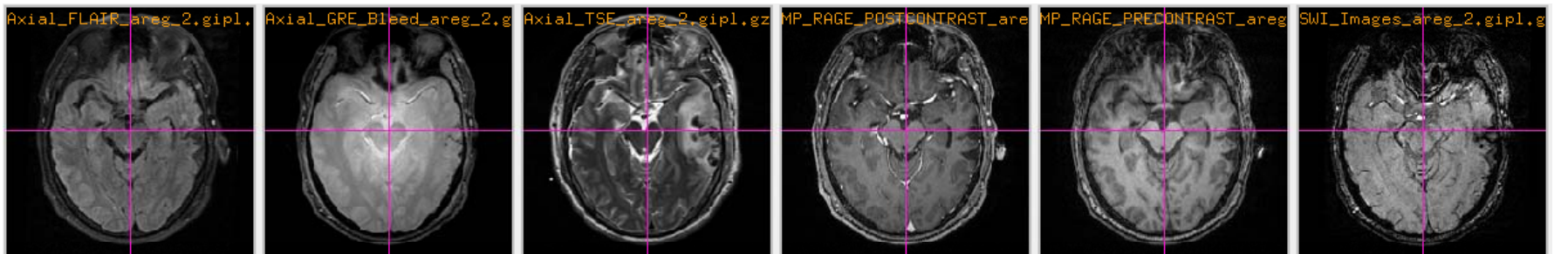
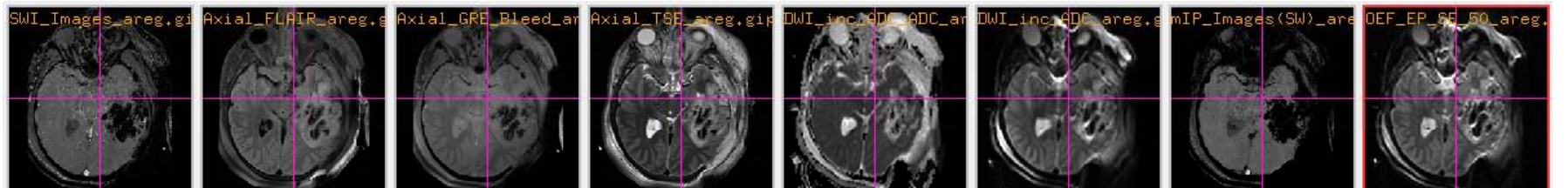
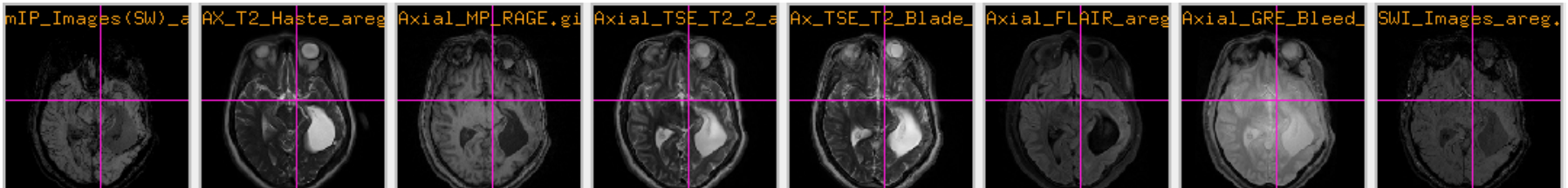
TBI data
courtesy
UCLA (P.
Vespa)

- T1 difficult quality (motion, contrast, non-isotropic voxels)
- Automatic brain segmentation.
- User-supervised level-set segmentation of lesions and ventricles.
- T1 hyperintense lesions shown in yellow.



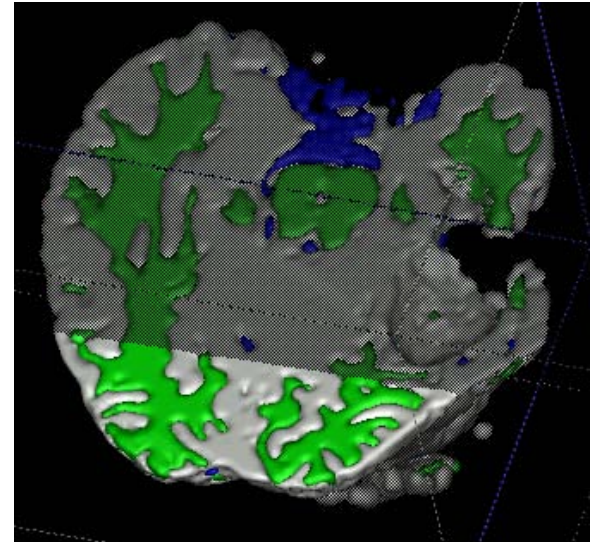
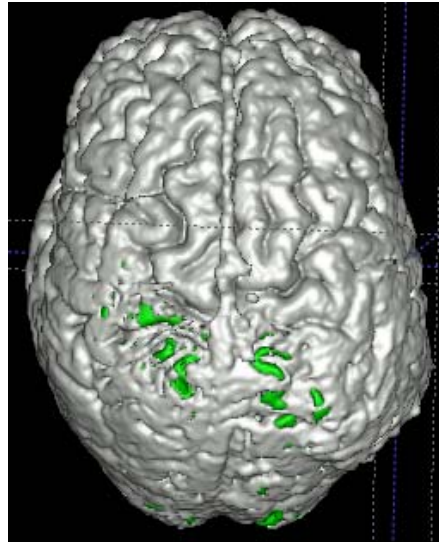
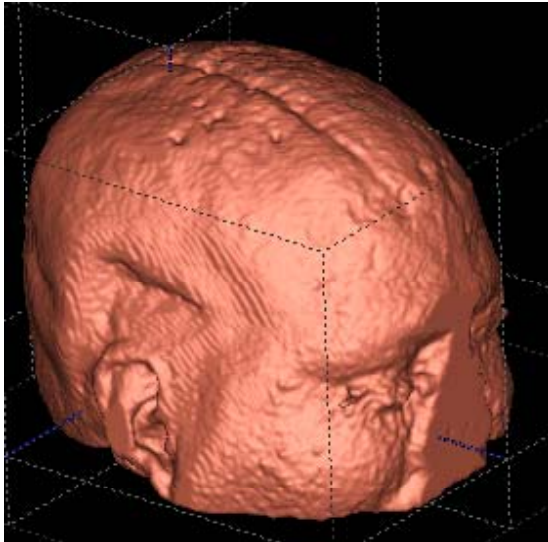


3 new Cases Nov. 2010 coregistered with ABC





New Case 1

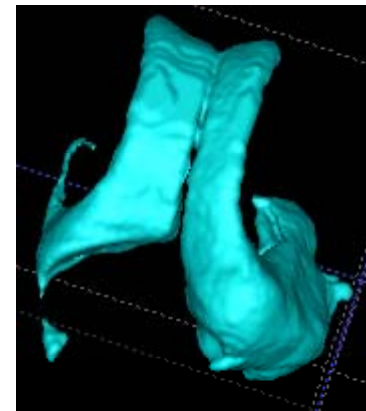
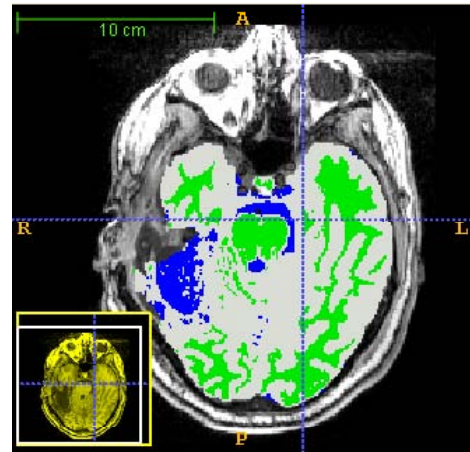
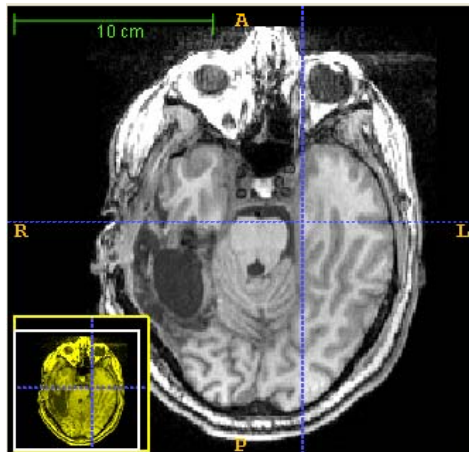
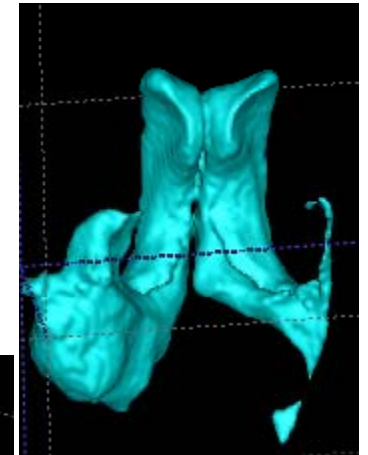
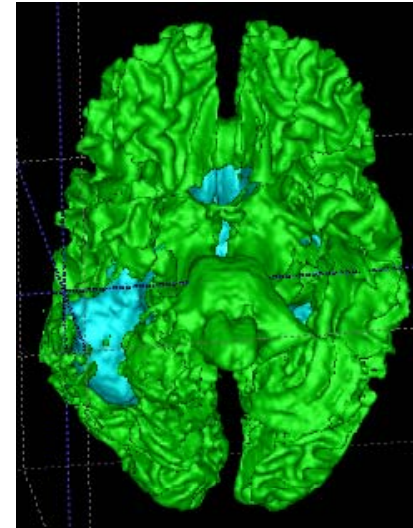
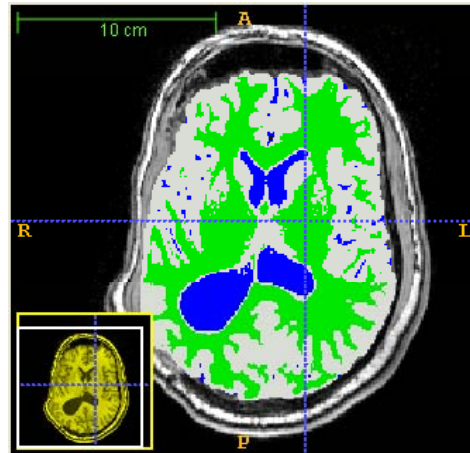
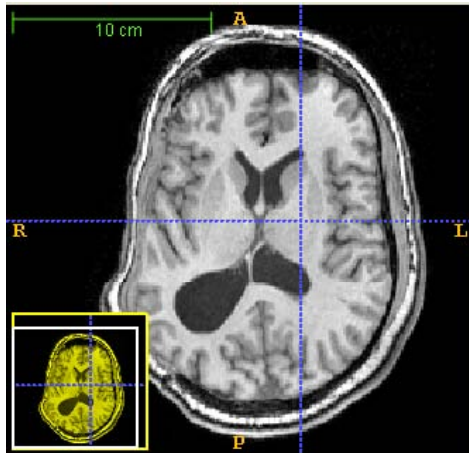


Processing:

- ABC for automatic brain tissue segmentation and brain stripping
- 3D snake for ventricles
- not yet done: segmentation of damages (bleeding, edema, white matter damages)

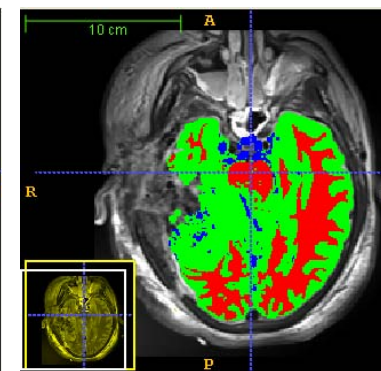
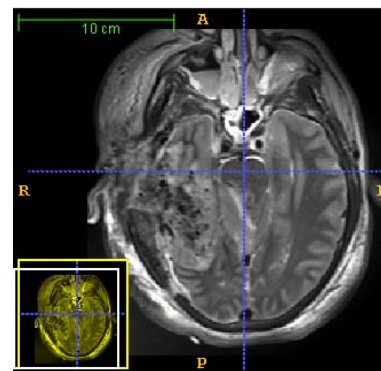
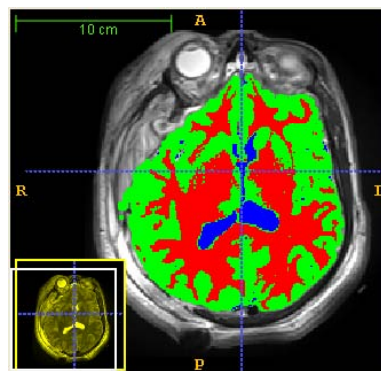
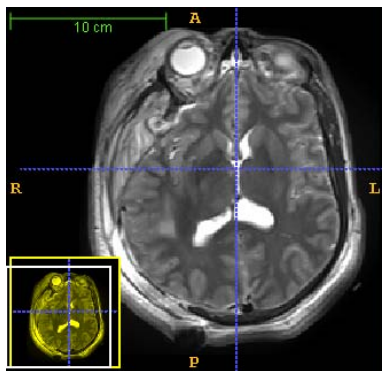
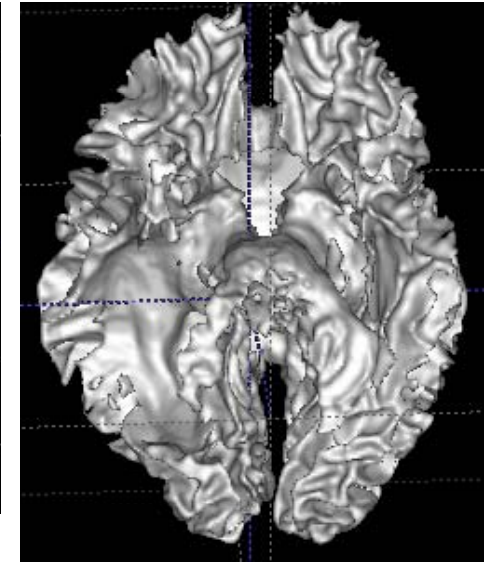
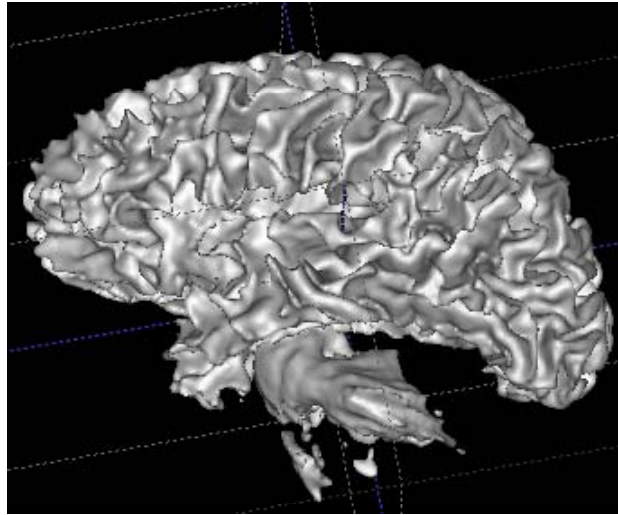
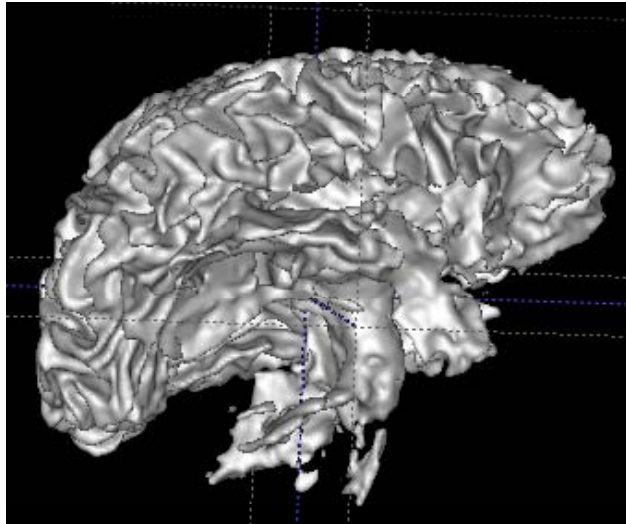


New Case 1



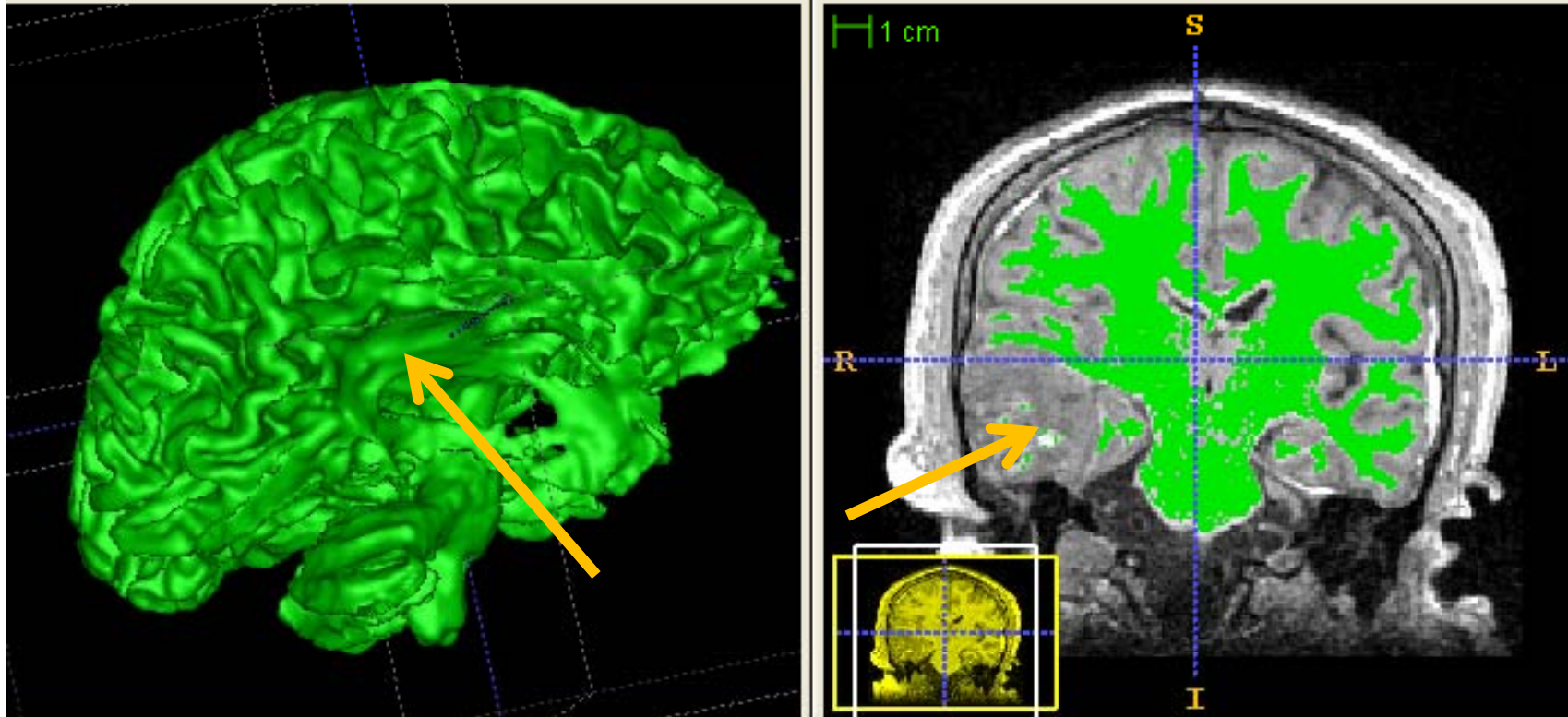


New Case 2





New Case 3



Brain tissue segmentation, display of white matter surface with right temporal lobe



Discussion

- Early tests:
 - Multi-modal fusion (linear co-registration, ABC)
 - Tissue classification with normal atlas prior, deformable (fluid) atlas to subject registration
 - Segmentation of lesions, bleedings, shunt etc. via 3D snakes
- In progress:
 - Robust tissue segmentation with outlier detection and more categories (wm,gm,csf, hemorrhage, lesions, etc.)
 - Advanced “brain stripping/atlas registration” via joint surface/volume deformable registration
 - User-guidance to “seed” categories
 -