HAMMER: Hierarchical Attribute Matching Mechanism for Elastic Registration

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Learning Objective

- 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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Install HAMMER Module

```
-xterm
-bash-3.2$ cd ...
-bash-3.2$ cd ...
-bash-3.2$ ls

Install HAMMER Module

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-8-
```
Install HAMMER Module

```
/home/grwu/Software/Slicer3-ext/HammerRegistration-build/CMakefiles 1 2
[100%] Built target HammerRegistration
make[1]: Leaving directory `/home/grwu/Software/Slicer3-ext/HammerRegistration-build'
/home/grwu/Software/Slicer3-ext/CMake-build/bin/cmake -E cmake_progress_start /home/grwu/Software/Slicer3-ext/HammerRegistration-build/CMakeFiles
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-ext/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 (564240 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
```

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Install HAMMER Module

Search modules

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Install HAMMER Module

[Image of the 3D Slicer Version 3.5 Alpha 1.0 extension manager window with HAMMER registration highlighted]
Install HAMMER Module

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Using HAMMER

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

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

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

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Using HAMMER

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

- EM Segment Command-Line (Brad Davis, Will Schroeder)
- EM Segment Simple (Brad Davis, Will Schroeder)
- EM Segment Template Builder (Brad Davis, Will Schroeder)
- Simple Region Growing (Jim Miller)
- Otsu Threshold (Bill Lorensen)
Using HAMMER

Moving Image (intensity, segmented)

Working directory

Fixed Image (intensity, segmented)
Open the Fixed Intensity Brain

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Open the Fixed Intensity Brain
Open the Moving Intensity Brain

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Open the Moving Intensity Brain

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Affine Registration

‘Affine Registration’ Module in Slicer3
**Affine Registration**

- **Default parameters**
- **Fixed Image**: `model_cbq.hdr`
- **Moving Image**: `subject_cbq.hdr`
- **Output Transform**: `Affine Registration Transform`

*Rename the output Transform*
Output Volume: Subject_cbq_LR.hdr

Rename the output transform
Affine Registration Result on Intensity Images
Save the Affine Results

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Save the Affine Results

Working directory
Save the affine registration and affine transformation matrix.

Change to ‘analyze’ format.
Check the Transformation
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Check the Transformation

Affine registration Transform
Open the Fixed Segmented Brain

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Open the Fixed Segmented Brain

Model_seg.hdr
Open the Moving Segmented Brain
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Perform Affine Transform

Resample Scalar/Vector/DWI Volume
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
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**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
Run HAMMER

Warping Result (intensity image)
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HAMMER: Validation

Experiment 1: 18 Elder Brains From BLSA Dataset
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**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/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 an changes over time, as in development or degeneration. An atlas enables comparison across individuals, modalities of states. Differences between species can be cataloged. 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.
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HAMMER: Results
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