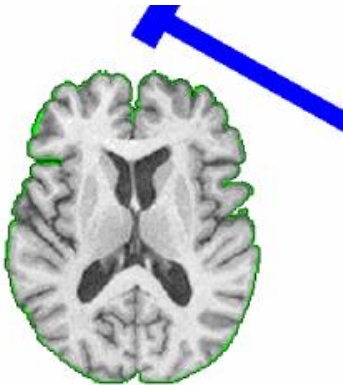


Using HAMMER in 3D Slicer



Guorong Wu*, Xiaodong Tao⁺, Jim Miller⁺, and Dinggang Shen*

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

⁺Visualization and Computer Vision Laboratory, GE Research, U.S.A.

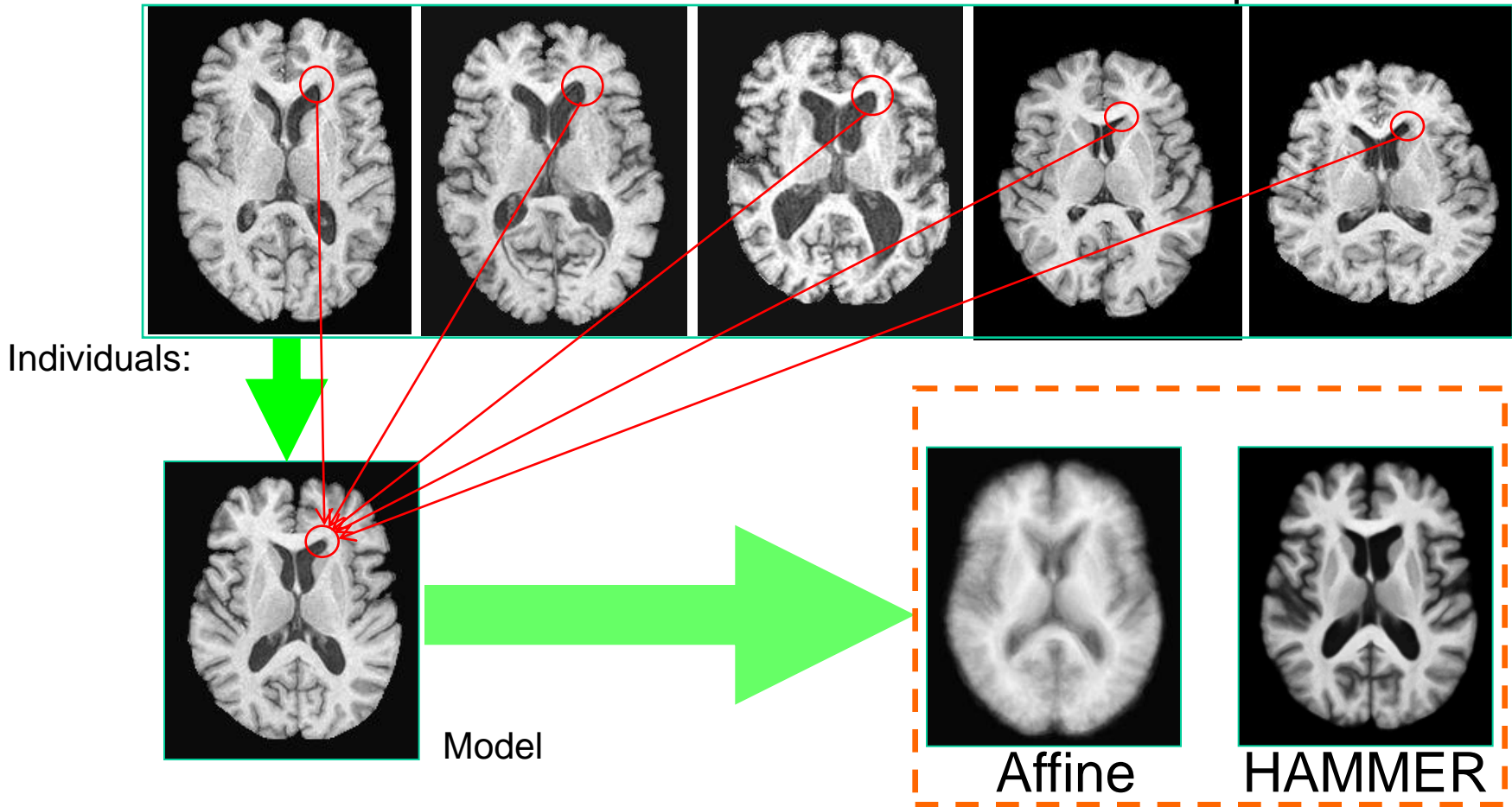
Using HAMMER in 3D Slicer

Contents

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

Introduction

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

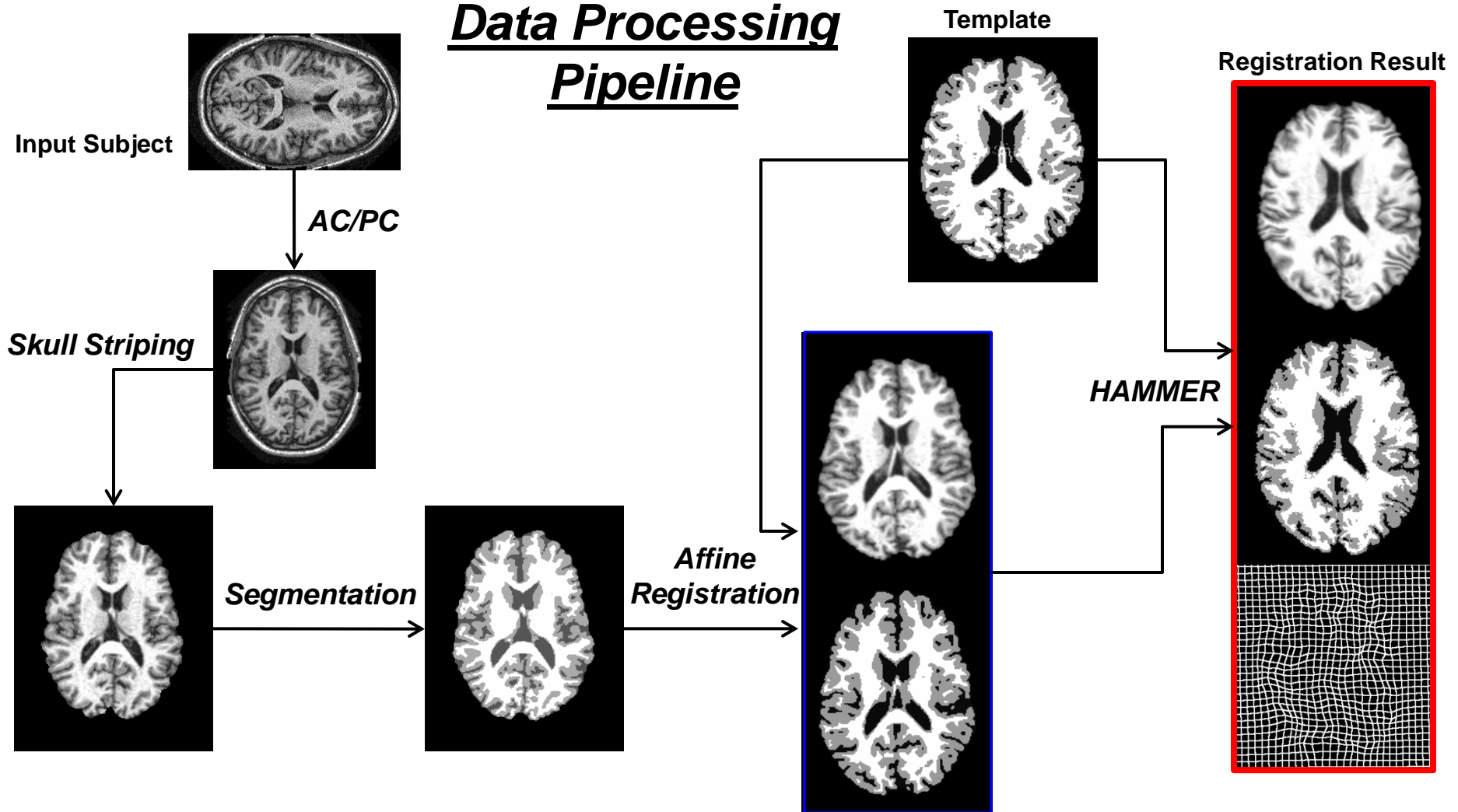


- Clinical applications:

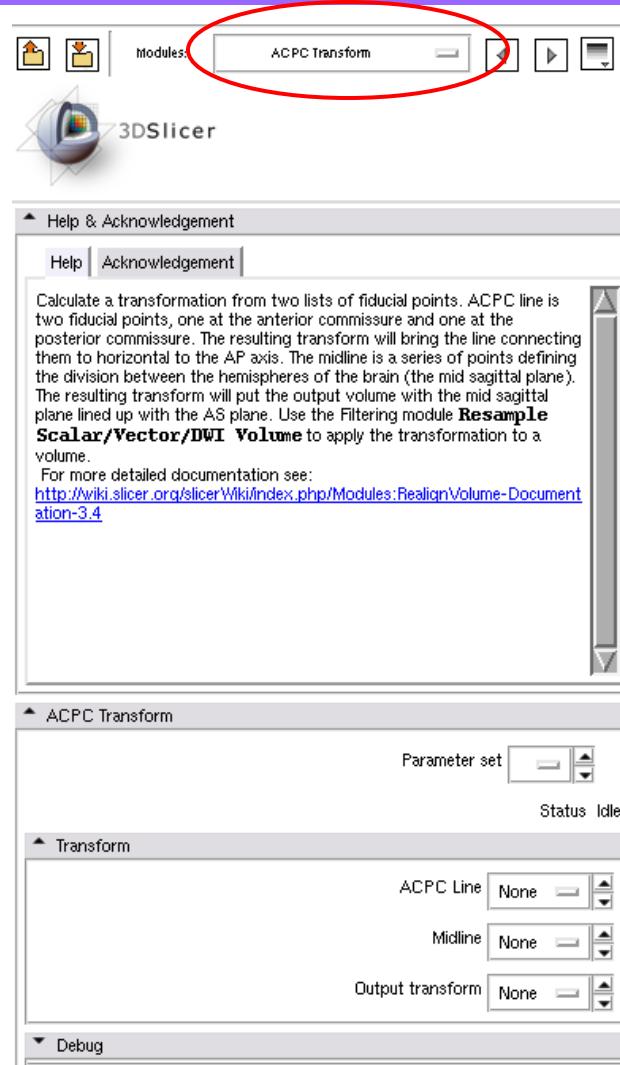
- † Spatial normalization of functional images, *for group analysis*.
- † Measurement of structures, *by deforming a model to individual*.
- † Image data mining *in lesion-deficit studies*.

- 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



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

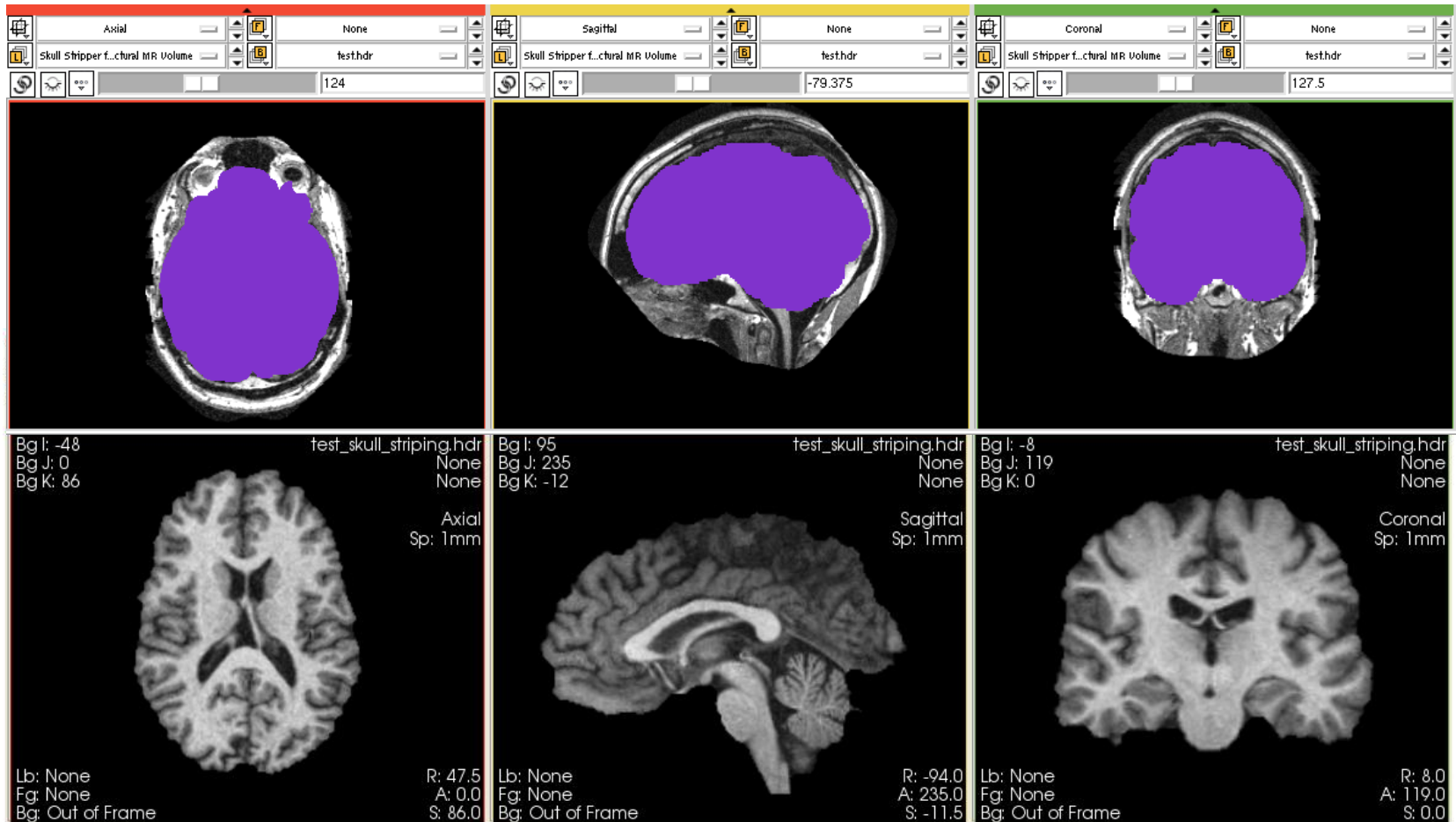
← Brain mask file

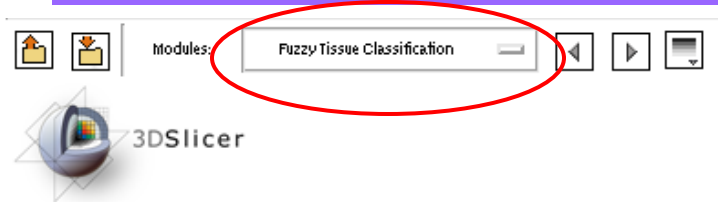
← Iterations used in skull stripping

← The number of sub-divisions

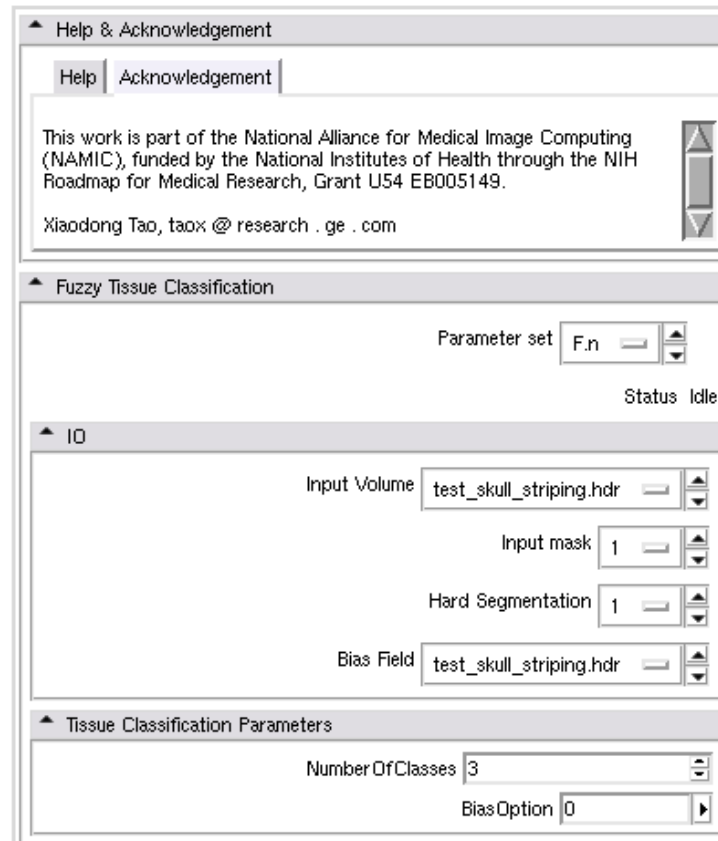
← The dilation radius after deformation

Skull Stripping





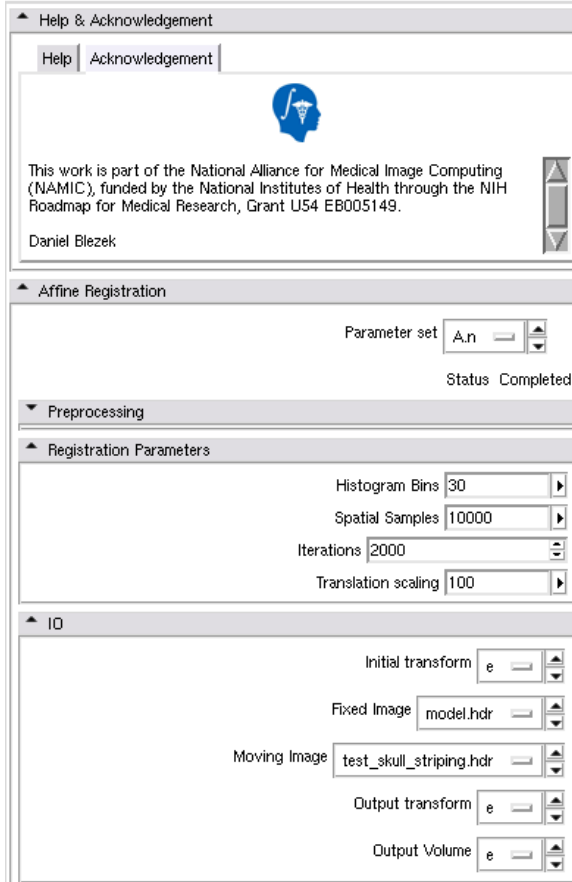
Segmentation and bias correction with 'Fuzzy Tissue Classification' in 3D Slicer



- ← *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

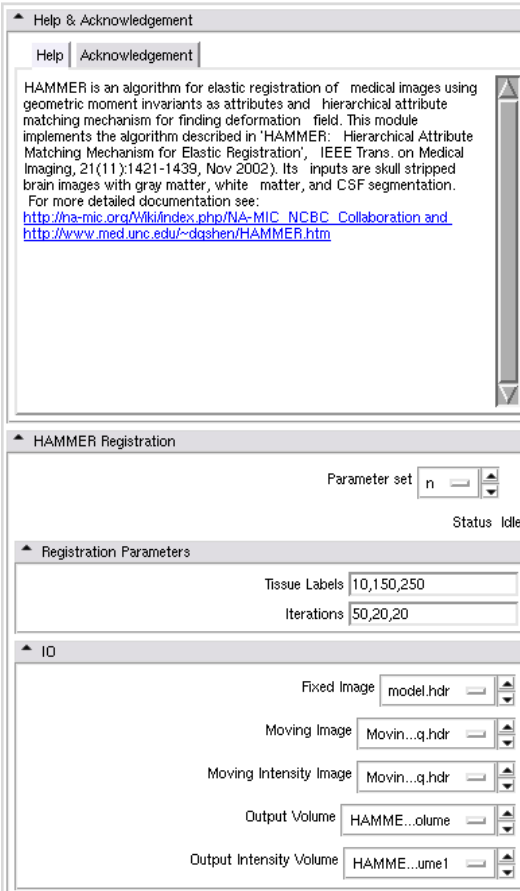
Moving image

Output transformation

Output affine registration result



HAMMER Registration in Slicer3



← The number of iterations in each resolution

← Fixed image

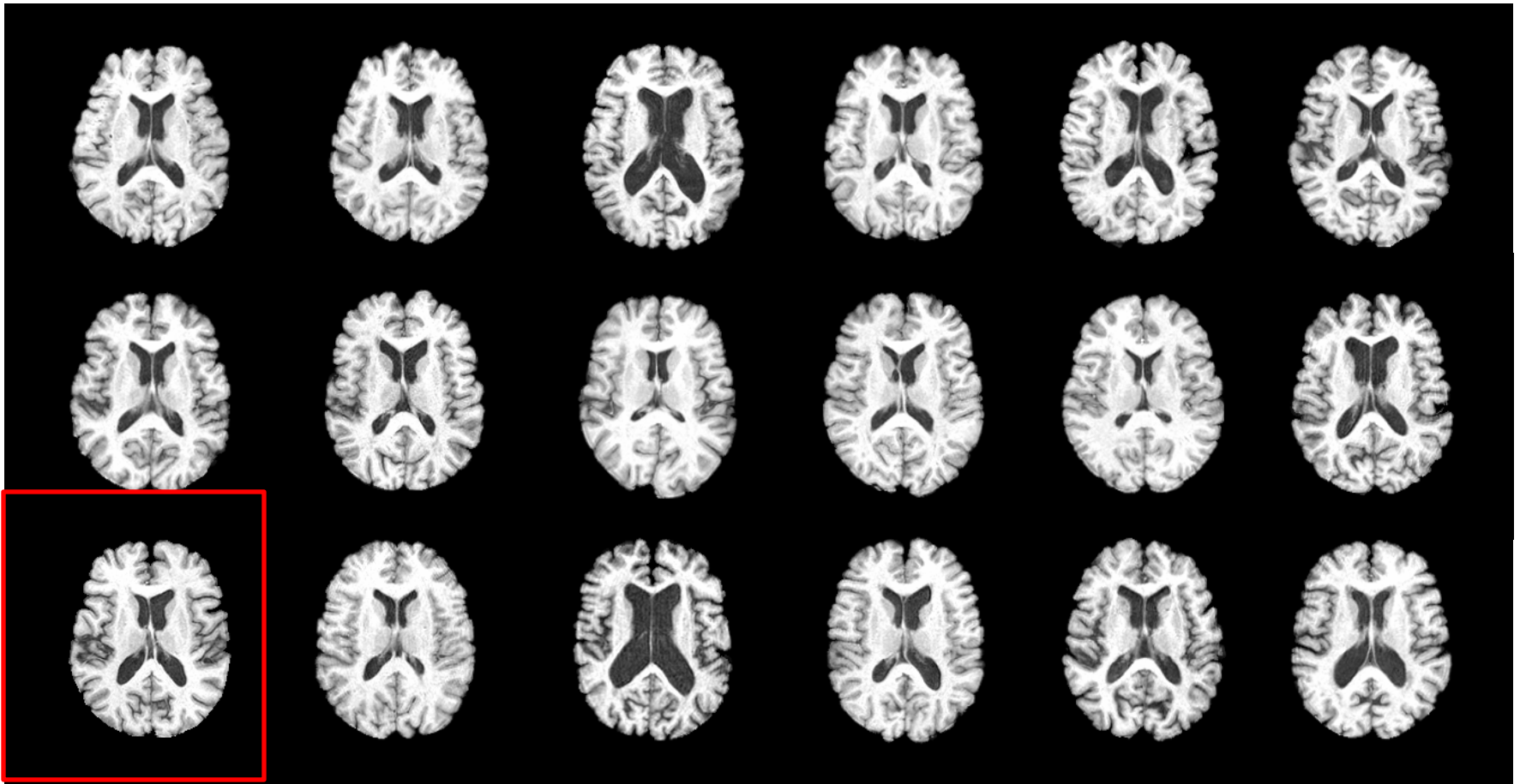
← Moving segmented image

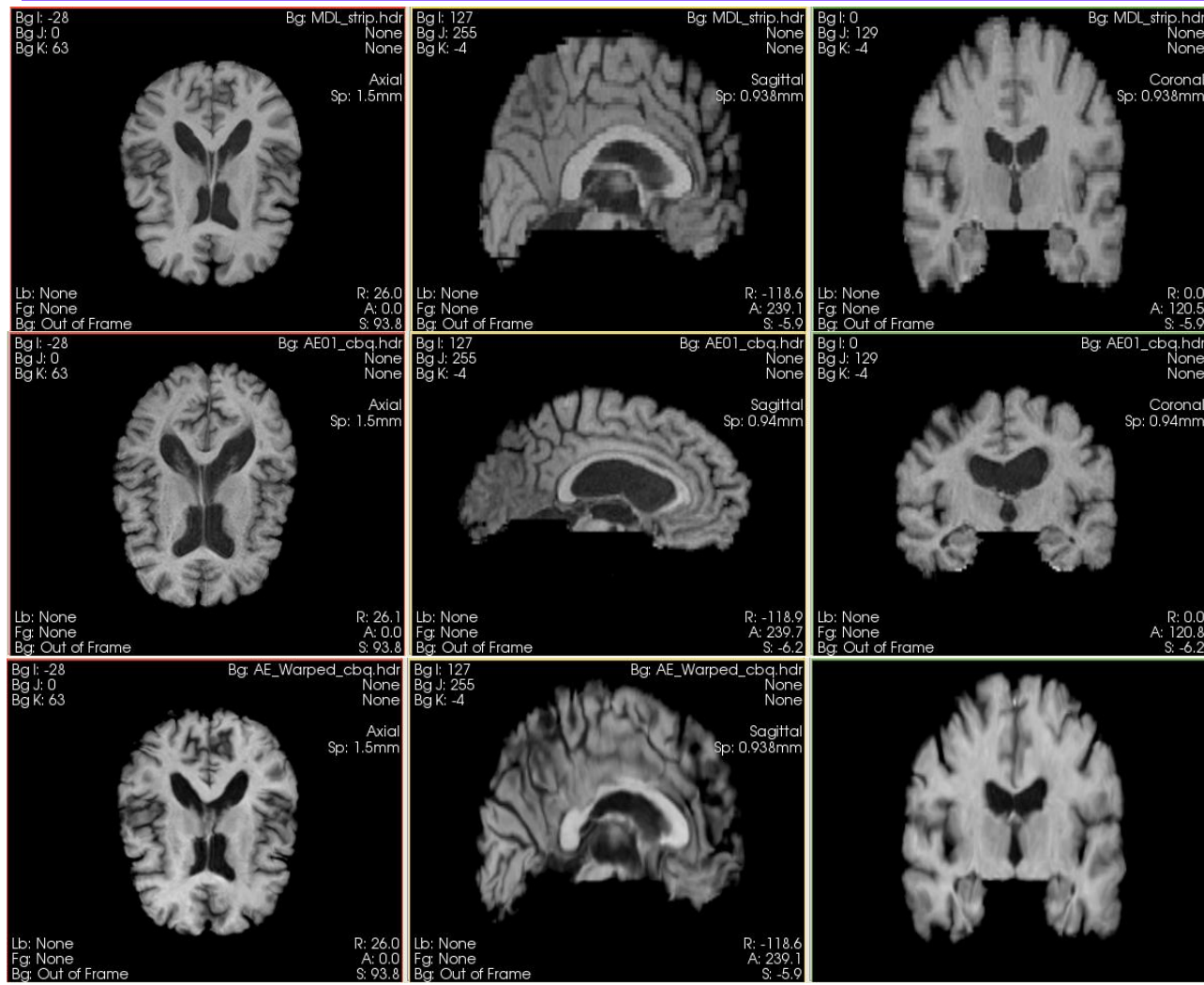
← Moving intensity image

← Output segmented image

← Output intensity image

Experiment 1: 18 Elderly Brains From BLSA Dataset



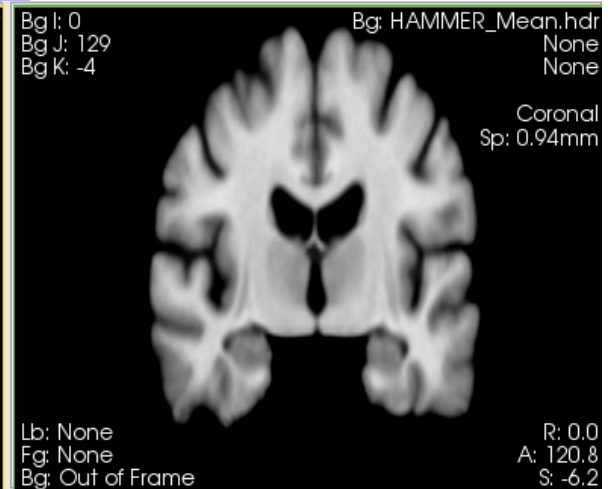
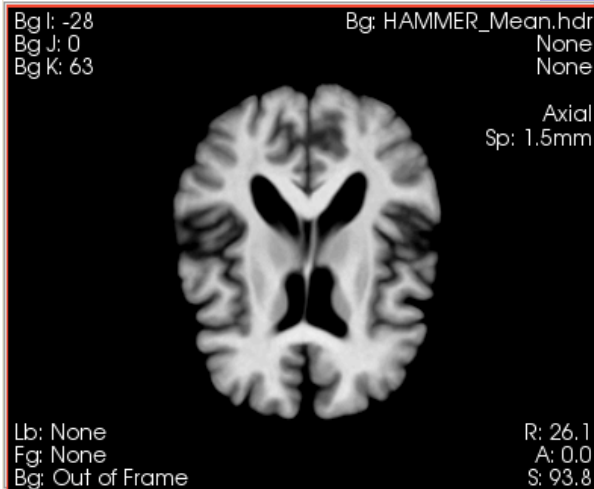
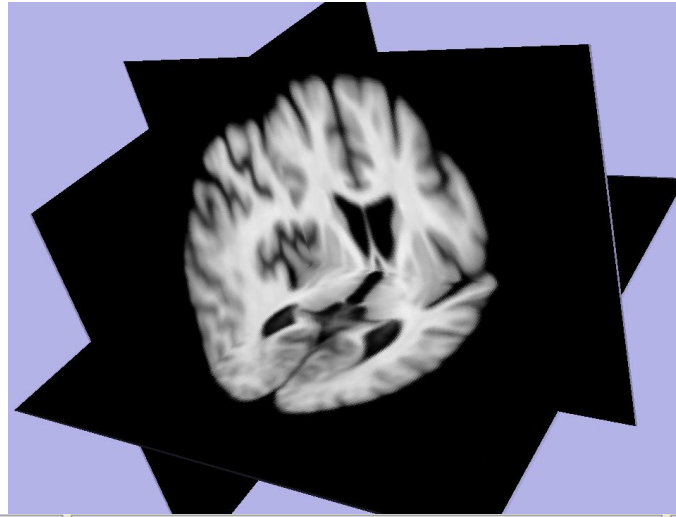


Template

Subject

Registration by
HAMMER

Average Image



40 LONI Dataset with 54 manually labeled RIOs

Laboratory of Neuro Imaging

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[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

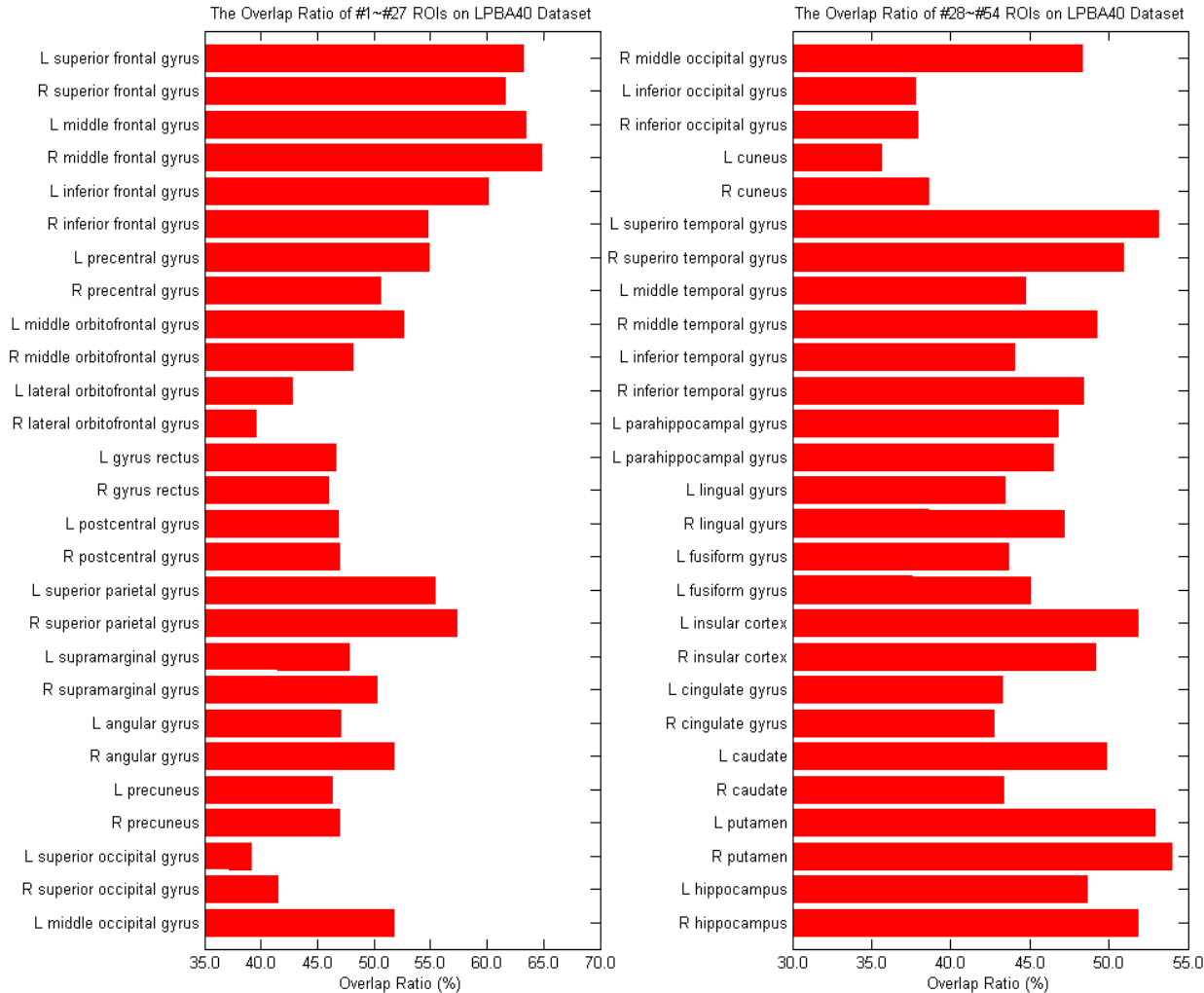
[Alzheimer's Disease Template](#)
[Human Atlas](#)
[ICBM 452 T1 Atlas](#)
[ICBM DTL-81 Atlas](#)
[ICBM Probabilistic Atlases](#)
[ICBM T2 Atlas](#)
[ICBM Template](#)
[LPBA40](#)
[Monkey Atlas](#)
[Mouse Atlas](#)
[Mouse Minimum](#)
[Deformation Atlas \(MDA\)](#)
[Neonatal \(P0\) Mouse Nissl](#)
[Brain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

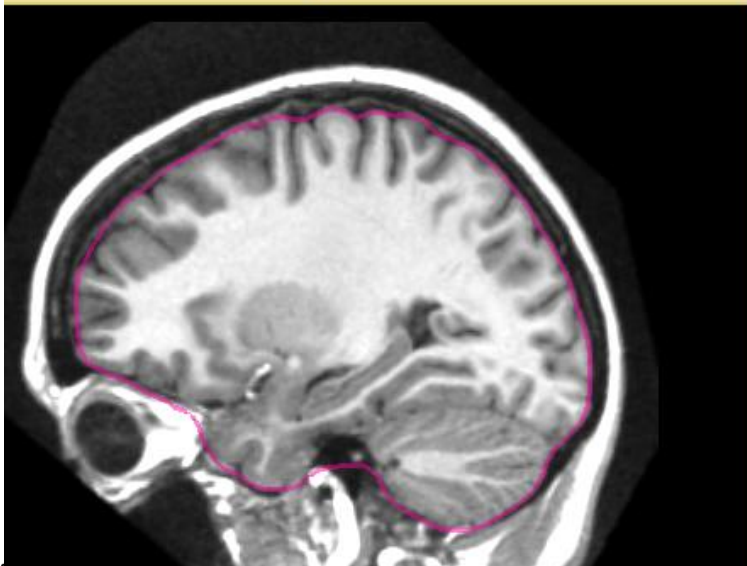
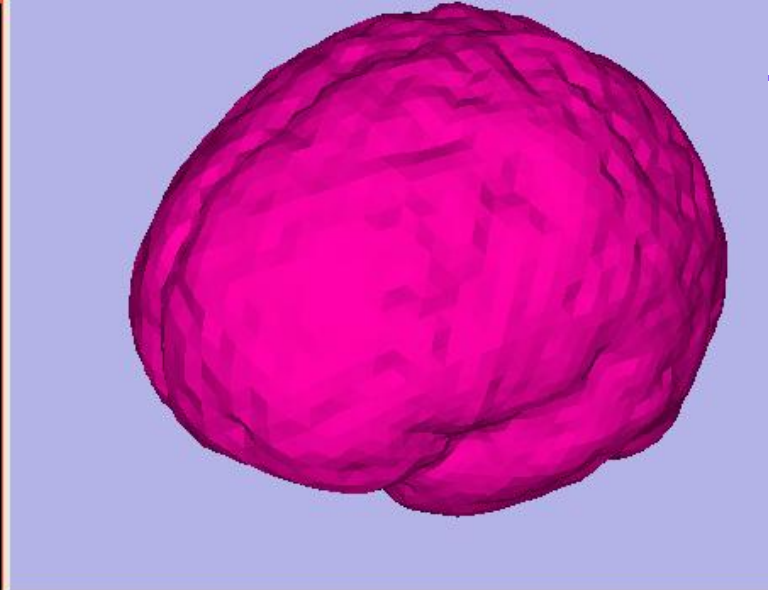
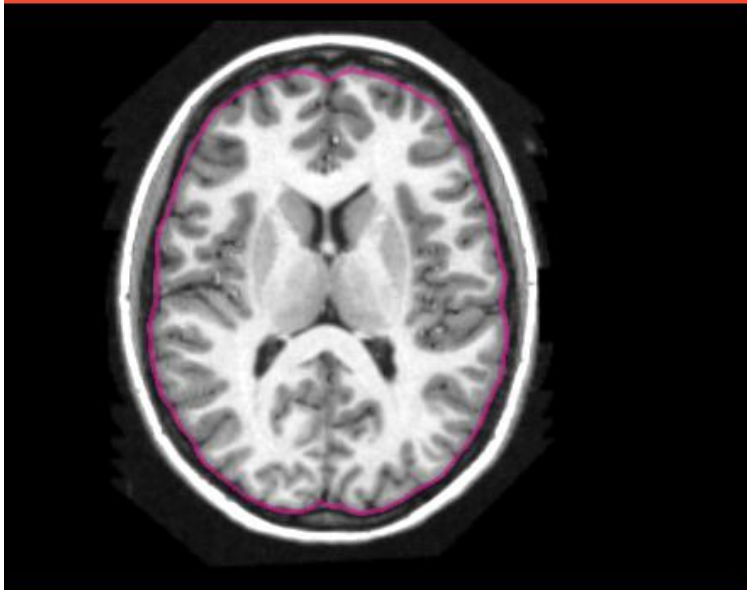
HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration

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



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL





Step-by-step tutorial

HAMMER - 3D Slicer Setup



```
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
  
```

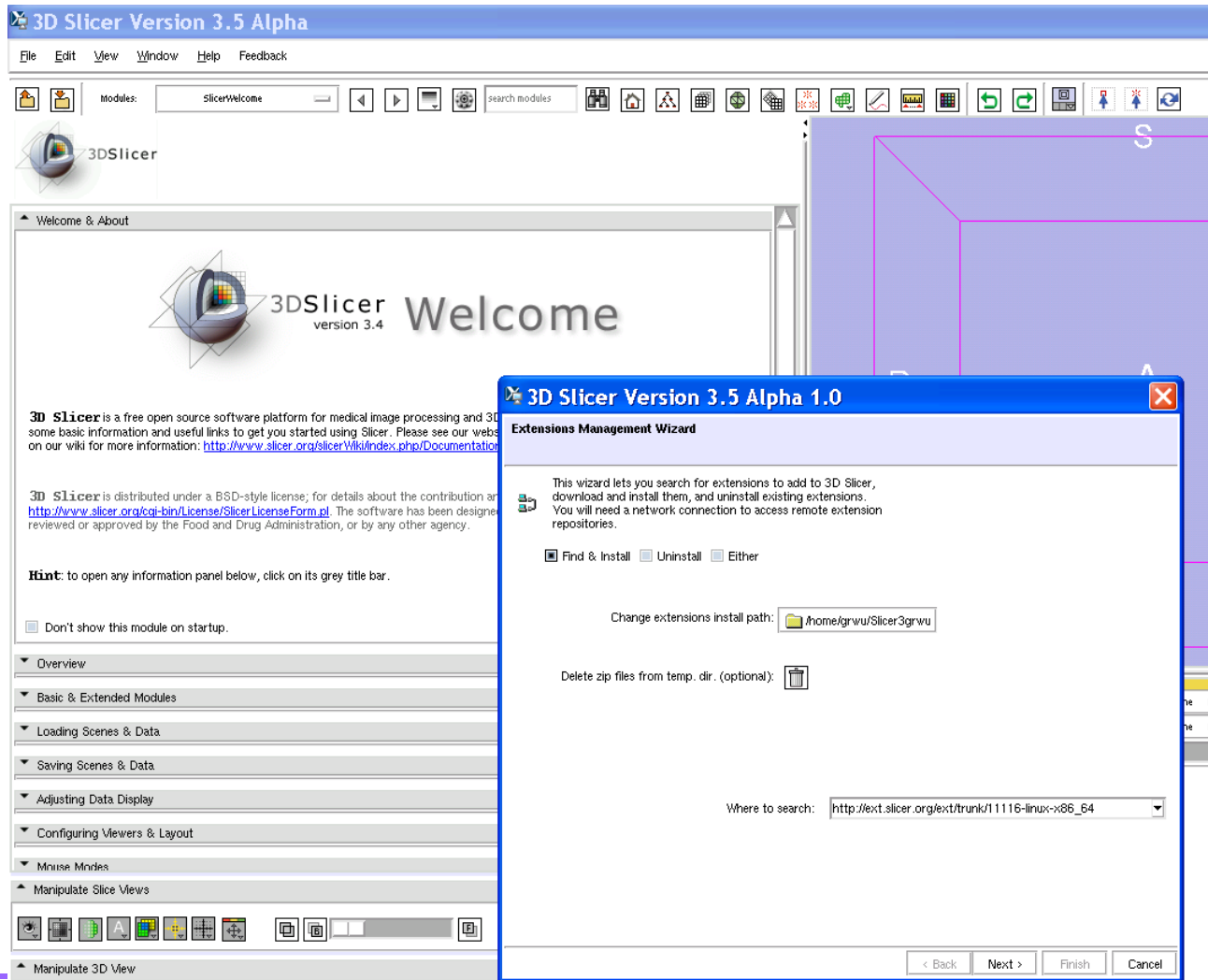
```

/home/grwu/Software/Slicer3-ext/HammerRegistration-build/CMakeFiles 1 2
[100%] Built target HammerRegistration
make[1]: Leaving directory `/home/grwu/Software/Slicer3-ext/HammerRegistration-b
uild'
/home/grwu/Software/Slicer3-lib/CMake-build/bin/cmake -E cmake_progress_start /h
ome/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-b
uild'
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-ins
tall/lib/Slicer3/Plugins/HammerRegistration
-- Removed runtime path from "/home/grwu/Software/Slicer3/../../Slicer3-ext/HammerR
egistration-install/lib/Slicer3/Plugins/HammerRegistration"

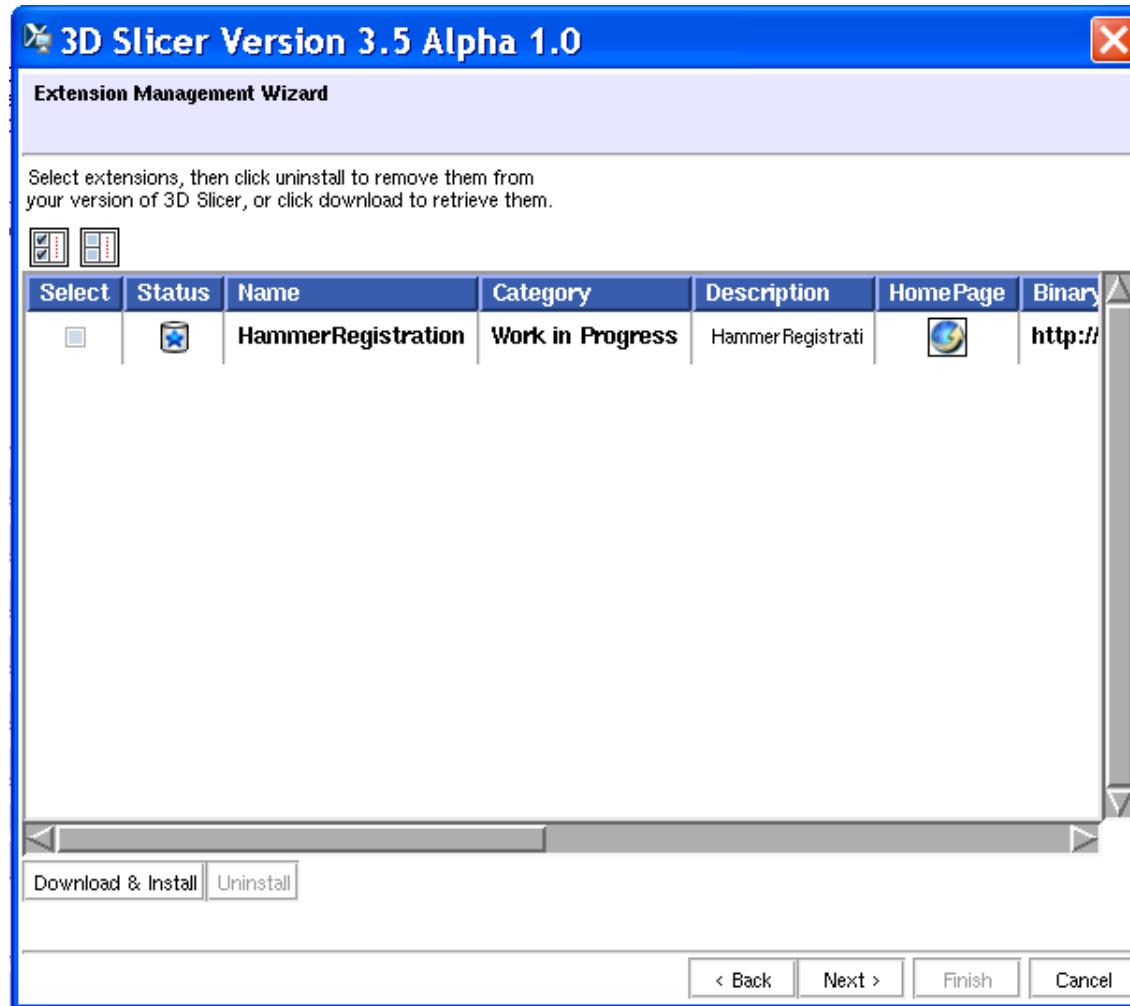
running: zip -r9 /home/grwu/Software/Slicer3/../../Slicer3-ext/HammerRegistration-i
nstall/lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip
*
  adding: HammerRegistration (deflated 79%)

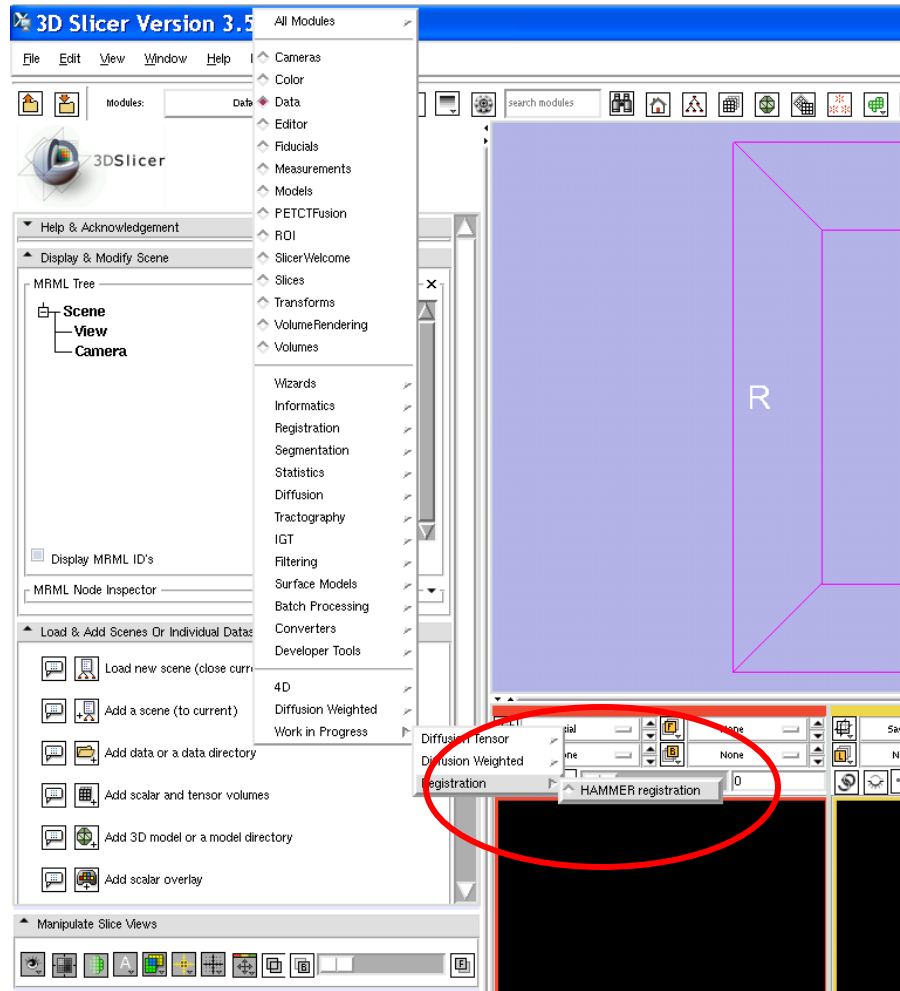
Uploading /home/grwu/Software/Slicer3/../../Slicer3-ext/HammerRegistration-install/
lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip to ext
.slicer.org port 8845...
uploaded /home/grwu/Software/Slicer3/../../Slicer3-ext/HammerRegistration-install/l
ib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip (964240
bytes)
Uploading /home/grwu/Software/Slicer3/../../Slicer3-ext/Extensions/HammerRegistrati
on.s3ext to ext.slicer.org port 8845...
uploaded /home/grwu/Software/Slicer3/../../Slicer3-ext/Extensions/HammerRegistratio
n.s3ext (787 bytes)
*****
BUILT:
  /home/grwu/Software/Slicer3/../../Slicer3-ext/Extensions/HammerRegistration.s3ext
100.0% succeeded
[grwu@bass-comp4:~/Software/Slicer3] $ █

```

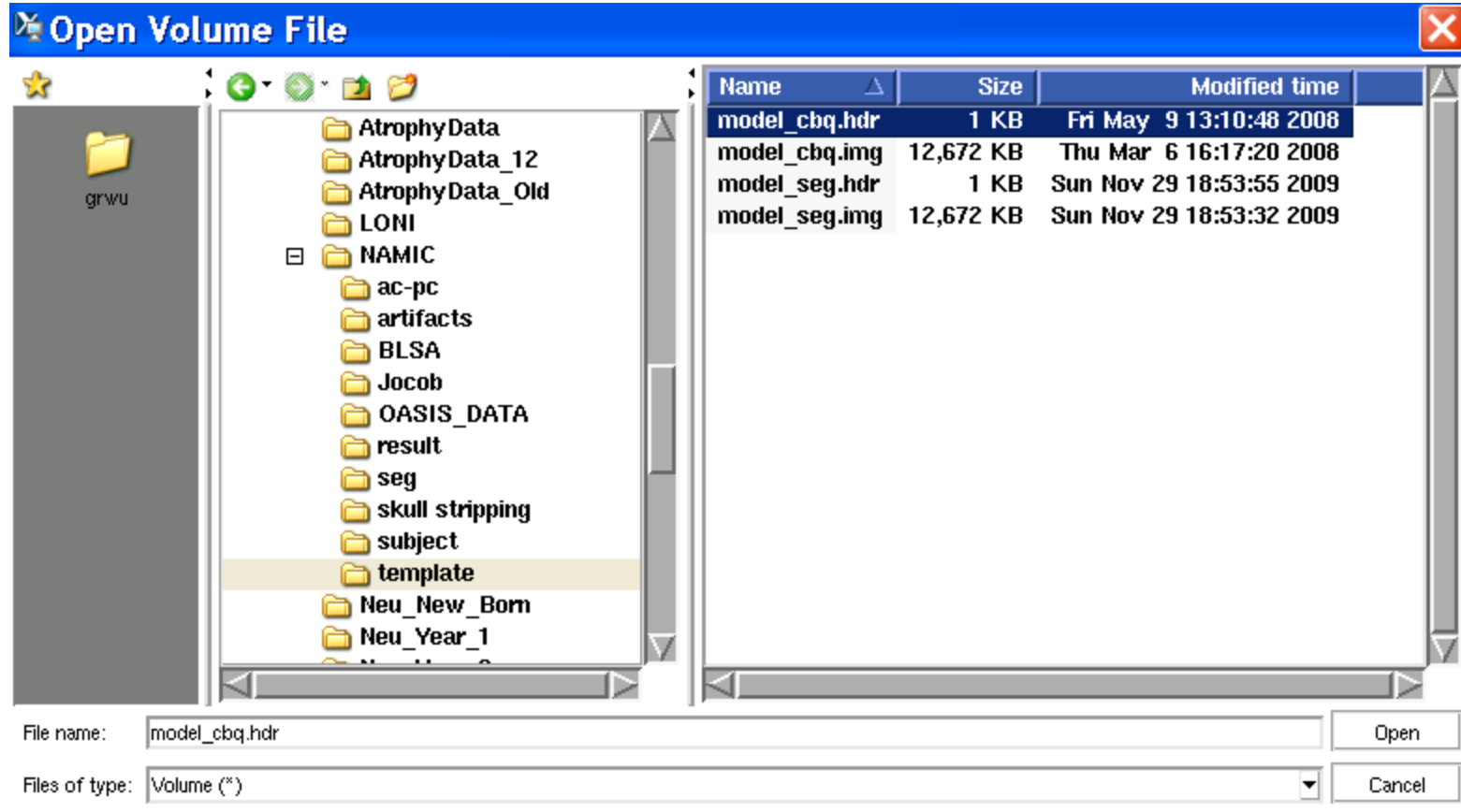


HAMMER – 3D Slicer Setup





Load model images

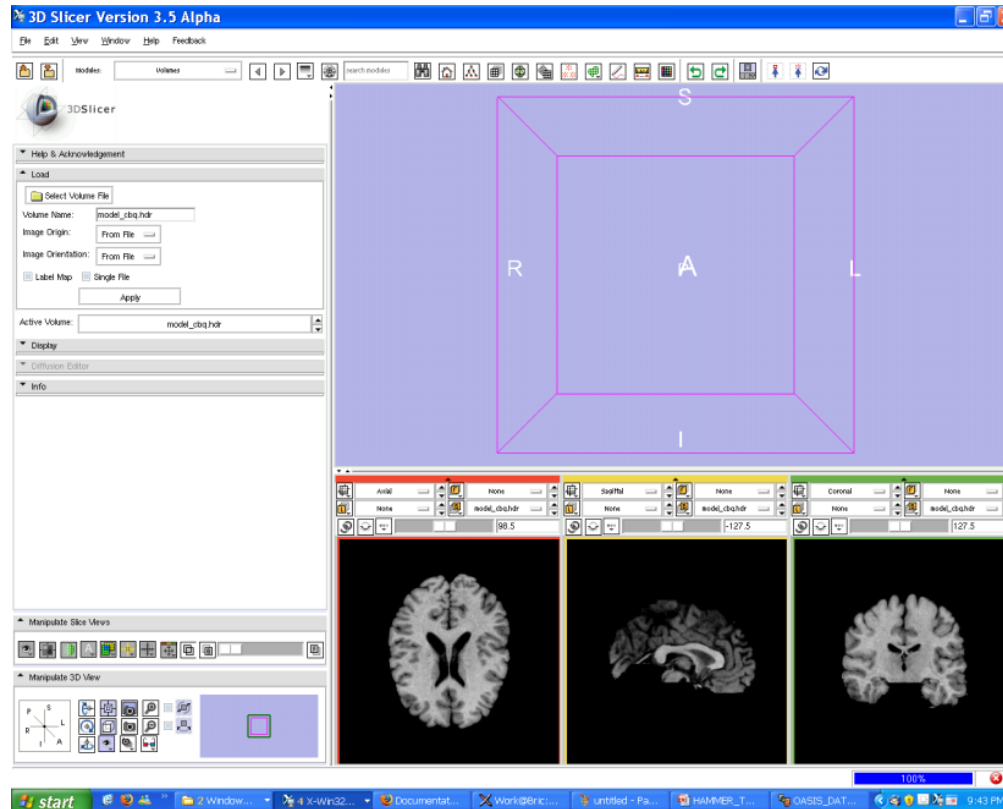




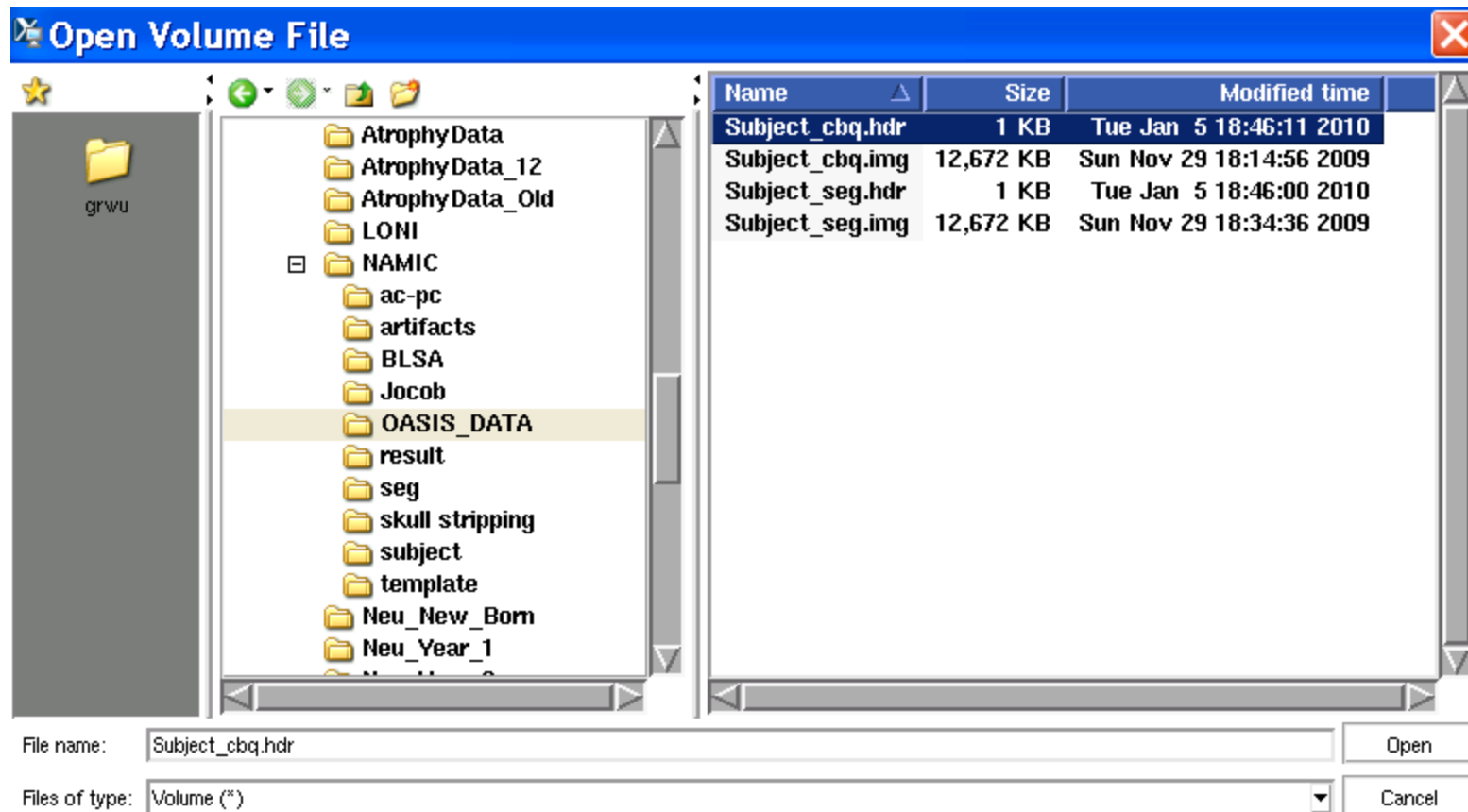
Using HAMMER in 3D Slicer



Load images



Load subject images

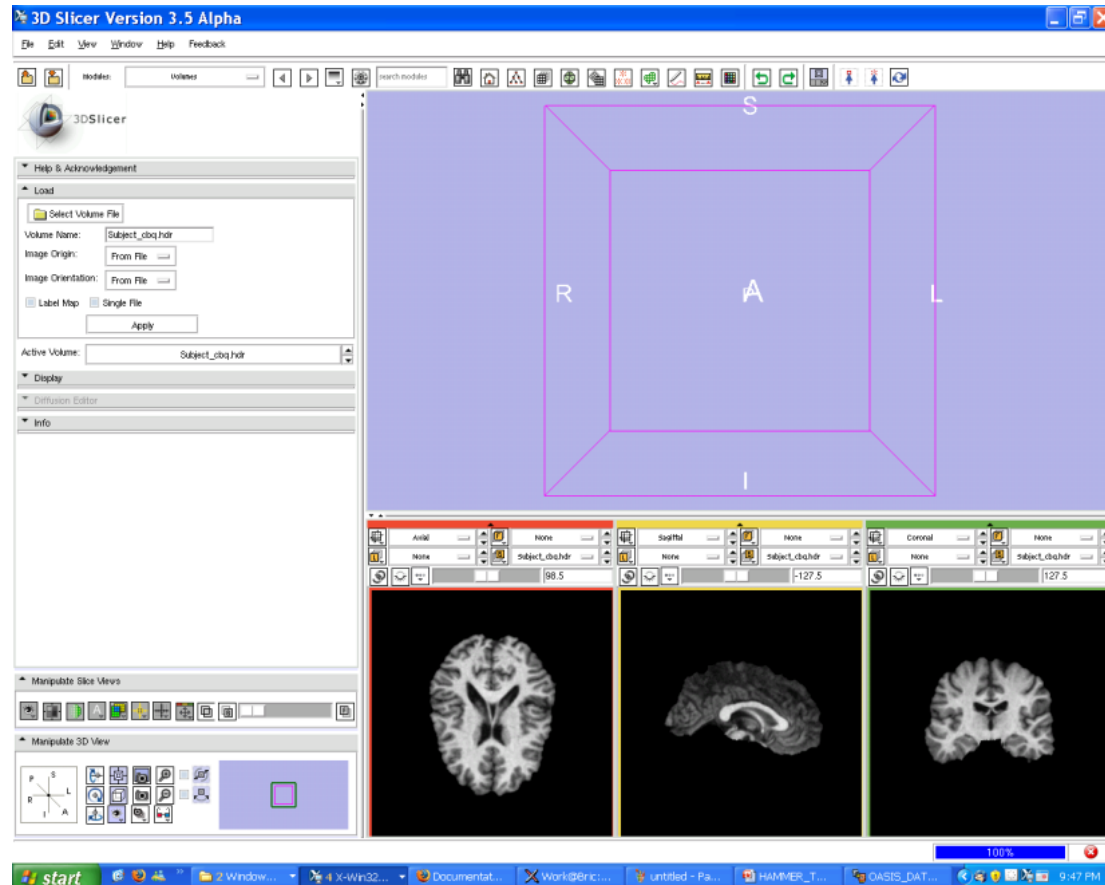




Using HAMMER in 3D Slicer



Load subject images

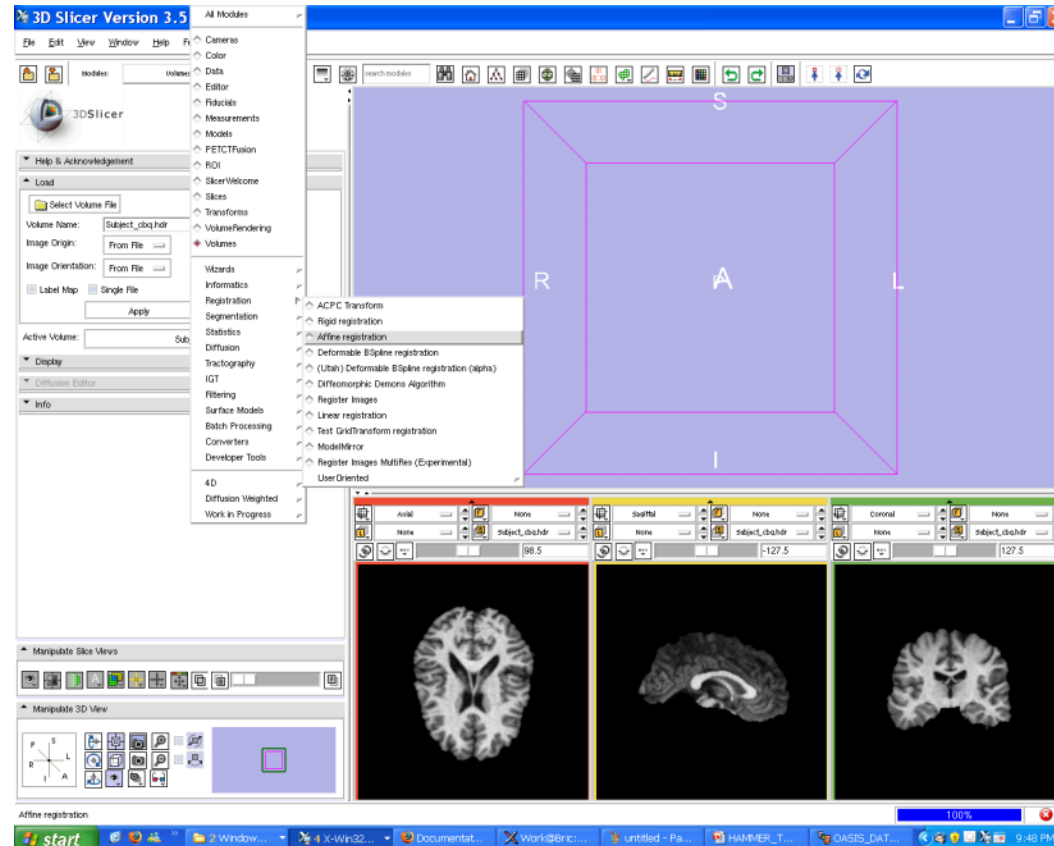




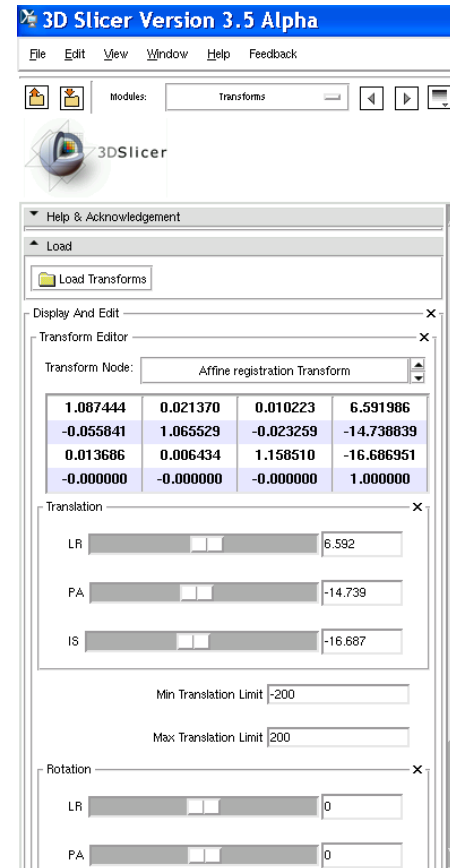
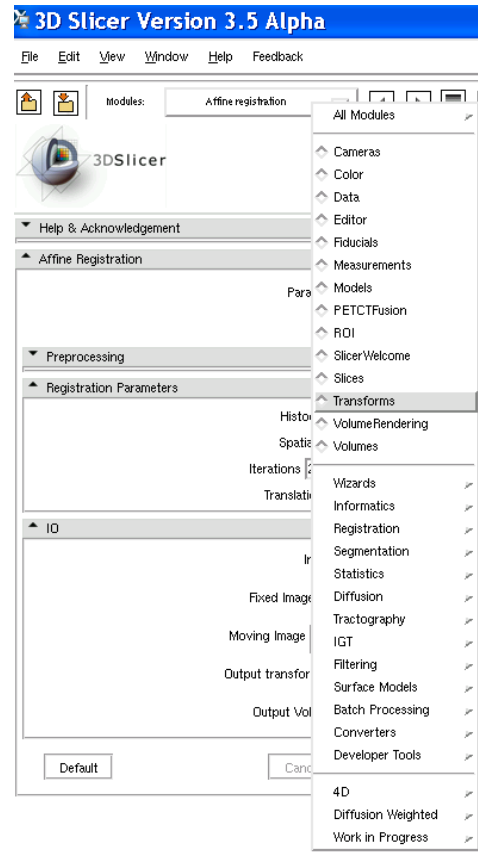
Using HAMMER in 3D Slicer



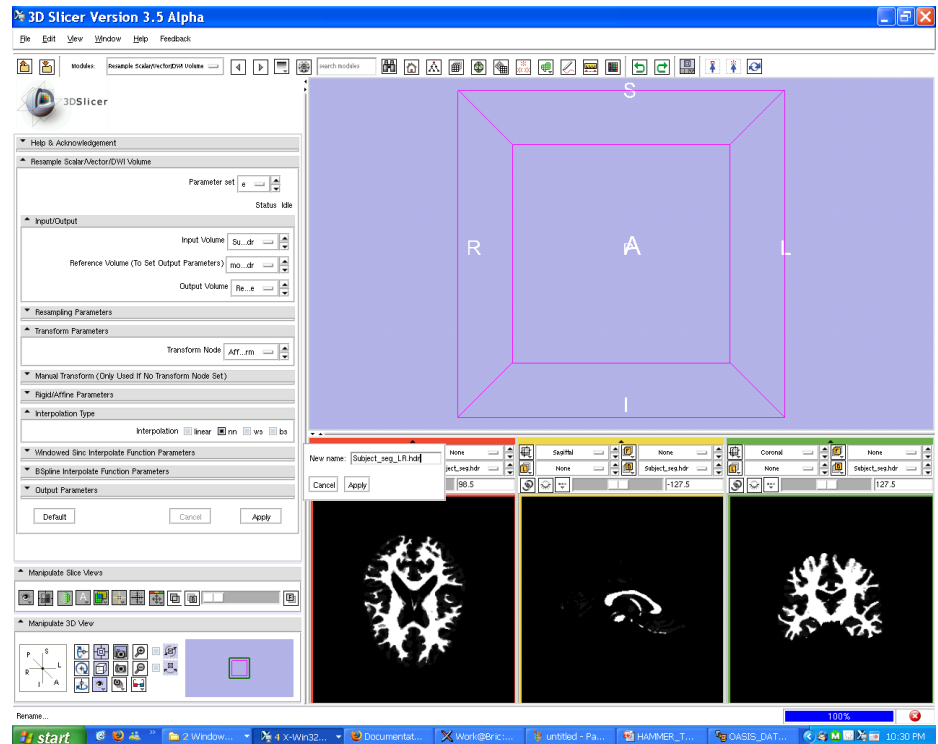
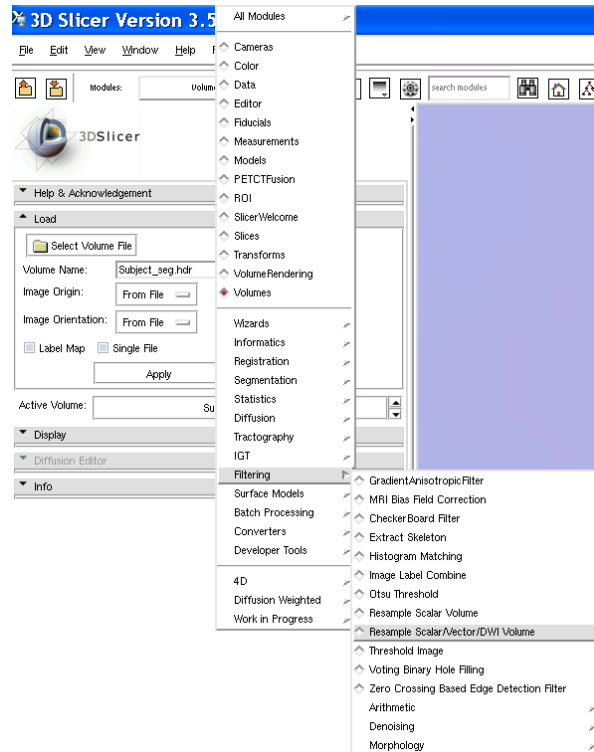
Affine registration in 3D Slicer



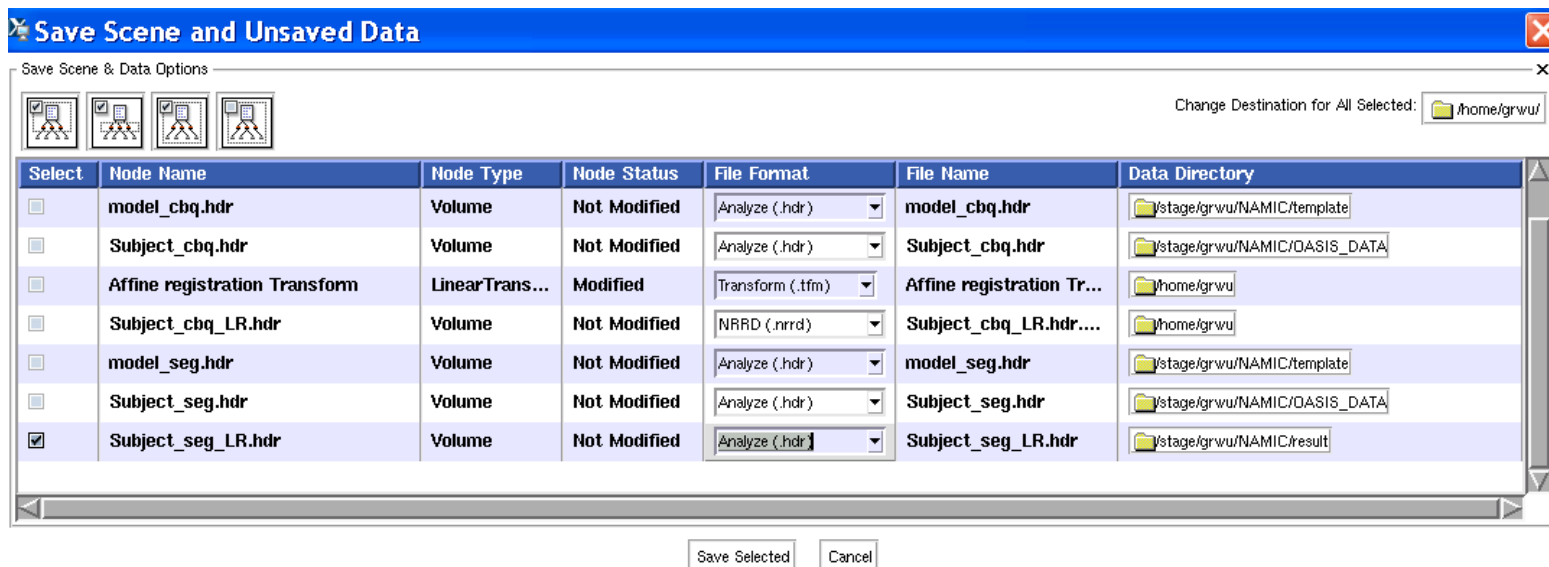
Check the 4x4 affine transformation matrix



Apply affine matrix to segmented image



The input to HAMMER





Using HAMMER in 3D Slicer



Parameters for HAMMER



Hit “Apply” button to run HAMMER

Acknowledgments



National Alliance for Medical Image Computing

NIH U54EB005149



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UNC at Chapel Hill