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Slicer3 Tutorial

Atlas Registration & Label Merging

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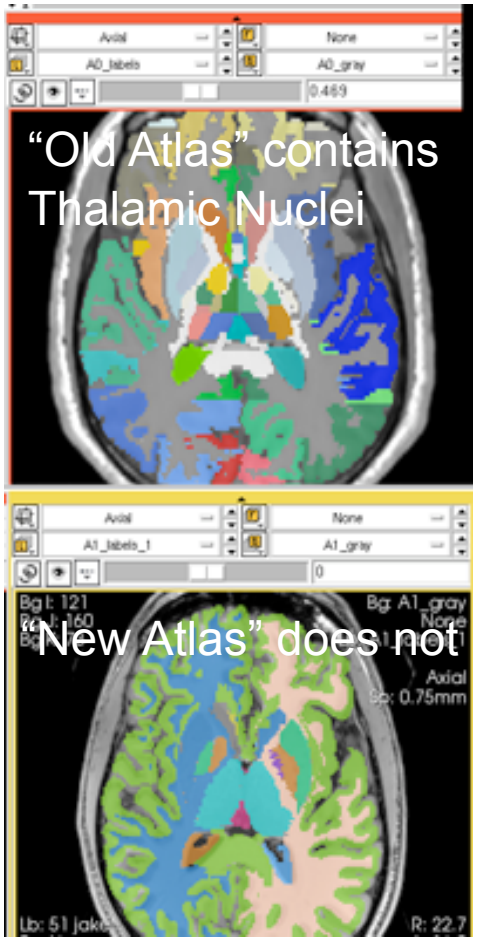
Note: if wish to skip parts of the tutorial, you will find the data generated by individual steps in the Example Data Folder. You may load these individually via the “File/ Add Data…” menu.

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

Introduction / Scenario

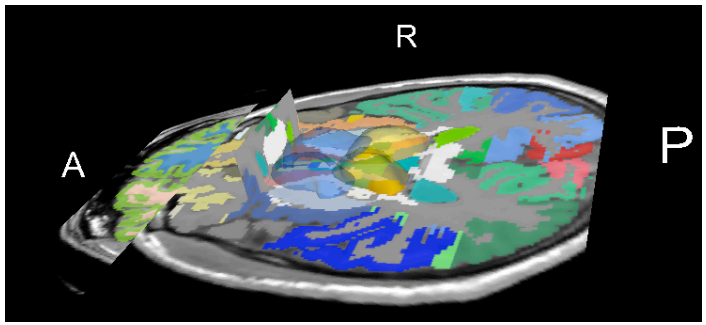
- We have two anatomic atlases, obtained from two separate individuals by expert radiologist tracing. We refer to them as A0 (“old atlas”) and A1 (“new atlas”)
- The “old atlas” A0 contains labels for 25 thalamic nuclei and substructures that are not present in the “new atlas” A1.
- We want to transfer 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



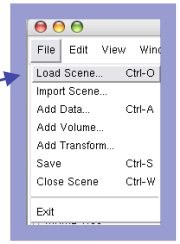
Prerequisites

- 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

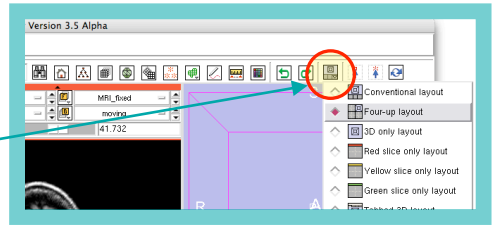
1. Loading Example Dataset

To get the Example Dataset loaded into Slicer:

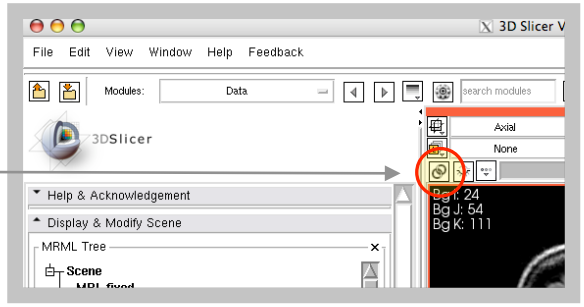
1. File Menu: File: Load Scene…
   - Select the Slicer Scene file that comes with the downloaded example dataset, called: AtlasMerge_SlicerScene.mrml
   - This will load all the necessary images



2. Select Layout: From the icon bar, click on the Layout menu and select "Conventional Layout".



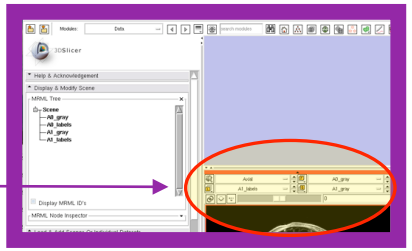
3. Link Views: Click on the Ring Icon in any of the slice views to link all the views together. This will save you the work of making selections for each slice window separately.



4. Choose Foreground: A0_gray

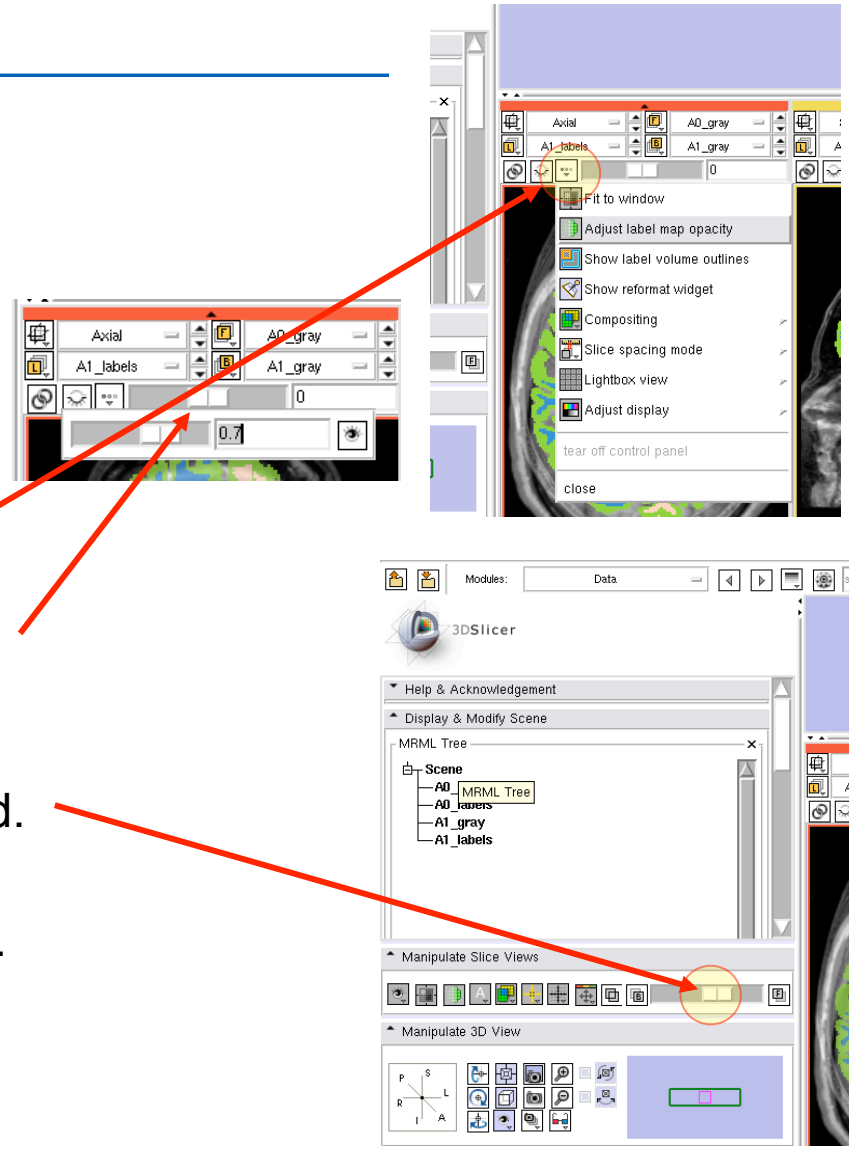
5. Choose Background: A1_gray

6. 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.

Build Thalamus Mask

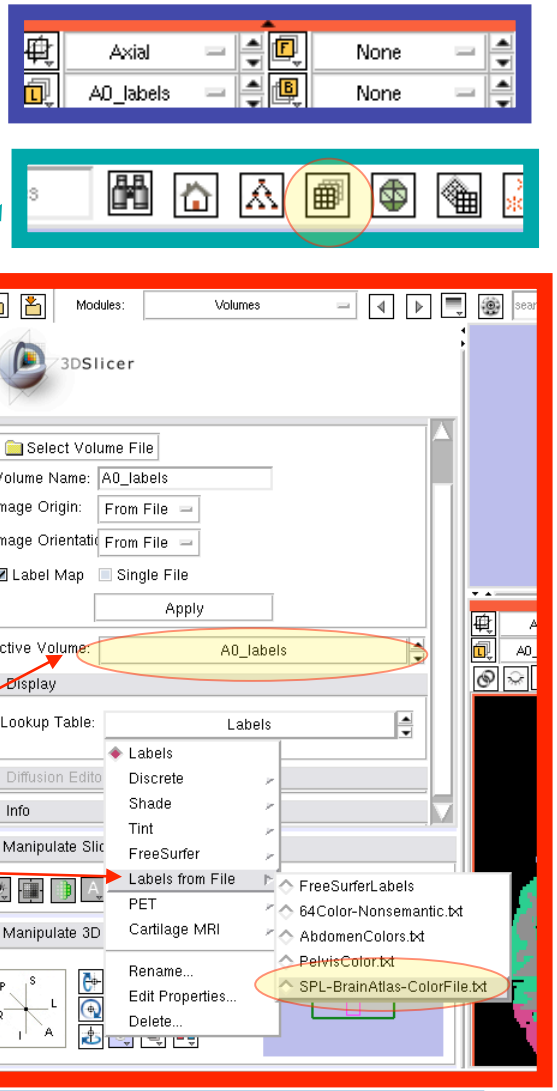
1. For registration we need a model of the entire thalamus. Hence we must first merge the labels of all the nuclei

2. Turn off all display other than A0_labels, i.e. select “None” for fore- & background.

3. The current colormap shows all nuclei labels as green. To see the individual structures, we select a new colormap: Go to the Volumes Module.

4. As “Active Volume” select “A0_labels”

5. Under “Lookup Table”, select “Labels From File” and “SPL-BrainAtlas-ColorFile.txt”



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)

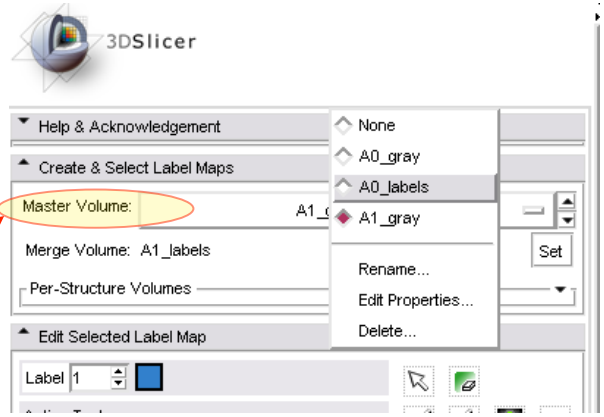
8  Go to the “Volumes” module. From the “Active Volume” menu, select “A0_labels”. Then scroll down to the “Info” tab and uncheck the box called “Label Map”. Label Map: 

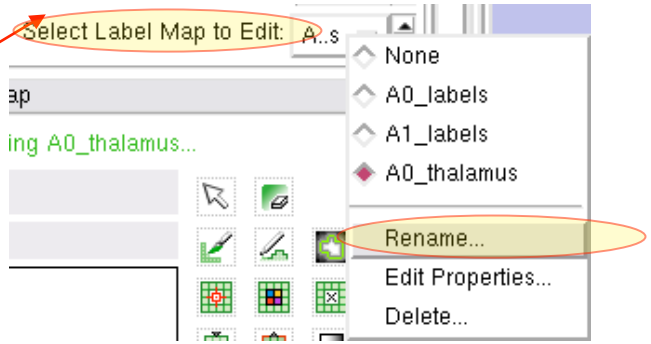
9. Go to the “Editor” module

10. Under “Master Volume”, select “A0_labels”. Then click Apply on the dialog that appears.

11.  Under “Select Labelmap to Edit”, select the newly created “A0_lables-label” and then select “Rename”. Rename the new volume to “A0_thalamus”

12. From the icon panel, select the “Threshold Icon”

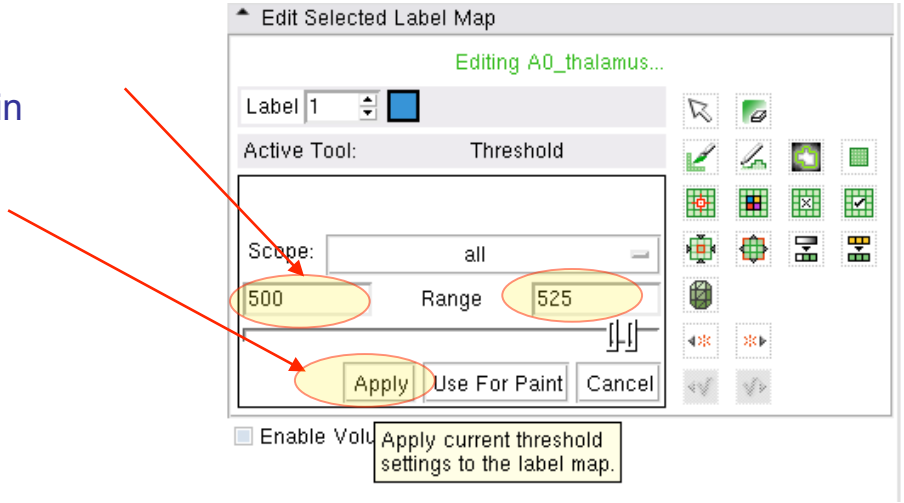


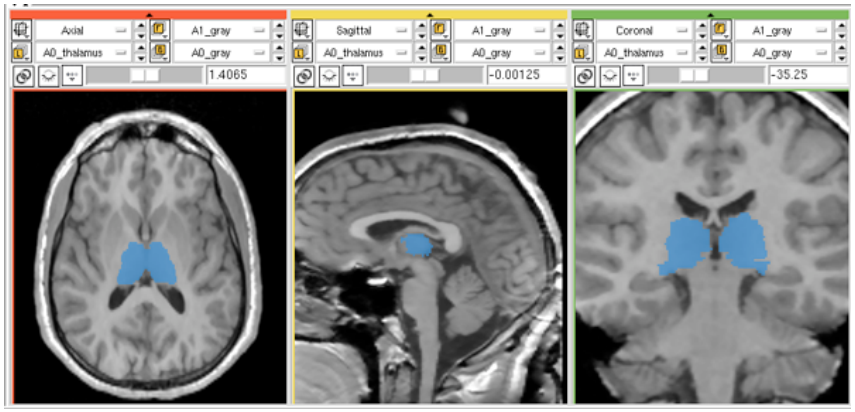


Build Thalamus Mask (4)

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

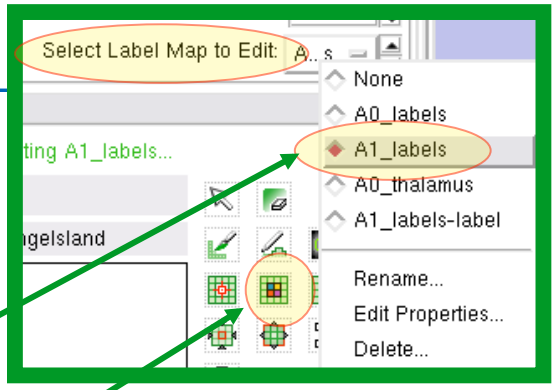


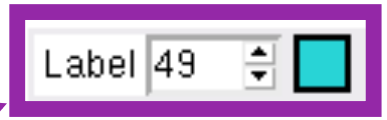


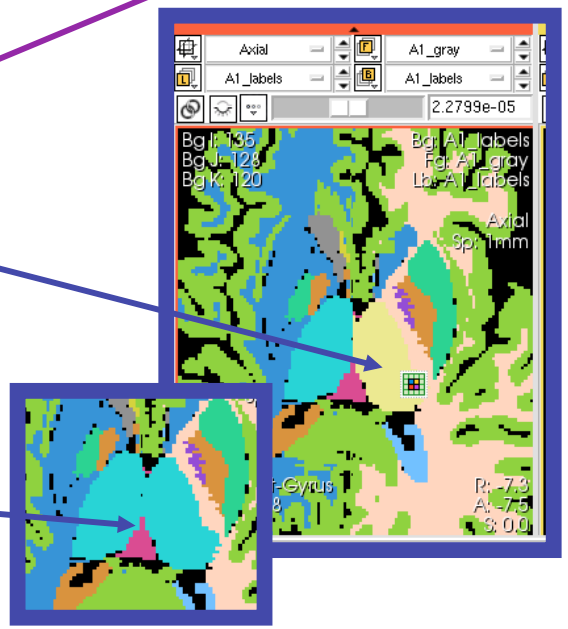
Build Mask for New Atlas

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 “Label Map to Edit”, select “A1_label”

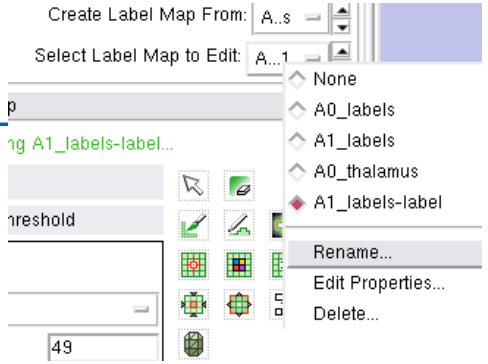
3. Select the “Change Island Icon”
4. Change the label field to 49
5. In the axial view, left click in the yellow area representing the left thalamus. Upon the click, the area should become the same turquoise color as the right thalamus.



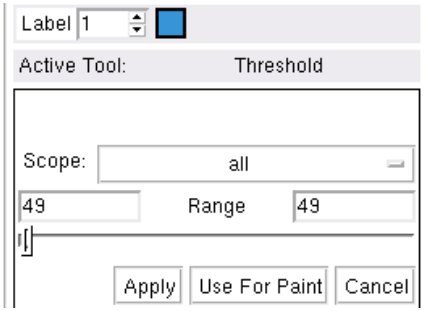




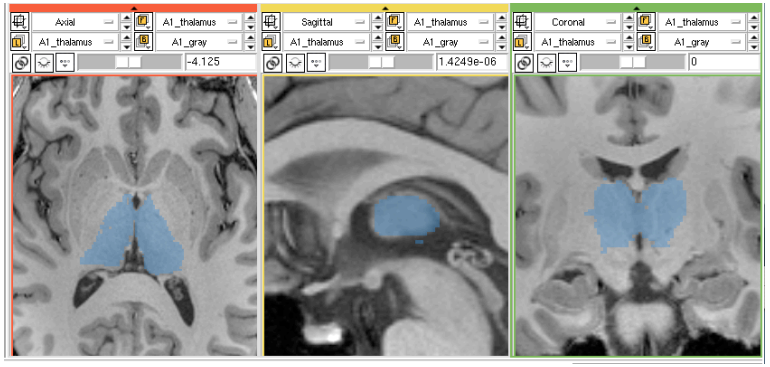
Build Mask for New Atlas (2)



1. Now we repeat the thresholding to extract only label 49.
   1. For “Create Label Map From”, select “A1_label”. For “Select Label Map to Edit”, select new “A1_label-label”, and choose “Rename”. Rename to “A1_thalamus”
   2. Set the label field back to 1.
   3. Select the “thresholding” icon, and for the range enter 49 in both fields.
   4. Hit Apply

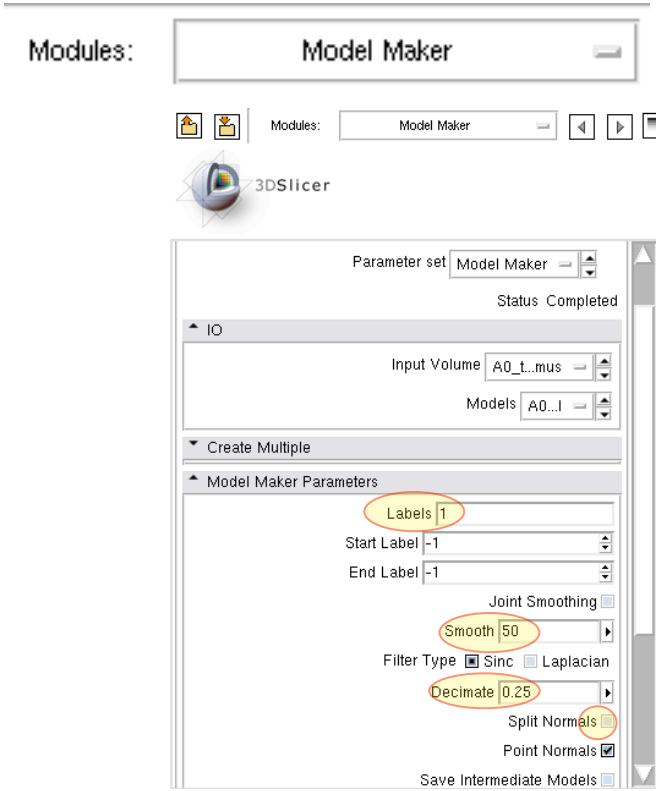


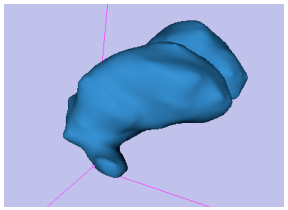
2. We now have label volumes for the thalamus in both atlases.
3. Next we build models for both.



Build Thalamus Models

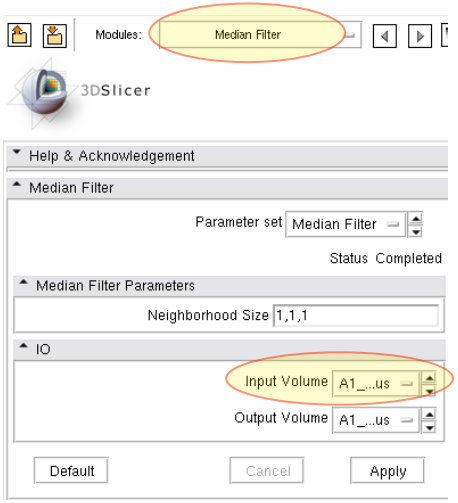
1. Go to the “Model Maker” Module (under Surface Models).
2. For “Input Volume”, select “A0_thalamus”
3. For “Models”, select “Create New Model Hierarchy”, then select “Rename” and enter “A0_ThalamusModel”
4. In the “Labels” field, enter 1.
5. Set the “Smooth” iterations field to 50
6. Leave the “Decimate” 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.

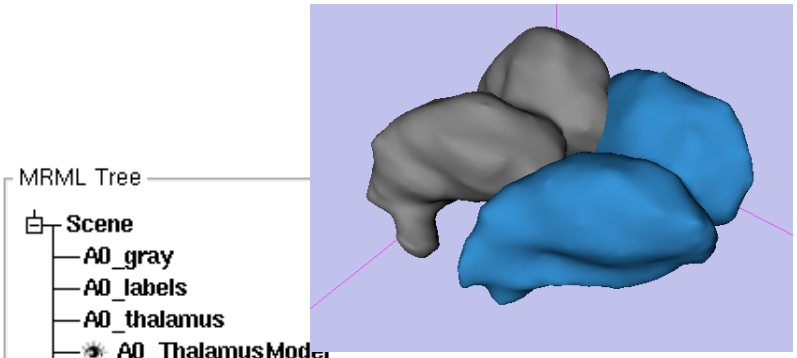




Build Thalamus Models (2)

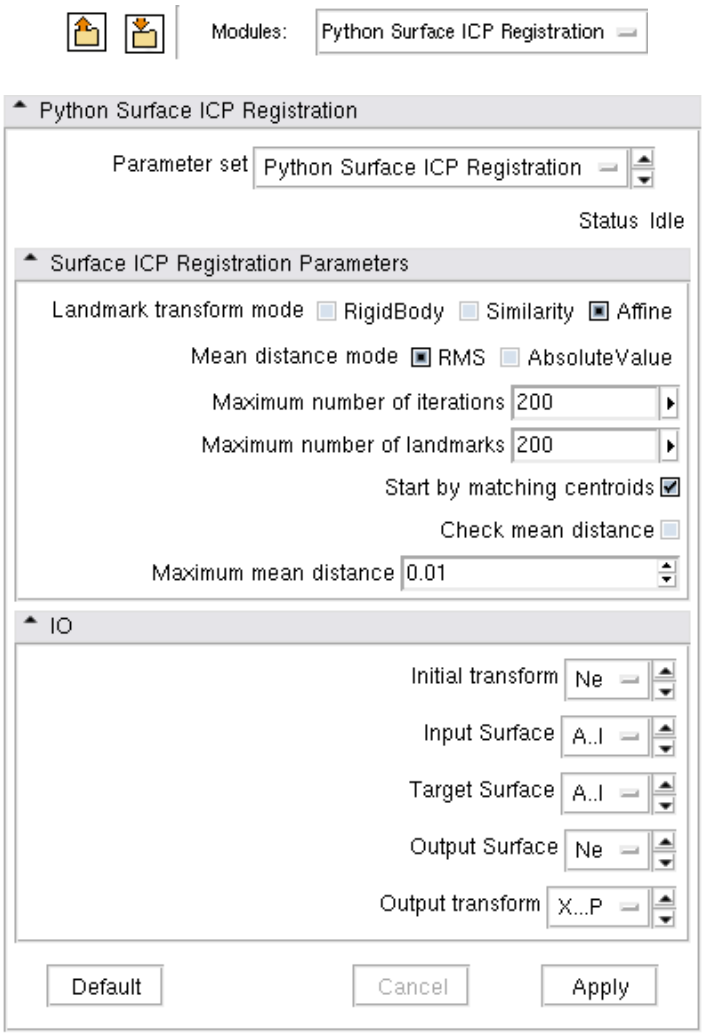
10. Before we build the second model, we apply some morphological cleanup to the second labelmap: Go to “Filtering / Denoising / MedianFilter” module. Select “A1_thalamus” as both input and output, leave defaults and click apply. The jagged edges at the surface will disappear.
11. We now Repeat the steps 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

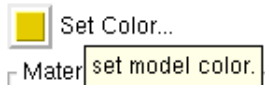
9. Click in the 3D view to force a redraw. You should now see the two models on top of each other.

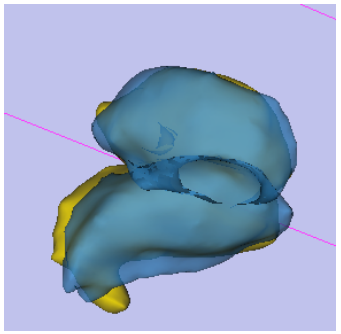
10. Go to the “Models” volume.

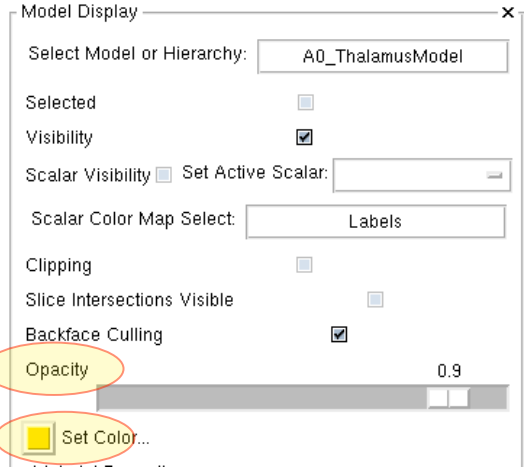
11. Select “A0_ThalamusMode” from the menu, click on the “Set Color” button and change color to yellow.

12. Set the opacity slider to 0.9

13. Select “A1_ThalamusModel” and set the opacity to 0.7

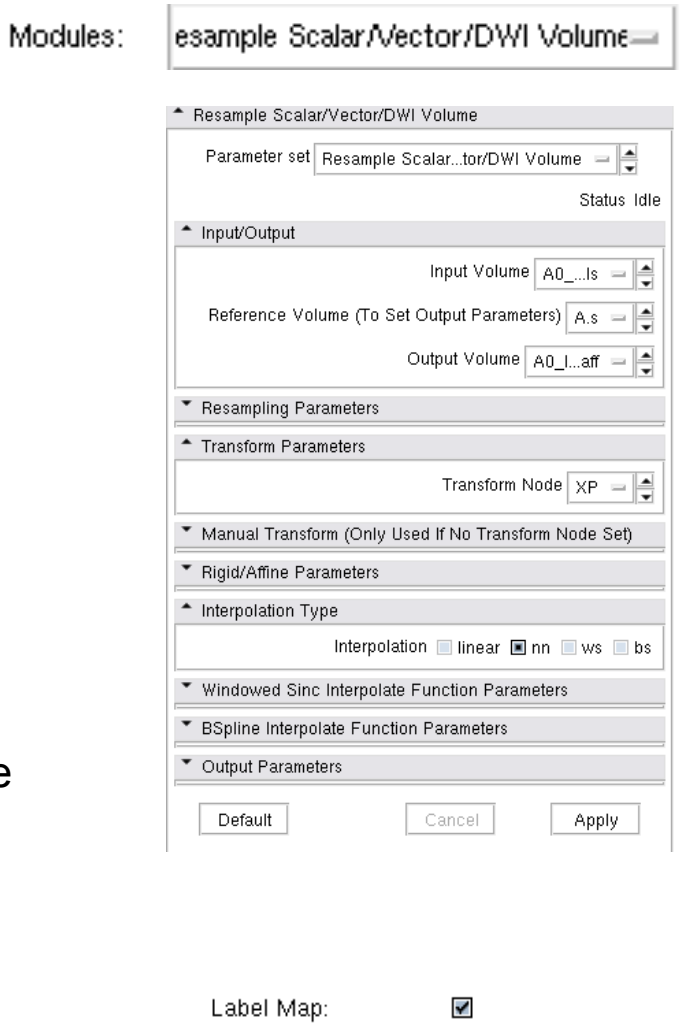






Apply Registration to Labelmap

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.



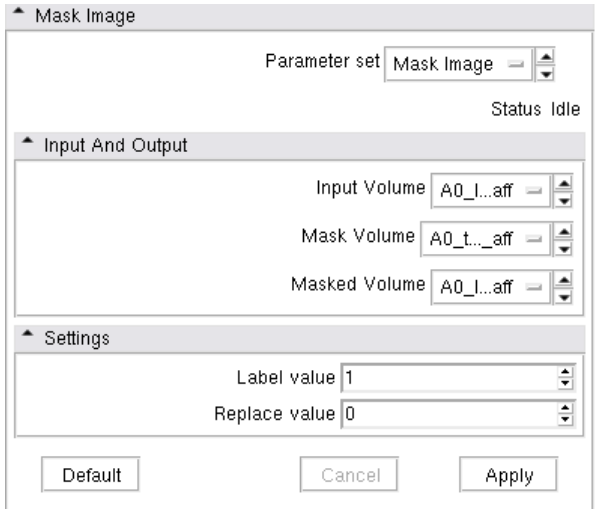
Mask New Labelmap

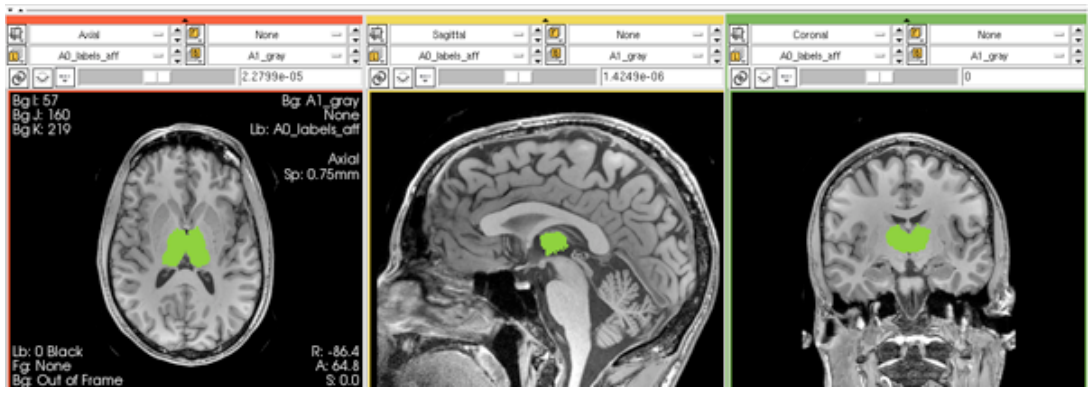
From the new labelmap we want to keep only the thalamic structures:

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”.

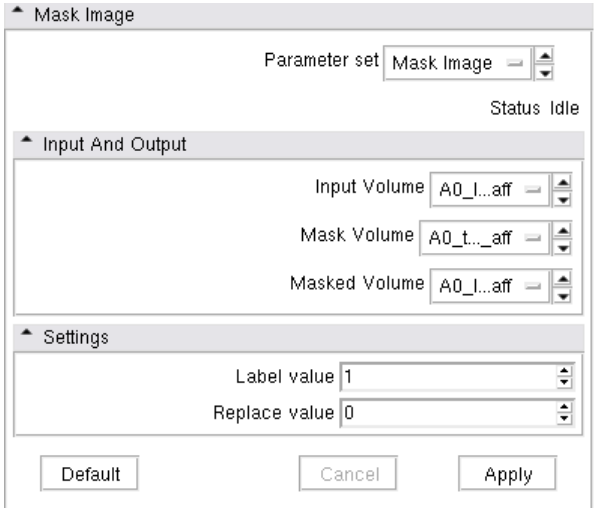




Mask New Labelmap (2)

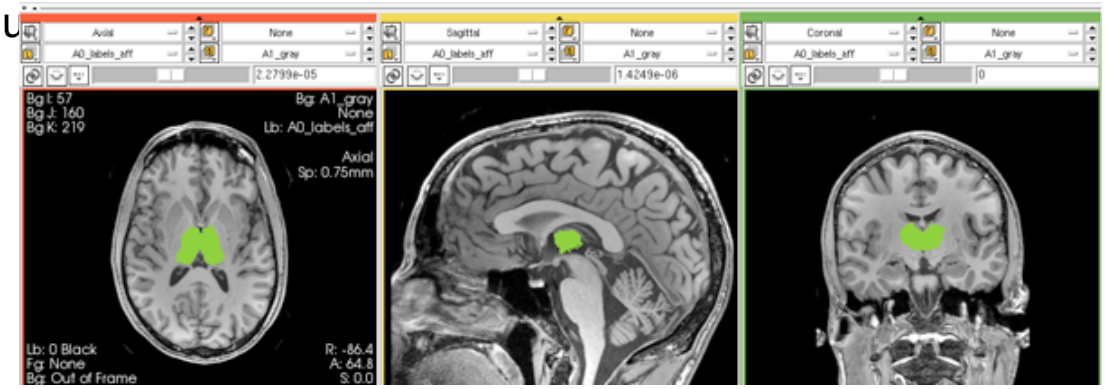
4. Finally we mask again with the thalamus of the new (target) atlas. This is to prevent replacing labels other than the thalamus in places where the registered volume extends beyond the target. In other words we clip off anything “sticking out” beyond the boundaries of the A1 thalamus:

5. Go to the “Mask Image” module



6. Input Volume: “A0_labels_aff”
Mask Volume: “A1_thalamus_aff”
Masked Volume: “Create New Volu
“A0_labels aff_clip”

7. Click “Apply”.



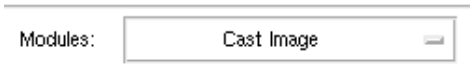
Type Cast Atlas Labelmap

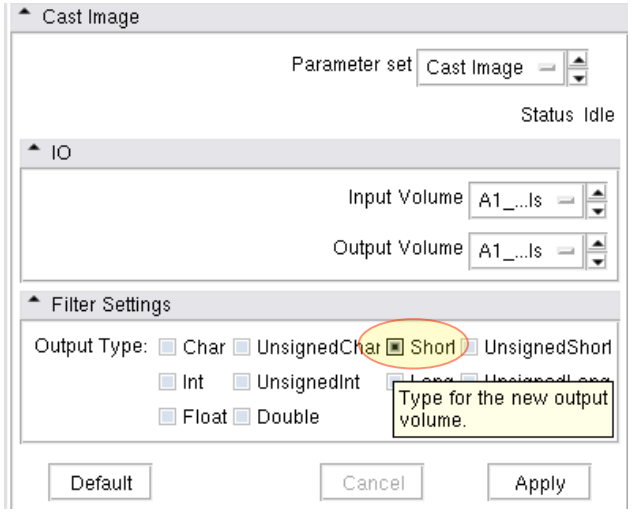
Some labelmaps can have different datatypes, which can cause problems when merging. To ensure both volumes to be merged have the same datatype we check the info in the “Volumes” module. To change we use the “Cast Volume” module”:

1. Go to the “Cast Image” module

2. Input Volume: “A1_label”
   Output Volume: “A1_label”
   Output Type: “short”

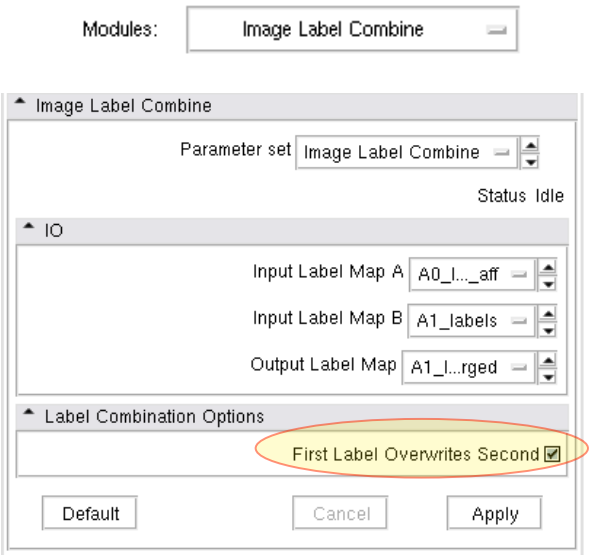
3. Click Apply





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”

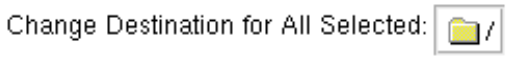
3. Check box: First label overwrites second.

4. Click Apply

5. Go To “Volumes” module, select the new “A1_labels_merged” and check the “Labelmap” box.

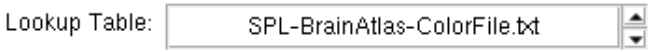
Save

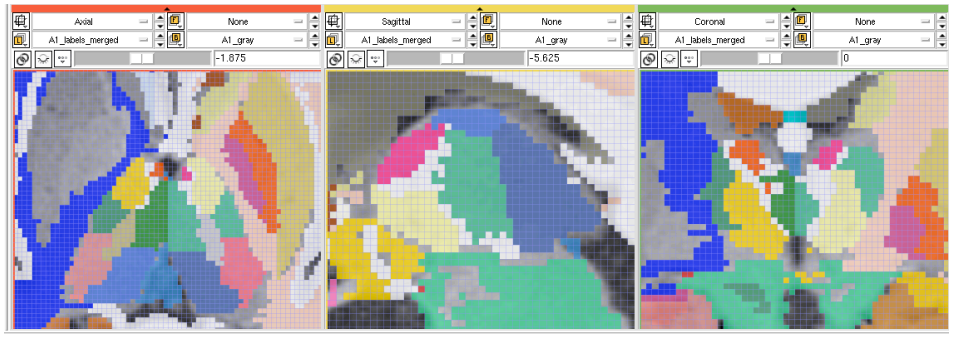
1. Select “Save” from the File Menu.
2. Check all boxes except the original input images “A0_gray”, “A0_labels” etc.
3. Create a new output directory, and select it via the “Change Destination For All Selected” button.
4. click “Save Selected”.

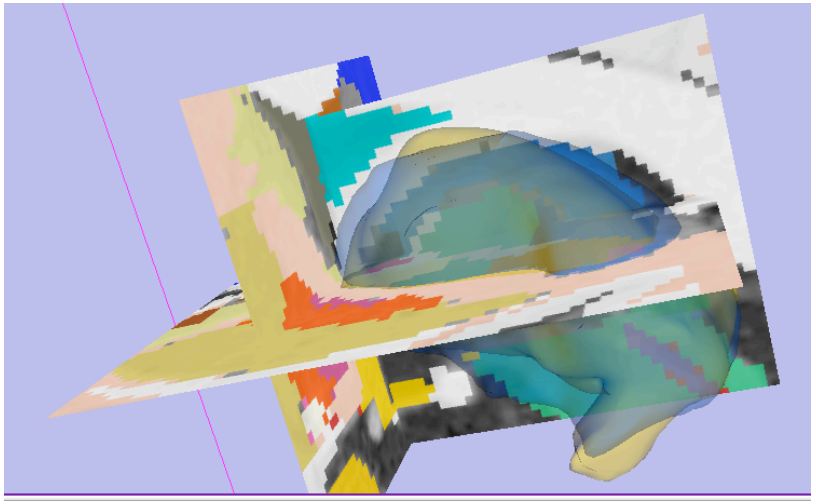


View Result

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







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

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