



NA-MIC

National Alliance for Medical Image Computing

<http://na-mic.org>

Slicer3 Tutorial

Atlas Registration & Label Merging

Dominik Meier, Ron Kikinis

February 2010



Overview

- | | | |
|-----|-------------------------------|-----------------------|
| 1. | Introduction | takes how long to do? |
| 2. | Prerequisites | |
| 3. | Modules Used | |
| 4. | Loading Example Dataset | 1 min |
| 5. | Viewing Input Data | 3 min |
| 6. | Build Thalamus Mask Images | 10 min |
| 7. | Build Thalamus Surface Models | 3 min |
| 8. | Register Surfaces | 3 min |
| 9. | Apply Transform | 5 min |
| 10. | Mask & Clip | 5 min |
| 11. | Merge Labels & Save | 5 min |

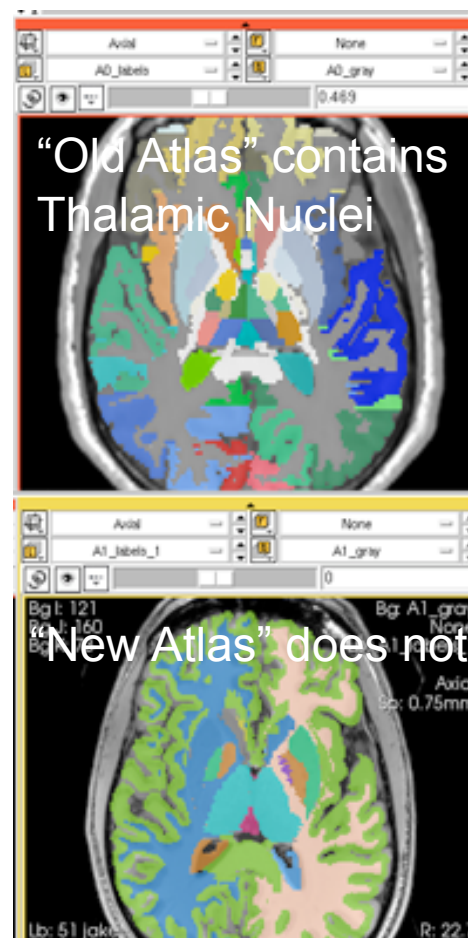
Note: if wish to skip parts of the tutorial, you will find the data generated by individual steps in the Example Data Folder. You may load these individually via the “File/ Add Data...” menu.

The SlicerScene file that comes with the tutorial will only load the initial volume data.



Introduction / Scenario

- We have two anatomic atlases, obtained from two separate individuals by expert radiologist tracing. We refer to them as A0 (“old atlas”) and A1 (“new atlas”)
- The “old atlas” A0 contains labels for 25 thalamic nuclei and substructures that are not present in the “new atlas” A1.
- We want to transfer these labels from A0 -> A1, i.e. obtain a best possible estimate about the thalamic nuclei in A1 based on the information in A0
- To this end we co-register the two atlases such that the thalamus of both align as good as possible. Then we merge the two label maps.
- Because the two atlases hail from different individuals, no perfect alignment can be expected.
- Because we’re interested only in the thalamus, we seek optimal alignment there and do not care much about the rest of the brain.

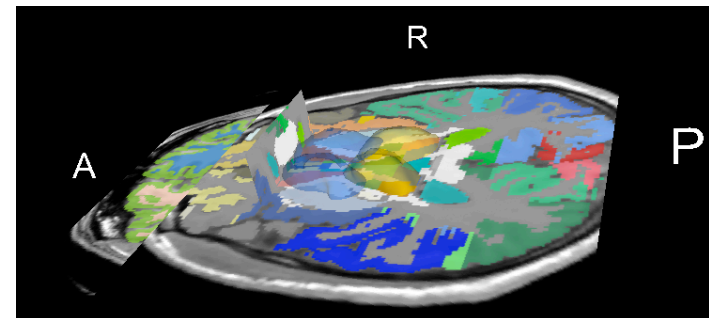


animated GIFs: view in Presentation Mode



Modules Used

- To accomplish this task we will use the following modules:
 - Editor (thresholding)
 - Editor (change island)
 - Python Surface ICP Registration
 - Mask Image
 - Cast Image
 - Label merge
 - Color
 - Models





Prerequisites

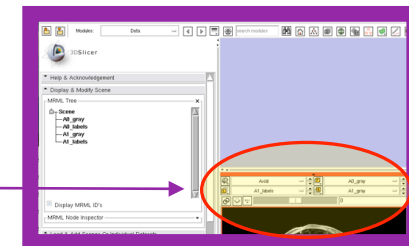
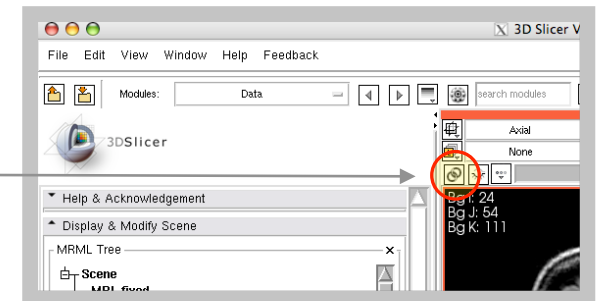
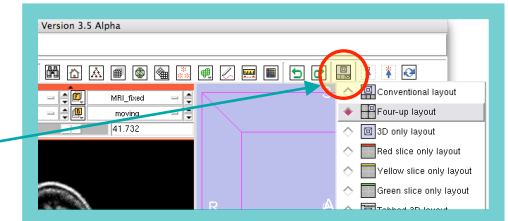
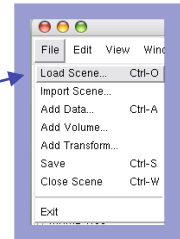
- Slicer version 3.5 or later
- **Example Dataset:** download and extract the dataset for this tutorial: Slicer_AtlasMerge.zip. It should contain:
 - ManualRegTutorial.ppt Power Point File with this tutorial
 - ManualRegTutorial.pdf PDF with this tutorial
 - AtlasMergeTutorial_SlicerScene.mrml Slicer Scene File to load
 - A0_gray.nrrd, A1_gray.nrrd grayscale images of both atlases
 - A0_label.nrrd, A1_label.nrrd labelmap images of both atlases
- **Tutorials to complete first** (helpful but not required):
 - Slicer3Minute Tutorial
 - Loading and Viewing Data
 - <http://www.slicer.org/slicerWiki/index.php/Slicer3.4:Training>



1. Loading Example Dataset

To get the Example Dataset loaded into Slicer:

- File** Menu: File: Load Scene...
 - Select the Slicer Scene file that comes with the downloaded example dataset, called: AtlasMerge_SlicerScene.mrml
 - This will load all the necessary images
- Select Layout:** From the icon bar, click on the Layout menu and select “Conventional Layout”.
- Link Views:** Click on the Ring Icon in any of the slice views to link all the views together. This will save you the work of making selections for each slice window separately.
- Choose Foreground:** A0_gray
- Choose Background:** A1_gray
- Choose Labelmap:** A1_labels

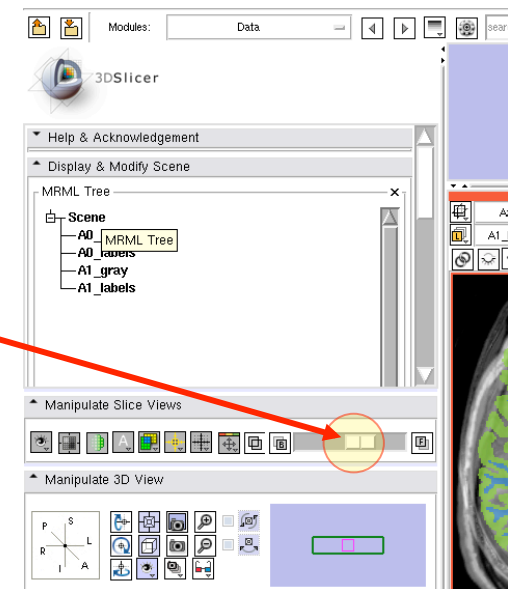
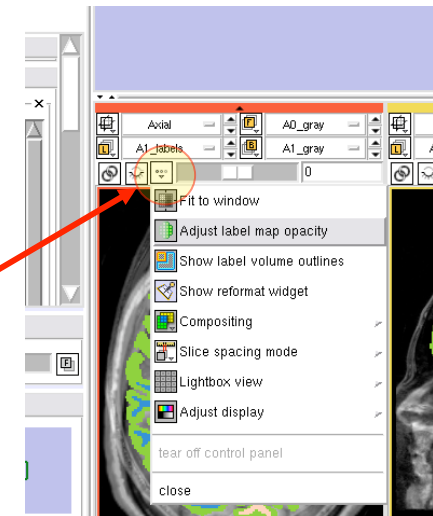
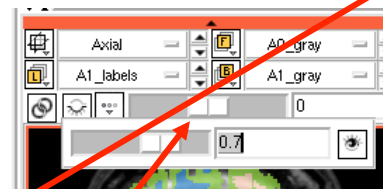




Adjust Slice Views


To get an idea of the initial data and misalignment, perform the following to see both datasets in one image:

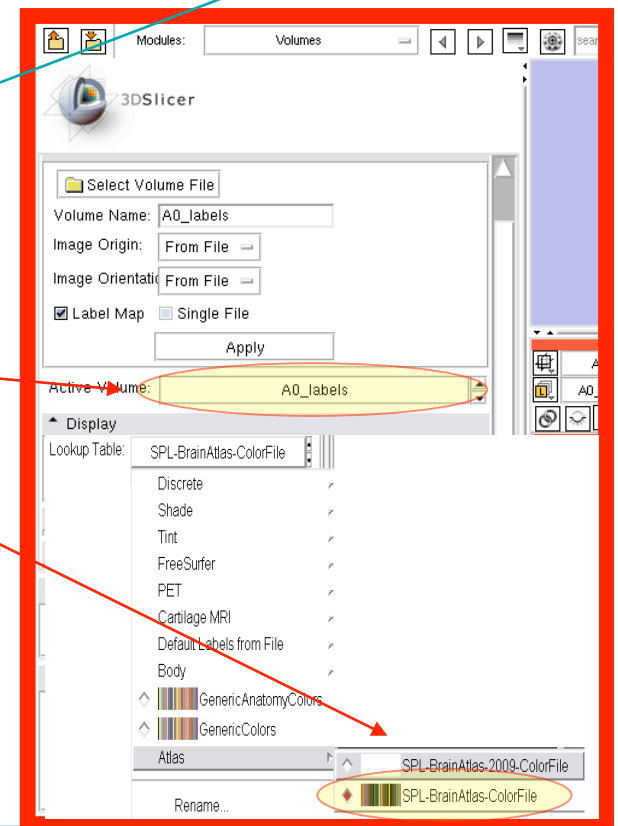
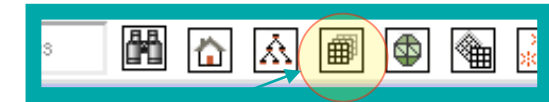
1. Adjust the **labelmap opacity** to see both the grayscale image and the labelmap. Set the slider to about 0.7
2. Set **Visibility Slider** to halfway between foreground and background. This allows you to see both atlases. You can see the initial misalignment.





Update Color-/Label Lookup Table

1. If using Slicer version 3.6 or later, you may have to change the color lookup table for the two atlas volumes to have the proper colors and labels displayed. To test, when holding the mouse over a region, the “Lb: “ display in the slice views should give you the proper anatomical name, e.g. “putamen” etc. If not, follow the steps below
2. Go to the Volumes Module.
3.  As “Active Volume” select “A0_labels”
4. Under “Lookup Table”, in the “Atlas” sub-menu select “SPL-BrainAtlas-ColorFile.txt”
5. As “Active Volume” select “A1_labels”
6. Under “Lookup Table”, in the “Atlas” sub-menu, select “SPL-BrainAtlas-2009-ColorFile.txt”





Build Thalamus Mask

1. For registration we need a model of the entire thalamus. Hence we must first merge the labels of all the nuclei
2. Turn off all display other than A0_labels, i.e. select “None” for fore- & background.








Build Thalamus Mask (2)

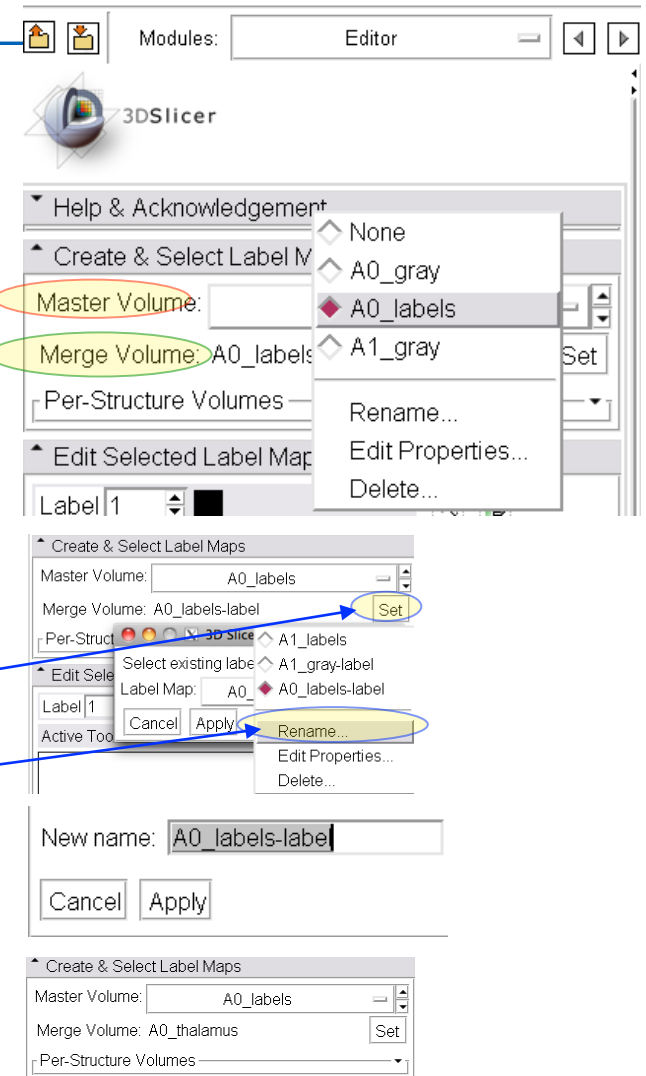
6. Via the right mouse button, zoom in. You should see the individual nuclei. If you hover the mouse over each, the label and number are displayed under “Lb:”
7. All thalamic structures have labels from 500-525. We use this to merge them into a single mask volume.






Build Thalamus Mask (3)

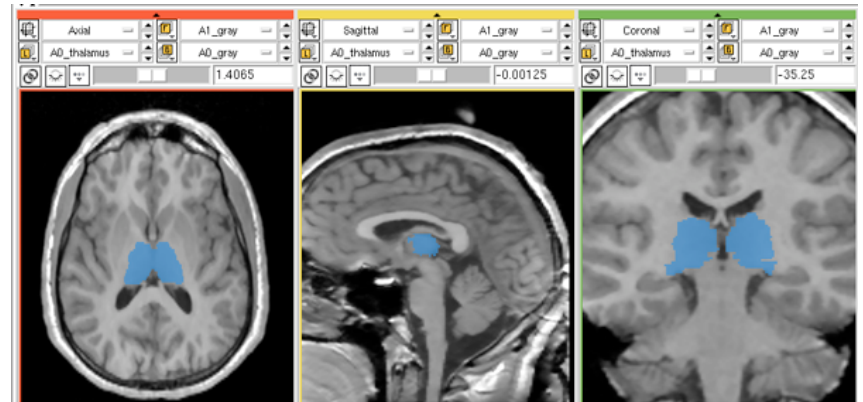
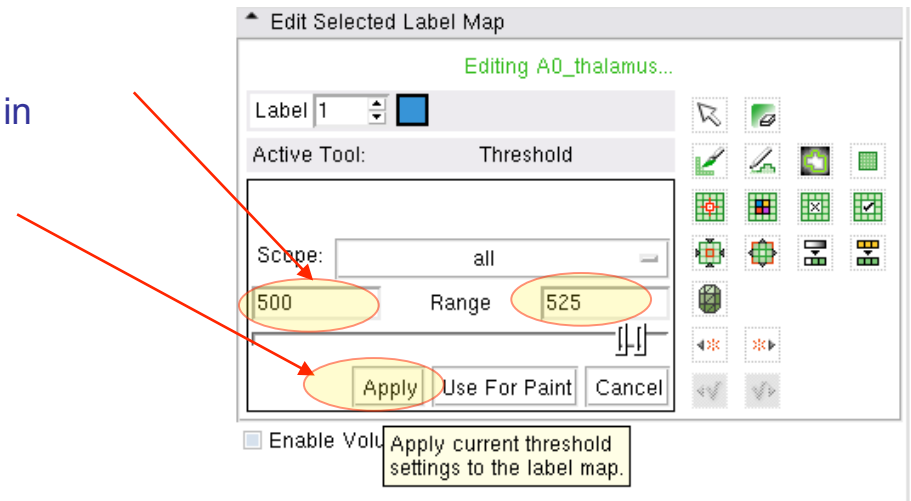
8.  Go to the “Volumes” module. From the “Active Volume” menu, select “A0_labels”. Then scroll down to the “Info” tab and uncheck the box called “Label Map”
9.  Go to the “Editor” module
10. Under “Master Volume”, select “A0_labels”. Then click Apply on the dialog that appears.
11. Under “Merge Volume”, you should see a newly created “A0_labels-label”. If not, click on the “Set” button to the right and select: “Create New”
12. Rename the new volume to “A0_thalamus”: click on on the “Set” button to the right, select “A0_labels-label” and then select “Rename” from the same menu and change the name to “A0_thalamus”
13.  From the icon panel, select the “Threshold Icon”





Build Thalamus Mask (4)

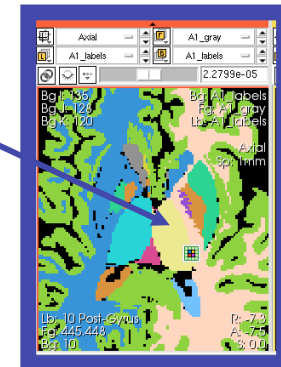
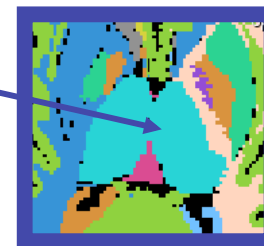
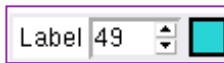
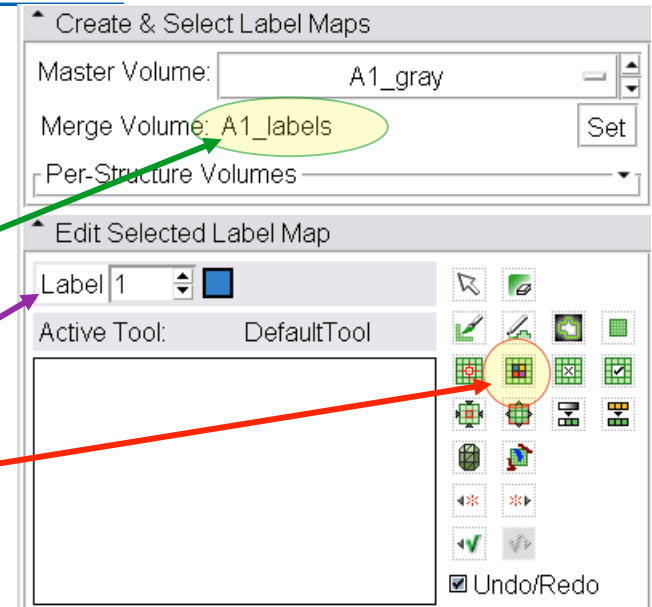
12.  In the numeric fields, type the range: 500 and 525. You will see the selected structure “blink” in blue
13. Click on “Apply” to create the new volume. When selecting the new “A0_thalamus” as the labelmap, you should now see something like the image on the right.





Build Mask for New Atlas

1. Now we repeat the process to build the mask volume for the new atlas A1. A1 only has 2 labels for the left and right thalamus, respectively: 49 and 10. Because they are non-sequential we first change one.
2. In the Editor, for “Master Volume”, select “A1_gray” and for “Merge Volume”, select “A1_label”
3. Select the “Change Island Icon”
4. Change the label field to 49
5. In the axial view, left click in the yellow area representing the left thalamus. Upon the click, the area should become the same turquoise color as the right thalamus.





Build Mask for New Atlas (2)

1. Now we repeat the thresholding to extract only label 49.



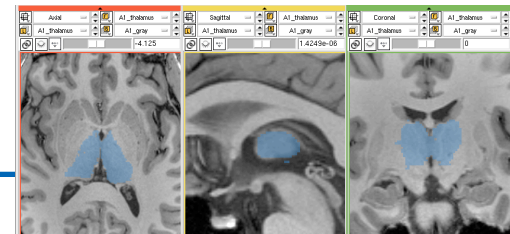
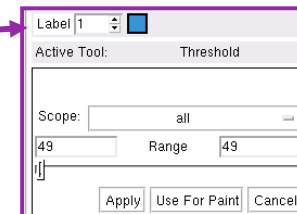
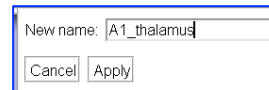
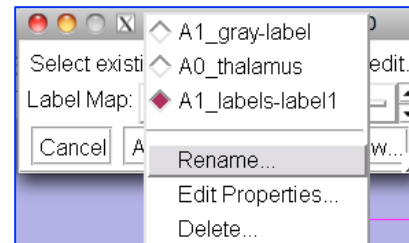
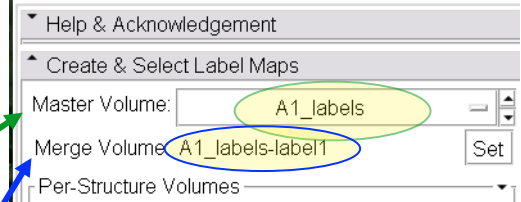
1. Make “A1_label” editable: go to the Volumes module and uncheck the “labelmap” box.
2. Return to the Editor. For “Master Volume”, select “A1_label”. When prompted for a color table, leave “Labels” and click Apply.
3. You should see a new “A1_labels-label” being created and selected under “Merge Volume”. We will rename this: Click the “Set: button. Make sure “A1_labels-label” is selected; then in the menu below select “Rename” and type “A1_thalamus”



4. Set the label field back to 1.
5. Select the “thresholding” icon, and for the range enter 49 in both fields.
6. Hit Apply



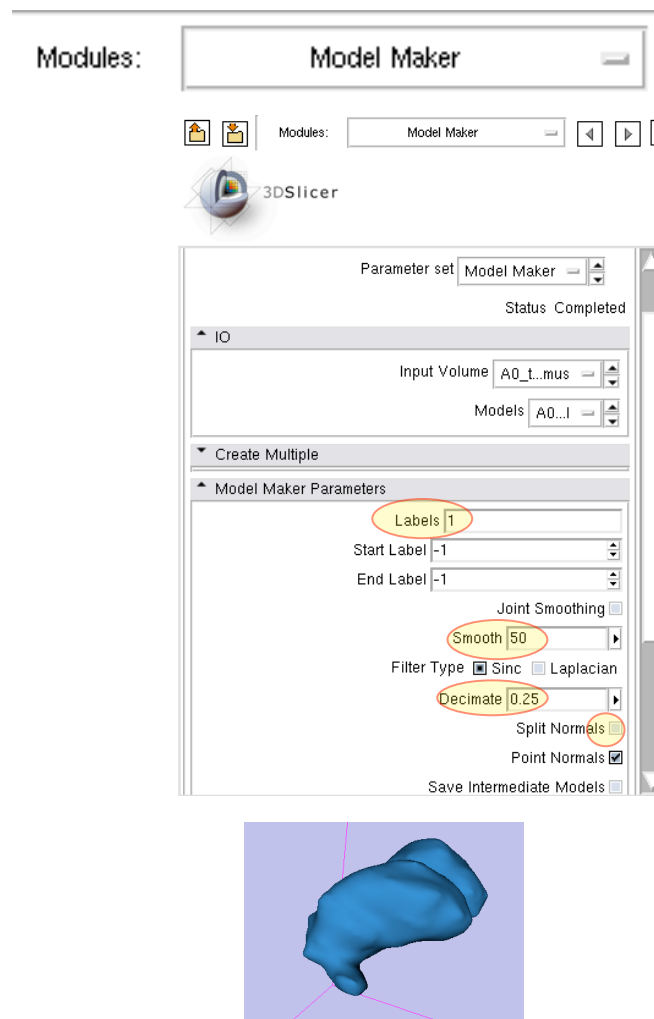
2. We now have label volumes for the thalamus in both atlases.
3. Next we build models for both.





Build Thalamus Models

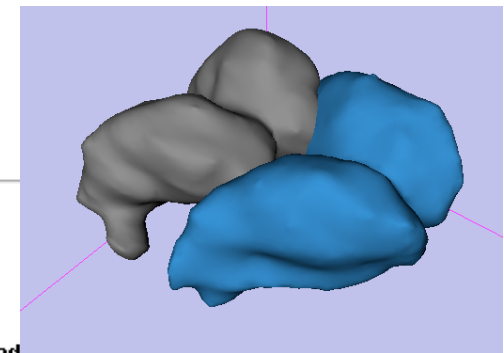
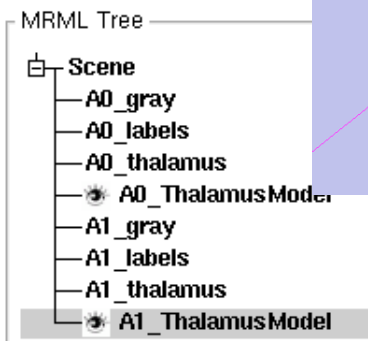
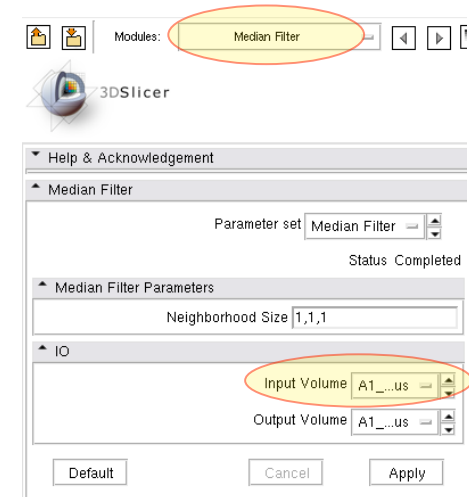
1. Go to the “Model Maker” Module (under Surface Models).
2. For “Input Volume”, select “A0_thalamus”
3. For “Models”, select “Create New Model Hierarchy”, then select “Rename” and enter “A0_ThalamusModel”
4. In the “Labels” field, enter 1.
5. Set the “Smooth” iterations field to 50
6. Leave the “Decimate” field at the default of 0.25
7. Turn off “Split Normals” checkbox
8. Click “Apply”
9. After a few seconds of processing, you should see a model appear in the 3D view.





Build Thalamus Models (2)

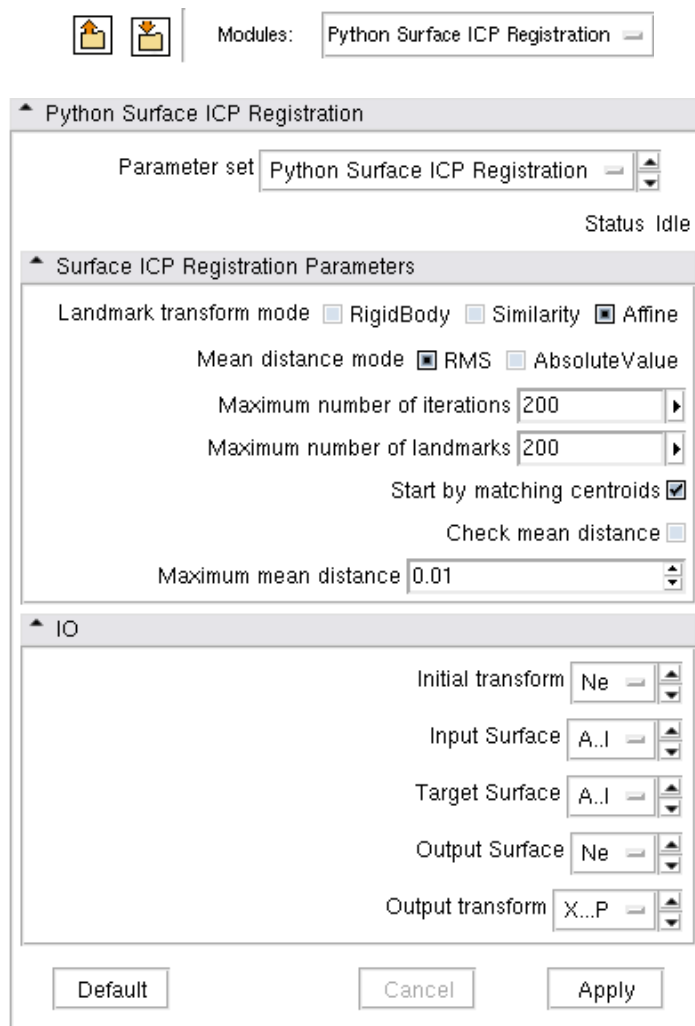
10. Before we build the second model, we apply some morphological cleanup to the second labelmap: Go to “Filtering / Denoising / MedianFilter” module. Select “A1_thalamus” as both input and output, leave defaults and click apply. The jagged edges at the surface will disappear.
11. We now Repeat the steps 1-9 on the previous slide for the second atlas, i.e. create “A1_ThalamusModel” from the “A1_thalamus” volume.
12. You should now have 2 models for each atlas, as seen on the right.





Register Thalamus Model Surfaces

1. Go to the “Python Surface ICP Registration” module
2. Select “Affine” and “RMS” and “Start by matching centroids”
3. For “maximum number of iterations” and “landmarks”, set 200 each.
4. Input Surface: A0_ThalamusModel
Target Surface: A1_ThalamusModel
5. Output transform: “Create New Linear Transform”, then select “Rename” and rename to “Xform_A0affine_ICP”
6. Click “Apply”.





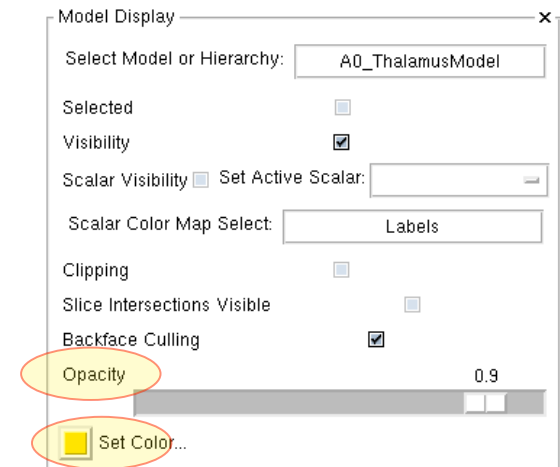
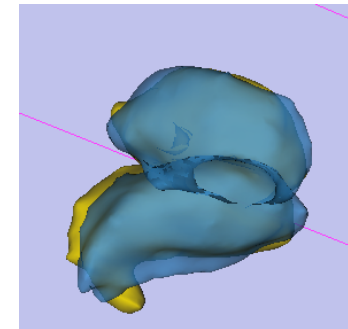
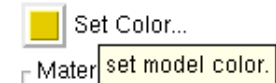
Register Thalamus Model Surfaces (2)



7. Go to the “Data” module
8. Select the node “A0_ThalamusModel” and drag it on top of the “Xform_A0affine_ICP” node
9. Click in the 3D view to force a redraw. You should now see the two models on top of each other.



10. Go to the “Models” volume.
11. Select “A0_ThalamusModel” from the menu, click on the “Set Color” button and change color to yellow.
12. Set the opacity slider to 0.9
13. Select “A1_ThalamusModel” and set the opacity to 0.7





Apply Registration to Labelmap

1. Go to the “Resample Scalar/Vector/DWI Volume” module
2. Input Volume : “A0_labels”
Reference Volume : “A1_labels”
Output Volume : “Create New Volume”, rename to “A0_labels_aff”
3. Transform Node: “Xform_A0Affine_ICP”
4. Interpolation Type: “nn”
5. Click “Apply”.
6. Repeat for the “A0_Thalamus” volume, i.e. create a new “A0_Thalamus_aff”
7. Go to the “Volumes” module, select the newly created “A0_labels_aff” and “A0_thalamus_aff”, then check the “Labelmap” box.

Modules:

esample Scalar/Vector/DWI Volume

Resample Scalar/Vector/DWI Volume

Parameter set: Resample Scalar...tor/DWI Volume

Status: Idle

Input/Output

Input Volume: A0_...ls

Reference Volume (To Set Output Parameters): A.s

Output Volume: A0_...aff

Resampling Parameters

Transform Parameters

Transform Node: XP

Manual Transform (Only Used If No Transform Node Set)

Rigid/Affine Parameters

Interpolation Type

Interpolation: linear nn ws bs

Windowed Sinc Interpolate Function Parameters

BSpline Interpolate Function Parameters

Output Parameters

Default Cancel Apply

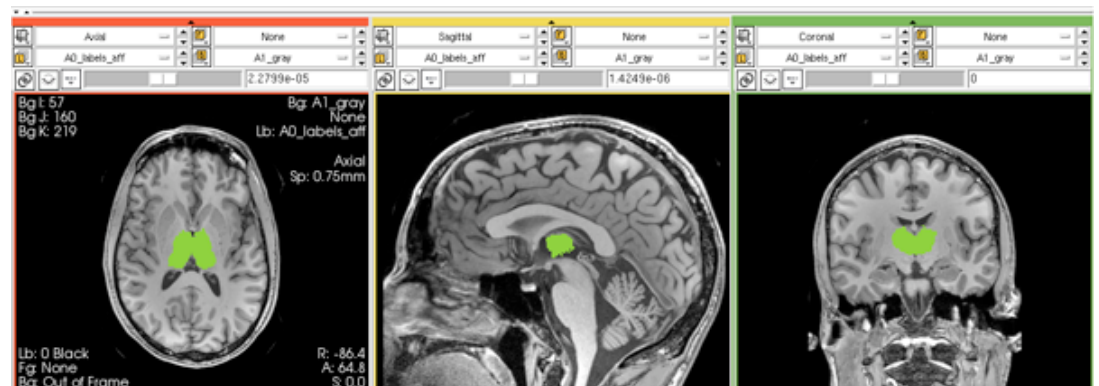
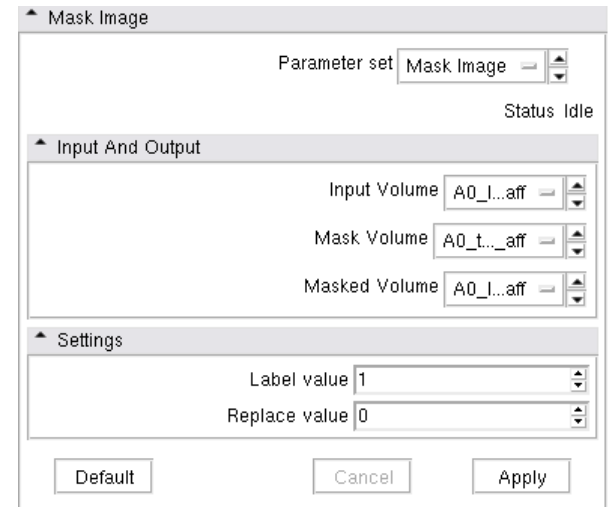
Label Map:



Mask New Labelmap

From the new labelmap we want to keep only the thalamic structures:

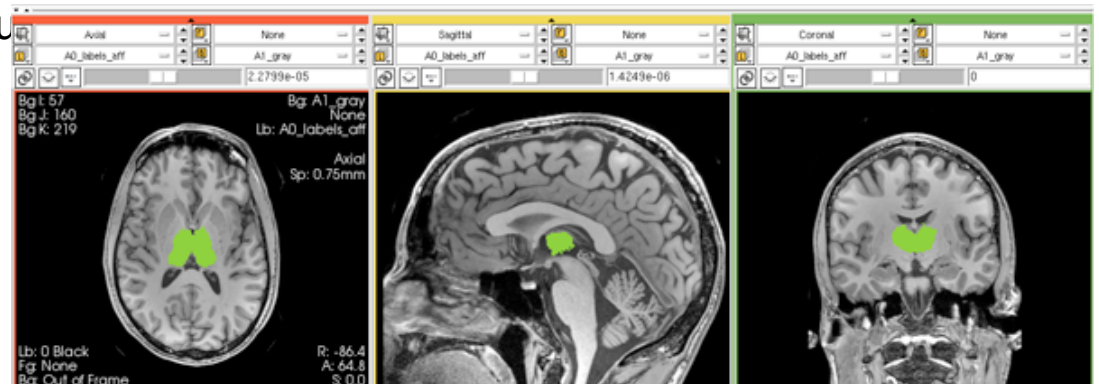
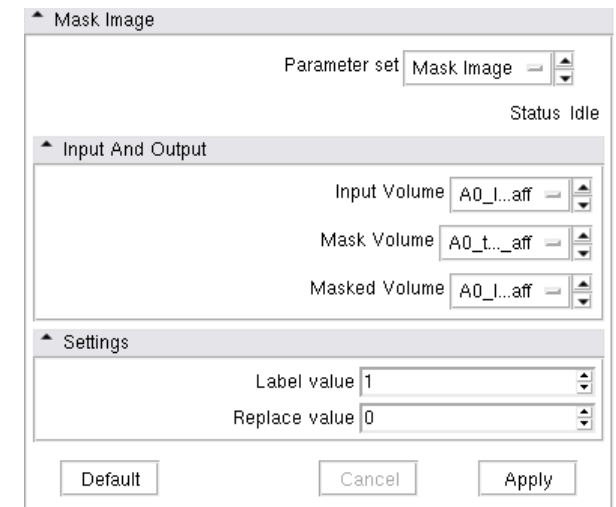
1. Go to “Mask Image” module
2. Input Volume: “A0_labels_aff”
Mask Volume: “A0_thalamus_aff”
Masked Volume: “A0_labels aff”
(Note we overwrite the volume with the masked one, if you get an error at this step you need to repeat the previous resampling step)
3. Click “Apply”.





Mask New Labelmap (2)

4. Finally we mask again with the thalamus of the new (target) atlas. This is to prevent replacing labels other than the thalamus in places where the registered volume extends beyond the target. In other words we clip off anything “sticking out” beyond the boundaries of the A1 thalamus:
5. Go to the “Mask Image” module
6. Input Volume: “A0_labels_aff”
Mask Volume: “A1_thalamus_aff”
Masked Volume: “Create New Volume”
“A0_labels aff_clip”
7. Click “Apply”.

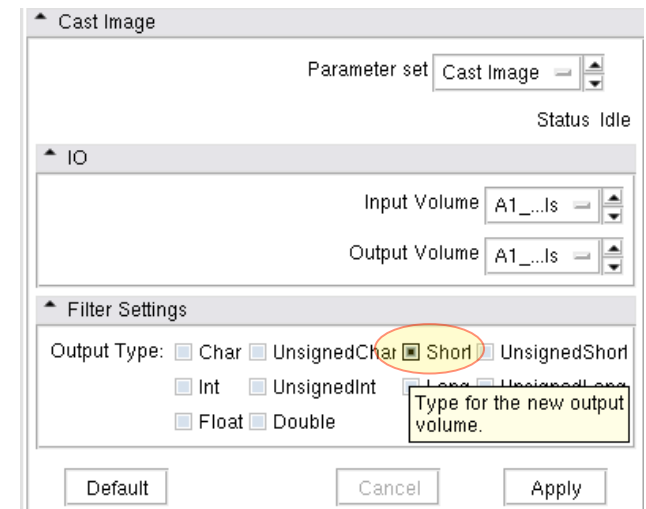
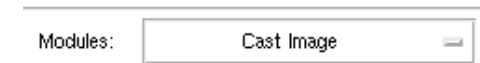




Type Cast Atlas Labelmap

Some labelmaps can have different datatypes, which can cause problems when merging. To ensure both volumes to be merged have the same datatype we check the info in the “Volumes” module. To change we use the “Cast Volume” module”:

1. Go to the “Cast Image” module
2. Input Volume: “A1_label”
Output Volume: “A1_label”
Output Type: “short”
3. Click Apply

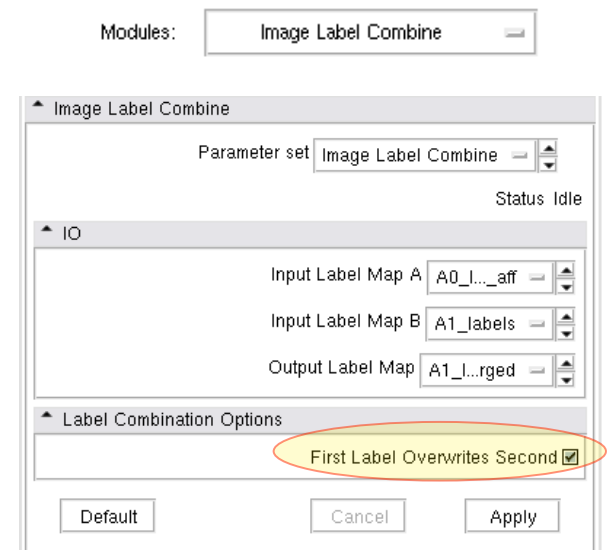




Merge Labelmaps

Last step is to transfer the Thalamic Nuclei labels into the A1 labelmap.


1. Go to the “Image Label Combine” module
2. Input Label Map A: “A0_label_aff_clip”
Input Label Map B: “A1_labels”
Output Label Map: “Create New Volume”, rename to “A1_labels_merged”
3. Check box: First label overwrites second.
4. Click Apply
5. Go To “Volumes” module, select the new “A1_labels_merged” and check the “Labelmap” box.





Save

1. Select “Save” from the File Menu.
2. Check all boxes except the original input images “A0_gray”, “A0_labels” etc.
3. Create a new output directory, and select it via the “Change Destination For All Selected” button.
4. click “Save Selected”.

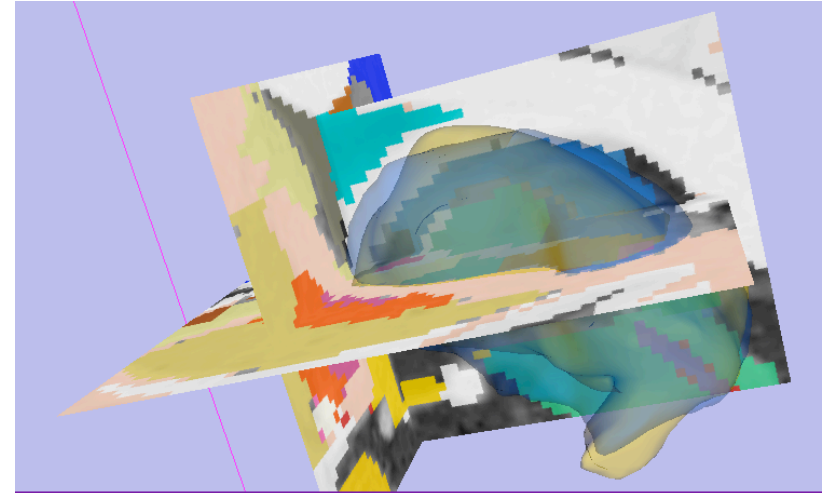
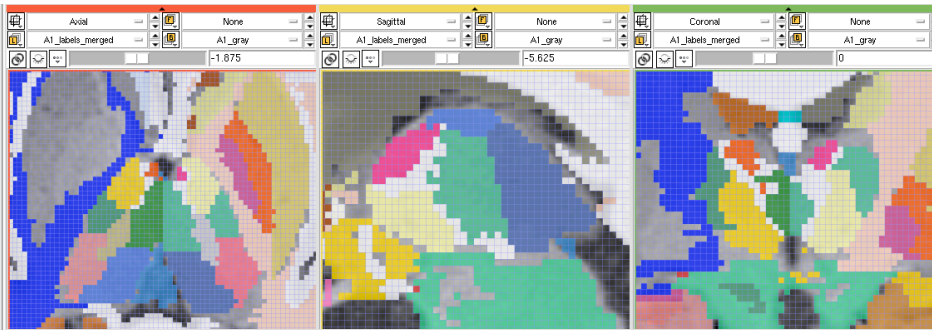
Change Destination for All Selected: 



View Result

1. Go to the “Volumes” module, select “A1_label_merged”. Under “Display”, select a new colormap: “Labels from File / SPL-BrainAtlas-ColorFile.txt”
2. In the slice view, select “A1_gray” for for background, “A1_labels_merged” for labelmap.
3. Set the labelmap opacity to ~0.7

Lookup Table:





What Next

- Try the Manual Registration Tutorial or one of the tutorials from the Registration Case Library.
 - <http://www.slicer.org/slicerWiki/index.php/Slicer3.4:Training>
 - <http://na-mic.org/Wiki/index.php/Projects:RegistrationDocumentation:UseCaseInventory>
 - http://www.slicer.org/slicerWiki/index.php/Slicer3:Registration#Registration_in_3D_Slicer|Main
- Feedback: anything amiss? If you have suggestions on how we can improve this and other documentation, please let us know: visit:
 - <http://na-mic.org/Wiki/index.php/Projects:RegistrationDocumentation>



Acknowledgements



National Alliance for Medical Image Computing
NIH U54EB005149



Neuroimage Analysis Center
NIH P41RR013218 -12S1 (ARRA Suppl)