NA-MIC Highlights: From Algorithms and Software to Biomedical Science

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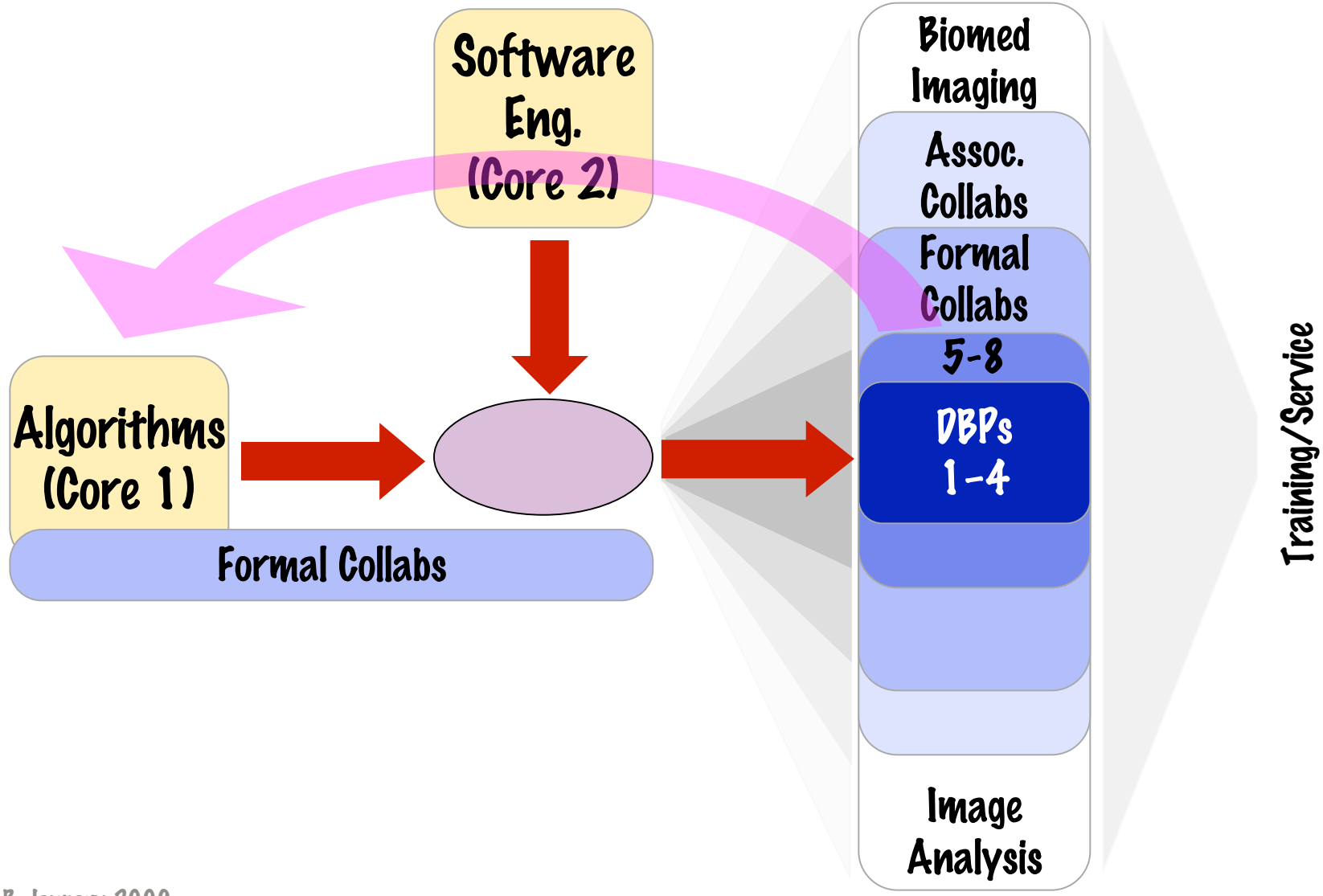
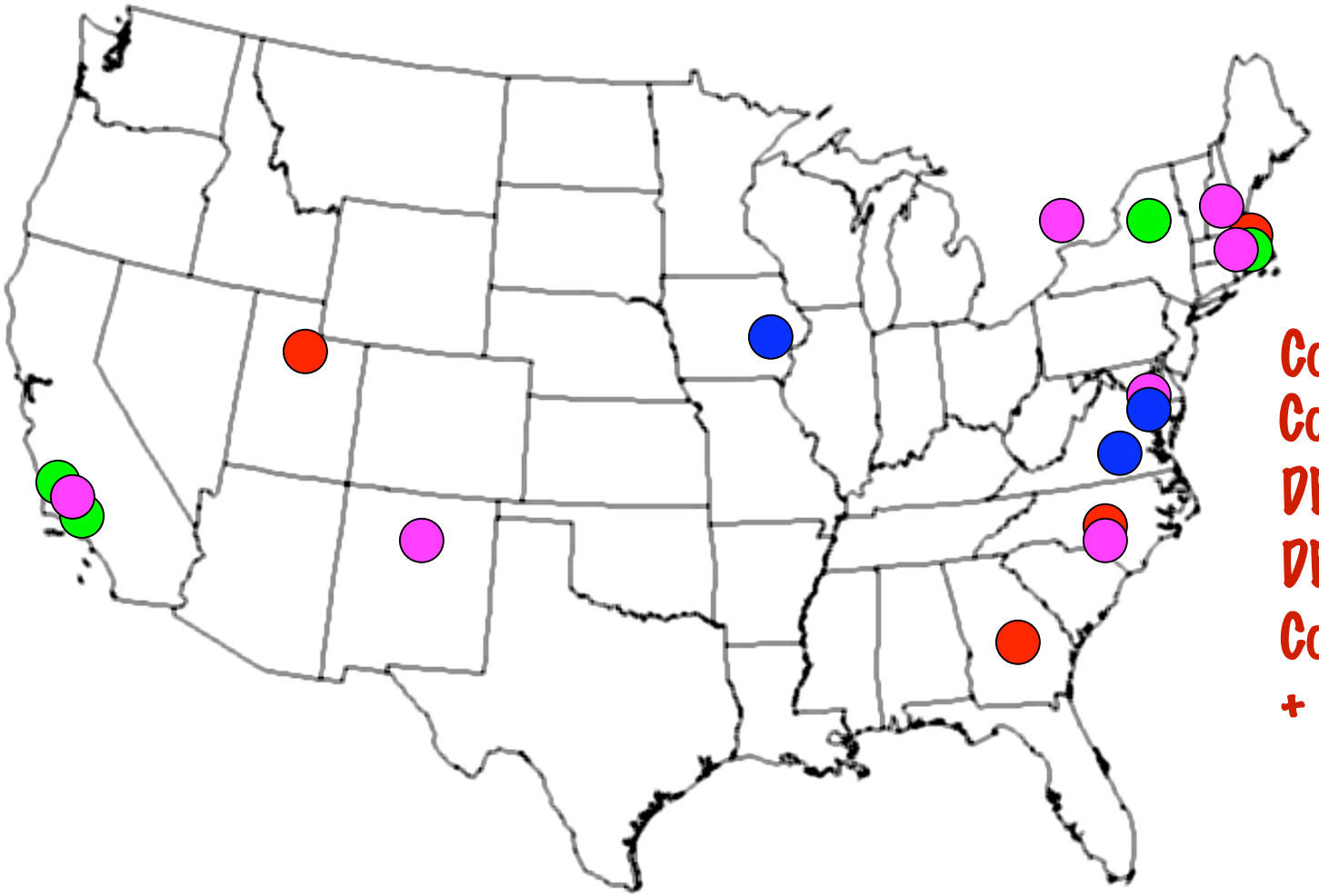
University of Utah

National Alliance for Biomedical Image Computing

Algorithms, Software, Science



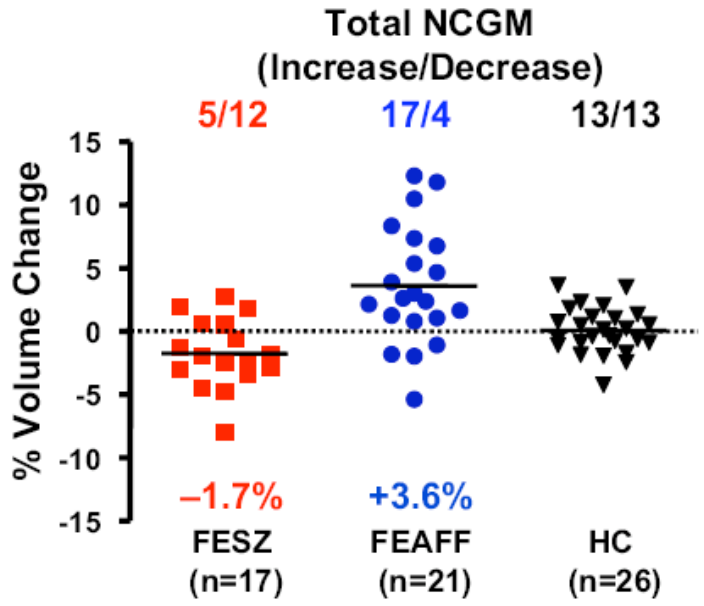
NA-MIC-A *National* Alliance

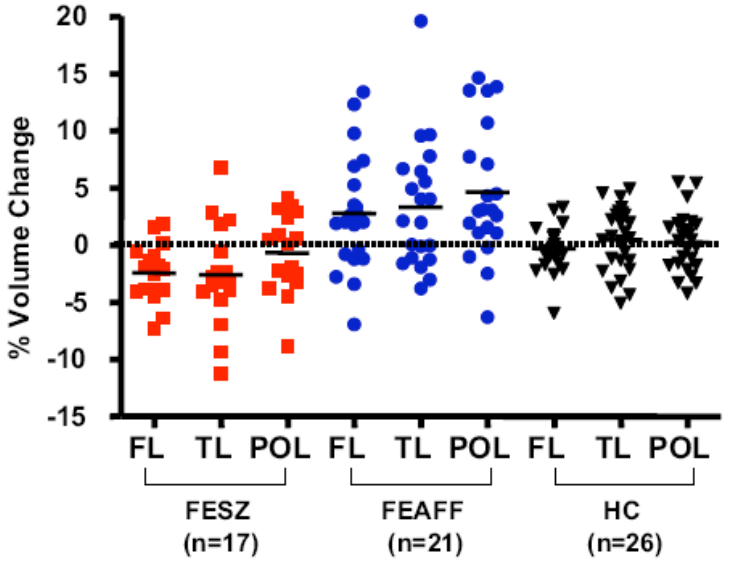


Core 1
Core 2
DBPs I
DBPs II
Collabs PAR
+ many others

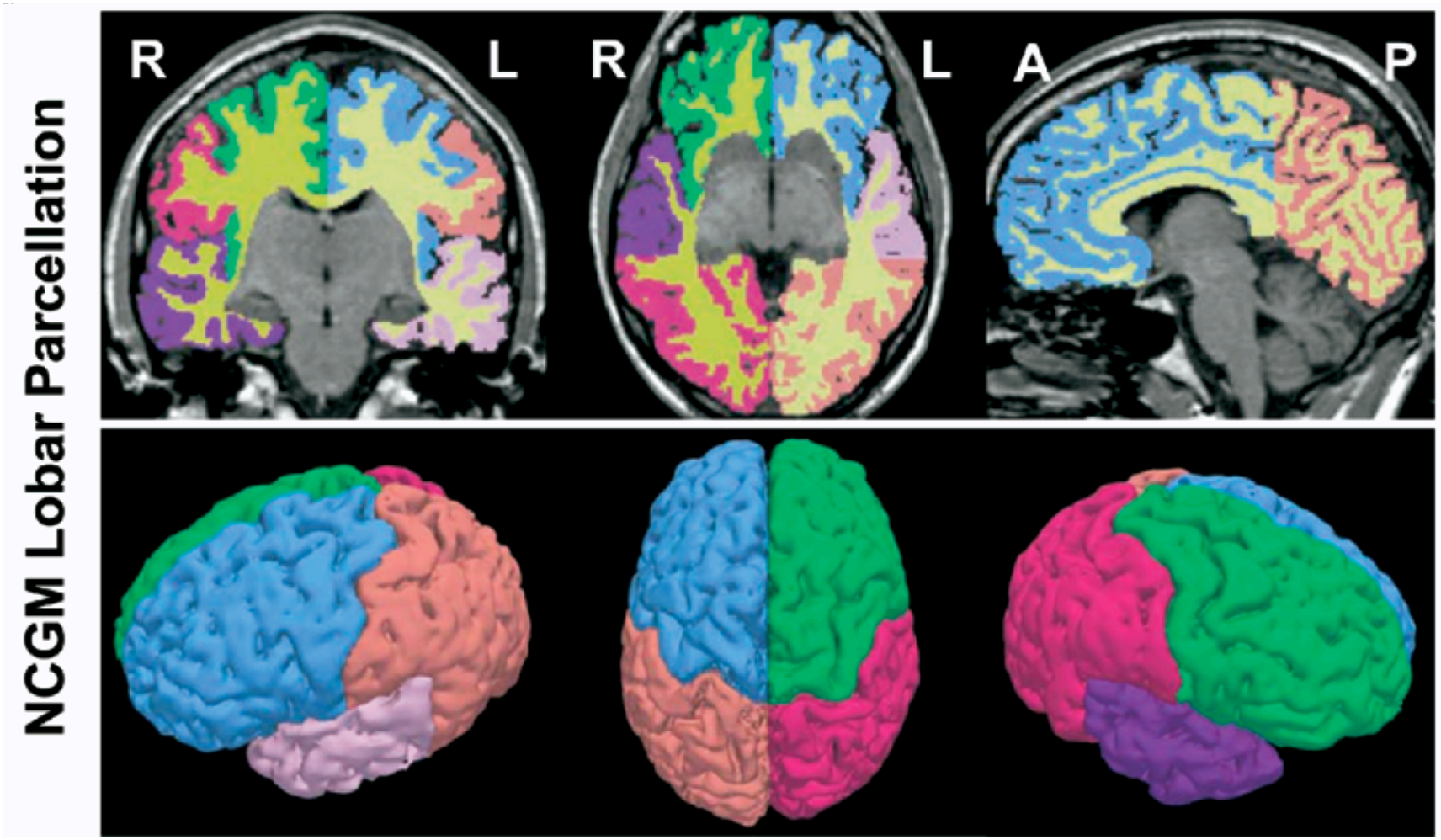
Schizophrenia-B&W, Shenton et al.

- M. Nakamura *et al.*, "Neocortical gray matter volume in first episode schizophrenia and first episode affective psychosis: a cross-sectional and longitudinal MRI study", Biological Psychiatry 2007.



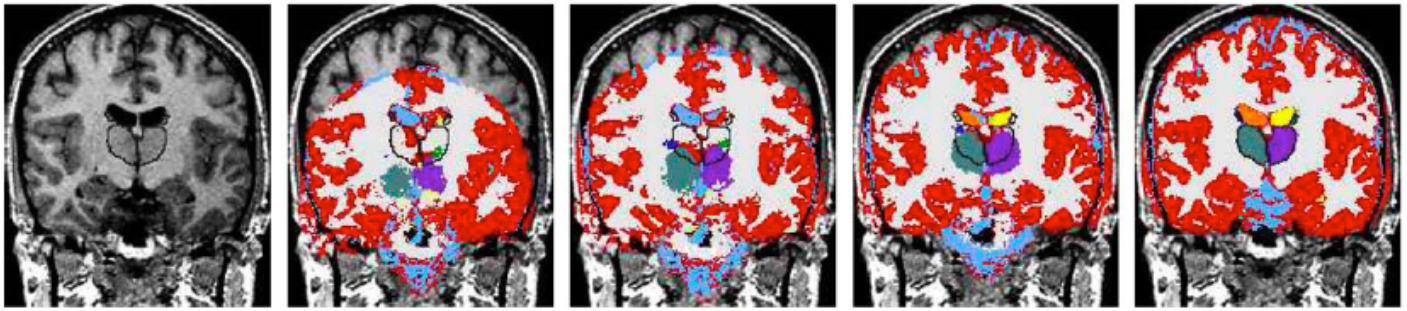


Segmentation: *EM Segmenter*



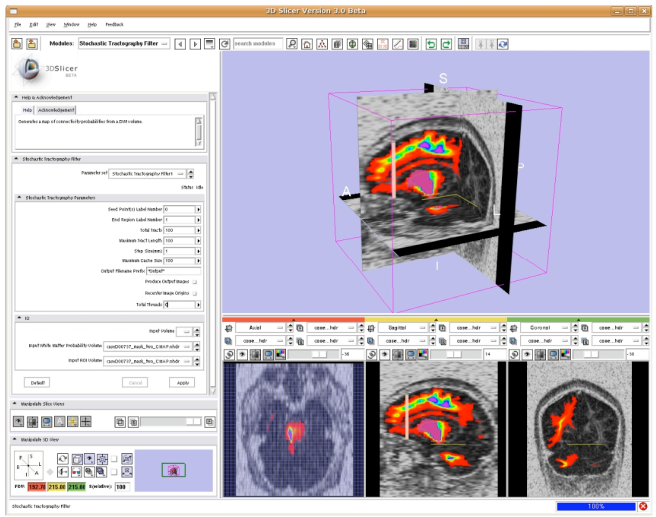
EM Segmenter

- Statistical methodology
  - Bayesian framework: data + atlases
- Validated
  - E.g. Pohl et al., "A bayesian model for joint segmentation and registration", NeuroImage, 2006
- Built on/within ITK
- Part of the *NA-MIC Kit*
- End-user application: *3D Slicer*

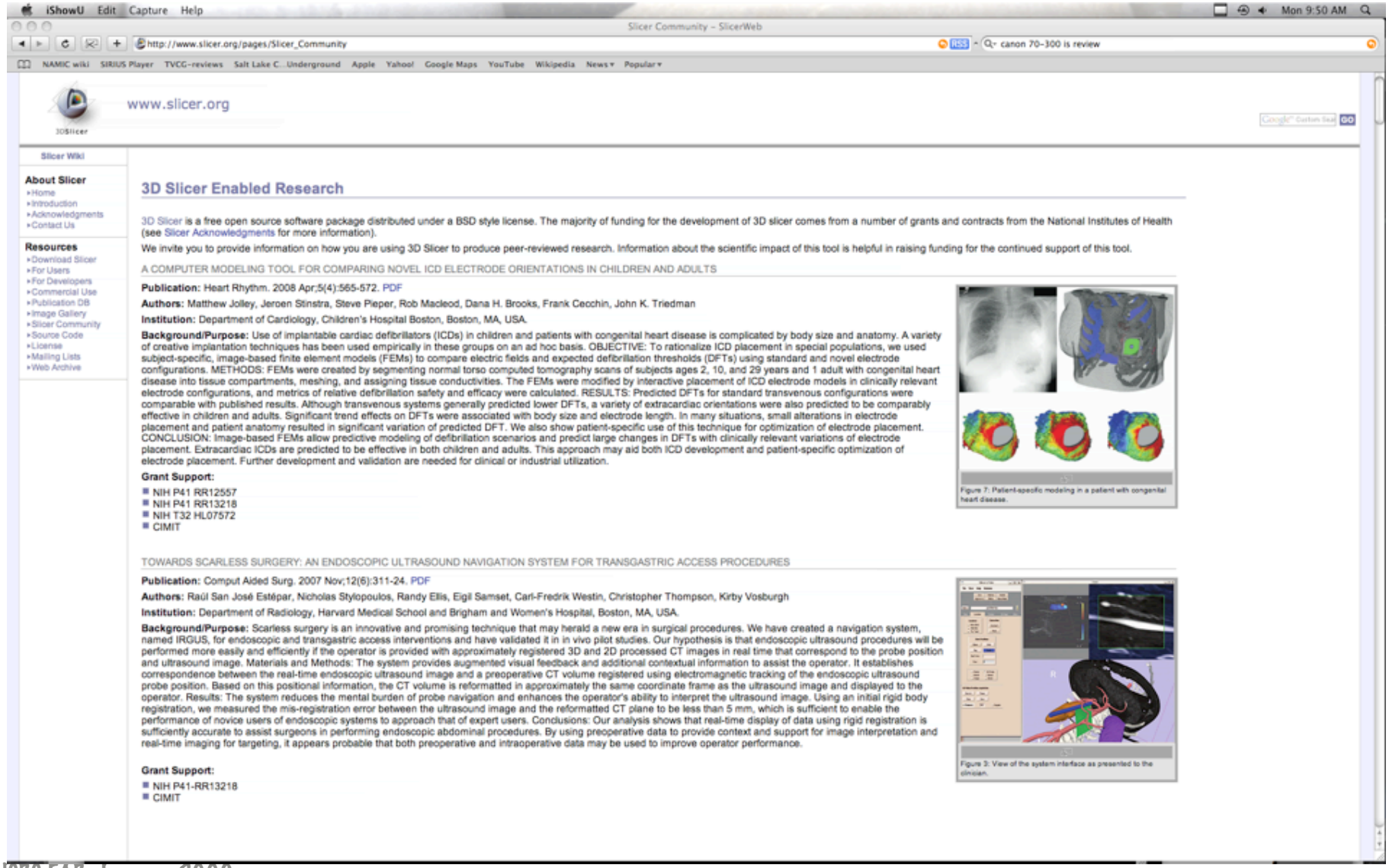


3D Slicer

- End-user application
- Visualization and analysis tools
- Modular architecture
  - ITK & VTK
  - Dozens of plug-ins already written
- ★ Slicer 3.2 Released Aug 2008
- ★ > 5,000 downloads in the past 12 months
  - Downloads ≠ users
  - Downloads -> activity

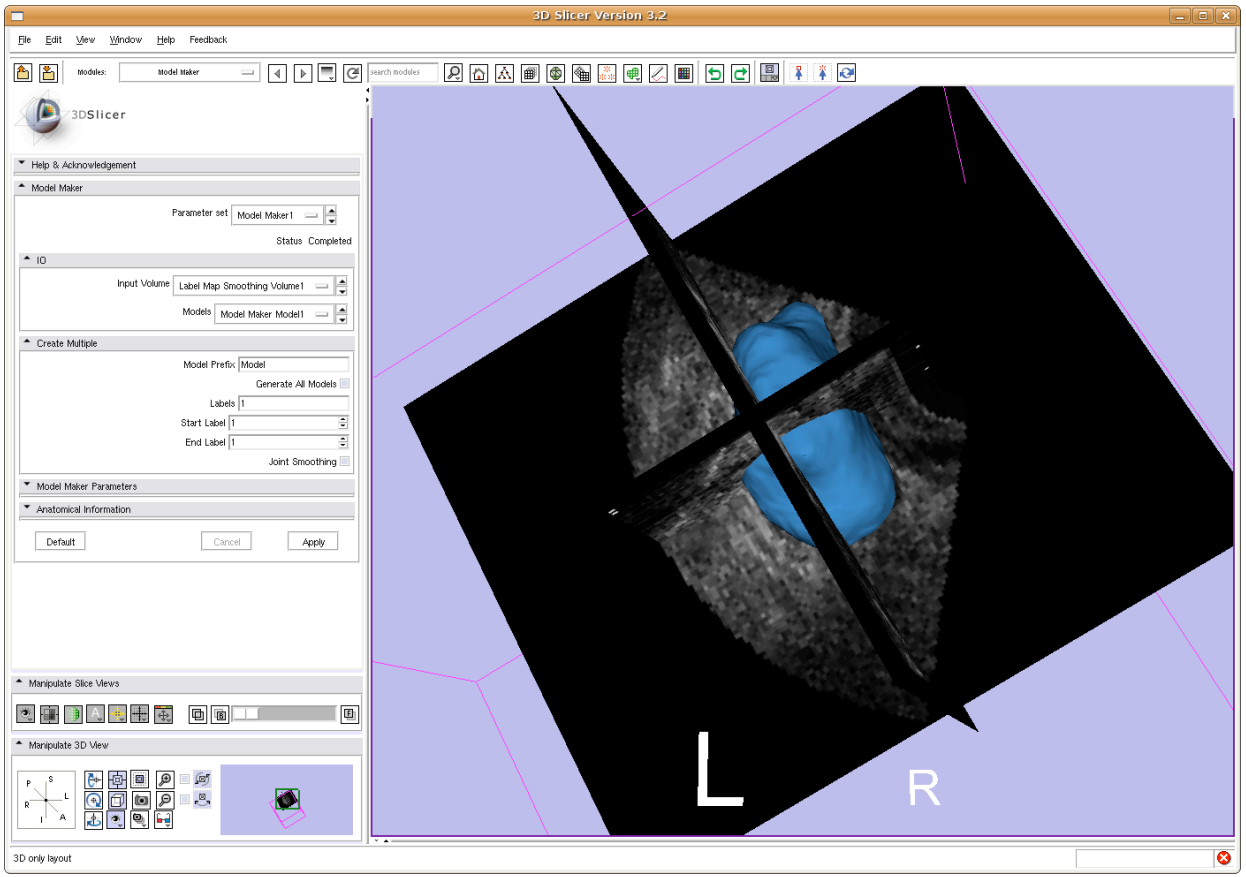


3D Slicer - Impact...



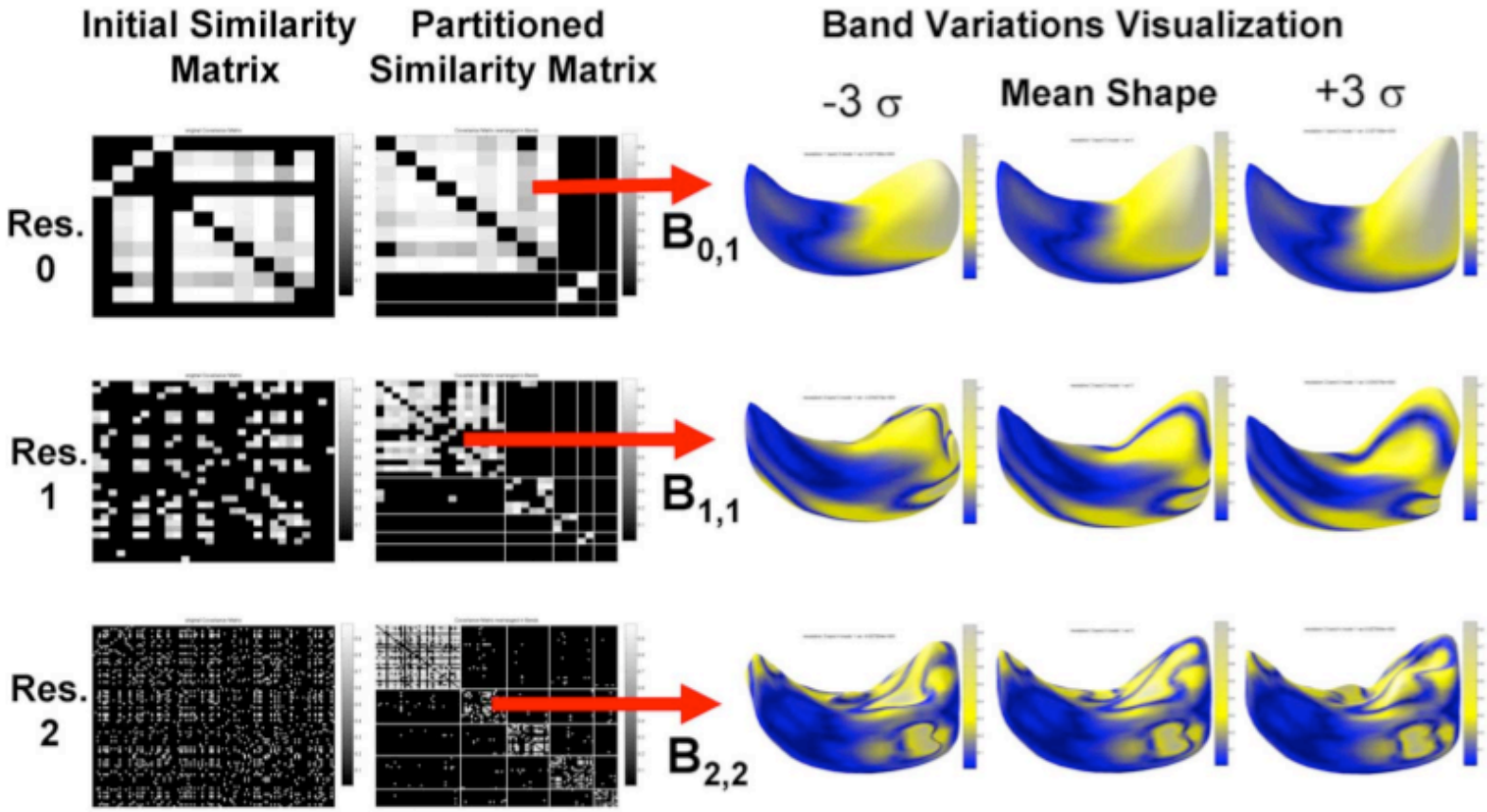
Random Walk to Optimize Deformable Models

- Prostate segmentation: JHU/Queens w/GaTech



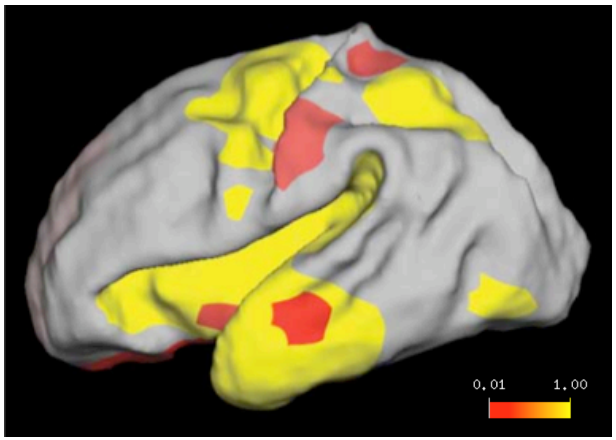
Wavelet Surface Representations – GaTech

- Multiscale + local for representation and analysis
- Nain et al., IEEE TMI 2007

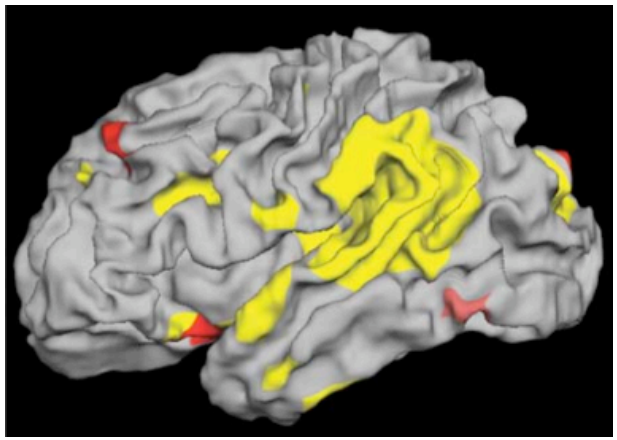


Spherical Wavelets for Shape Analysis
MIT, MGH

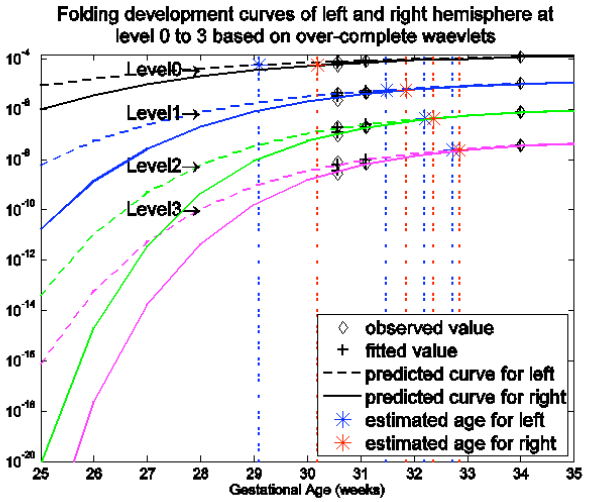
- Cortical folding in neonatal development
  - Yu et al., IEEE TMI, 2007
- Rate of cortical folding on cortex over time



0-33 weeks

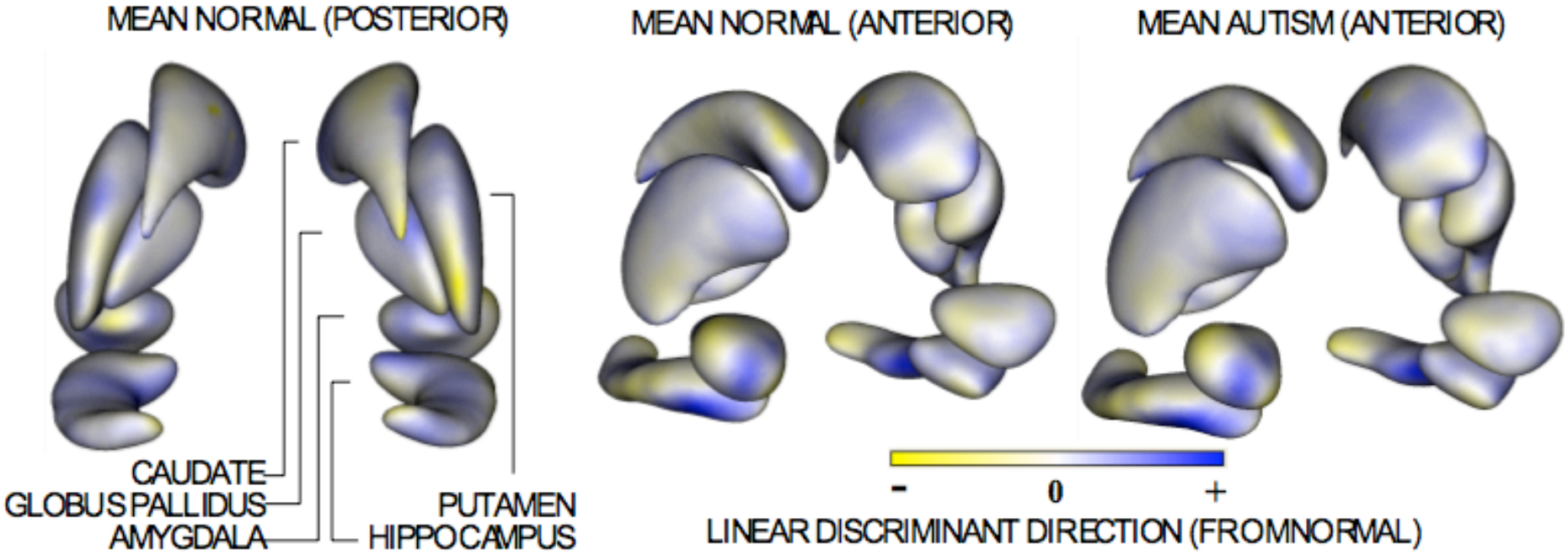


33-38 weeks



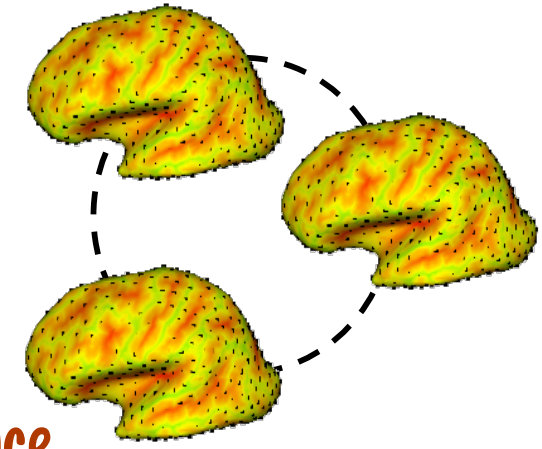
Hypothesis Testing on Shape Complexes in Autism

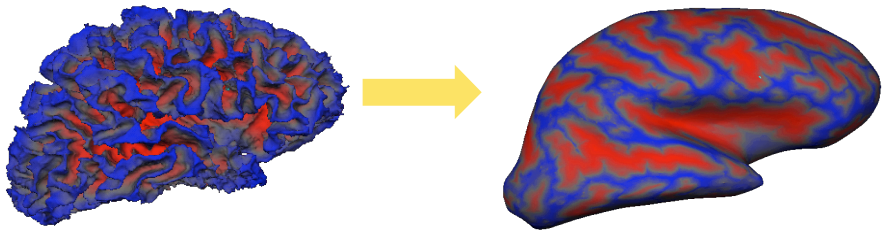
- Utah + UNC DBP – Joe Piven/Heather Hazlet
- ★ Cates et al., MICCAI 2008
- Localize (previous) volume differences in caudate and amygdala
- Particle system for shape correspondence
- Pipeline: PCA, parallel analysis, permutation testing



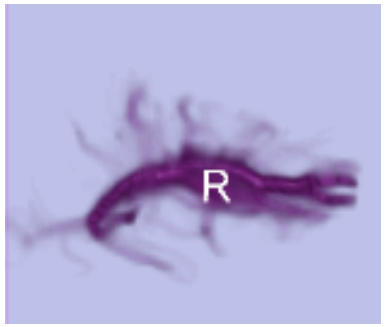
Cortical Correspondence

- Motivation: Cortical analysis of brain measures
  - Cortical thickness in Autism
- Need: local cortical correspondence
  - Shape features essential, e.g. sulcal depth
- Group-wise cortical correspondence
  - UNC/Utah collaboration
- Incorporation of shape & DTI for correspondence
  - Probabilistic DTI connectivity





Sulcal Depth



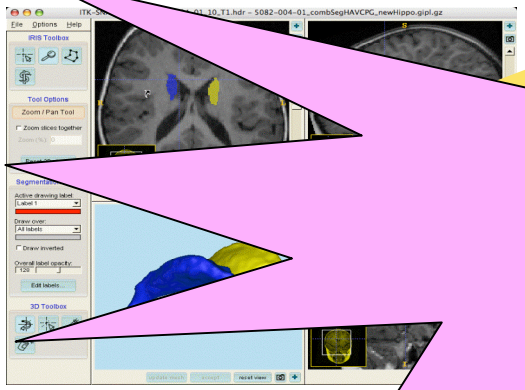
Prob Connectivity

Statistical Shape Analysis Pipeline – UNC

- UNC NA-MIC Shape Analysis Toolbox
  - SPHARM-PDM, Hotelling T^2, permutation, FDR
  - MDL implementation with curvature

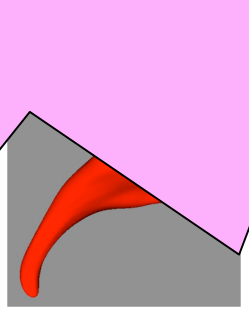
★ New developments:

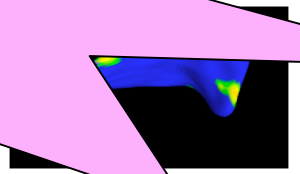
  - MANCOVA based hypothesis testing
  - Incorporates other representations (GaTech, Utah)



Binary Segmentation

Built on ITK



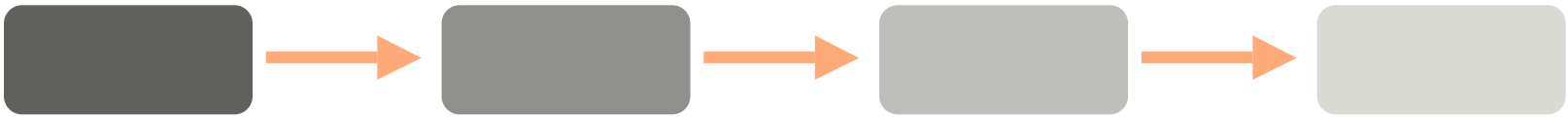


ITK As An Algorithm Repository

- Insight Toolkit
  - Circa 1999 w/funding from NLM
    - ...and NIDCR,NEI,NINDS,NIMH,NIDCD,NCI, NSF
  - Multidimensional image analysis (VHP)
    - API (rather than an application)
    - Community supported and open source
    - Large data, threading, volumes, ...

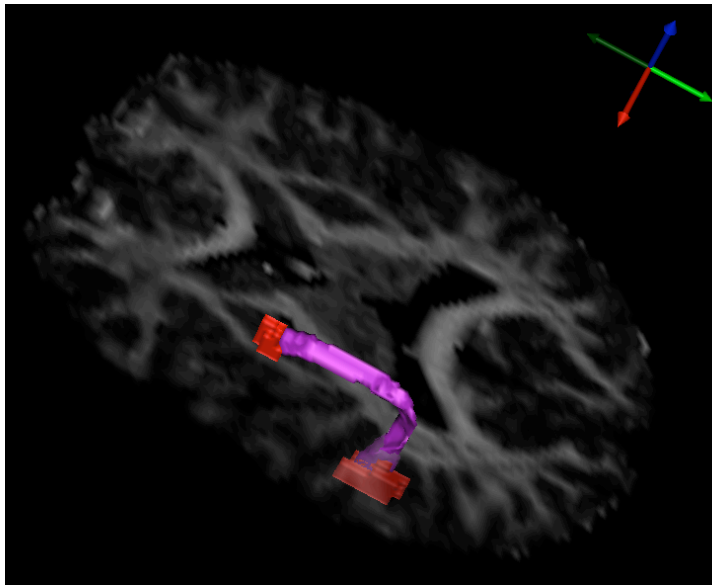
Software Infrastructure for Pipeline Processing of Images

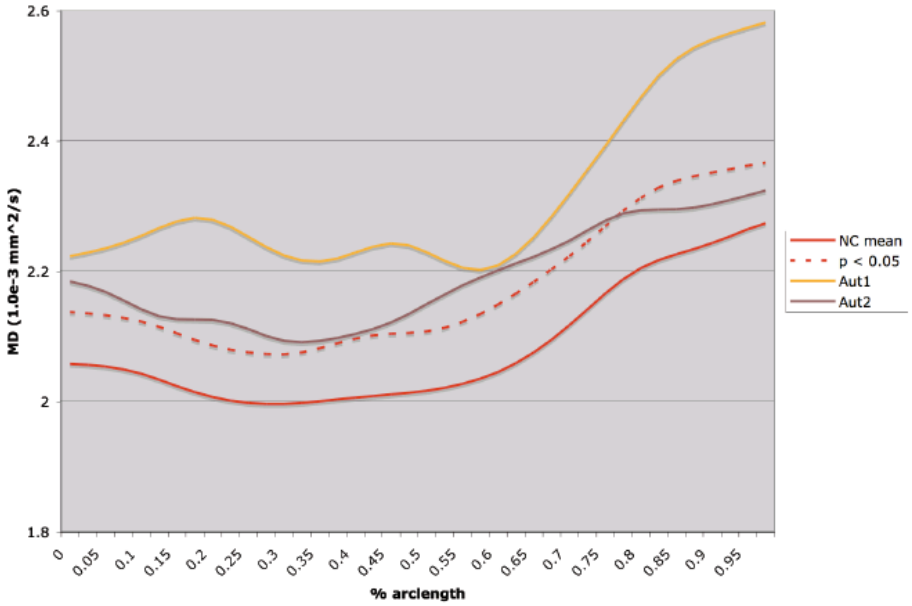
- ***BatchMake*** – Scripting language for batch processing of large datasets (Kitware)
  - Grid enabled (Condor)
  - GUI-based wizard
  - Integration into Slicer and NA-MIC kit
- ***XNAT*** – Archiving toolkit/API (WashU)
  - Distributed, security, quality control
  - Integrate into NA-MIC kit and BatchMake



DTI Analysis of the AF in Autism – Utah

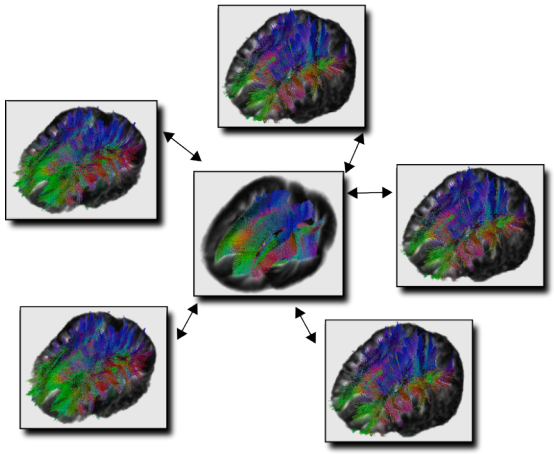
- W/Janet Lainhart, U. of Utah Autism Center
- Voxel-based characterization of white-matter tracts
  - *Optimal paths* framework
  - Arcuate Fasciculus – Wernicke's & Broca's
- ★ Quantifiable diffusivity differences in AF between patients and NCs



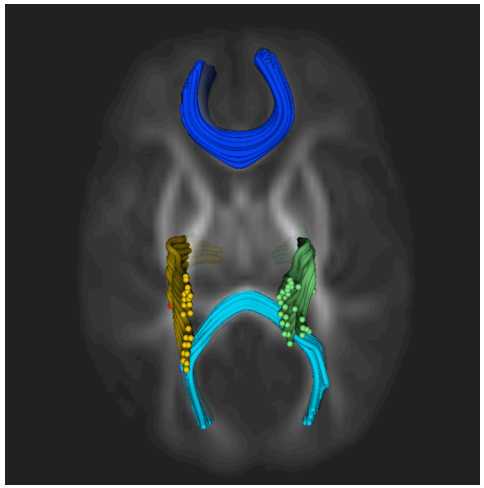


Atlas-Based DTI Analysis – Utah, UNC

- w/John Gilmore, UNC, Psychaitry
- ★ Gilmore et al.; Bio Psych 2008, NeuroImage 2008
- Prenatal mild mentriculomegaly (MVM) predicts white-matter abnormalities in splenium
  - Reduced FA, increased diffusivity (Frobenius norm)
- Software ITK/NA-MIC



Atlas



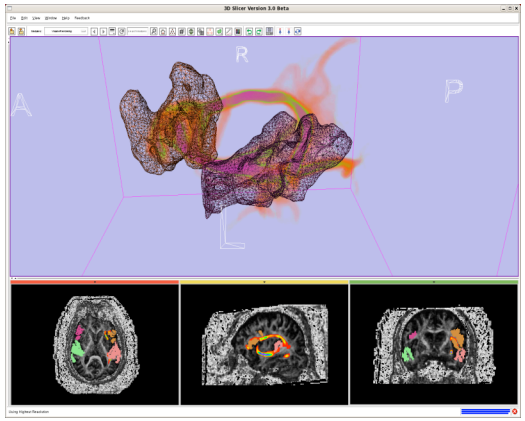
Tracts

Tract	p-value
Genu	.99
Splenium	**.0001**
Left cortico-spinal	.24
Right cortico-spinal	.80

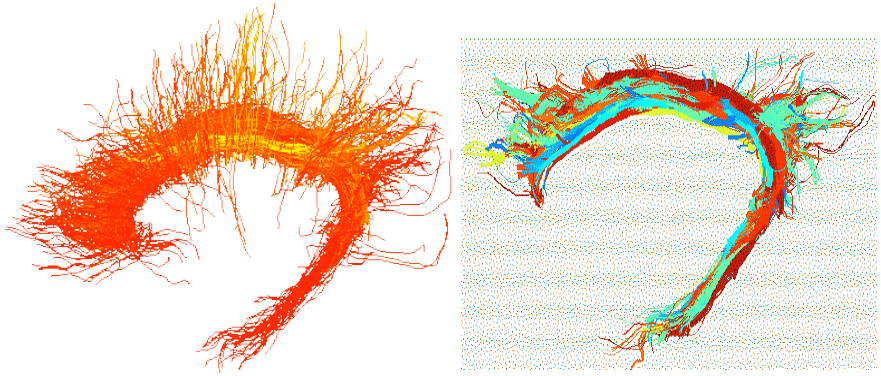
85 Controls, 13 MVMs

NA-MIC and DTI Analysis

- Other DTI work. E.g.
  - Harvard B&W - Stochastic Tractography
  - MIT - Tract clustering and data-driven fiber atlases



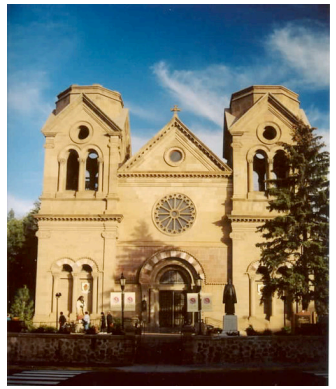
Stochastic Tractography in Slicer



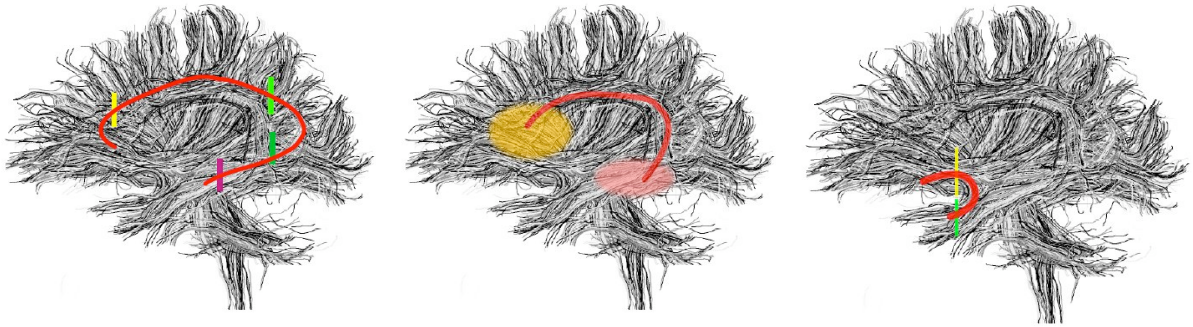
Fiber Clustering and Atlas Building

- A comprehensive software infrastructure for DWI/DTI processing
  - DICOM files -> Visualization/Statistical Analysis
  - Integrate DWI and anatomical images
  - ITK & Slicer

Method Evaluation: The NA-MIC DTI Sante Fe Workshop

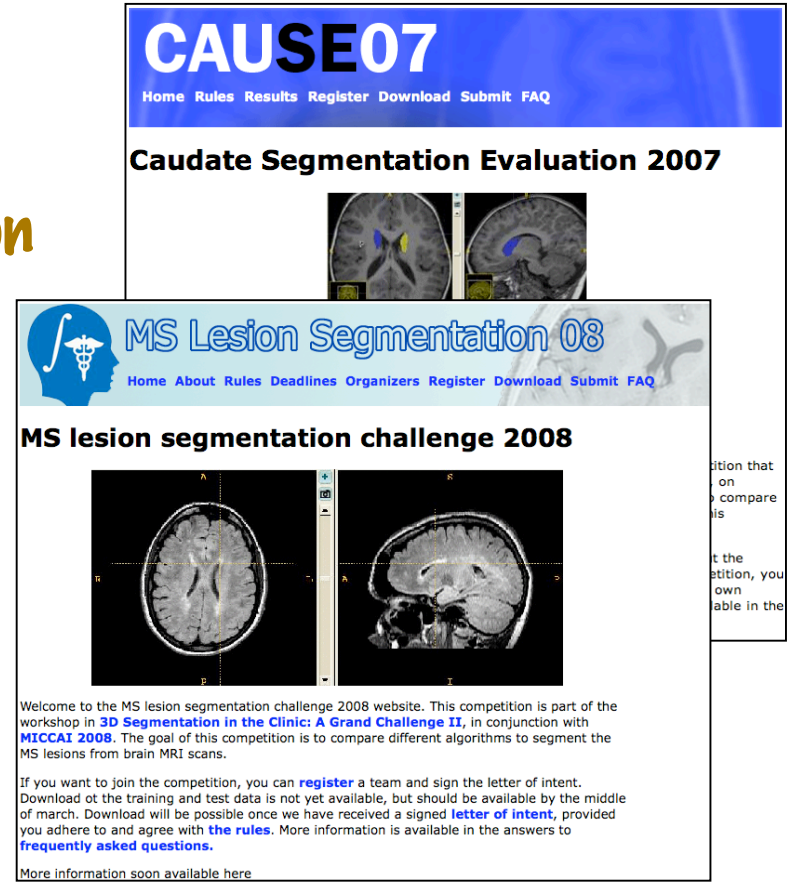


- Oct 2007
- ~25 participants
- Predefined datasets and tasks
  - DBP from Brigham and Women's (Kubicki)
- Technical meeting: compare and contrast differences of approaches/methods



Competitive Method Evaluation

- Tools/data for evaluation
- MICCAI workshops
  - 07: Caudate & liver segmentation
  - 08: Lesion segmentation
  - Largest MICCAI workshop
  - NAMIC: Co-sponsor
- Online evaluation continues
  - www.cause07.org
  - http://www.ia.unc.edu/MSseg
- Online proceedings
  - MIDAS journal, public



Projects

Please add a page for your project in Engineering:Project:2006 AHM Programming:Name, and add a link here. After you have a reasonable definition of your project, please fill in this powerpoint template (thanks to Gordon Kindlmann in helping prepare the template), upload, and link to your project page. We will review these powerpoints in a tcon on Jan 5th, and also at the programming week itself.

1. Define Joint Registration and Segmentation Framework (Kilian Pohl- MIT/BWH)
2. Affine Invariant Anisotropic Smoothing ITK Filter (John Melonakos-GT, Delphine Nain-GT, Jim Miller-GE)
3. Rule Based Segmentation Slicer Module (John Melonakos-GT, Delphine Nain-GT, Ramsey Al-Hakim-GT, Shawn Lankton-GT, Alex Yarmakovich-Isomics)
4. Basic image processing filters for DTI (Saurav Basu-Utah, Casey Goodlett-UNC, Tom Fletcher-Utah,Karthik Krishnan-Kitware, Xiaodong Tao-GE)
5. Automated image mosaicking and feature tracking for Electron Microscopy data (Tolga Tasdizen-Utah, Liz Jurrus-Utah, Paul Koshevoy-Utah, Ross Whitaker-Utah)
6. Slicer 3

EM Segmenter

E, Jeff

uyash

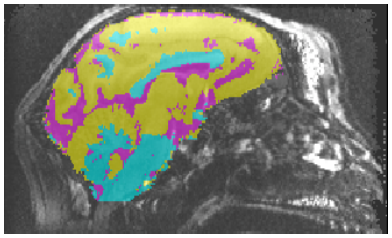
Vincent

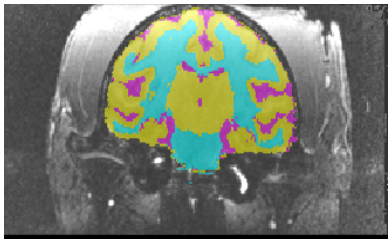
Oguz, Martin

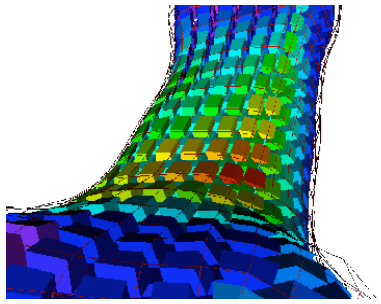
11. Improved DTMRI module tract display (Lauren O'Donnell - MIT, C-F Westin, BWH, Raul San Jose, BWH)
12. itku: Command-line ITK interface (Raul San Jose, Gordon Kindlmann - BWH)
13. Graphical framework to construct/ execute complex scientific analyses of data (Michael Pan, UCLA)
14. Simple to use UNC shape analysis LONI pipeline (Martin Styner, UNC)

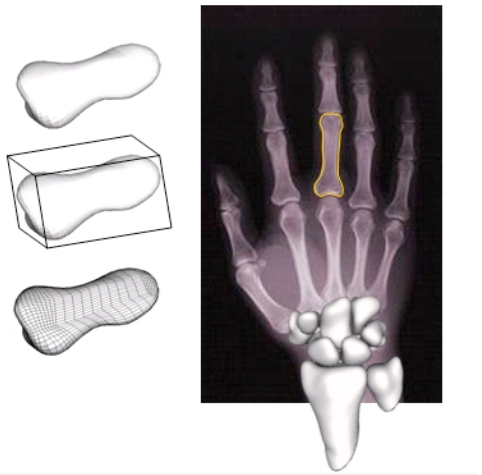
EM Segmenter: New Collaborations

- Virginia Tech: Ch. Wyatt, Wake Forrest: J. Daunais
  - Alcohol and stress in R. monkeys
  - Structural and diffusion MRI
- Iowa: Kiran H. Shivanna, Vincent A. Magnotta, Nicole M. Grosland
  - Hex grid generation
  - Biomechanical simulation





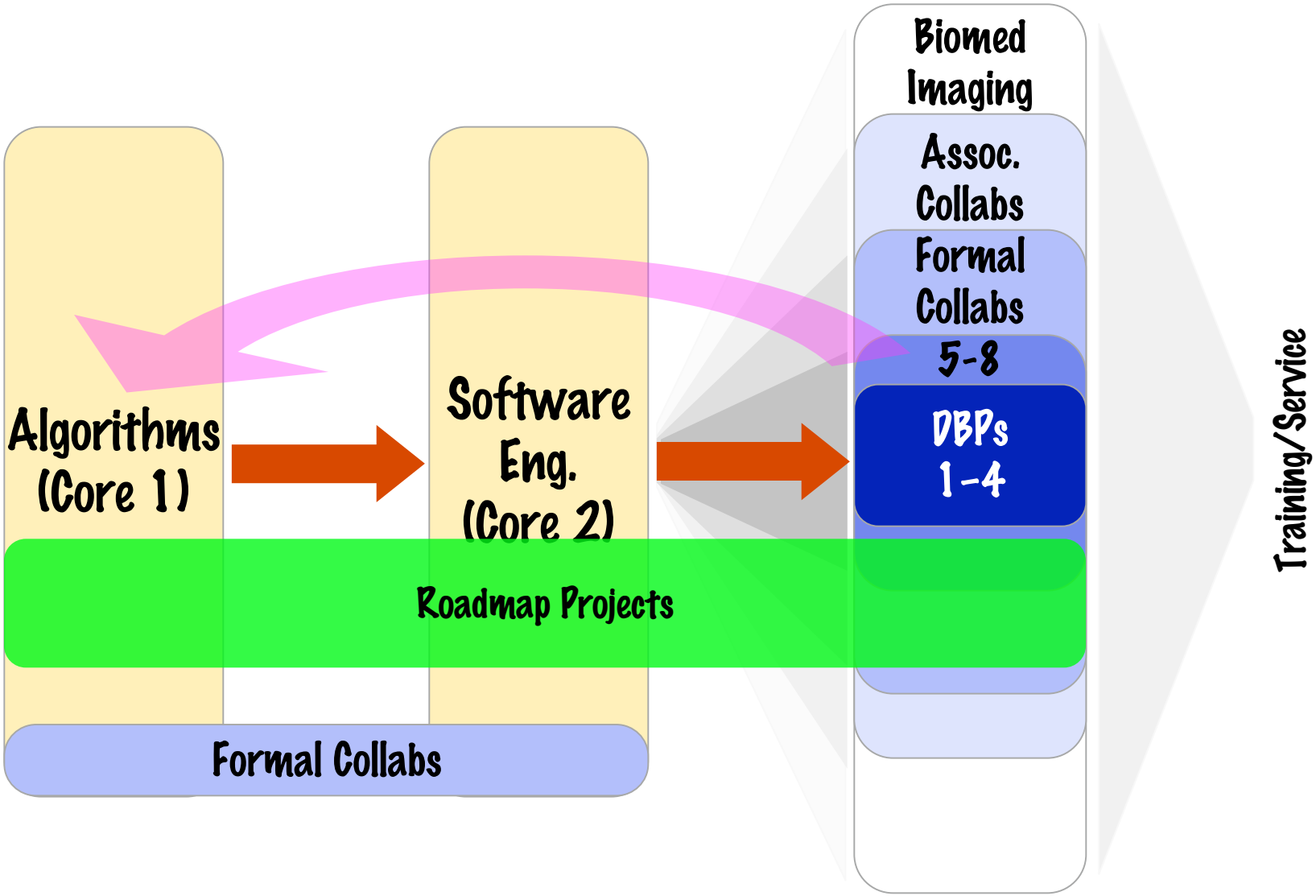




Thank you.

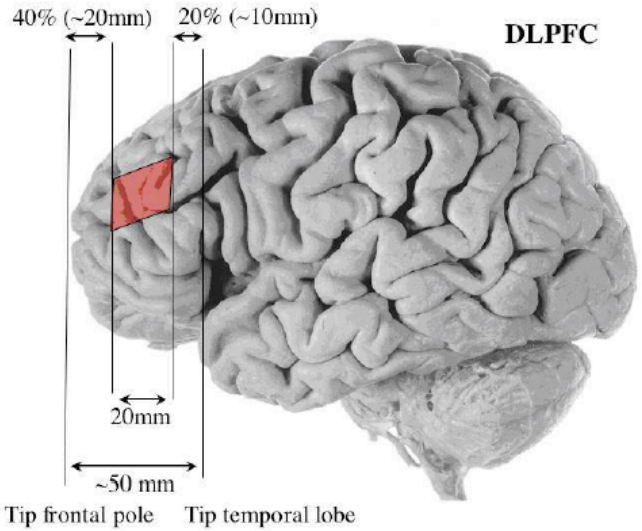
...and thanks to all our NA-MIC colleagues and collaborators.

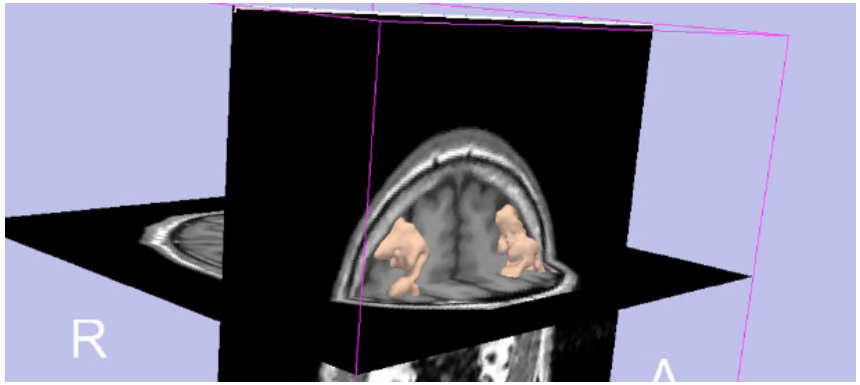
Algorithms, Software, Science

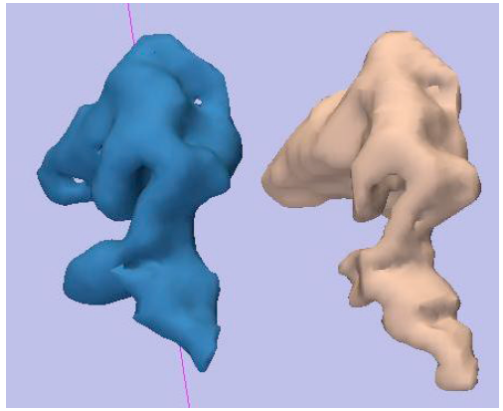


Segmentation: Rule-Based GaTech, UC-Irvine

EM-Segmenter
tissue classifications ->
Cortical parcellations







R. Al-Hakim, et al. "A Dorsolateral Prefrontal Cortex Semi-Automatic Segmenter". SPIE Medical Imaging, 2006.