HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration

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• The objective of this tutorial is to present how to use HAMMER registration algorithm in Slicer3.

• Deformable registration has many important clinical applications:
  – Spatial normalization for group analysis;
  – Measurement of structure by deforming a model to individual;
  – Image data mining in lesion-deficit studies.
HAMMER: Background

• The goal of deformable registration of brain images
  --- Establish the anatomical correspondence
HAMMER: Background

- Two novelties:

An **attribute vector**, defined for each voxel in an image, and reflecting the underlying structures at different scales.

**Driving voxel** is used to hierarchically estimate the deformation, initially in sulcal root, gyrus crown, and ventricle corners.
Find the build instructions at http://www.slicer.org/slicerWiki/index.php/Slicer3:Build_Instructions
Build Latest Slicer

Download the latest slicer source code
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Build Slicer3

```
grwu@bass-comp4:~ /Software
Attic/   QTModules/
Base/    README.txt
CMake/   Resources/
CMakeLists.txt Scripts/
CTestConfig.cmake Slicer3Config.cmake.in
CTestCustom.cmake.in Slicer3InstallConfig.cmake.in
Doc/     slicer_variables2.tcl
Doxfile   slicer_variables.tcl
Extensions/ Testing/
GenerateSlicer3Config.cmake UseSlicer3.cmake.in
launch.tcl.in* Utilities/
Libs/     vtkSlicerConfigure.h.in
License.txt* [grwu@bass-comp4:/Software/Slicer3] $ ./Slicer3/Scripts/getbuildtest.tcl --update --released
License.txt* [grwu@bass-comp4:/Software/Slicer3] $ cd ..
License.txt* [grwu@bass-comp4:/Software] $ ./Slicer3/Scripts/getbuildtest.tcl --update --released
Sourcing /home/grwu/Software/Slicer3/slicer_variables.tcl
Slicer3_HOME is /home/grwu/Software/Slicer3
making with make -j 16
```
Install HAMMER Module

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Install HAMMER Module

```
/home/gruu/Software/Slicer3-ext/HammerRegistration-build/CMakefiles 1 2

[100%] Built target HammerRegistration
make[1]: Leaving directory `/home/gruu/Software/Slicer3-ext/HammerRegistration-build'
/home/gruu/Software/Slicer3-lib/CMake-build/bin/cmake -E cmake_progress_start /home/gruu/Software/Slicer3-ext/HammerRegistration-build/CMakeFiles 0
make -f CMakeFiles/Makefile2 preinstall
make[1]: Entering directory `/home/gruu/Software/Slicer3-ext/HammerRegistration-build'
make[1]: Nothing to be done for `preinstall'.
make[1]: Leaving directory `/home/gruu/Software/Slicer3-ext/HammerRegistration-build'

Install the project...
/home/gruu/Software/Slicer3-lib/CMake-build/bin/cmake -P cmake_install.cmake
-- Install configuration: "Debug"
-- Installing: /home/gruu/Software/Slicer3/..../Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration
-- Removed runtime path from "/home/gruu/Software/Slicer3/..../Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration"

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

Uploading /home/gruu/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/gruu/Software/Slicer3/..../Slicer3-ext/HammerRegistration-install/lib/Slicer3/Plugins/HammerRegistration-svn153-2010-01-05-linux-x86_64.zip (564240 bytes)
Uploading /home/gruu/Software/Slicer3/..../Slicer3-ext/Extensions/HammerRegistration.s3ext to ext.slicer.org port 8845...
uploaded /home/gruu/Software/Slicer3/..../Slicer3-ext/Extensions/HammerRegistration.s3ext (787 bytes)

***************

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

100.0% succeeded
```

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Install HAMMER Module

3D Slicer Version 3.5 Alpha 1.0

Extension Management Wizard

Select extensions, then click uninstall to remove them from your version of 3D Slicer, or click download to retrieve them.

Select | Status | Name        | Category | Description  | HomePage | Binary
-------|--------|-------------|----------|--------------|----------|--------
  ✔    |        | HammerRegistration | Work in Progress | HammerRegistration | http://i

Download & Install Uninstall

Finish Cancel

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Install HAMMER Module
**Using HAMMER**

**Input:**
- Fixed intensity Image
- Moving intensity Image
- Fixed segmented Image
- Moving segmented Image

**Processing:**
- Skull striping
- Segmentation
- Registration
  - Affine Registration
  - Deformable Registration (HAMMER)

**Output:**
- Warped intensity Image
- Warped segmented Image
Using HAMMER

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Using HAMMER

http://www.slicer.org/slicerWiki/index.php/Documentation-3.4#Segmentation
Using HAMMER

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Moving Image (intensity, segmented)

Working directory

Fixed Image (intensity, segmented)
Open the Fixed Intensity Brain
Open the Moving Intensity Brain
Open the Moving Intensity Brain
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Affine Registration

Default parameters:

Fixed Image: model_cbq.hdr
Moving Image: subject_cbq.hdr
Output Transform: Affine Registration Transform

Rename the output Transform
Affine Registration

Output Volume: Subject_cbq_LR.hdr

Rename the output transform
Affine Registration

Affine Registration Result on Intensity Images
Save the Affine Results
Save the Affine Results

Working directory
Save the affine registration and affine transformation matrix.

Change to ‘analyze’ format.

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Check the Transformation

Transforms
Affine registration Transform
Open the Fixed Segmented Brain

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Open the Fixed Segmented Brain

Model_seg.hdr
Open the MovingSegmented Brain

Subject_seg.hdr
Perform Affine Transform

Resample Scalar/Vector/DWI Volume

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Perform Affine Transform

Input Volume: Subject_seg.hdr
Reference Volume: model_seg.hdr
Output: Subject_seg_LR.hdr
Transform Node: Affine registration Transform.tfm

Nearest neighborhood Interpolator
Save the Affine Results

Change to ‘Analyze’ format
Run HAMMER

Iterations in low, middle, and high resolution

Fixed Image: model_seg.hdr
Moving Image: Subject_seg_LR.hdr
Moving Intensity Image: Subject_cbq_LR.hdr
Output Volume: Subject_seg_HAMMER.hdr
Output intensity Volume: Subject_cbq_HAMMER.hdr

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HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration

Run HAMMER

Warping Result (intensity image)
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HAMMER: Validation

Experiment 1: 18 Elder Brains From BLSA Dataset
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HAMMER: Results

Average Image
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 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.
HAMMER: Results

The Overlap Ratio of #1-427 ROIs on LPBA40 Dataset

The Overlap Ratio of #35-464 ROIs on LPBA40 Dataset

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