ABC: Atlas-Based Classification

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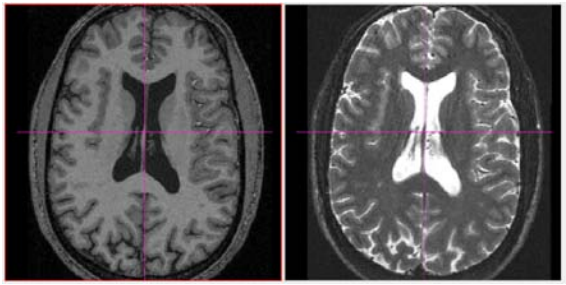
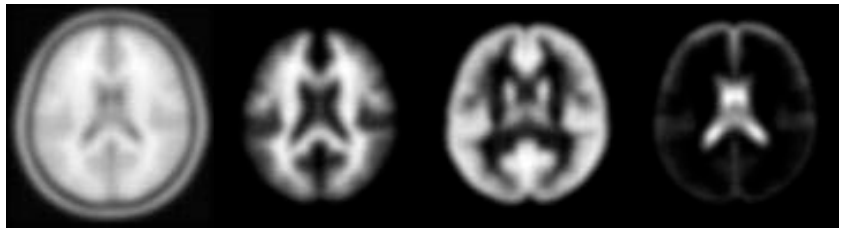
University of Utah and SCI Institute
Martin Styner, UNC

ABC: Fully Automatic Segmentation Method



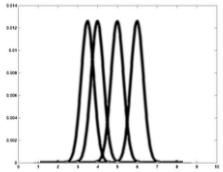
Multimodal co-registration



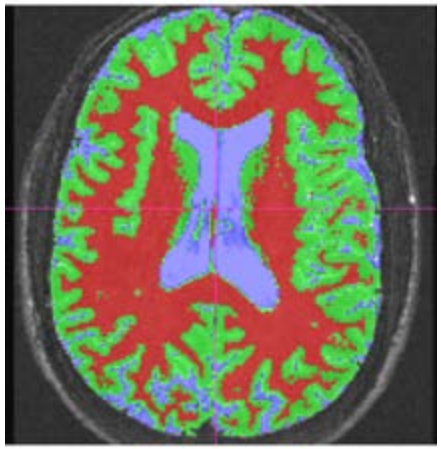
Atlas template with spatial priors for tissue categories

Atlas-subject warping

Bias correction



Compute tissue probabilities

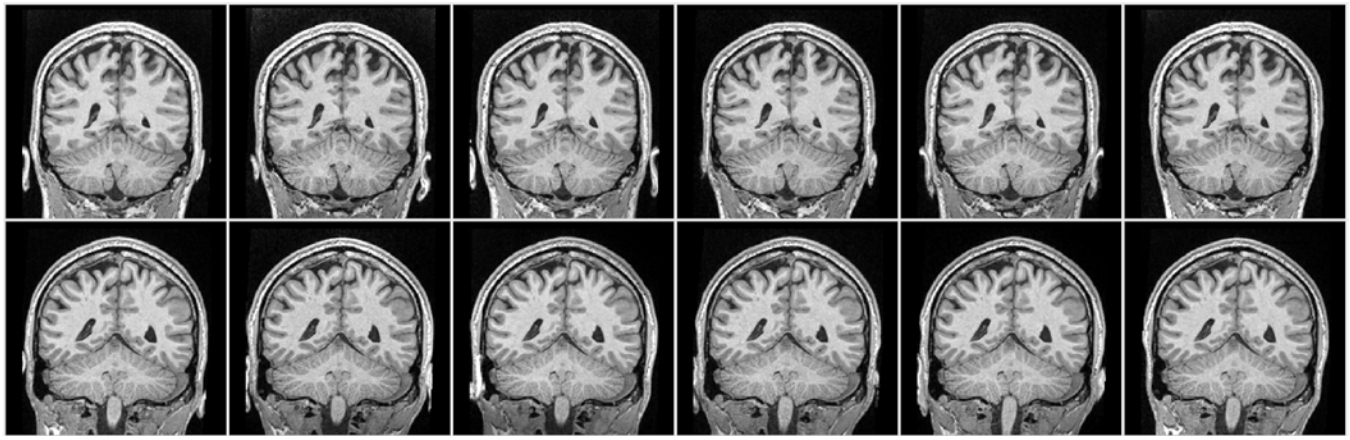


ABC: Properties

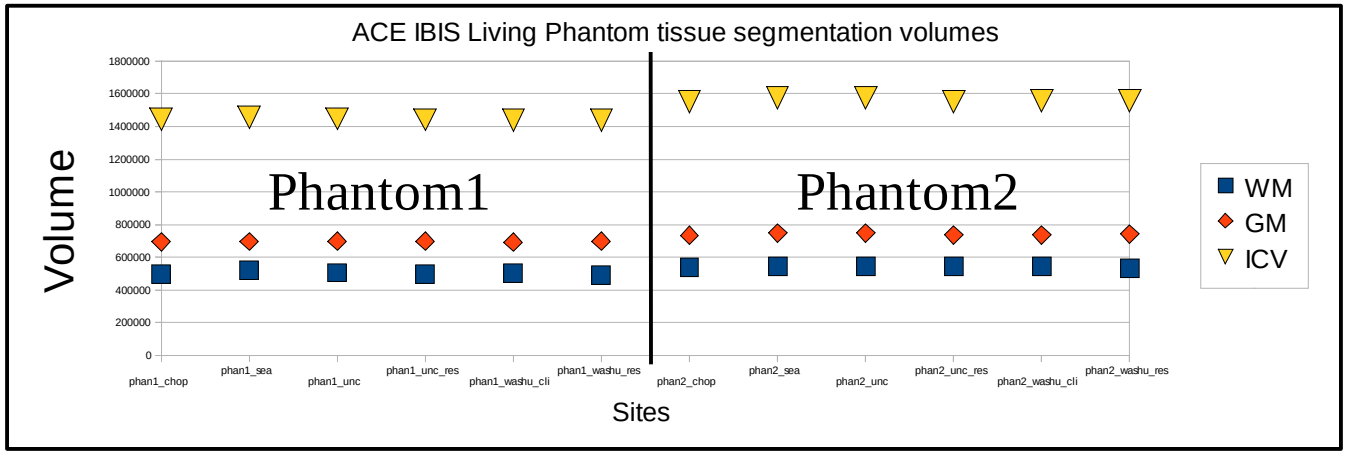
- Fully automatic, no user interaction required
- Arbitrary #channels/modalities: Co-registration
- Integrates brain stripping, bias correction and segmentation into one optimization framework ≠ set of separate procedures
- Atlas to subject warping: New deformable fluid flow registration
- Generic framework: Needs image(s) and prob. atlas → RUN
- Rigorous validation and testing
- Run time: Affine atlas matching: 0.5h, deformable: 2-3hrs
- In progress: Extension to pathologies

- K. Van Leemput, F. Maes, D. Vandermeulen, P. Suetens, P., Automated model-based tissue classification of MR images of the brain, IEEE TMI, 18(10) 1999
- N. Moon, E. Bullitt, K. van Leemput, G. Gerig, Automatic Brain and Tumor Segmentation, Proc. MICCAI '02, Springer LNCS 2488, 09/2002

ABC in human traveling phantom across-site MRI calibration



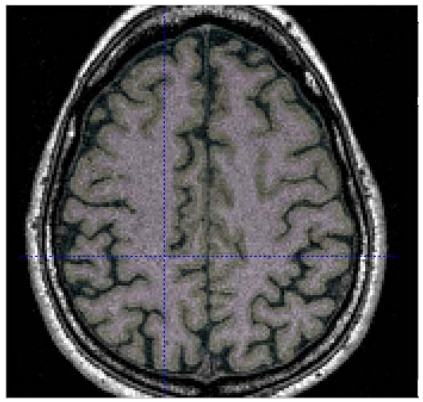
MRI and DTI scans of 2 traveling phantoms annually at 6 sites



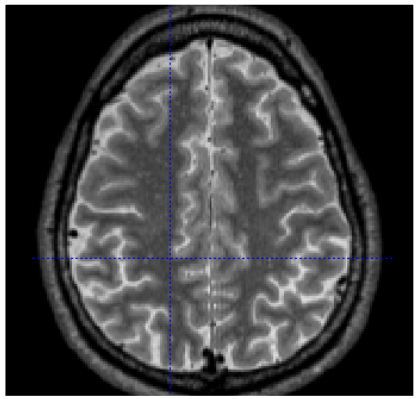
Scanner type $\mathcal{A}$	
tissue class	COV (%)
wm	0.573
gm	0.471
csf	0.988
icv	0.267

Courtesy ACE-IBIS autism study, Piven, UNC

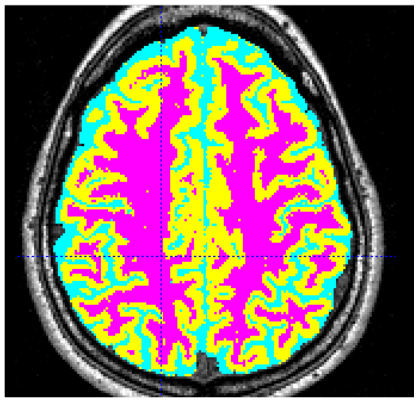
Tissue Segmentation T1/T2



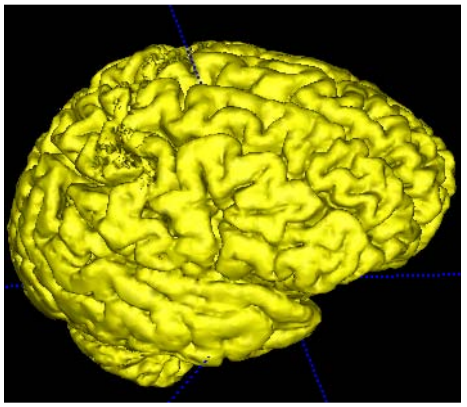
T1



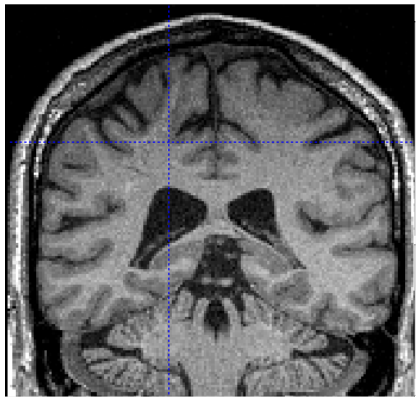
T2



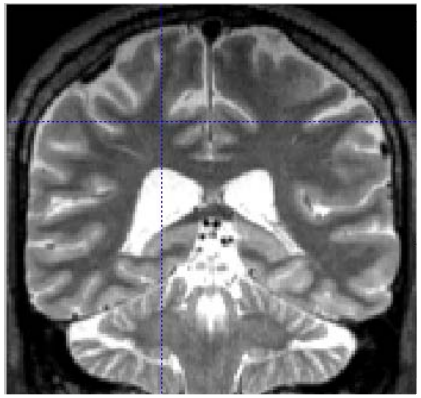
Brain Tissue



3D cortical surface



T1



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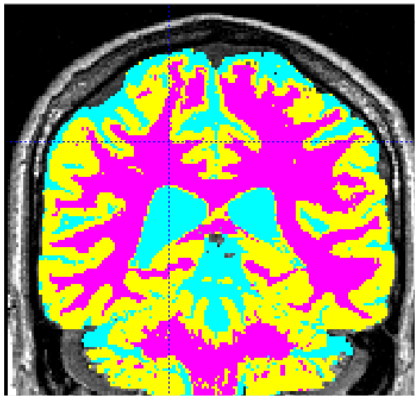
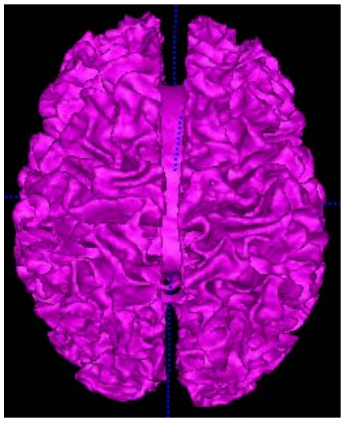


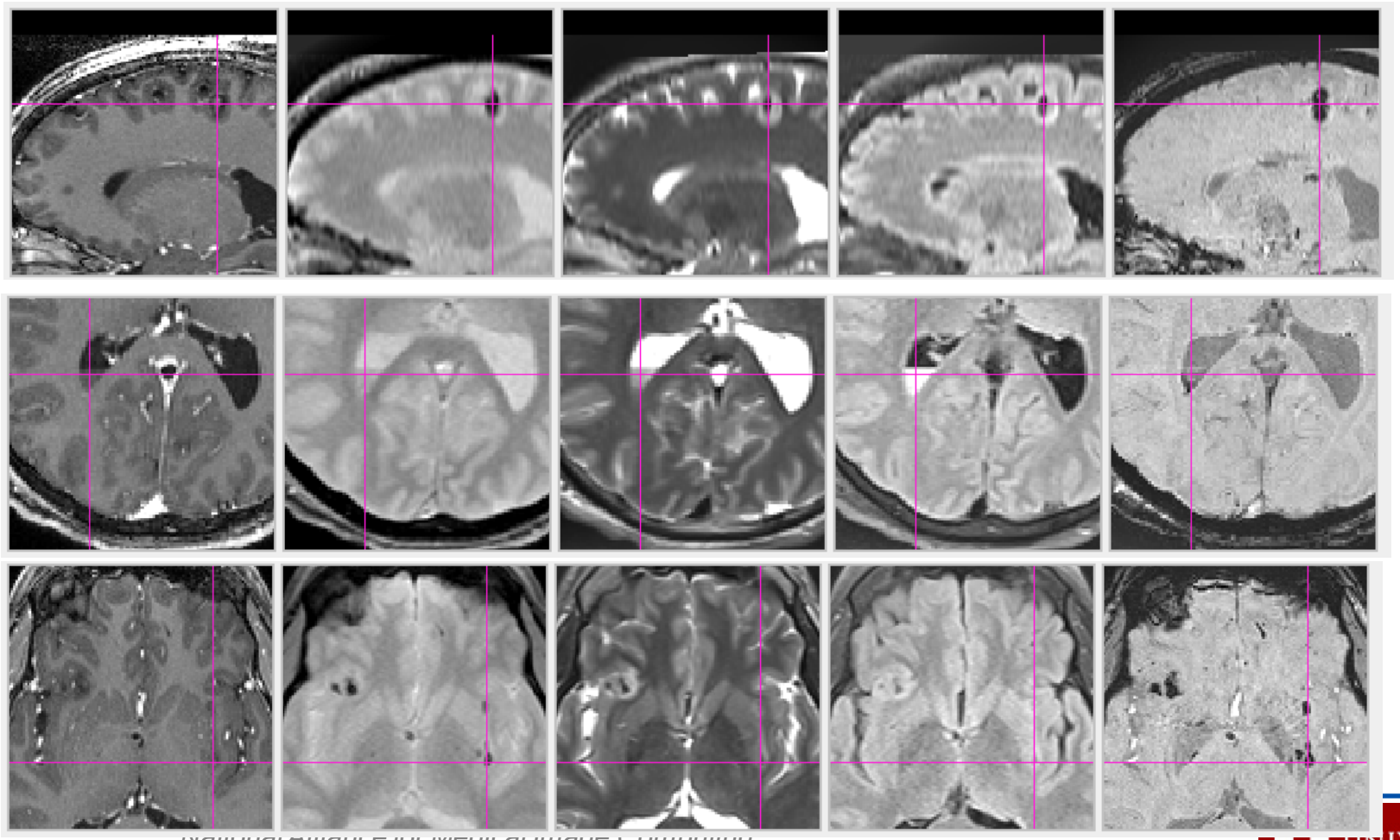
Brain Tissue



3D wm surface

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

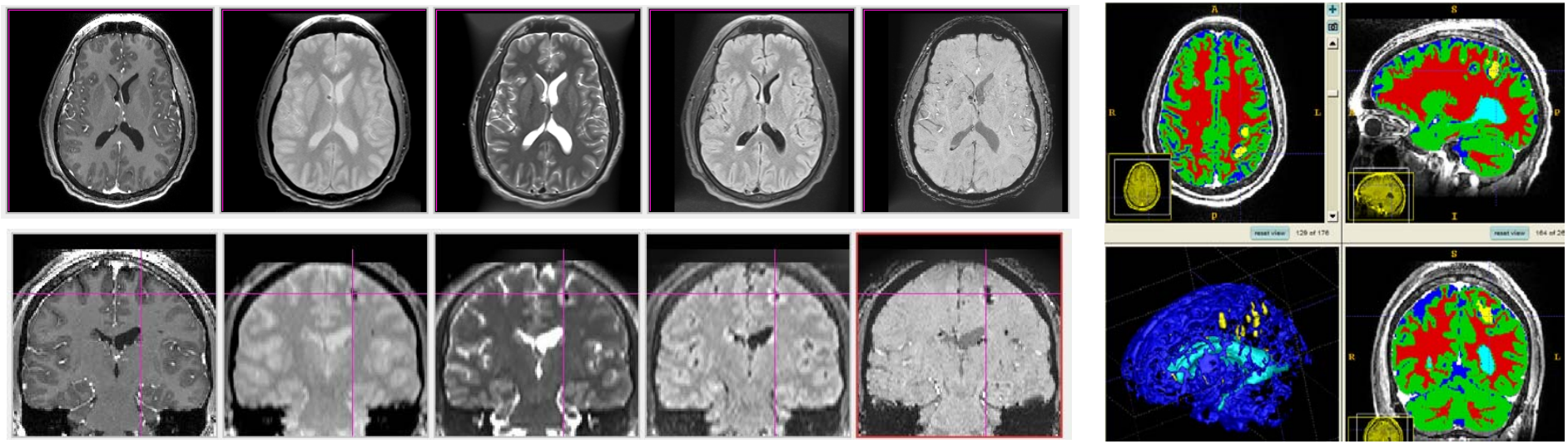
Mprage postcontrast GRE-bleed TSE FLAIR SWI



TBI case courtesy J. Horn , D. Hovda, UCLA

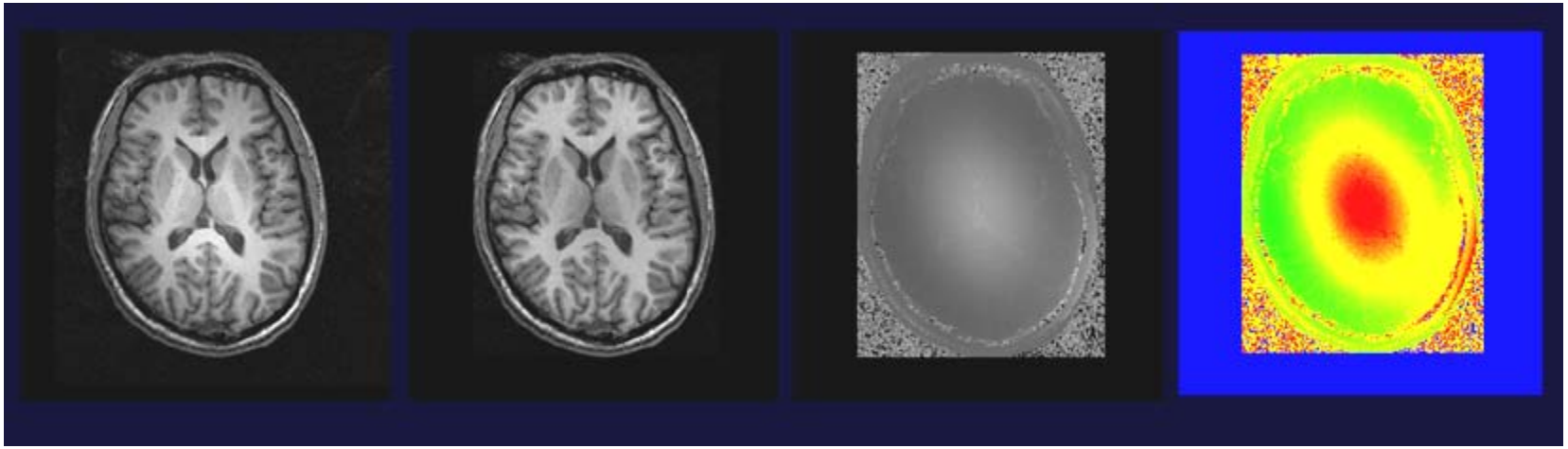
Automatic Brain Segmentation "ABC" applied to multi-modal MRI of TBI case

MPrage post GRE-bleed TSE FLAIR SWI Brain/csf segmentation



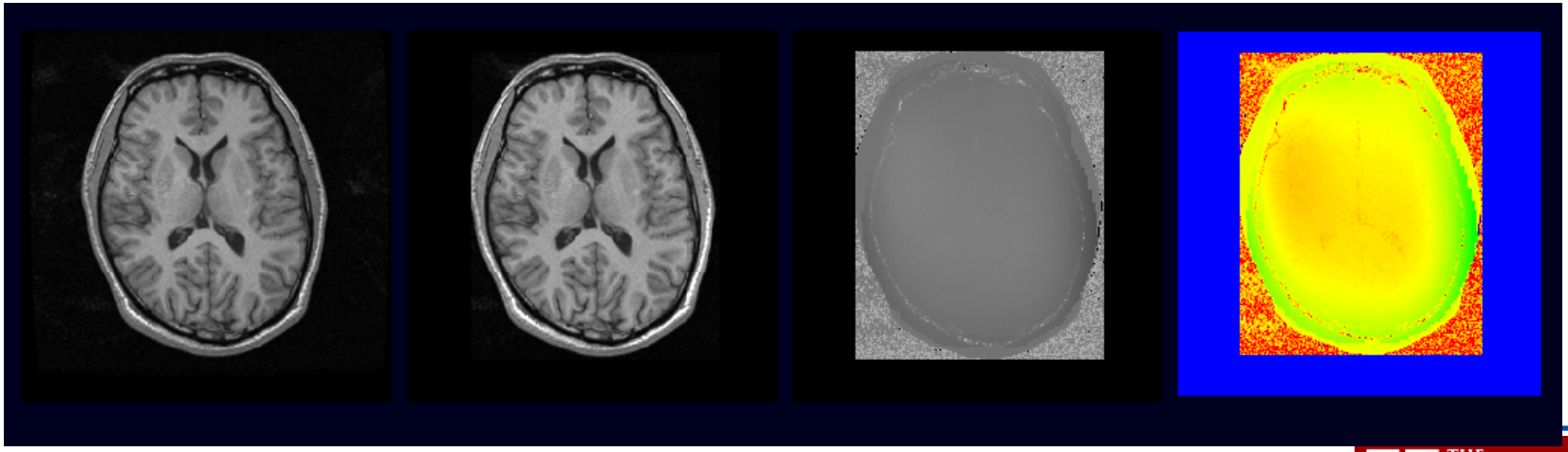
ABC performs co-registration of all input modalities (here 5 MRI channels) and atlas-based segmentation of brain tissue and csf. Bias-correction (all modalities) and brain-stripping is an integrative, automatic part of ABC.
White matter lesions and ventricles were segmented via postprocessing using level-set segmentation. MRI data courtesy of UCLA (John Van Horn and David Hovda).

“Byproduct” of ABC: Bias inhomogeneity correction



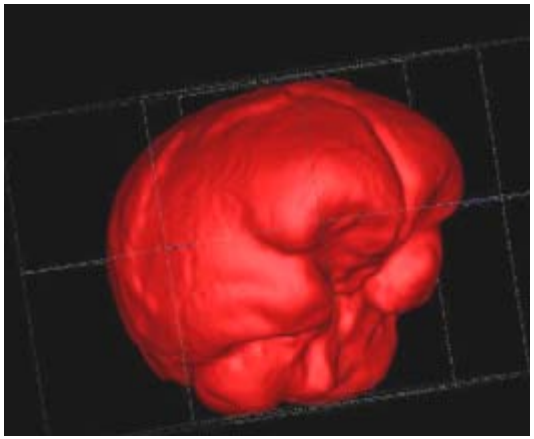
3T

T1 registered Corrected image Bias field

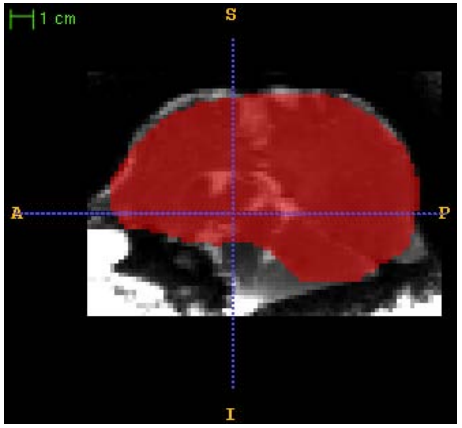


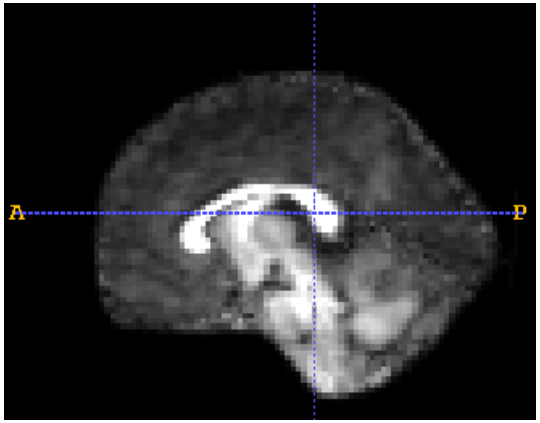
1.5T

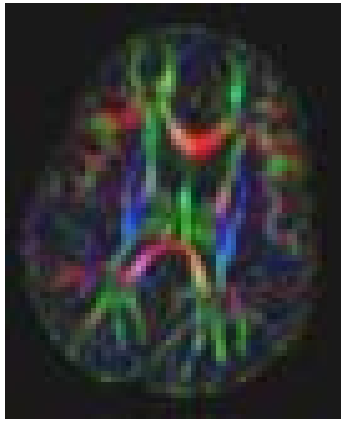
“Byproduct” of ABC: Brain Stripping



MRI segmentation: ICV as result of brain segmentation (gm+wm+csf)



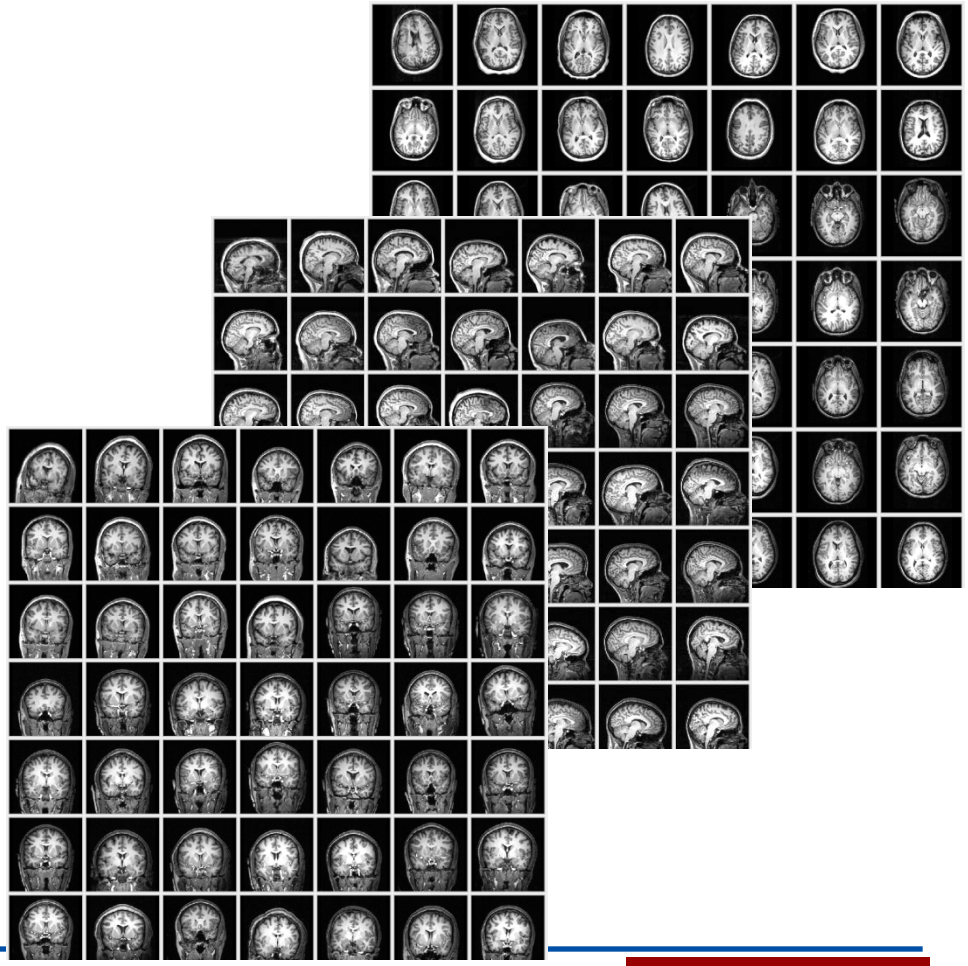




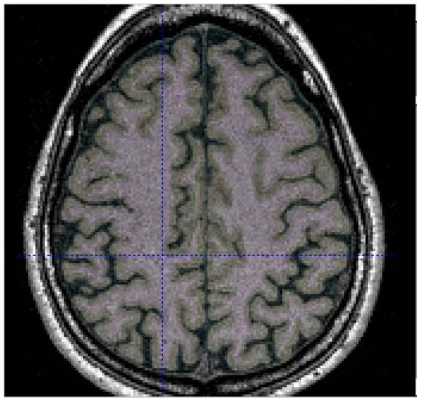
DTI: Brain masking via tissue segmentation of B0 image.

Typical Clinical Study

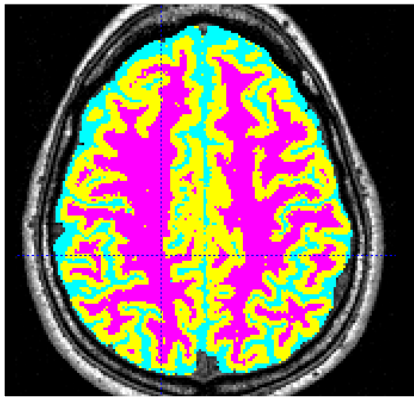
- Drug addition, effects on brain morphometry and function (sMRI/DTI)
- Yale: Linda Mayes, Marc Potenza
- UNC: Joey Johns
- Utah: Gerig/Gouttard



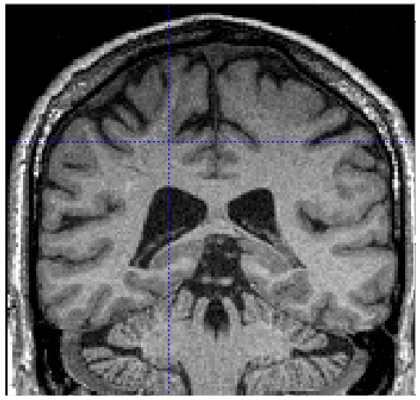
Tissue Segmentation T1 only



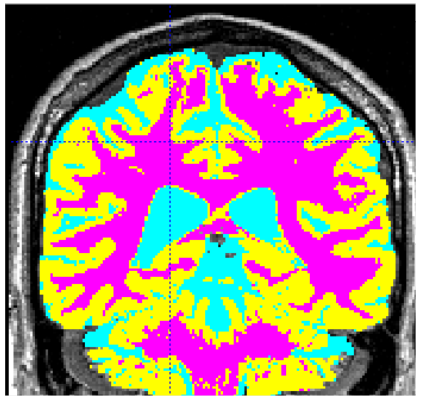
T1



Brain Tissue



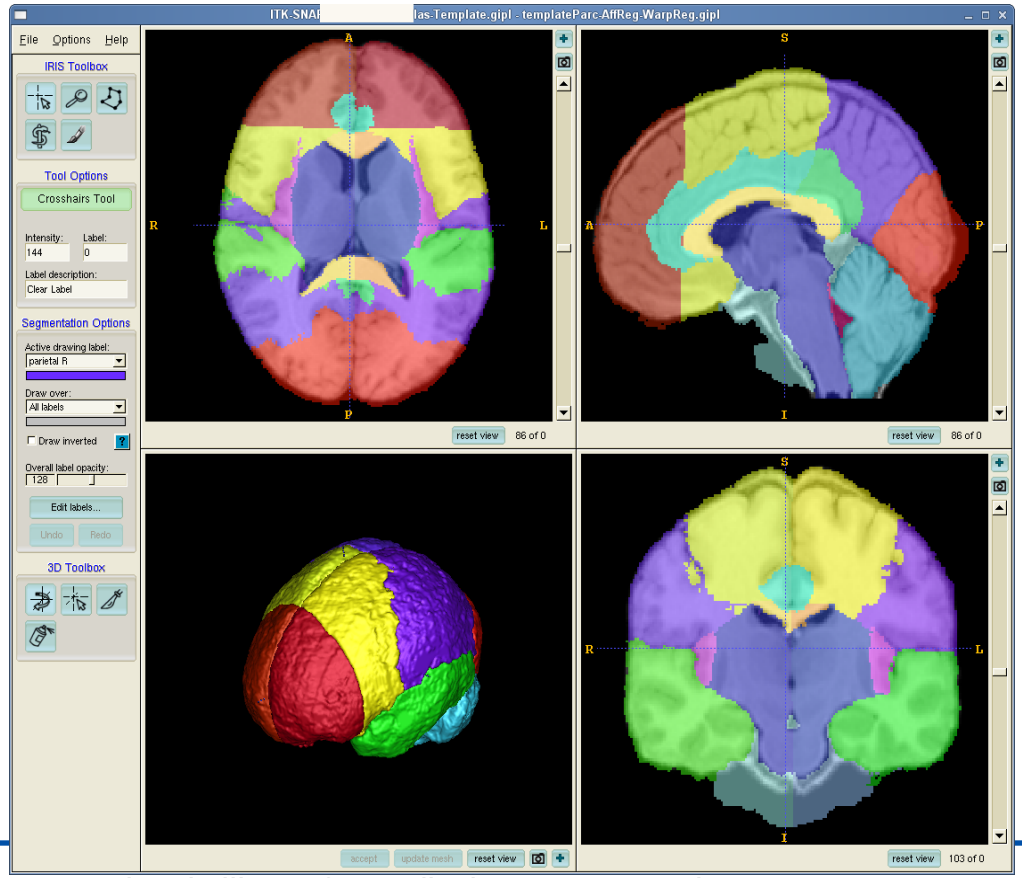
T1



Brain Tissue

Lobe parcellation

- Parcellation by nonlinear registration of template

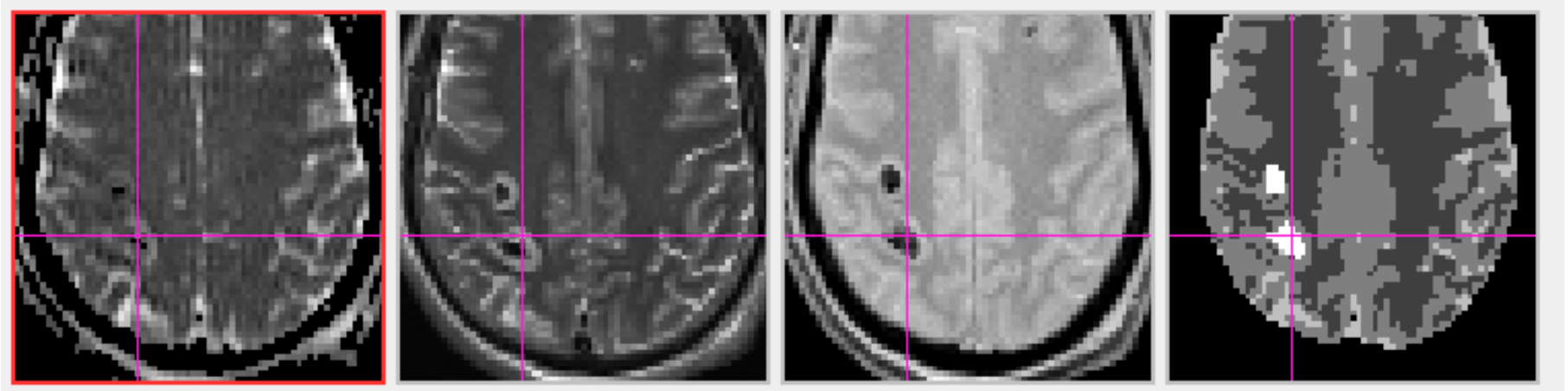


→ Table of gm/wm/csf per lobe -> biostatistical analysis

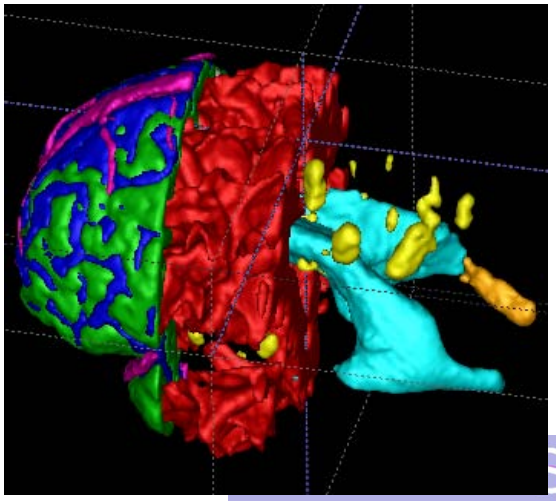
ABC Application: Joint analysis of sMRI and DTI

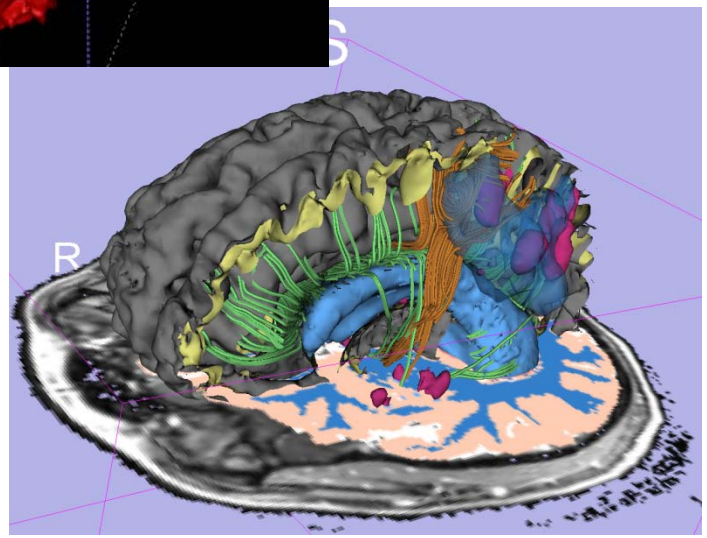
- Co-registration of structural modalities to DTI (baseline image registered to TSE) using ABC.
- DTI tensor field and structural images available in same coordinate system.

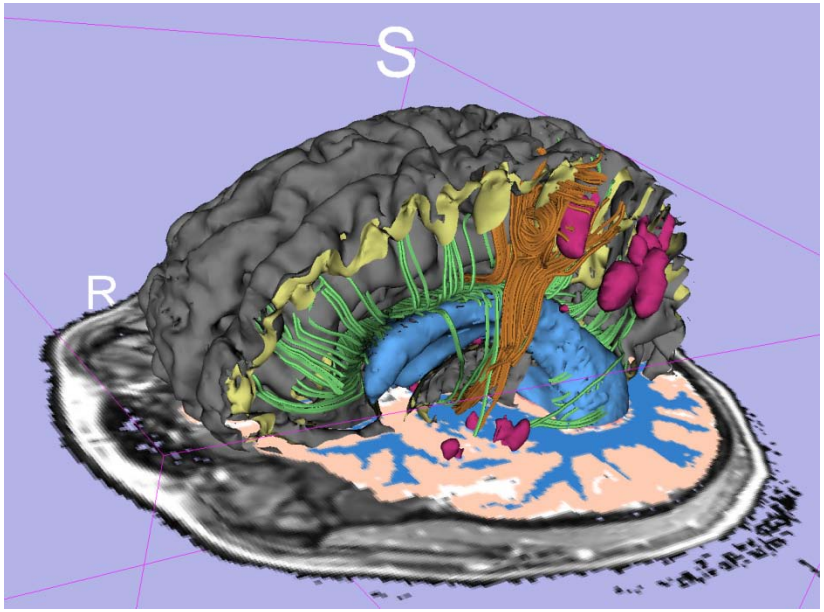
DTI (mean diffusivity) TSE GRE-bleed Segmentation



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

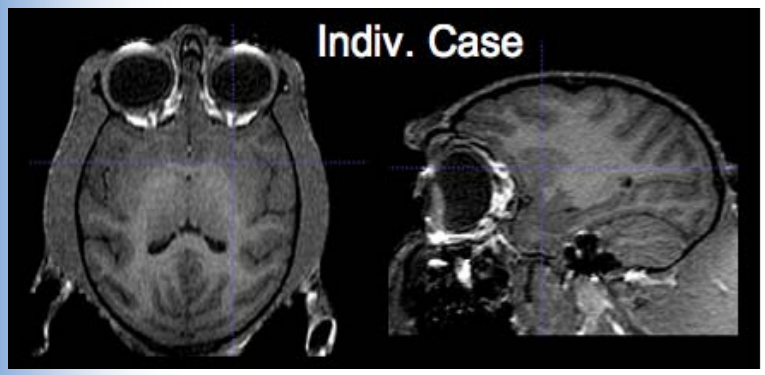


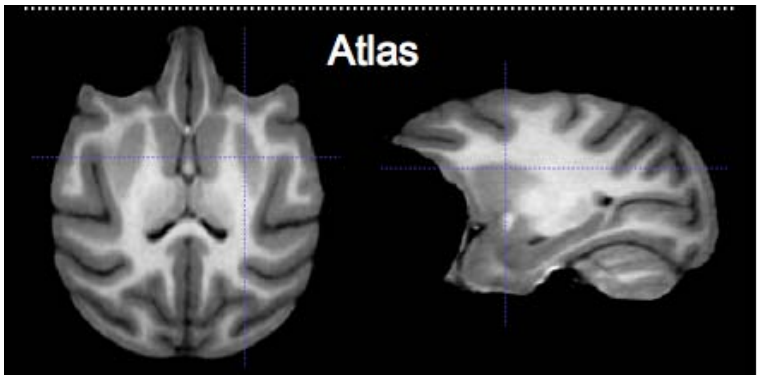


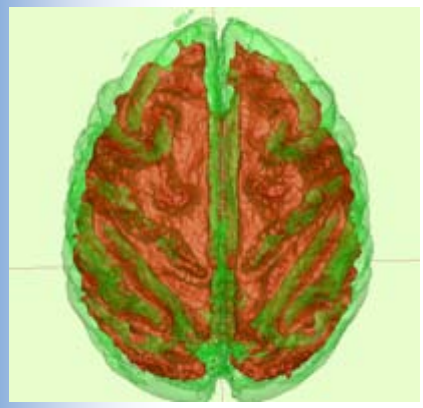


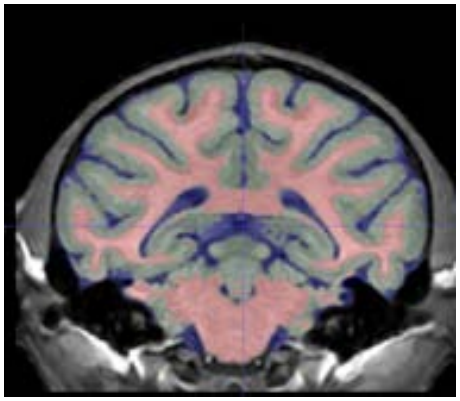
- Tractography, fiber clustering and composition by Ron Kikinis
- Co-registration DTI/sMRI and brain/lesion segmentation by Guido Gerig

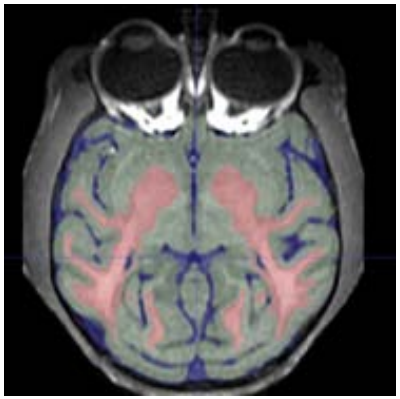
Monkey Brain Segmentation

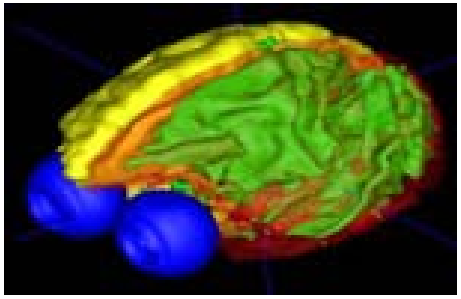






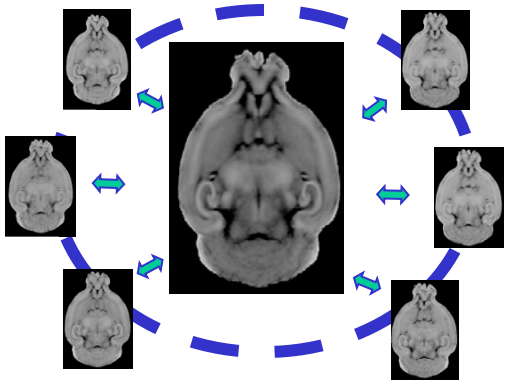


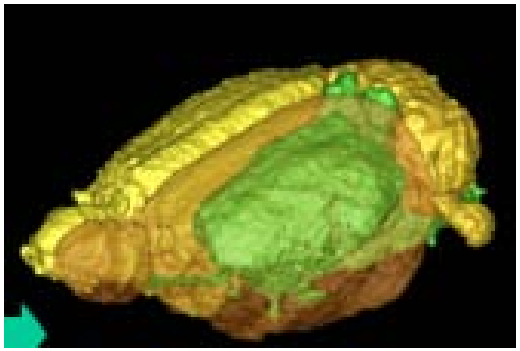




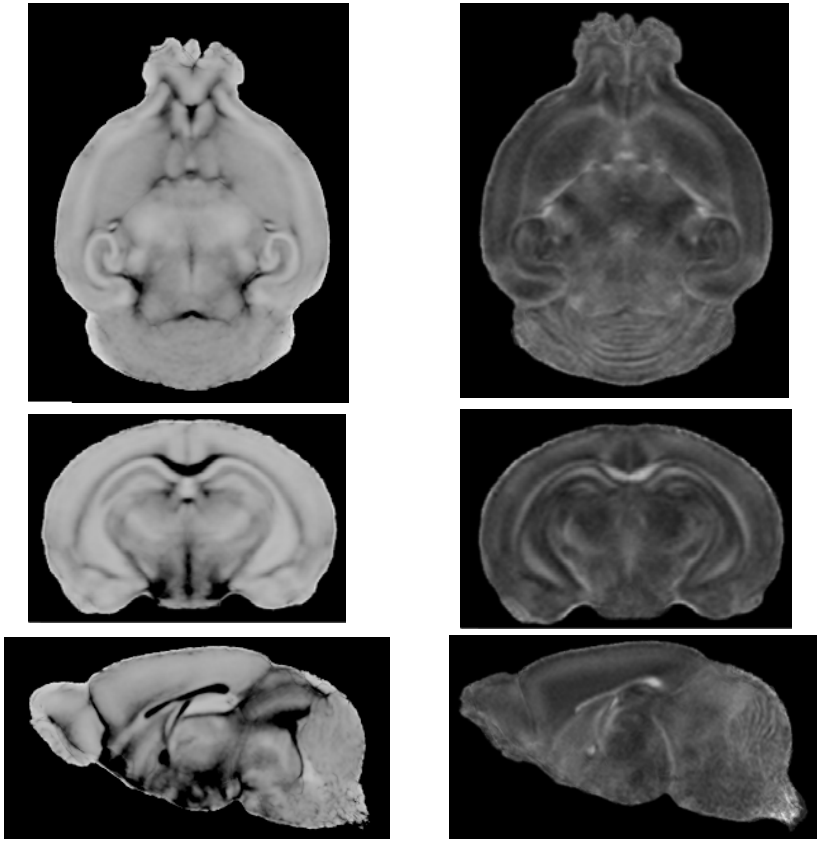
ABC applied to macaque brain processing: M. Styner, I. Oguz, UNC

ABC for Mouse "Brain Stripping"



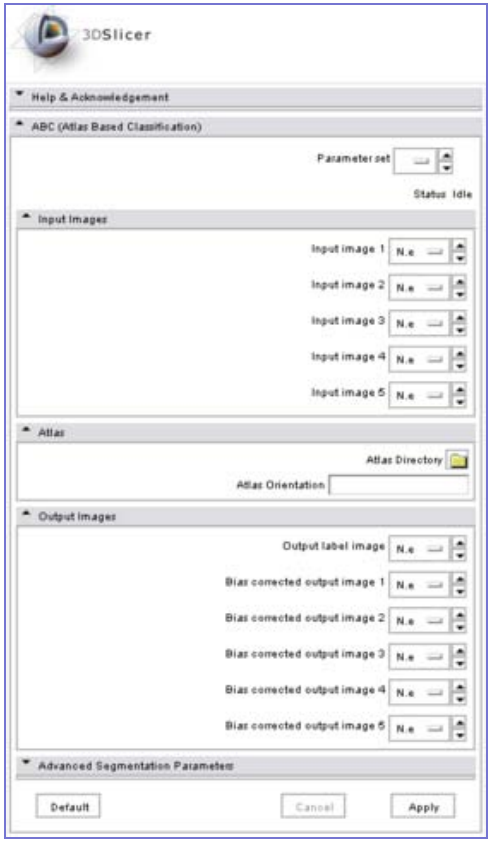


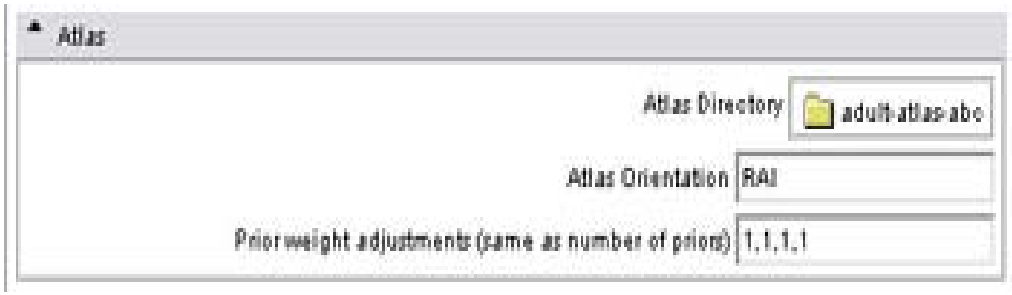
ABC applied to mouse brain processing: M. Styner, I. Oguz, UNC

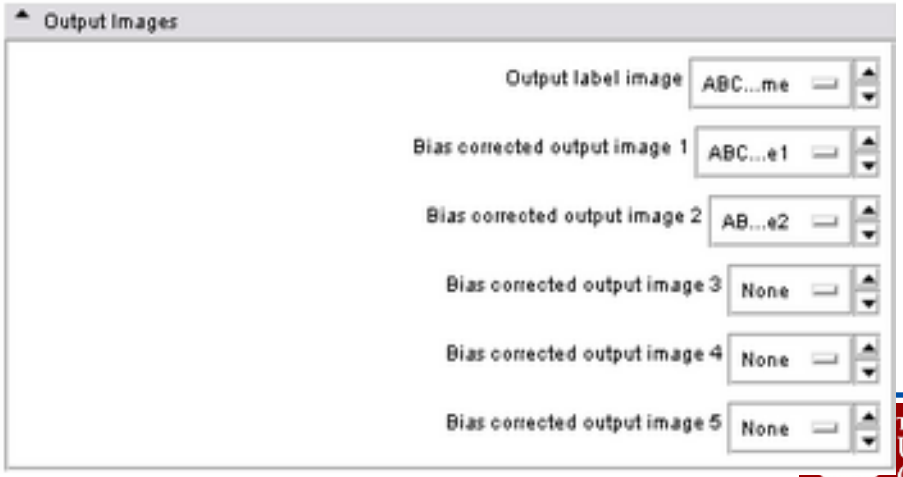


MD FA

Integration into Slicer 3





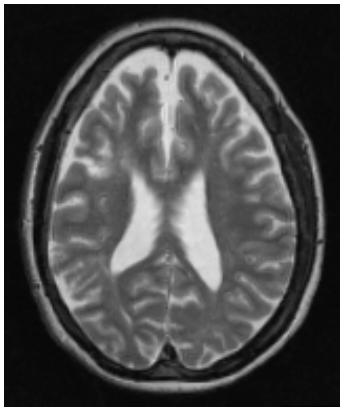


Integration into Slicer 3

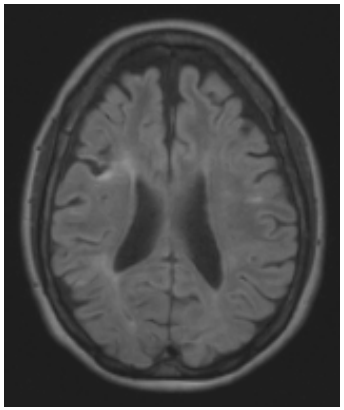
Advanced parameter settings:

- Type of linear transformation for intra-subject modalities
- Bias correction polynomial degree
- Amount of deformation of atlas (affine, fluid w. #iterations)

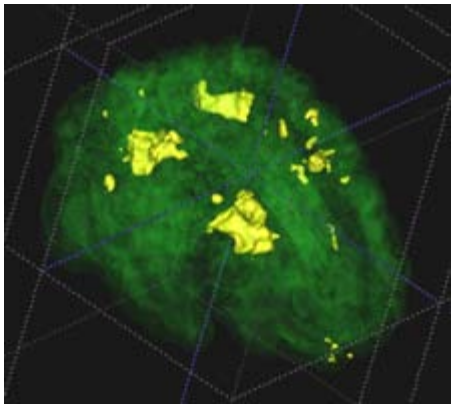
Current Extensions: Lesions and Pathology



T2

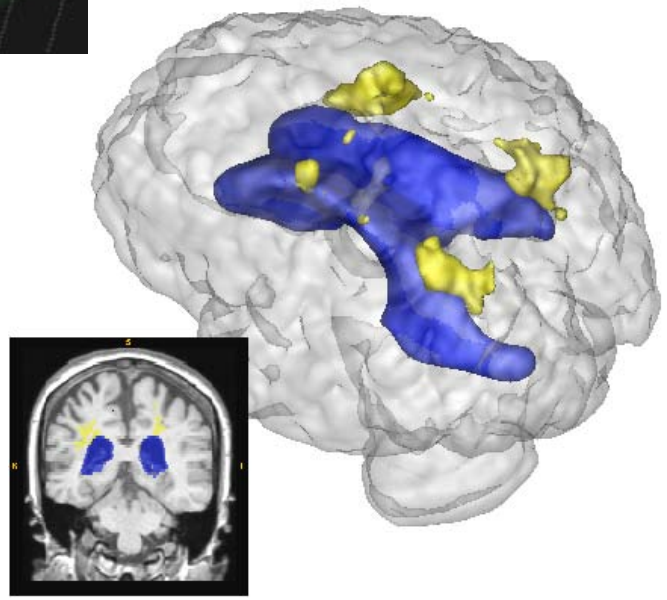


FLAIR



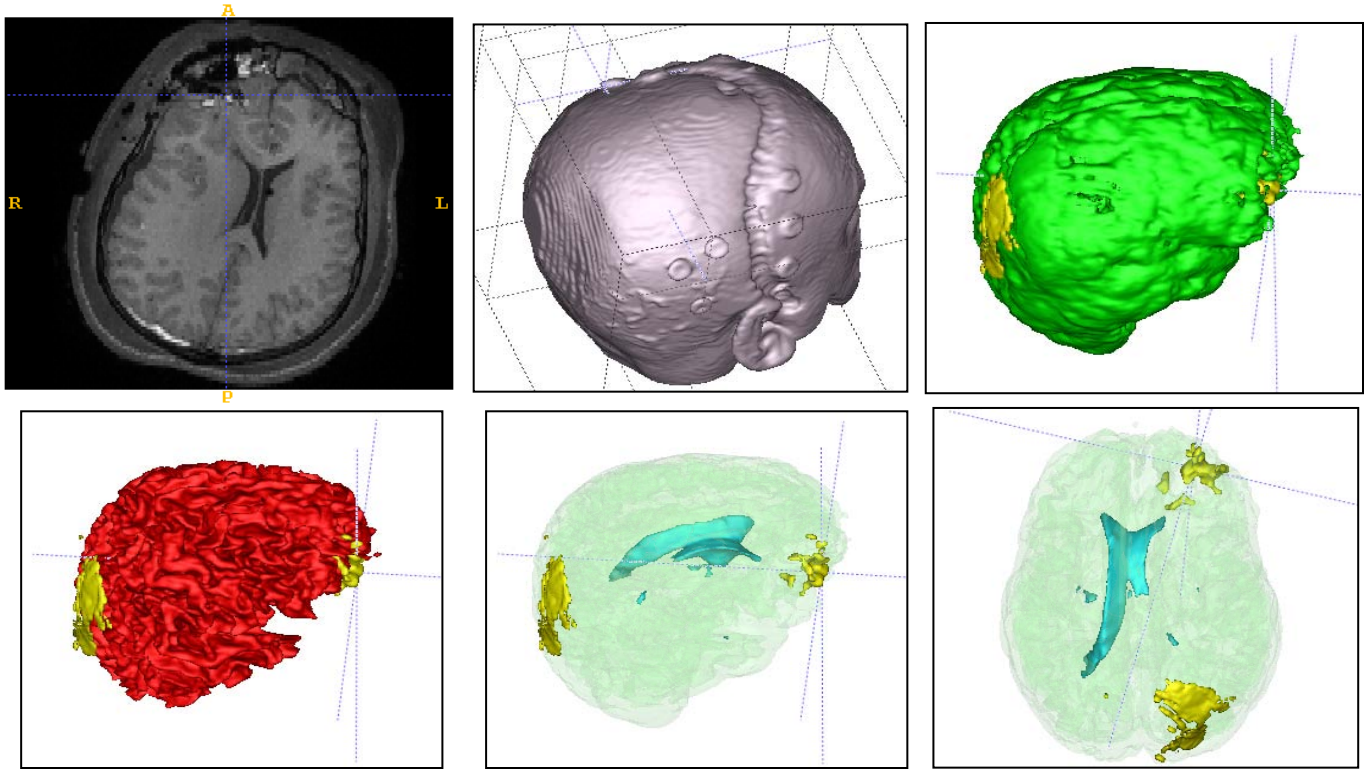
3D

WM lesions in lupus (MIND, J. Bockholt)



Marcel Prastawa and Guido Gerig. *Brain Lesion Segmentation through Physical Model Estimation*. International Symposium on Visual Computing (ISVC) 2008. Lecture Notes in Computer Science (LNCS) 5358, Pages 562-571

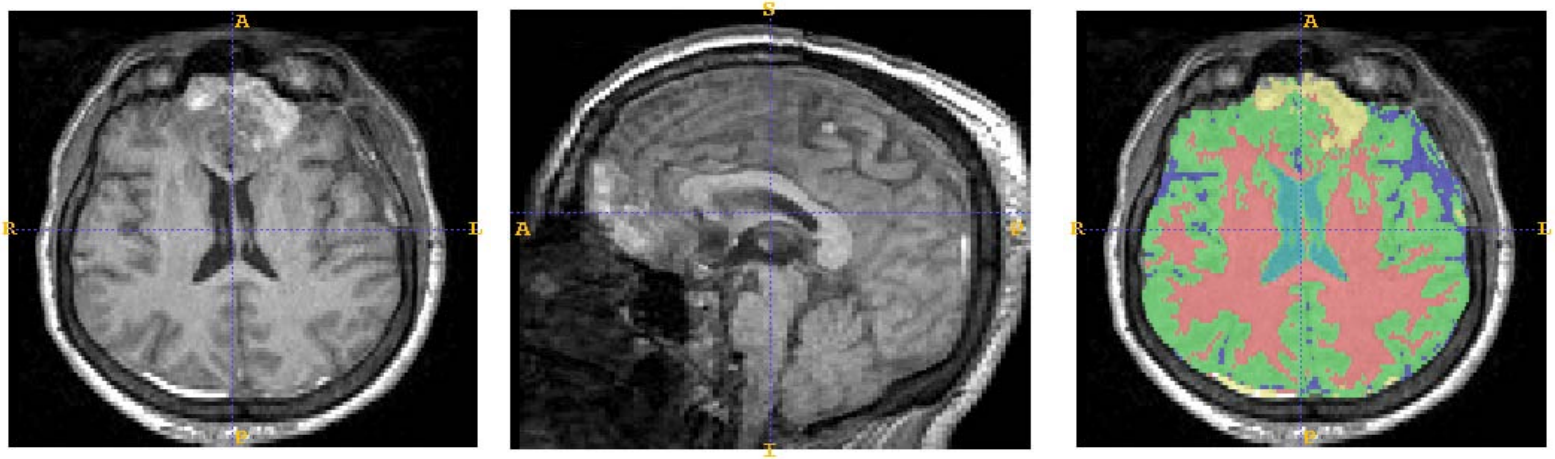
Segmentation Case 1 TBI



TBI data courtesy UCLA (D. Hovda)

- 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 (D. Hovda)

- 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.