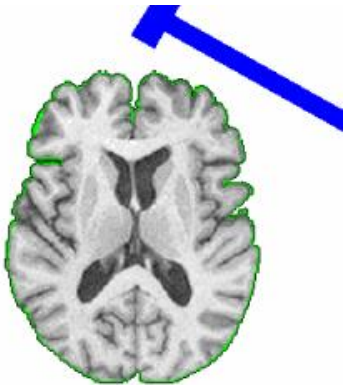


Using HAMMER in 3D Slicer



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**Department of Radiology and BRIC, University of North Carolina at Chapel Hill, U.S.A.*

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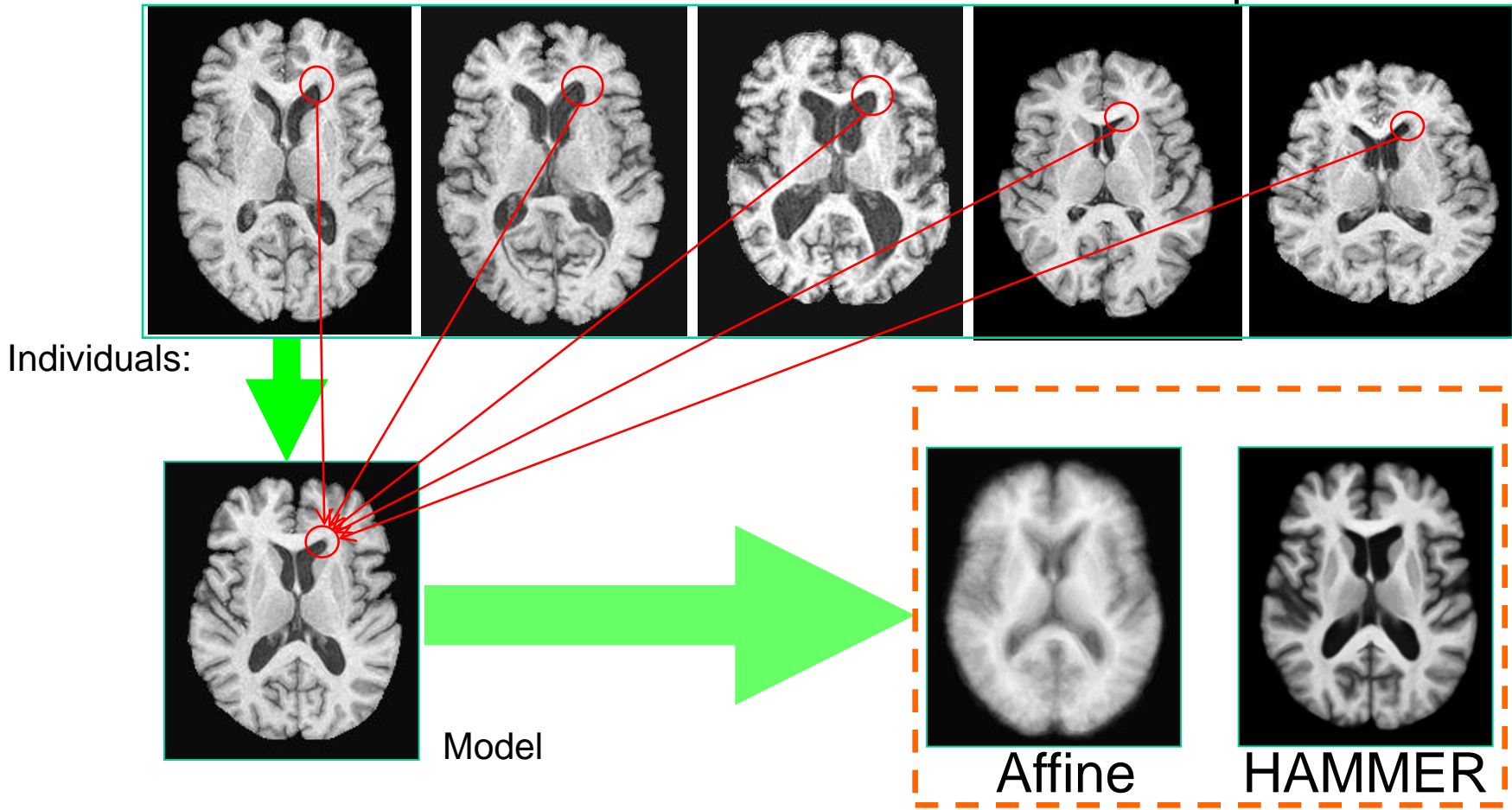
Using HAMMER in 3D Slicer



Contents

- Introduction
- Data processing pipeline
- Registration using HAMMER
- Step-by-step tutorial

- The goal of deformable registration of brain images
 --- Establish anatomical correspondences



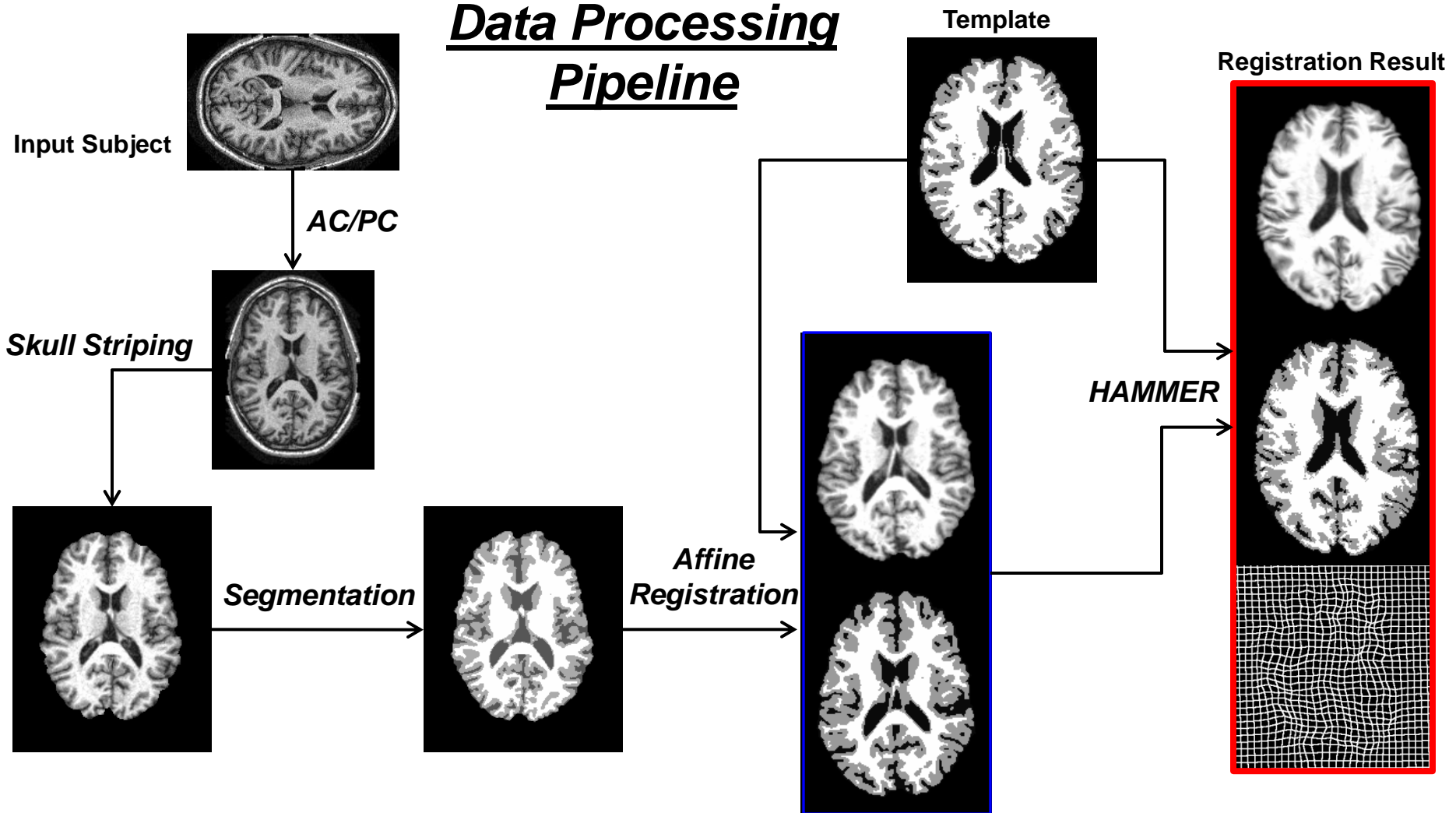


- Clinical applications:

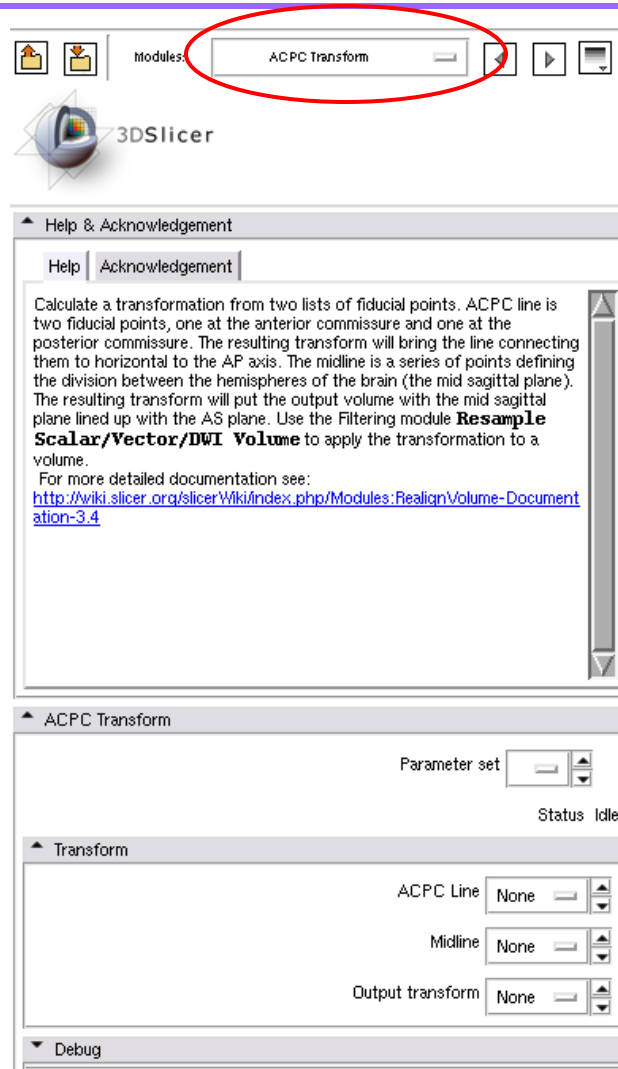
- † Spatial normalization of functional images, *for group analysis*.
- † Measurement of structures, *by deforming a model to individual*.
- † Image data mining *in lesion-deficit studies*.

- HAMMER has been used to align over 8,000 brains image since 2002.
- The TMI paper describing HAMMER received the 2006 Best Paper Award from the IEEE Signal Process Society.

Data Processing Pipeline



AC/PC alignment



The screenshot shows the 3D Slicer3 interface. In the top toolbar, the 'Modules' panel has 'ACPC Transform' selected and circled in red. Below it, the 'ACPC Transform' module's configuration window is open. The window has tabs for 'Help' and 'Acknowledgement'. The 'Help' tab is active, displaying the following text:

Calculate a transformation from two lists of fiducial points. ACPC line is two fiducial points, one at the anterior commissure and one at the posterior commissure. The resulting transform will bring the line connecting them to horizontal to the AP axis. The midline is a series of points defining the division between the hemispheres of the brain (the mid sagittal plane). The resulting transform will put the output volume with the mid sagittal plane lined up with the AS plane. Use the Filtering module **Resample Scalar/Vector/DWI Volume** to apply the transformation to a volume.

For more detailed documentation see:
<http://wiki.slicer.org/slicerWiki/index.php/Modules:RealignVolume-Documentation-3.4>

The configuration window also shows a 'Parameter set' dropdown, a 'Status' indicator set to 'Idle', and a 'Transform' section with three dropdown menus: 'ACPC Line' (set to 'None'), 'Midline' (set to 'None'), and 'Output transform' (set to 'None'). A 'Debug' section is visible at the bottom.

Skull stripping

Help & Acknowledgement

Help Acknowledgement

This work is part of the National Alliance for Medical Image Computing (NAMIC), funded by the National Institutes of Health through the NIH Roadmap for Medical Research, Grant U54 EB005149.

Xiaodong Tao, taox @ research . ge . com

Skull Stripper For Structural MR

Parameter set R ←

Status Completed

IO

Input Volume t.r ←

Output brain surface S...l ←

Brain Mask e ←

Skull Stripping Parameters

Iterations 100 ←

Subdivisions 20 ←

Dilation Radius after deformation 3 ←

Optional Output

Default Cancel Apply

Default parameter set

Input file name

Output brain surface file name

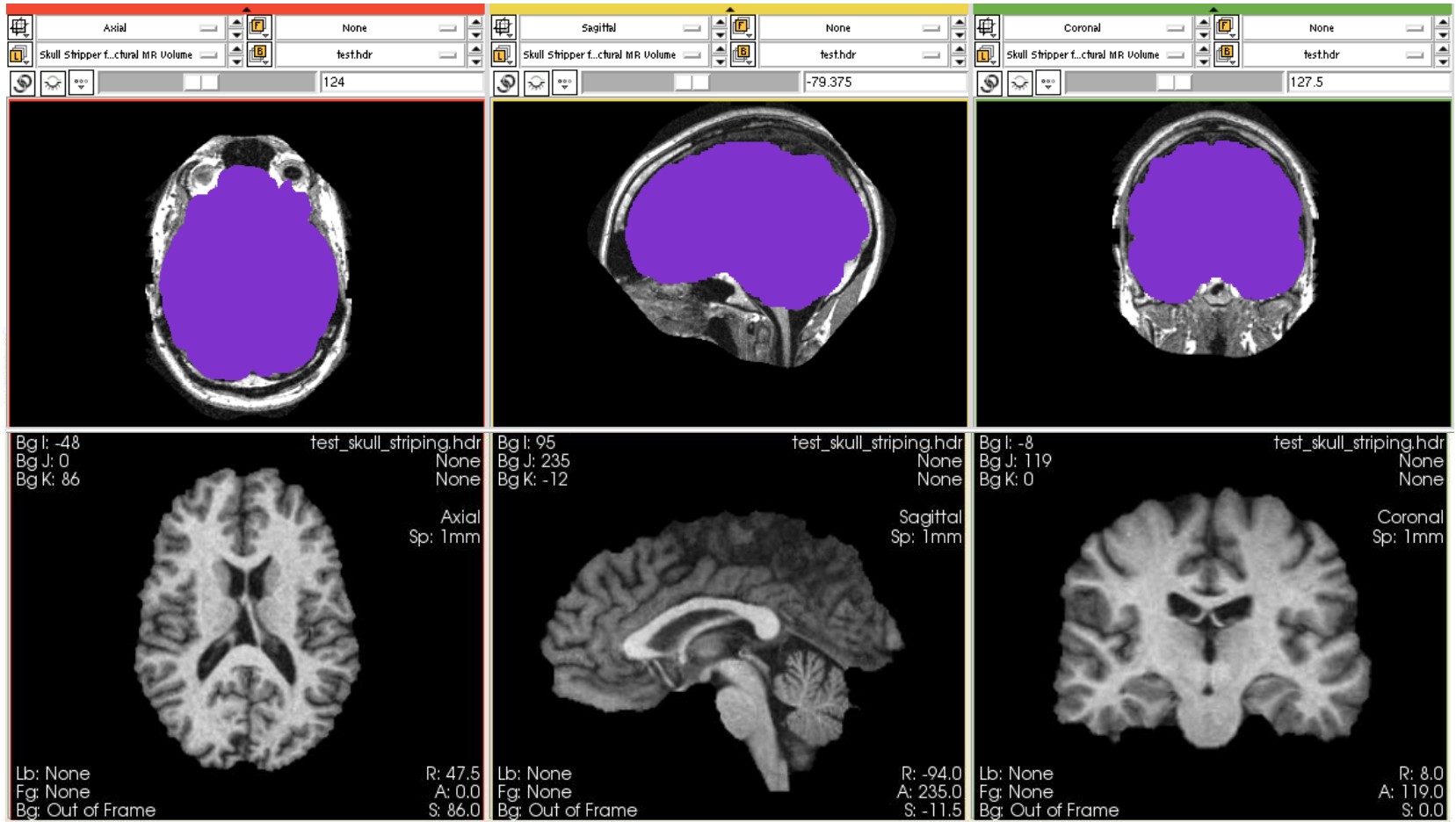
Brain mask file

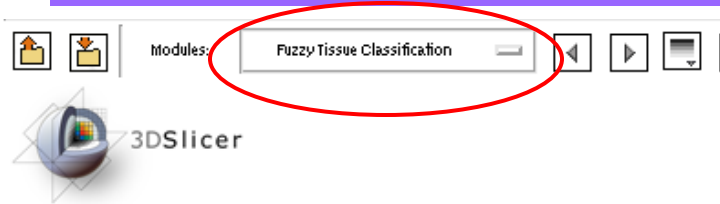
Iterations used in skull stripping

The number of sub-divisions

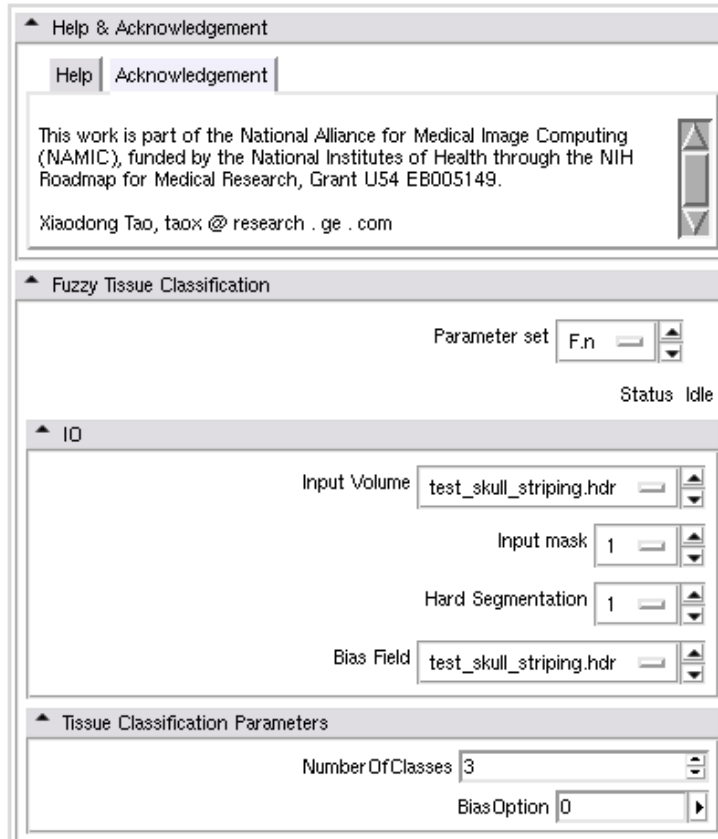
The dilation radius after deformation

Skull Stripping





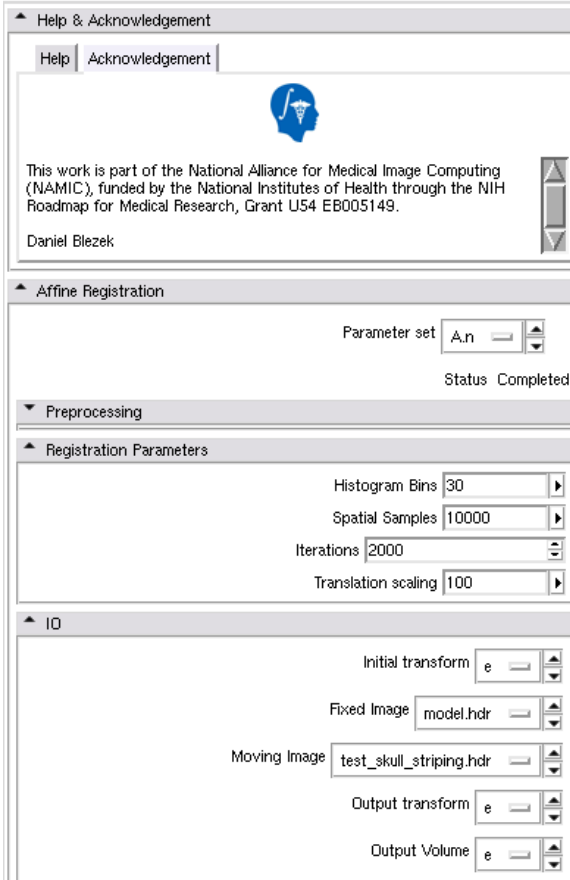
Segmentation and bias correction with 'Fuzzy Tissue Classification' in 3D Slicer



- ← *Input file name*
- ← *Input mask file name*
- ← *Output hard segmentation result*
- ← *Output bias field result*
- ← *The number of tissue types*
- ← *The option for bias correction*



Affine Registration in Slicer3



← The number of histogram bins

← The number of iterations

← Fixed image

← Moving image

← Output transformation

← Output affine registration result

Modules: HAMMER registration



HAMMER Registration in Slicer3

Help & Acknowledgement

Help | Acknowledgement

HAMMER is an algorithm for elastic registration of medical images using geometric moment invariants as attributes and hierarchical attribute matching mechanism for finding deformation field. This module implements the algorithm described in 'HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration', IEEE Trans. on Medical Imaging, 21(11):1421-1439, Nov 2002). Its inputs are skull stripped brain images with gray matter, white matter, and CSF segmentation. For more detailed documentation see: http://na-mic.org/Wiki/index.php/NA-MIC_NCBC_Collaboration_and <http://www.med.unc.edu/~dqshen/HAMMER.htm>

HAMMER Registration

Parameter set: n

Status: Idle

Registration Parameters

Tissue Labels: 10,150,250

Iterations: 50,20,20

IO

Fixed Image: model.hdr

Moving Image: Movin...q.hdr

Moving Intensity Image: Movin...q.hdr

Output Volume: HAMME...olume

Output Intensity Volume: HAMME...ume1

← The number of iterations in each resolution

← Fixed image

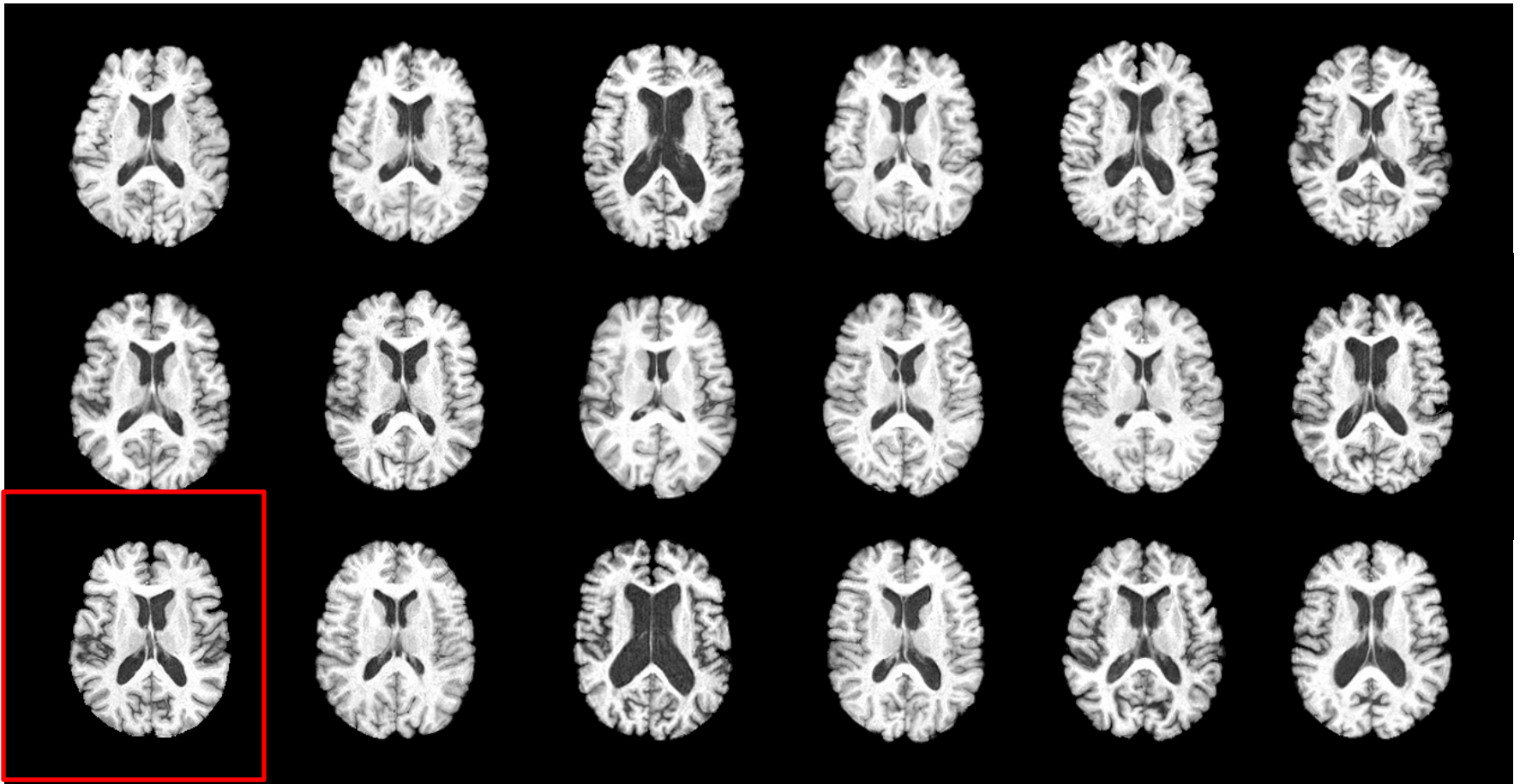
← Moving segmented image

← Moving intensity image

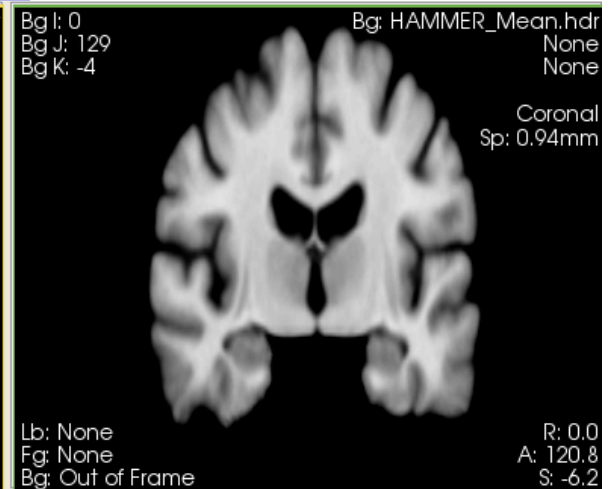
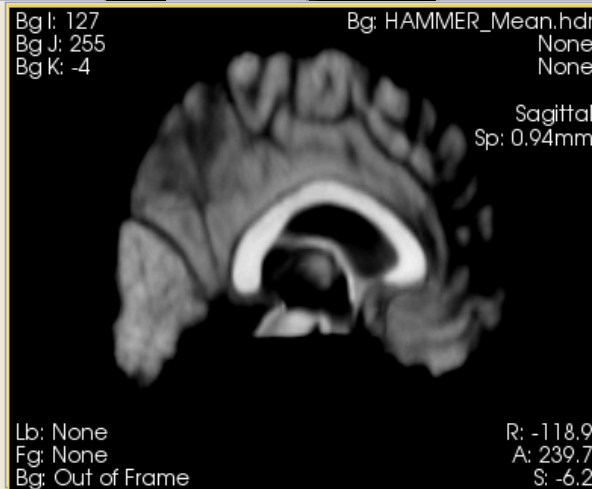
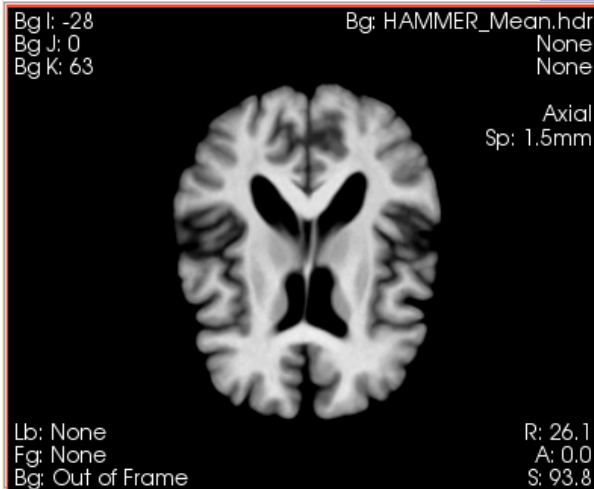
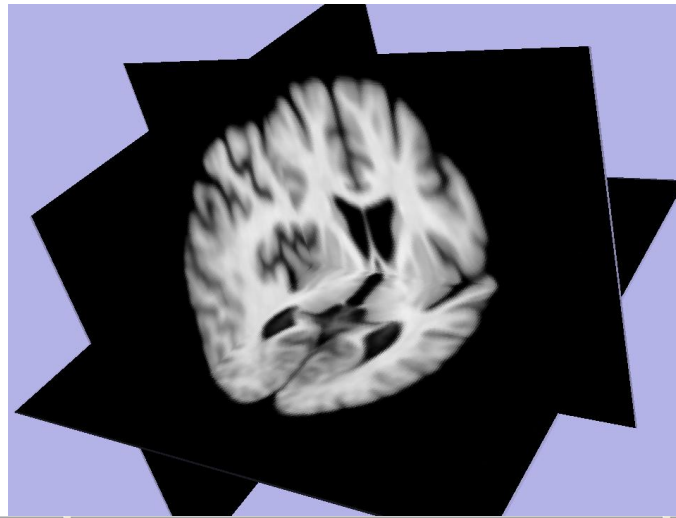
← Output segmented image

← Output intensity image

Experiment 1: 18 Elderly Brains From BLSA Dataset



Average Image



40 LONI Dataset with 54 manually labeled RIOs

Laboratory of Neuro Imaging

[Home](#)[About LONI](#)[Research](#)[Visualization](#)[News & Events](#)[Software](#)[Data](#)[LONI >](#)

LONI Atlases

An atlas of the brain allows us to define its spatial characteristics. Where is a given structure; relative to what other features; what are its shape and characteristics and how do we refer to it? Where is this region of functional activation? How different is this brain compared with a normal database? An atlas allows us to answer these and related questions quantitatively.

Brain atlases are built from one or more representations of brain. They describe one or more aspects of brain structure and/or function and their relationships after applying appropriate registration and warping strategies, indexing schemes and nomenclature systems. Atlases made from multiple modalities and individuals provide the capability to describe image data with statistical and visual power.

An atlas can take on many forms, from descriptions of structure or function of the whole brain to maps of groups or populations. Individual systems of the brain can be mapped as can changes over time, as in development or degeneration. An atlas enables comparison across individuals, modalities or states. Differences between species can be catalogued. But in most cases, the value added by brain atlases is the unique and critical ability to integrate information from multiple sources. The utility of an atlas is dependent upon appropriate coordinate systems, registration and deformation methods along with useful visualization strategies. Accurate and representative atlases of brain hold the most promise for helping to create a comprehensive understanding of brain in health and disease.

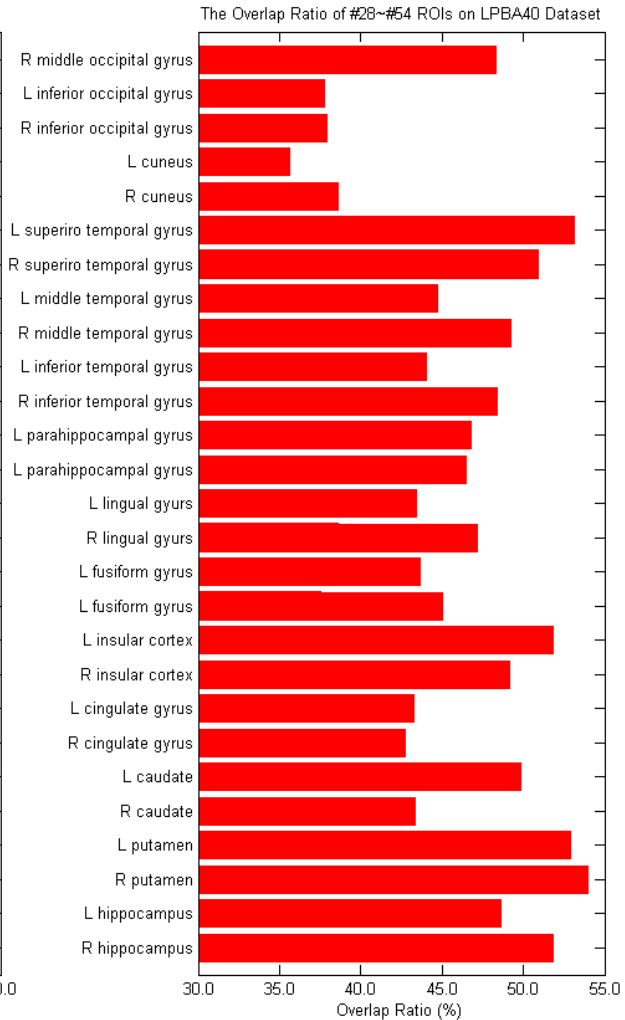
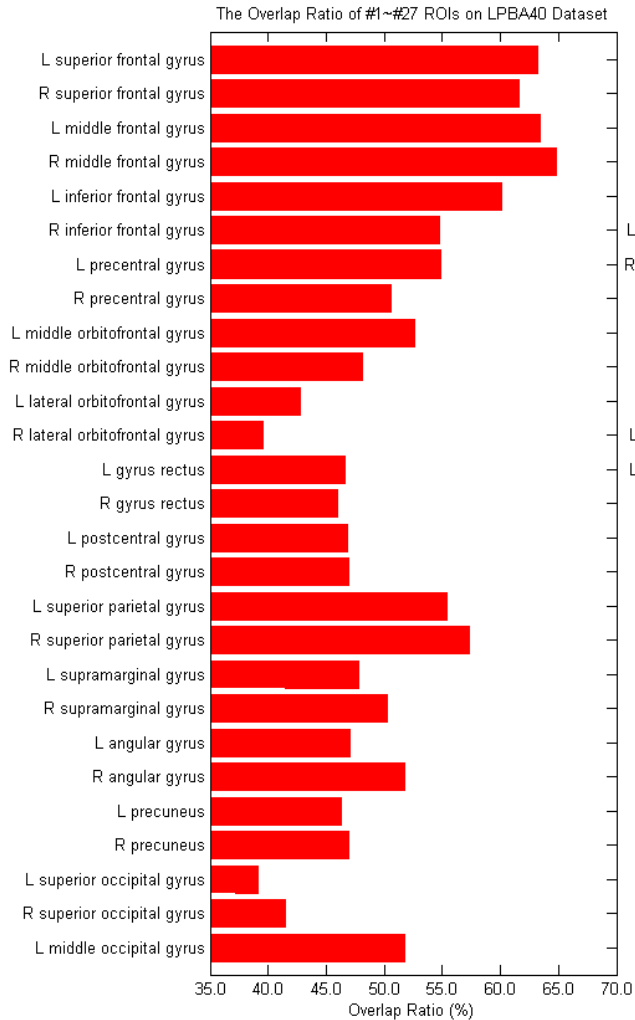
IN THIS SECTION:

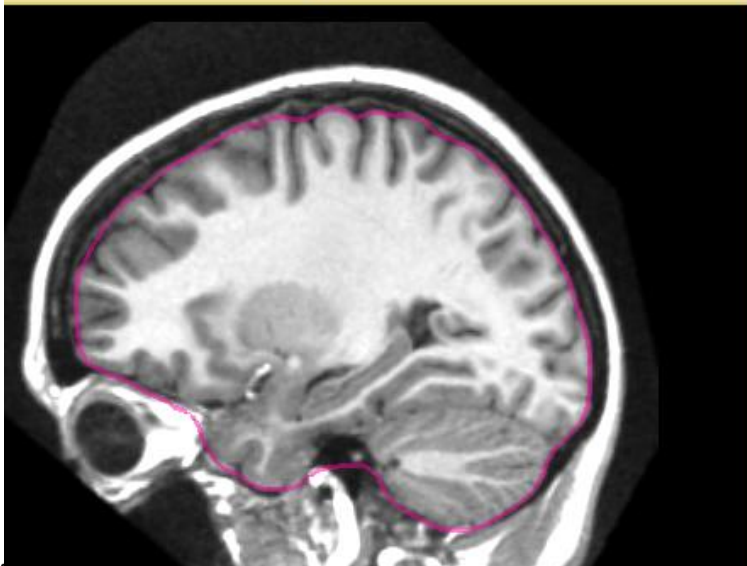
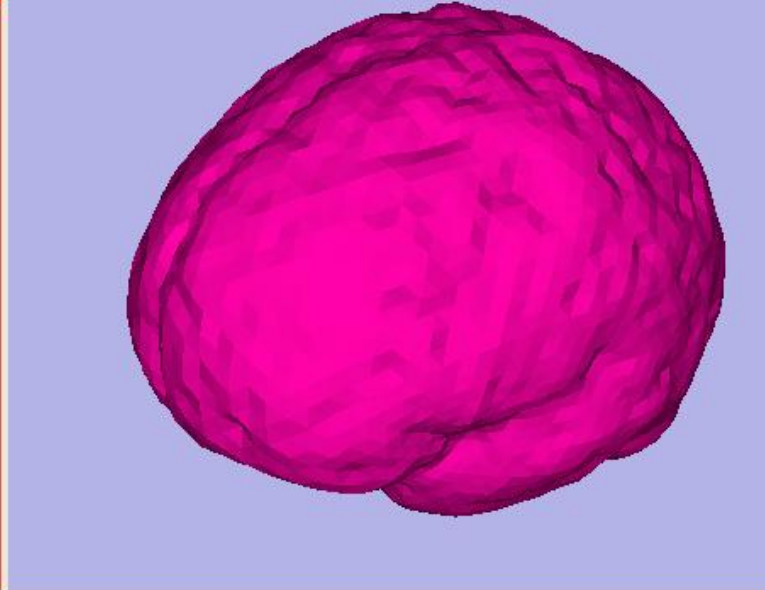
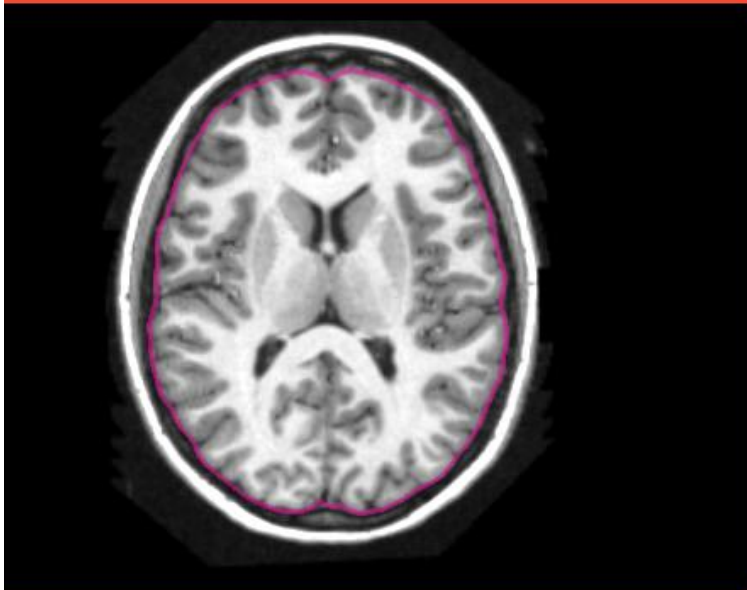
Available Atlases

[Alzheimer's Disease Template](#)[Human Atlas](#)[ICBM 452 T1 Atlas](#)[ICBM DTI-81 Atlas](#)[ICBM Probabilistic Atlases](#)[ICBM T2 Atlas](#)[ICBM Template](#)[LPBA40](#)[Monkey Atlas](#)[Mouse Atlas](#)[Mouse Minimum](#)[Deformation Atlas \(MDA\)](#)[Neonatal \(P0\) Mouse Nissl](#)[Brain Atlas](#)[Neonatal \(P0\) MRI Mouse](#)[Brain Atlas](#)[Rat Atlas](#)

HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration

Guorong Wu, Ph.D., University of North Carolina at Chapel Hill





Step-by-step tutorial

```
grwu@ bass-comp4: ~  
u ...  
Last login: Tue Jan 5 15:16:21 2010 from bass-comp0.cs.unc.edu  
Kickstarted Wed Oct 7 09:34:55 EDT 2009  
-bash-3.2$ source ~/grwu/.bashrc  
[grwu@bass-comp4:~] $ svn co http://svn.slicer.org/Slicer3/trunk Slicer3  
A Slicer3/CMake  
A Slicer3/CMake/Slicer3ValgrindSuppressions.supp  
A Slicer3/CMake/Slicer3ModulesMacros.cmake  
A Slicer3/CMake/Slicer3QTModuleMacros.cmake  
A Slicer3/CMake/Slicer3ParseArgumentsMacro.cmake  
A Slicer3/CMake/RemoveTemporaryFiles.cmake.in  
A Slicer3/CMake/Slicer3Macros.cmake  
A Slicer3/CMake/Slicer3FindQT.cmake  
A Slicer3/CMake/Slicer3PluginsMacros.cmake  
A Slicer3/CMake/Slicer3SampleBuildTest.cmake.in  
A Slicer3/CMake/cuda  
A Slicer3/CMake/cuda/make2cmake.cmake  
A Slicer3/CMake/cuda/empty.depend.in  
A Slicer3/CMake/cuda/parse_cubin.cmake  
A Slicer3/CMake/cuda/CudaDependency.cmake  
A Slicer3/CMake/cuda/FindCuda.cmake  
A Slicer3/CMake/CMakeLists.txt  
A Slicer3/CMake/Slicer3PersistenceMacros.cmake  
A Slicer3/CMake/Slicer3QTBaseLibraryMacros.cmake
```



```
grwu@ bass-comp4: ~/Software
Attic/
Base/
CMake/
CMakeLists.txt
CTestConfig.cmake
CTestCustom.cmake.in
Doc/
Doxyfile
Extensions/
GenerateSlicer3Config.cmake
launch.tcl.in*
Libs/
License.txt*
QTModules/
README.txt
Resources/
Scripts/
Slicer3Config.cmake.in
Slicer3InstallConfig.cmake.in
slicer_variables2.tcl
slicer_variables.tcl
Testing/
UseSlicer3.cmake.in
Utilities/
vtkSlicerConfigure.h.in
[grwu@bass-comp4:~/Software/Slicer3] $ ./Slicer3/Scripts/getbuildtest.tcl --update --releasecd ..
[grwu@bass-comp4:~/Software/Slicer3] $ cd ..
[grwu@bass-comp4:~/Software] $ ./Slicer3/Scripts/getbuildtest.tcl --update --release
Sourcing /home/grwu/Software/Slicer3/slicer_variables.tcl
Slicer3_HOME is /home/grwu/Software/Slicer3
making with make -j 16
running: svn switch http://svn.slicer.org/Slicer3/trunk
```

```
home/grwu/software/slicer3-ext/HammerRegistration-build/Makefiles 1 2
[100%] Built target HammerRegistration
make[1]: Leaving directory `/home/grwu/Software/Slicer3-ext/HammerRegistration-build'
/home/grwu/Software/Slicer3-lib/CMake-build/bin/cmake -E cmake_progress_start /home/grwu/Software/Slicer3-ext/HammerRegistration-build/CMakeFiles 0
make -f CMakeFiles/Makefile2 preinstall
make[1]: Entering directory `/home/grwu/Software/Slicer3-ext/HammerRegistration-build'
make[1]: Nothing to be done for `preinstall'.
make[1]: Leaving directory `/home/grwu/Software/Slicer3-ext/HammerRegistration-build'
Install the project...
/home/grwu/Software/Slicer3-lib/CMake-build/bin/cmake -P cmake_install.cmake
-- Install configuration: "Debug"
-- Installing: /home/grwu/Software/Slicer3/./Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration
-- Removed runtime path from "/home/grwu/Software/Slicer3/./Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration"

running: zip -r9 /home/grwu/Software/Slicer3/./Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip
*
  adding: HammerRegistration (deflated 79%)

Uploading /home/grwu/Software/Slicer3/./Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip to ext.slicer.org port 8845...
uploaded /home/grwu/Software/Slicer3/./Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip (964240 bytes)
Uploading /home/grwu/Software/Slicer3/./Slicer3-ext/Extensions/HammerRegistration.s3ext to ext.slicer.org port 8845...
uploaded /home/grwu/Software/Slicer3/./Slicer3-ext/Extensions/HammerRegistration.s3ext (787 bytes)
*****

BUILT:
  /home/grwu/Software/Slicer3/./Slicer3-ext/Extensions/HammerRegistration.s3ext

100.0% succeeded
[grwu@bass-comp4:~/Software/Slicer3] $ █
```



HAMMER – 3D Slicer Setup



The screenshot displays the 3D Slicer Version 3.5 Alpha software interface. The main window shows a 'Welcome & About' dialog box with the 3DSlicer logo and version 3.4. Below the logo, there is a 'Welcome' heading and a paragraph of introductory text. A 'Hint' section suggests clicking on grey title bars to open information panels. A sidebar on the left contains a tree view with categories like 'Overview', 'Basic & Extended Modules', 'Loading Scenes & Data', 'Saving Scenes & Data', 'Adjusting Data Display', 'Configuring Viewers & Layout', 'Mouse Modes', and 'Manipulate Slice Views'. A toolbar is visible at the bottom of the sidebar.

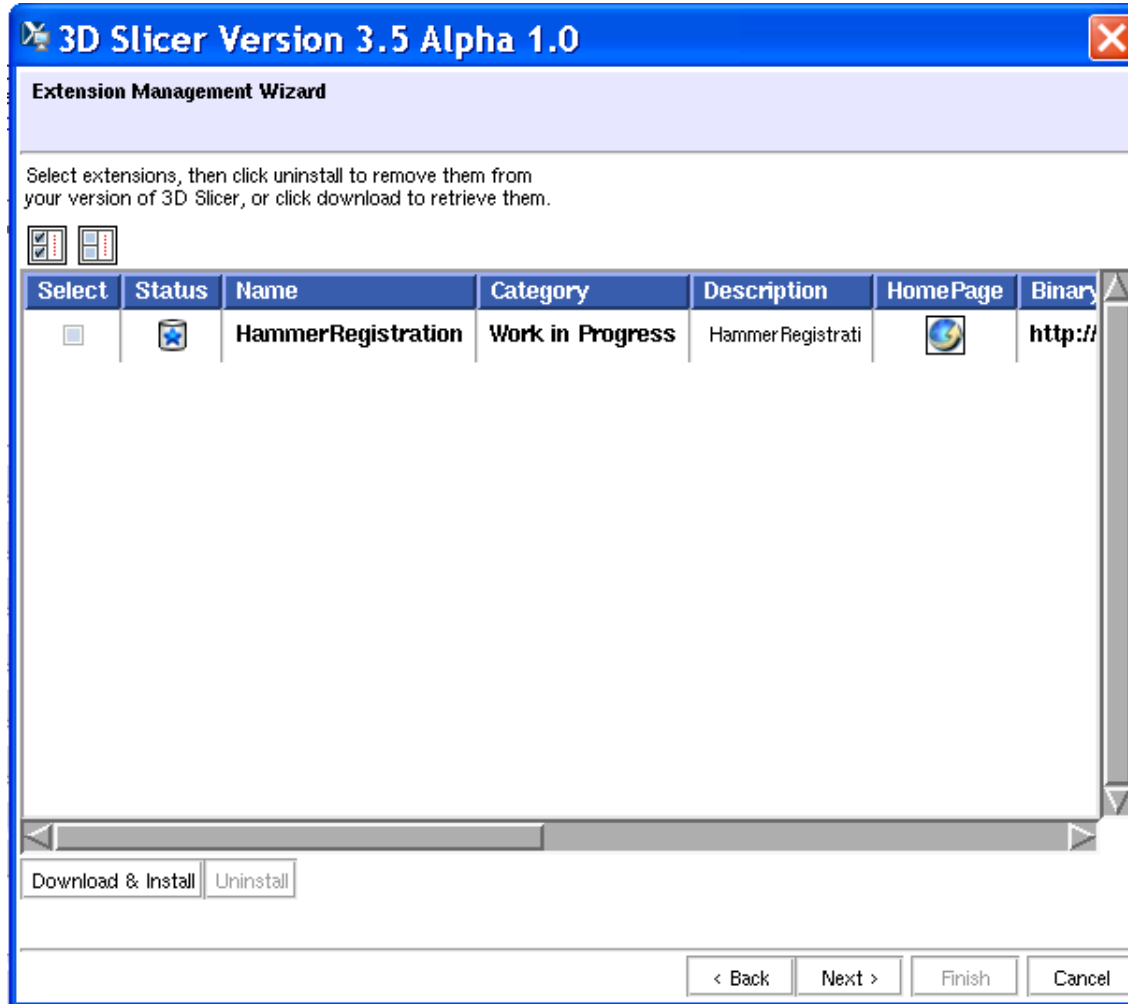
Overlaid on the main window is a smaller dialog box titled '3D Slicer Version 3.5 Alpha 1.0' with the subtitle 'Extensions Management Wizard'. The wizard text reads: 'This wizard lets you search for extensions to add to 3D Slicer, download and install them, and uninstall existing extensions. You will need a network connection to access remote extension repositories.' Below this text are three radio buttons: 'Find & Install' (selected), 'Uninstall', and 'Either'. A text field for 'Change extensions install path:' shows the path '/home/grwu/Slicer3grwu'. Another text field for 'Delete zip files from temp. dir. (optional):' has a trash icon. A dropdown menu for 'Where to search:' is set to 'http://ext.slicer.org/ext/trunk/11116-linux-x86_64'. At the bottom of the wizard are buttons for '< Back', 'Next >', 'Finish', and 'Cancel'.

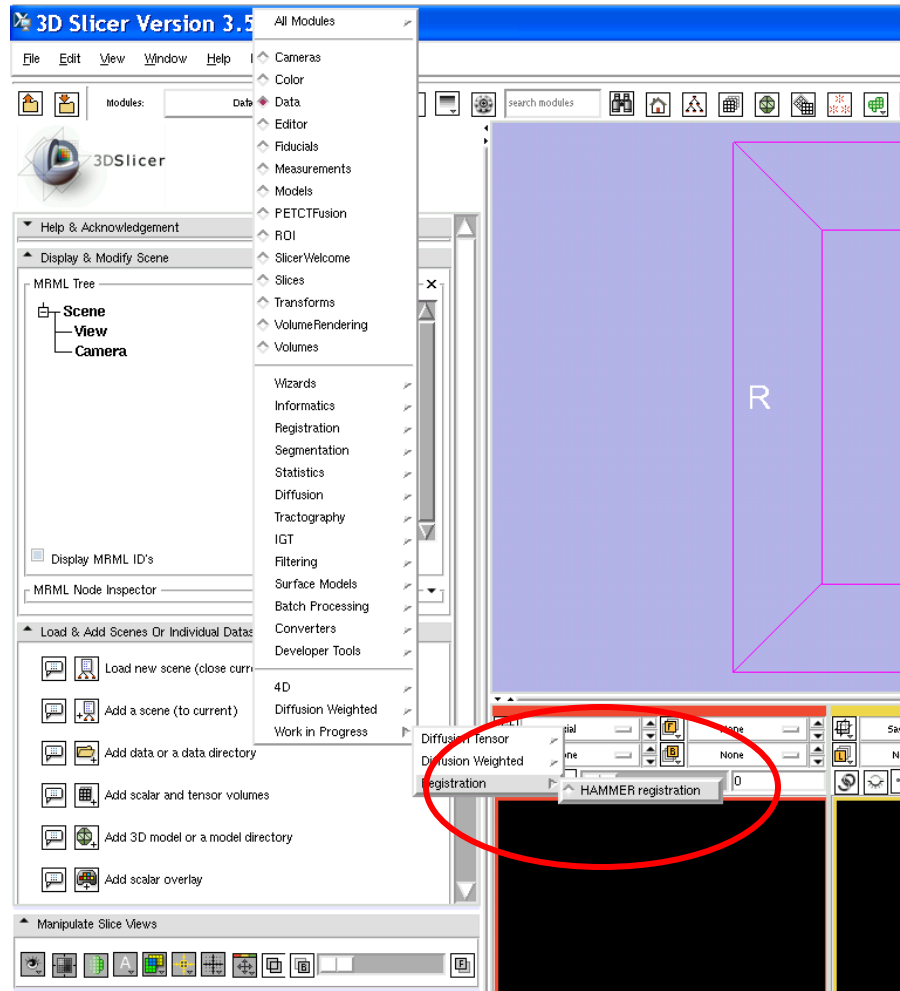


HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration
Guorong Wu, Ph.D., University of North Carolina at Chapel Hill

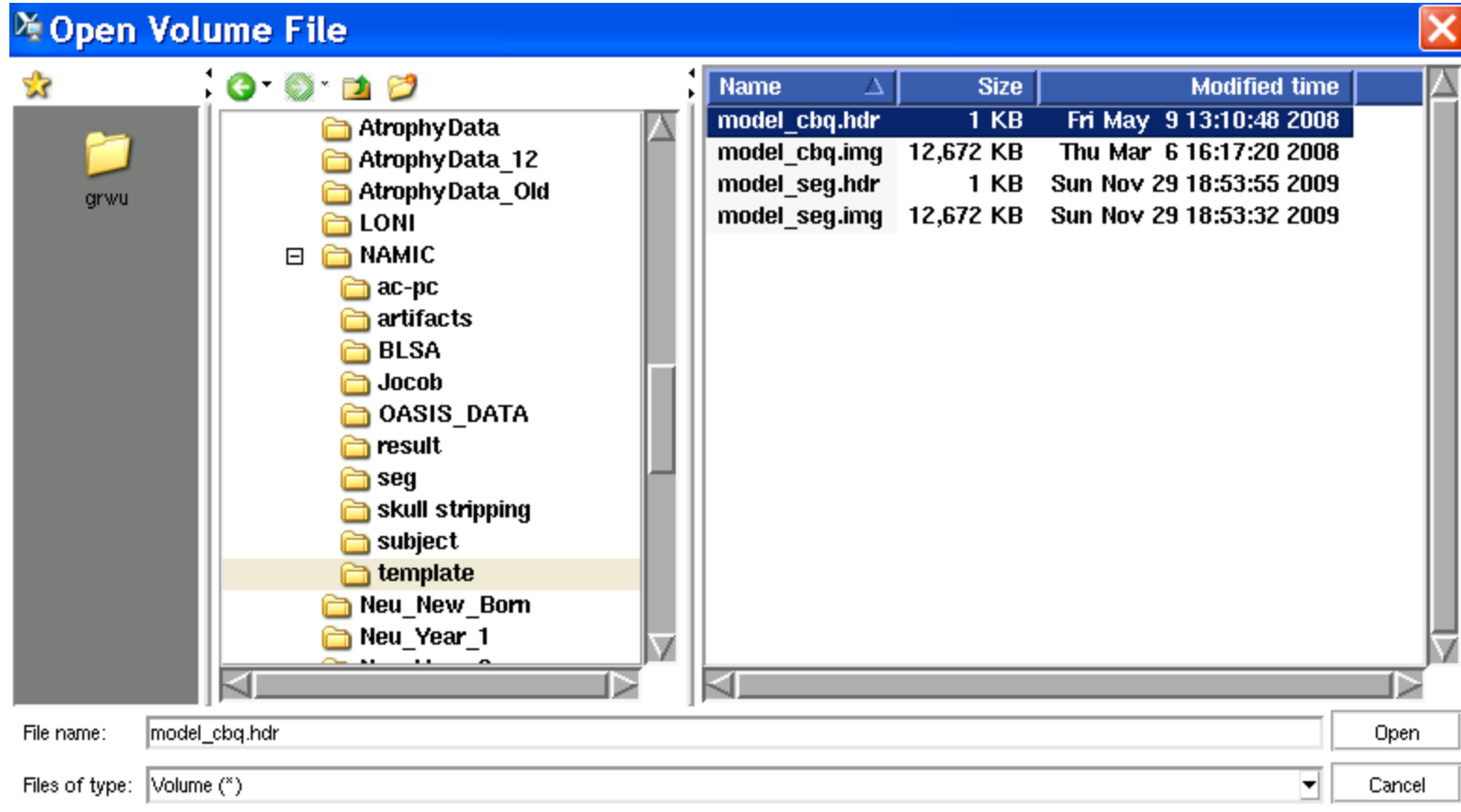


THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

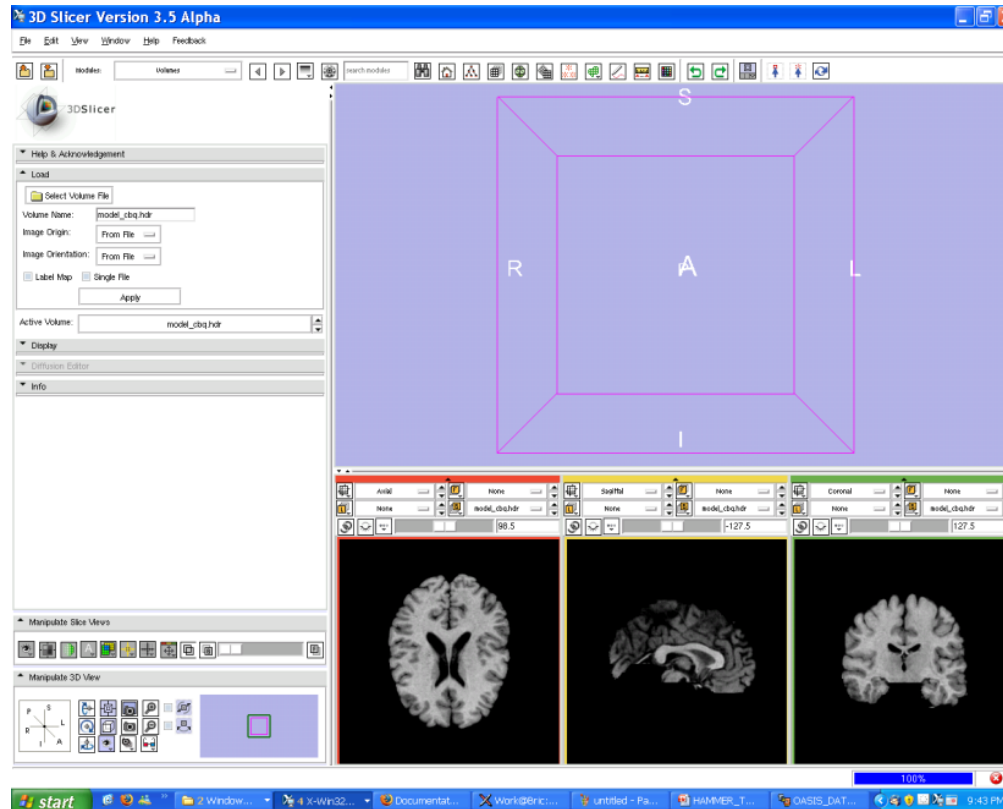




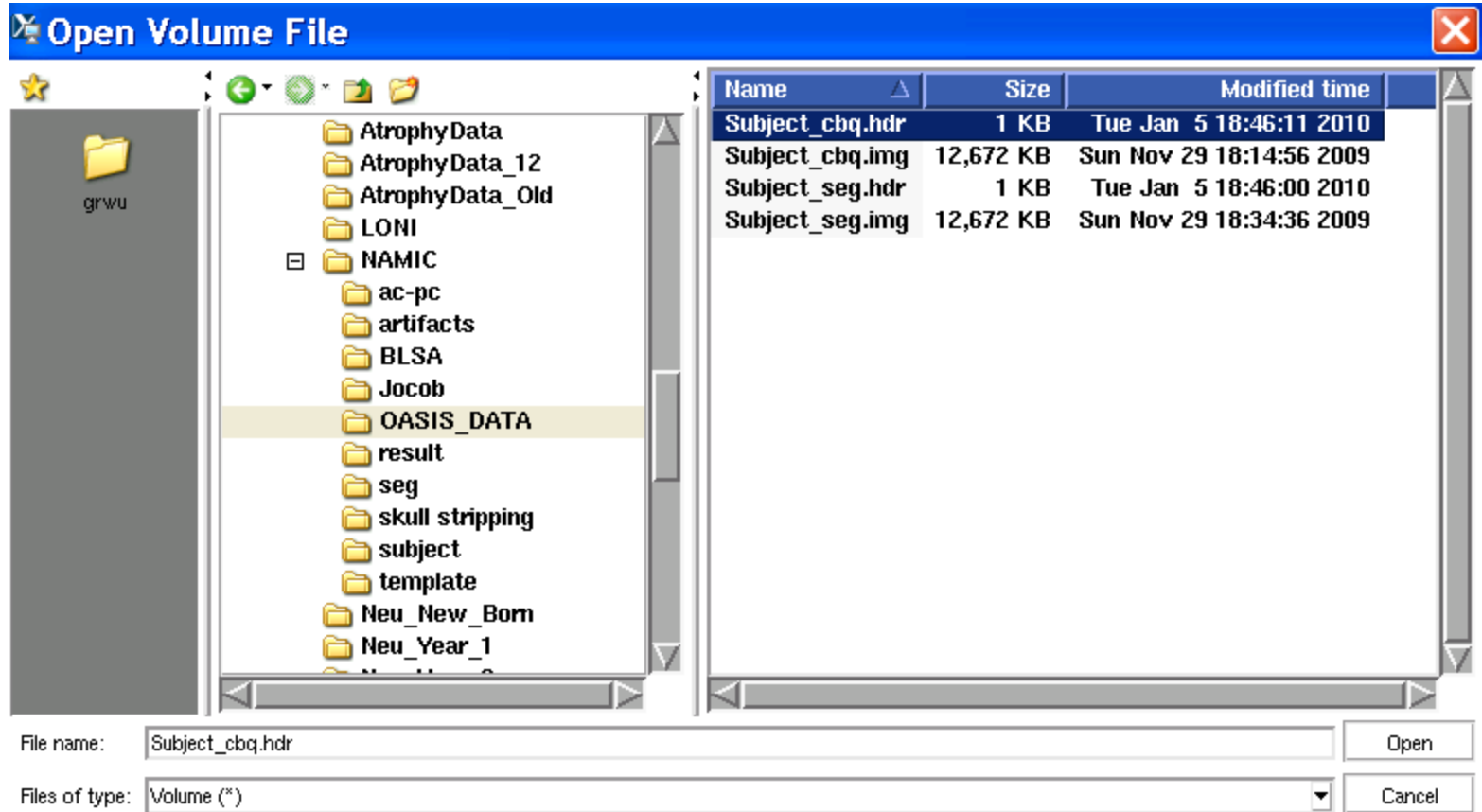
Load model images



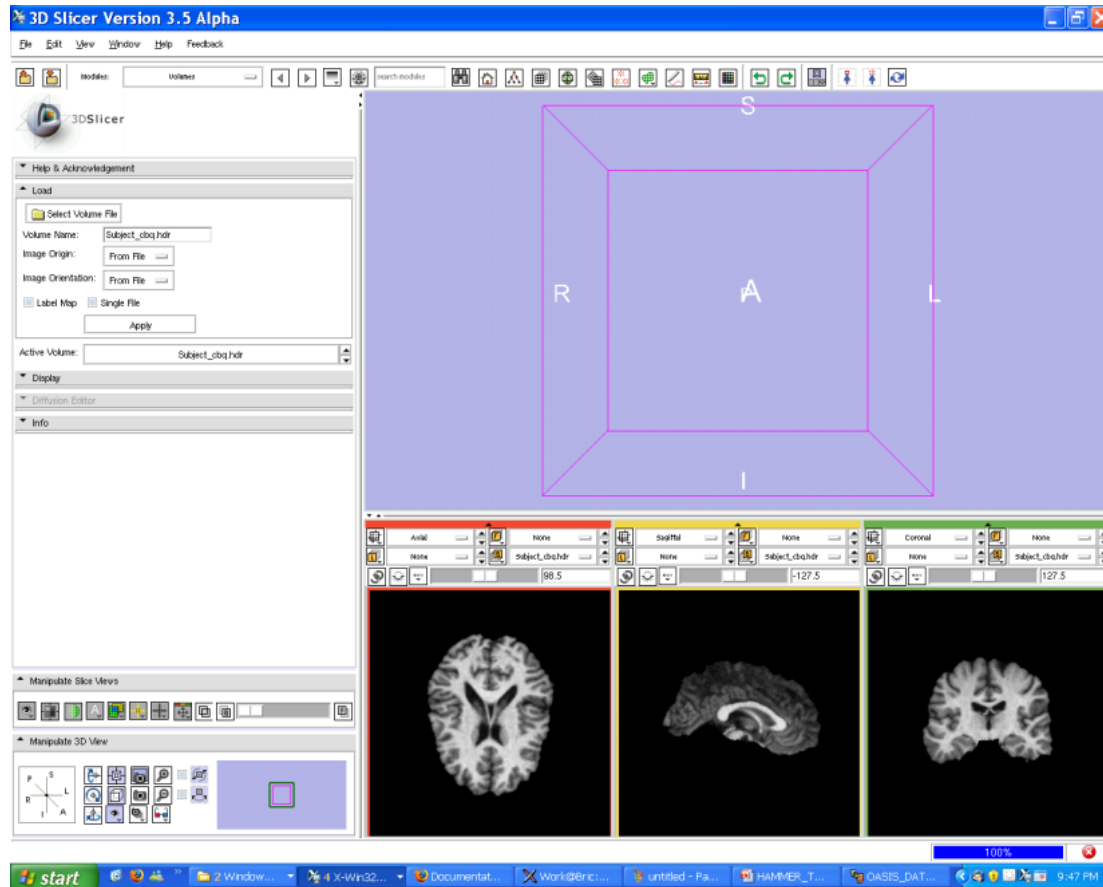
Load images



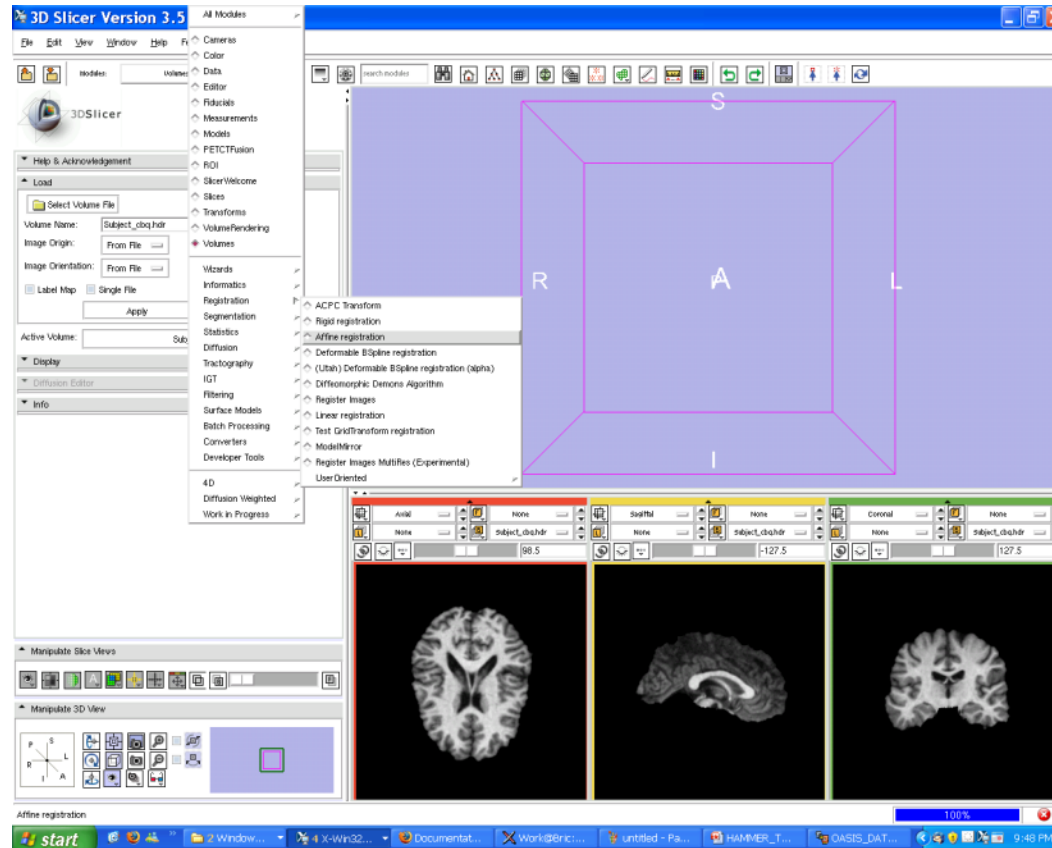
Load subject images



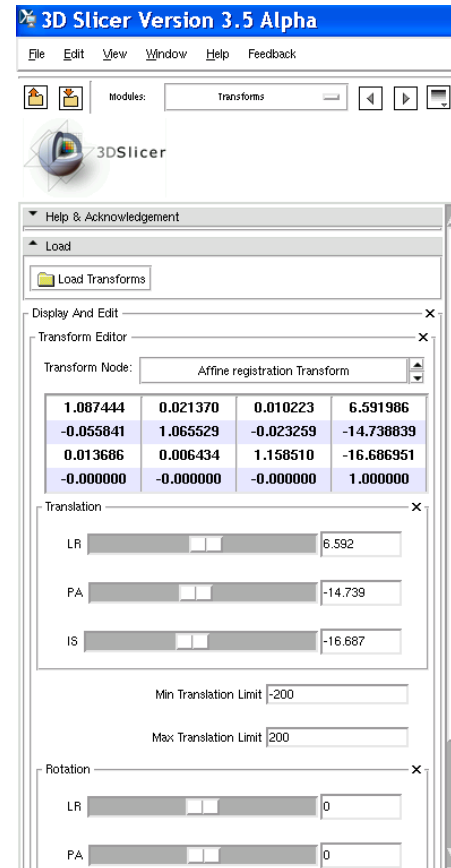
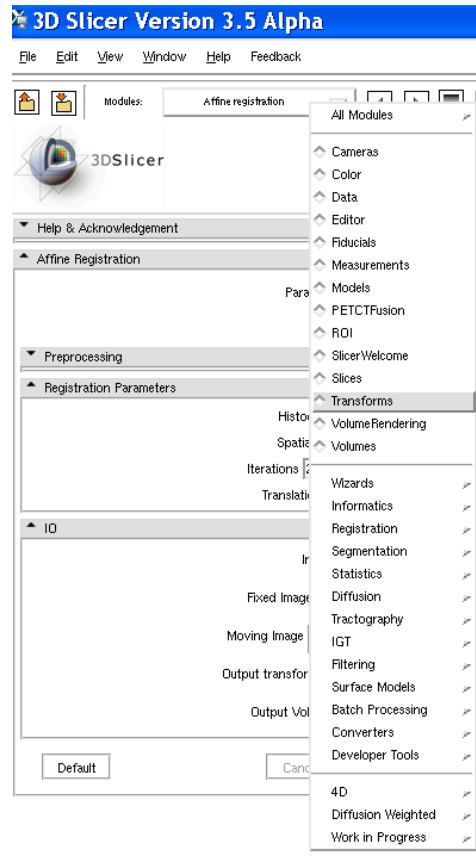
Load subject images



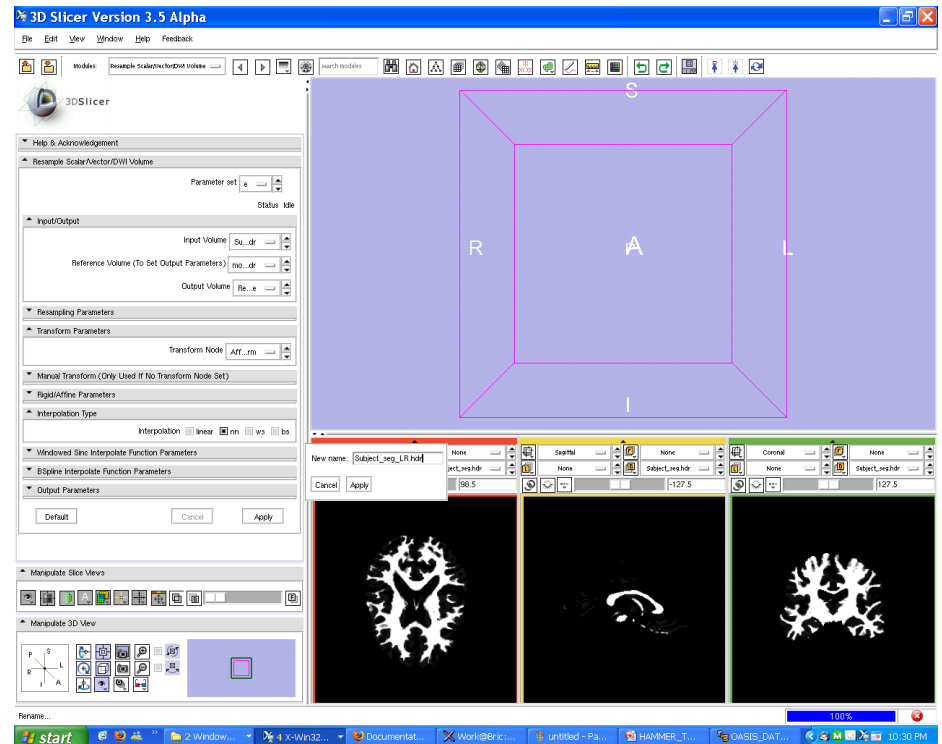
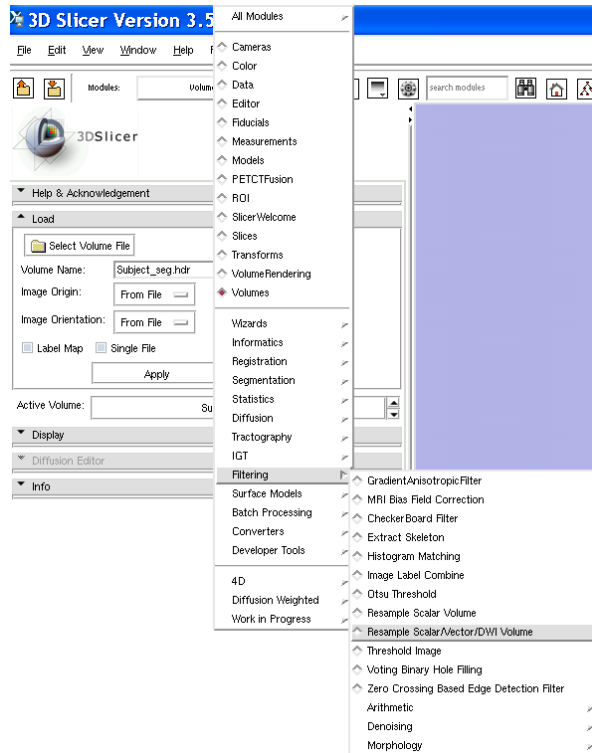
Affine registration in 3D Slicer



Check the 4x4 affine transformation matrix



Apply affine matrix to segmented image



The input to HAMMER

Save Scene and Unsaved Data

Save Scene & Data Options

Change Destination for All Selected:

Select	Node Name	Node Type	Node Status	File Format	File Name	Data Directory
<input type="checkbox"/>	model_cbq.hdr	Volume	Not Modified	Analyze (.hdr)	model_cbq.hdr	/stage/grwu/NAMIC/template
<input type="checkbox"/>	Subject_cbq.hdr	Volume	Not Modified	Analyze (.hdr)	Subject_cbq.hdr	/stage/grwu/NAMIC/OASIS_DATA
<input type="checkbox"/>	Affine registration Transform	LinearTrans...	Modified	Transform (.tfm)	Affine registration Tr...	/home/grwu
<input type="checkbox"/>	Subject_cbq_LR.hdr	Volume	Not Modified	NRRD (.nrrd)	Subject_cbq_LR.hdr....	/home/grwu
<input type="checkbox"/>	model_seg.hdr	Volume	Not Modified	Analyze (.hdr)	model_seg.hdr	/stage/grwu/NAMIC/template
<input type="checkbox"/>	Subject_seg.hdr	Volume	Not Modified	Analyze (.hdr)	Subject_seg.hdr	/stage/grwu/NAMIC/OASIS_DATA
<input checked="" type="checkbox"/>	Subject_seg_LR.hdr	Volume	Not Modified	Analyze (.hdr)	Subject_seg_LR.hdr	/stage/grwu/NAMIC/result

Save Selected Cancel

Parameters for HAMMER



Hit apply to run HAMMER