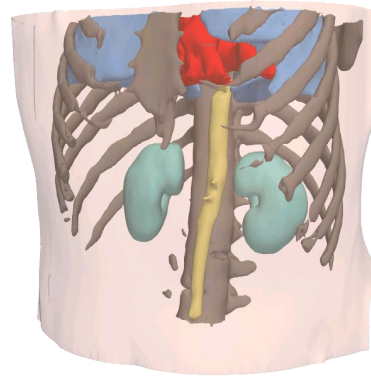
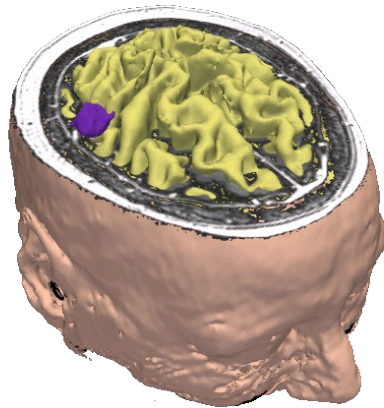




EMSegmenter Tutorial (Advanced Mode)



Dominique Belhachemi

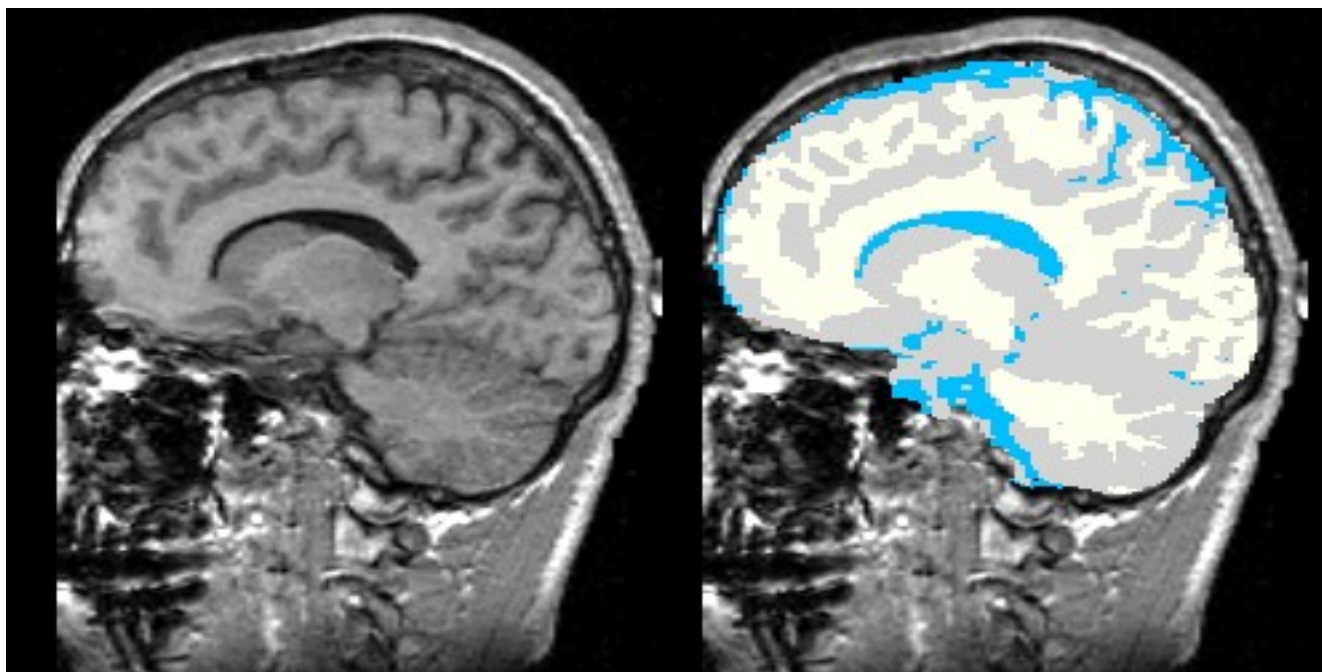
Section of Biomedical Image Analysis
Department of Radiology
University of Pennsylvania



Overview

The goal of this tutorial is to apply the EMSegmenter to MRI brain scans. We will segment the clinical T1 scan shown below into **grey matter**, **white matter**, and **cerebrospinal fluid**.

The tutorial is based on Slicer 3.6.3 .



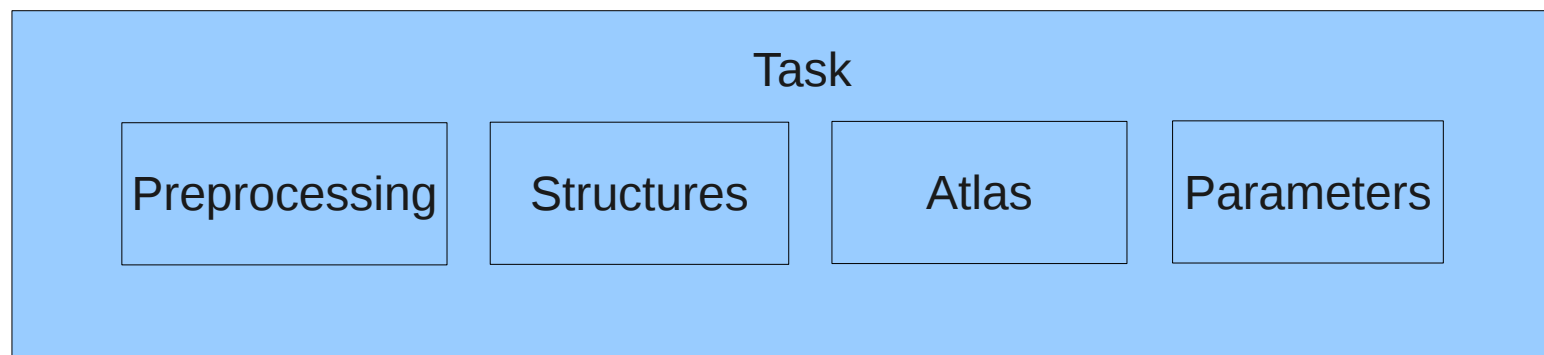
Before

After



Overview

We will segment the MRI scans by specifying a 'Task' for the EMSegmenter. The task captures the setting of the EMSegmenter for generating the automatic segmentation of the subject scan. A task specifies the pre-processing of the scan, such as the type of atlas-to-image registration. It also specifies the structures to be segmented and the atlas specifying the structures. Furthermore, the task specifies the parameters related to the optimization algorithm (EM).





Overview

The tutorial leads you through the steps necessary for creating a new task:

- Step 1: Define task name and type of pre-processing
- Step 2: Define Input Channel
- Step 3: Define the Anatomical Tree
- Step 4: Assign an atlas to each node in the tree
- Step 5: Defining the Atlas to Image Registration
- Step 6: Further specify pre-processing
- Step 7: Specifying the Intensity Distribution
- Step 8: Define EM Specific Parameters
- Step 9: Specify the Region of Interest and complete the Segmentation



Define Task

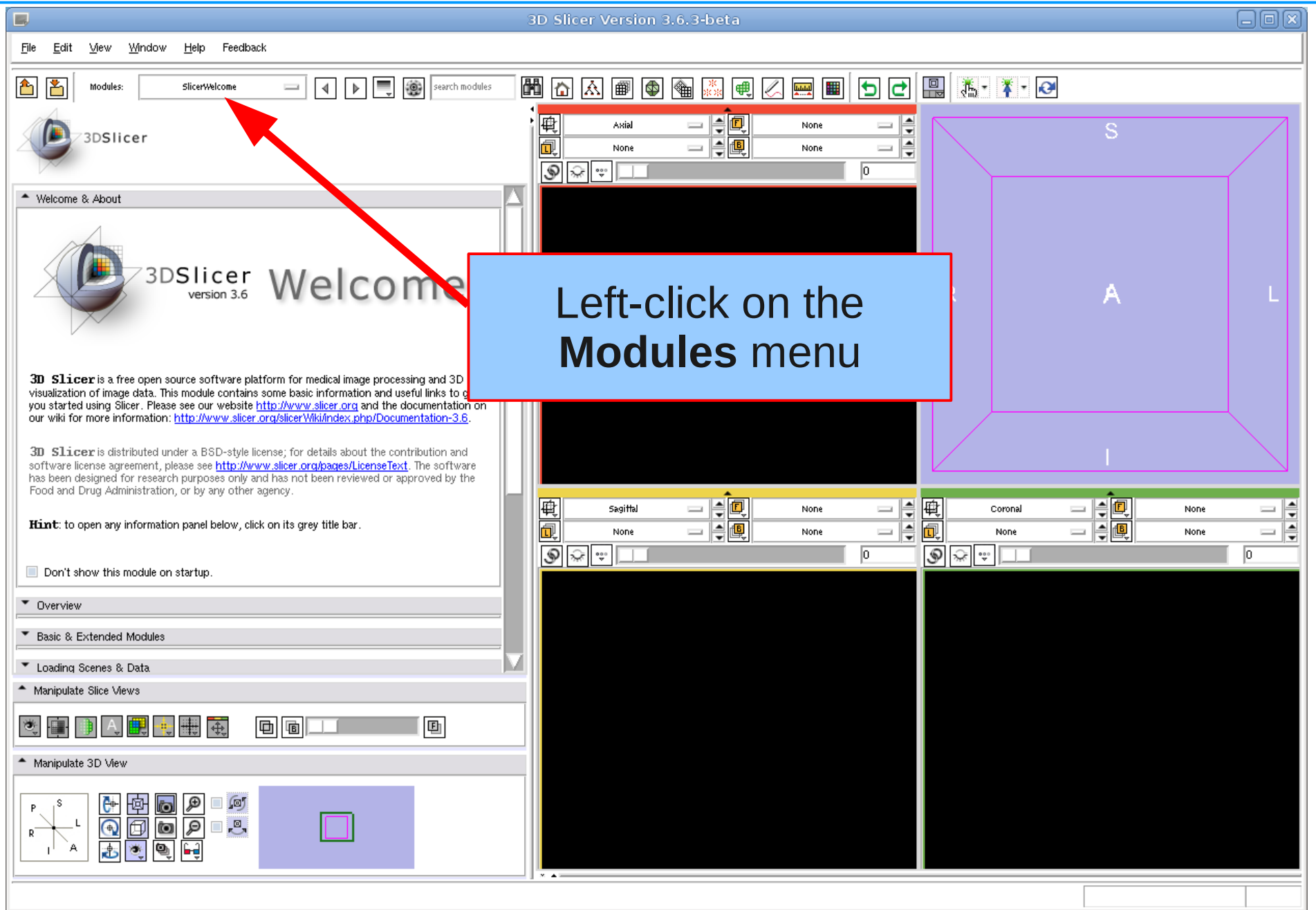
Step 1:

Define task name and type of pre-processing

The name should be a brief description of the segmentation scenario that the task addresses, such as 'T1 Brain Tissue Segmentation'. Each pre-processing type defines a sequence of approaches for modifying the scan before segmenting the scan into the structures of interest. For example, the pre-processing “MRI Human Brain” consists of image inhomogeneity correction and atlas registration. For further details please see <http://www.slicer.org/slicerWiki/index.php/EMSegmenter-Tasks>

EMSegmenter (Advanced mode)

3DSlicer





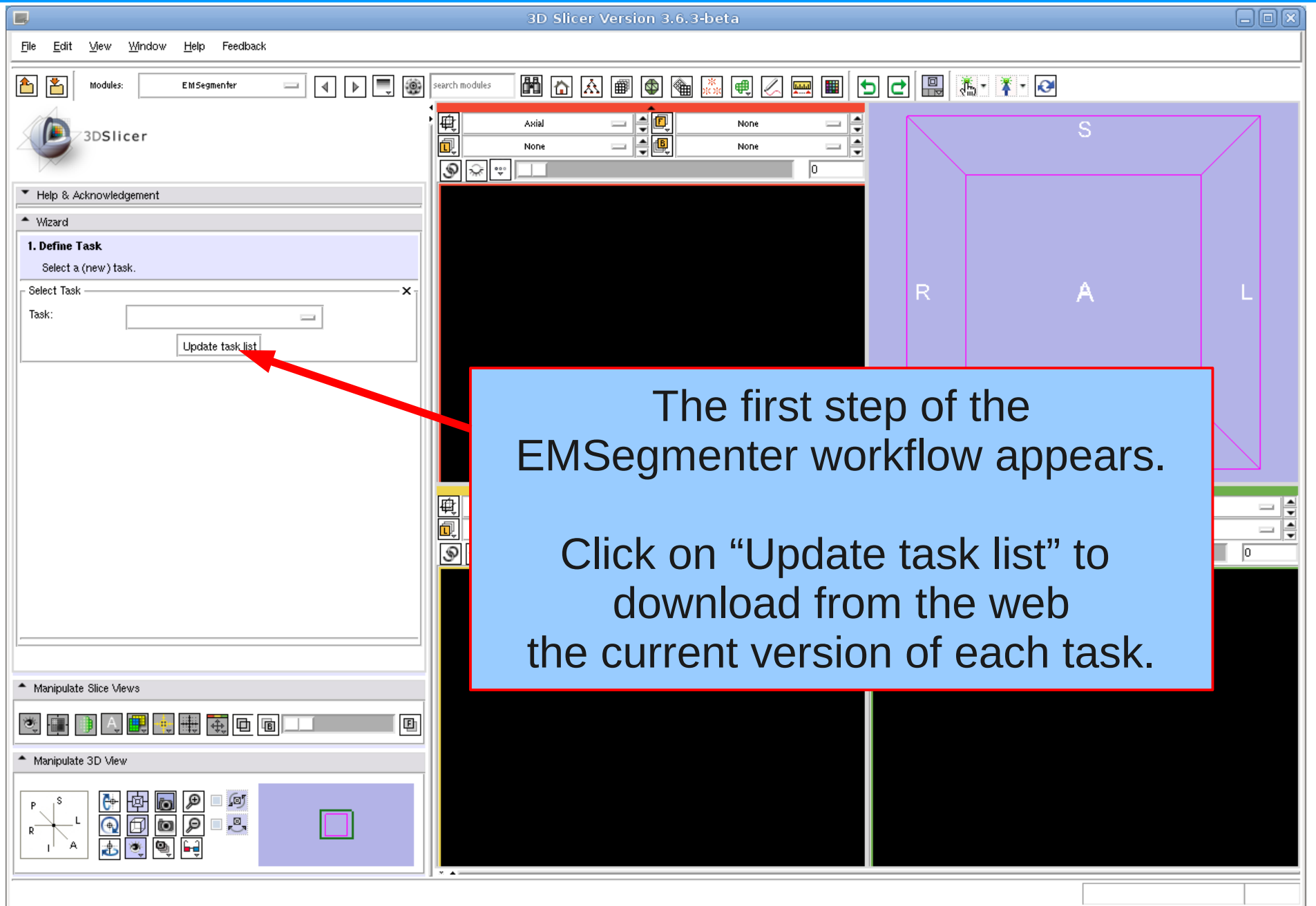
3DSlicer

Select EMSegmenter Module

The screenshot shows the 3D Slicer 3.6.3-beta interface. The 'Segmentation' menu is open, and the 'EMSegmenter' option is highlighted. A red arrow points from a blue callout box to the 'EMSegmenter' option. The callout box contains the text 'Select Segmentation → EMSegmenter'. The main window displays a 3D view of a brain slice with a purple bounding box and labels 'S', 'R', 'A', and 'L'. The 'EMSegmenter' module is selected in the bottom status bar.

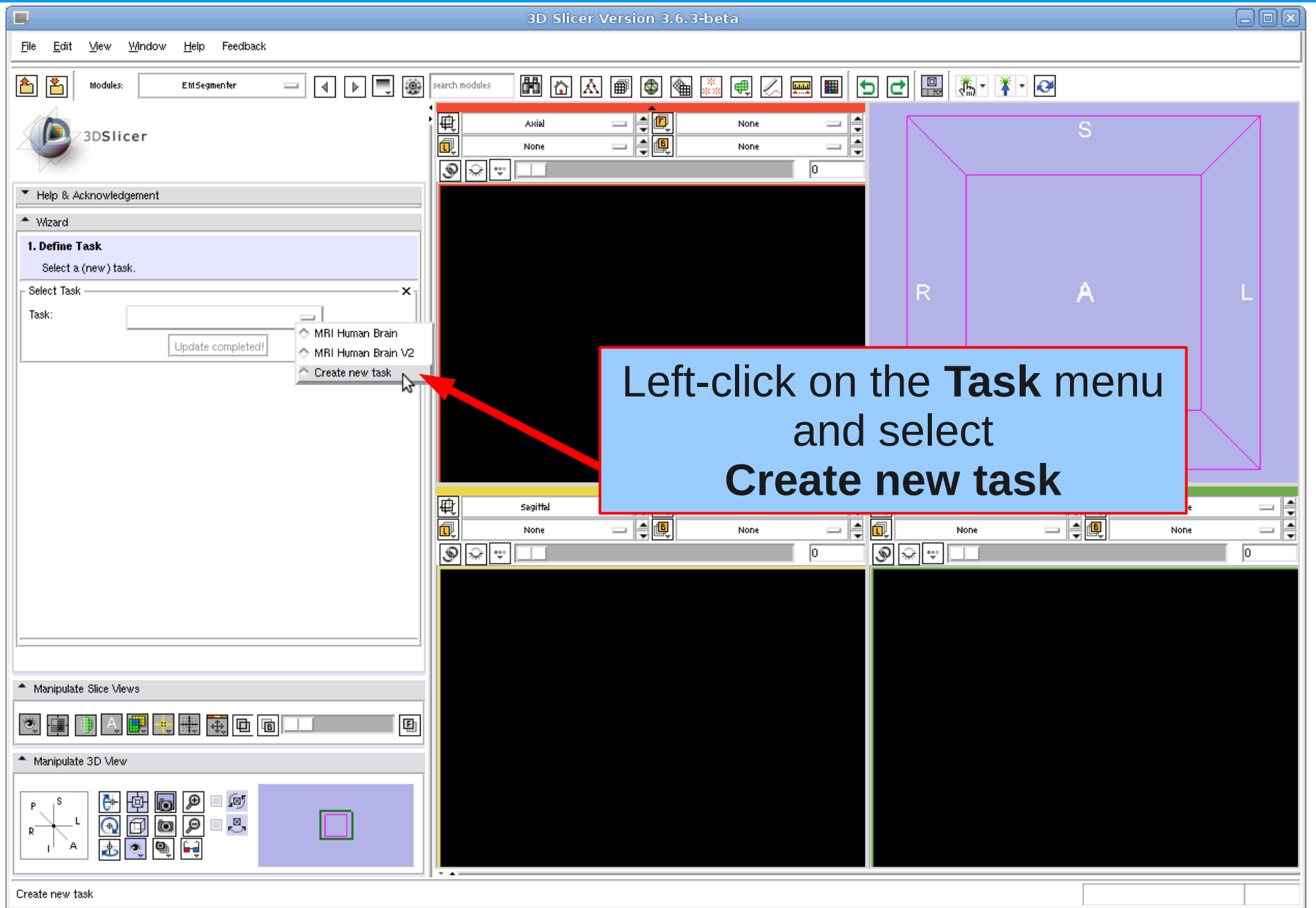


Update Task List





Create New Task





Create New Task

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

1. Define Task

Select a (new) task.

Select Task

Task:

Update task list

New Task Name: Tutorial

Preprocessing:

- MRI Human Brain
- None

Apply

Choose **Tutorial** as a new task name and select **MRI Human Brain** Pre-processing Click **Apply**

Updated preprocessing tasks will contain a version number (e.g. **MRI Human Brain V2**) Please select the latest version.



Define Input Channel

Step 2: Define Input Channel

The EMSegmenter is equipped for multi-channel segmentations. For this tutorial, we want to perform single channel T1 segmentation. We now specify the task accordingly by loading in a T1 scan and creating a single input channel.



Define Input Channels

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

Define Input Channels

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

Input Channel Error

Please define at least one input channel

OK

Click OK

< Back Next > Segment

Manipulate Slice Views

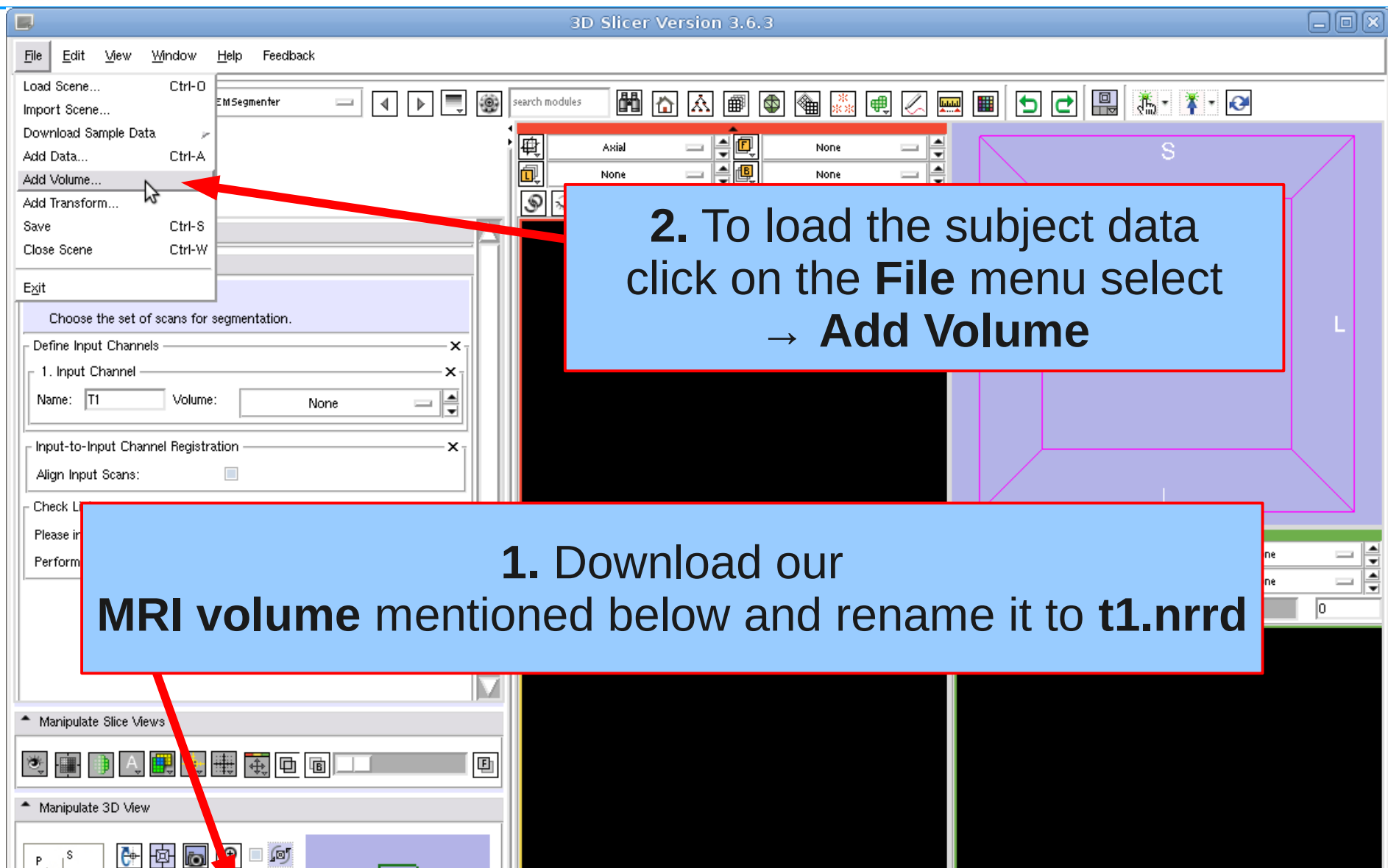
Manipulate 3D View

P S R L I A



3DSlicer

Load subject volume



2. To load the subject data click on the **File** menu select → **Add Volume**

1. Download our **MRI volume** mentioned below and rename it to **t1.nrrd**

http://www.slicer.org/slicerWiki/images/c/cd/MRIHumanBrain_T1_aligned.nrrd



Load Subject Data

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter

3DSlicer

Help & Acknowledgement

Wizard

2/3. Define Input Channels

Name the input channels and choose the set of scans for segment

Define Input Channels

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

Volume Options

Centered Ignore File Orientation Label Map Single File Name: t1

Recent Volumes: Browse to CWD

Apply Cancel

**Browse to your download location,
select t1.nrrd,
And click on Apply.**

name	Size	Modified
t1.nrrd	5,214 KB	Tue Nov 16 17:01:14



Define Input Channel

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

2/3. Define Input Channels

Name the input channels and choose the set of scans for segmentation.

Define Input Channels

Input Channel

Name: T1 Volume: t1

Add Channel Remove Channel

Input to Input Channel Registration

Align Input Scans:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

t1

Click on **Add Channel**.
Type 'T1' into the **Name** field.
Assign the **Volume t1**.
Click Next



Define Input Channel

The screenshot displays the 3D Slicer 3.6.3-beta interface. The 'Define Input Channels' wizard is active, showing a single input channel named 'T1' with a volume of 't1'. A blue text box overlaid on the wizard says 'To confirm click Yes'. A confirmation dialog box titled 'Change the number of input channels?' is open, asking 'Are you sure you want to change the number of input images?' with 'Yes' and 'No' buttons. The 'Yes' button is being clicked. The background shows three slice views: Axial, Coronal, and Sagittal, with a purple bounding box in the Axial view and a green bounding box in the Coronal view. The interface includes a menu bar, a toolbar, and various panels for slice manipulation and 3D view manipulation.



Define Anatomical Tree

Step 3: Define the Anatomical Tree

In this step we are defining the anatomical structures we want to segment and store the information in a tree data structure. Each node represents an anatomical structure. Additionally, a label and color can be assigned to each node, which are used when generating the segmentation map.



3DSlicer

Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree
Define a hierarchy of structures.

Anatomical Tree

- Root
 - Add sub-class
 - Delete sub-class

Node Attributes

Name: Root

Label: 1000 Color: [Black]

Select colormap: L...s

Entry	Name	Color
0	Black	[Black]
1	jake	[Blue]
2	Peach	[Orange]
3	Brain	[Purple]

Manipulate Slice Views

Manipulate 3D View

Add sub-class

Right-click on **Root**, and select **Add sub-class**

S R L A



3DSlicer

Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree
Define a hierarchy of structures.

Anatomical Tree

- Root
 - node_1008

Node Attributes

Name: node_1008

Label: 1008 Color: [Black]

Select colormap: L...s

Entry	Name	Color
0	Black	[Black]
1	jake	[Blue]
2	Peach	[Orange]
3	Brain	[Purple]

Manipulate Slice Views

Manipulate 3D View

File



Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree
Define a hierarchy of structures.

Anatomical Tree

- Root
 - Background

Node Attributes

Name: Background

Label: 1008 Color: [Black]

Change the node name to **Background**

Known KWWidgets Bug!
This field cannot be empty.
Sorry!

Axial None t1 129 0

Sagittal None t1 129 0

Coronal None t1 63 1.4211e-1

R A L S I

P L R I A

View



3DSlicer

Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree
Define a hierarchy of structures.

Anatomical Tree

- Root
 - B

Node Attributes

Name: Background

Label: 1008 Color: [Black]

Select colormap: L...s

Entry	Name	Color
0	Black	[Black]
1	jake	[Blue]
2	Peach	[Orange]
3	Brain	[Purple]

Manipulate Slice Views

Manipulate 3D View

Add sub-class

Right-click on Root, and select Add sub-class



Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree

Define a hierarchy of structures.

Anatomical Tree

- Root
 - Background
 - Intracranial Cavity

Node Attributes

Name: Intracranial Cavity

Label: 1003 Color: [Black]

Select colormap: L...s

Entry	Name	Color
0	Black	[Black]
1	jake	[Blue]
2	Peach	[Orange]
3	Brain	[Purple]

Manipulate Slice Views

Manipulate 3D View

Sagittal None Coronal None

S I A L

R I A

S I A L

The anatomical tree contains two components: **Background** and **Intracranial Cavity**



Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree

Define a hierarchy of structures.

Anatomical Tree

- Root
 - Background
 - Air
 - Intracranial Cavity

Node Attributes

Name: Air

Label: 0 Color: [black box]

Select colormap: L...s

Entry	Name	Color
0	Black	[black]
1	jake	[blue]
2	Peach	[orange]
3	Brain	[purple]

Manipulate Slice

Manipulate 3D View

Edit

Right click on **Background**, and select **Add sub-class**.

Add the sub-class **Air** to **Background**.

Click on the colored box next to **Color**

A new widget appears, choose

- Default Labels from file
- Slicer3_2010_Brain_Labels

Set the label value for **Air** to 0.



3DSlicer

Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree

Define a hierarchy of structures.

Anatomical Tree

- Root
 - Background
 - Air
 - Skull
 - Intracranial Cavity

Node Attributes

Name: Skull

Label: 3 Color:

Select colormap: L...s

Entry	Name	Color
0	Black	
1	jake	
2	Peach	
3	Brain	

Manipulate Slice Views

Manipulate 3D View

Window

129 0

63 1.4211e-1

S

L

0

0



3DSlicer

Define Anatomical Tree

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree

Define a hierarchy of structures.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Node Attributes

Name: CSF

Label: 5 Color:

Select colormap: L...s

Entry	Name	Color
0	Black	
1	jake	
2	Peach	
3	Brain	

Manipulate Slice Views

Manipulate 3D View

File

Using the same process, right-click on **Intracranial Cavity**, and add the three following Sub-classes:

- Grey Matter, label 9
- White Matter, label 10
- CSF, label 5

Click on **Next** to assign the atlas to the structures



Define Atlas

Step 4: Assign an atlas to each node in the tree

We now further characterize each anatomical structure by specifying the atlas associated with that structure. For the EMSegmenter, the atlas defines the spatial distribution of the structure of interest, which is the frequency the structure appeared at each image location in a given set of scans.

For further information on generating these atlas please read:

L. Zöllei, M. Shenton, W.M. Wells III, K.M. Pohl. “The Impact of Atlas Formation Methods on Atlas-Guided Brain Segmentation, Statistical Registration.” In Pair-wise and Group-wise Alignment and Atlas Formation Workshop at MICCAI 2007: Tenth International Conference on Medical Image Computing and Computer-Assisted Intervention, pp. 39 - 46, 2007.

<https://www.rad.upenn.edu/sbia/Kilian.Pohl/publications/zollei-miccai-2007.pdf>



3DSlicer

Define Atlas

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter search modules



Help & Acknowledgement

Wizard

4/9. Define Atlas

Assign structure specific atlases to corresponding anatomy in the tree.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Probability Map

Class: Air

Select Volume:



< Back Next

Manipulate Slice Views



Manipulate 3D View



Edit

In the following steps we are assigning atlas volume data to each structure.

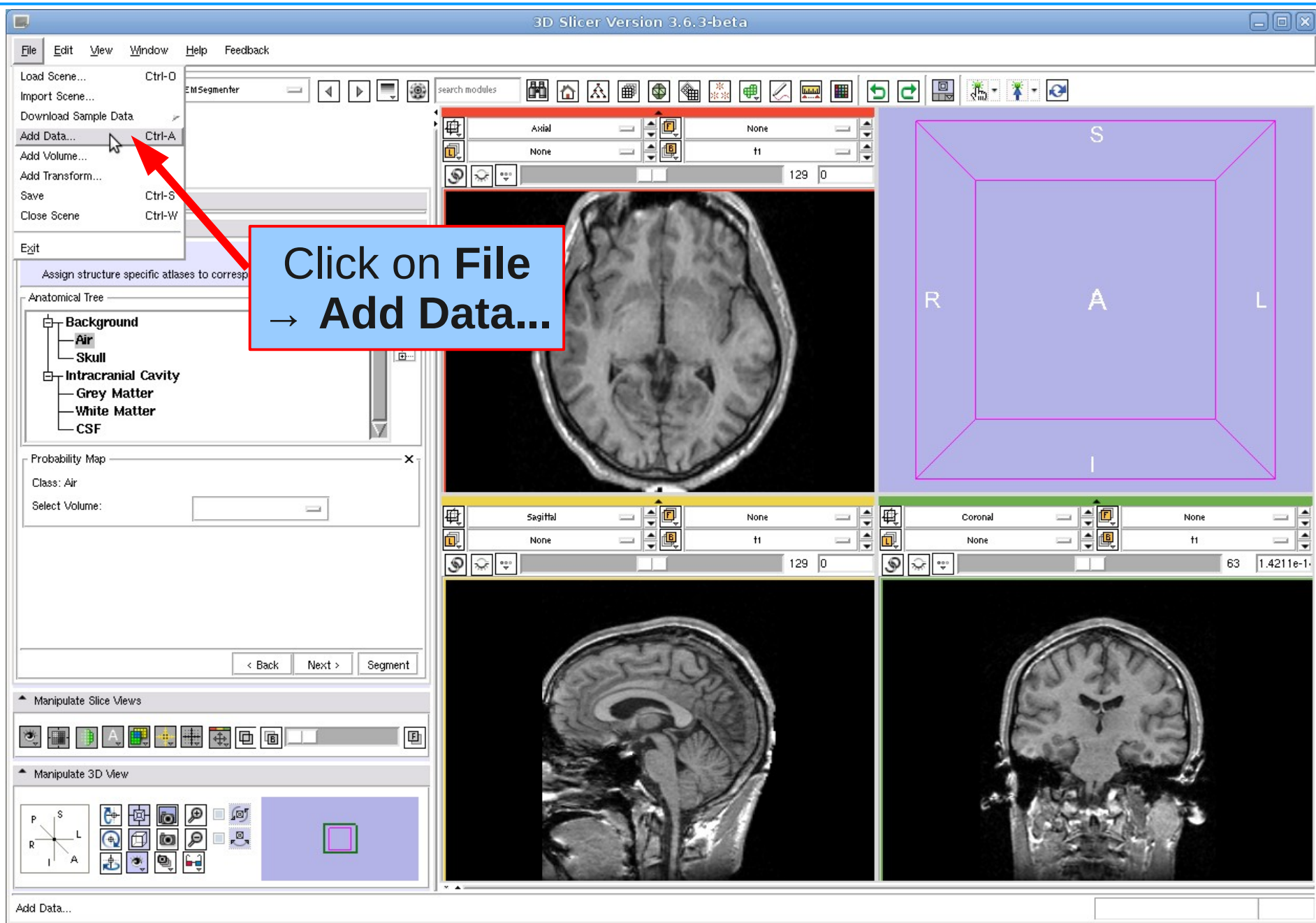
Your version might contain the field **Select Probability Map** instead of **Select Volume**.

The field **Select Parcellation Map** can be ignored.



3DSlicer

Load Atlas Data





Load Atlas Data

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

4/9. Define Atlas

Assign structure specific atlases to correspo

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Probability M

Class: Air

Select Volum

Manipulate S

Manipulate 3D View

Add Data...

Select File

Name	Size	Modified time
.svn		Tue Nov 16 12:33:20 2010
atlas_air.nrrd	438 KB	Mon Nov 15 14:24:59 2010
atlas_csf.nrrd	749 KB	Mon Nov 15 14:24:59 2010
atlas_greymatter.nrrd	1,158 KB	Mon Nov 15 14:24:59 2010
atlas_skulneck.nrrd	680 KB	Mon Nov 15 14:24:59 2010
atlas_t1.nrrd	5,214 KB	Mon Nov 15 14:24:59 2010
atlas_whitematter.nrrd	1,070 KB	Mon Nov 15 14:24:59 2010

bin
include
lib
share
Free Surfer
MRML
Slicer3
Modules

Add from Current Directory Add Directory Add File(s) Apply Cancel

P S
R L
I A



3DSlicer

Load Atlas Data

Click on **Label None** to uncheck all **LabelMap** checkboxes
Click **Apply**

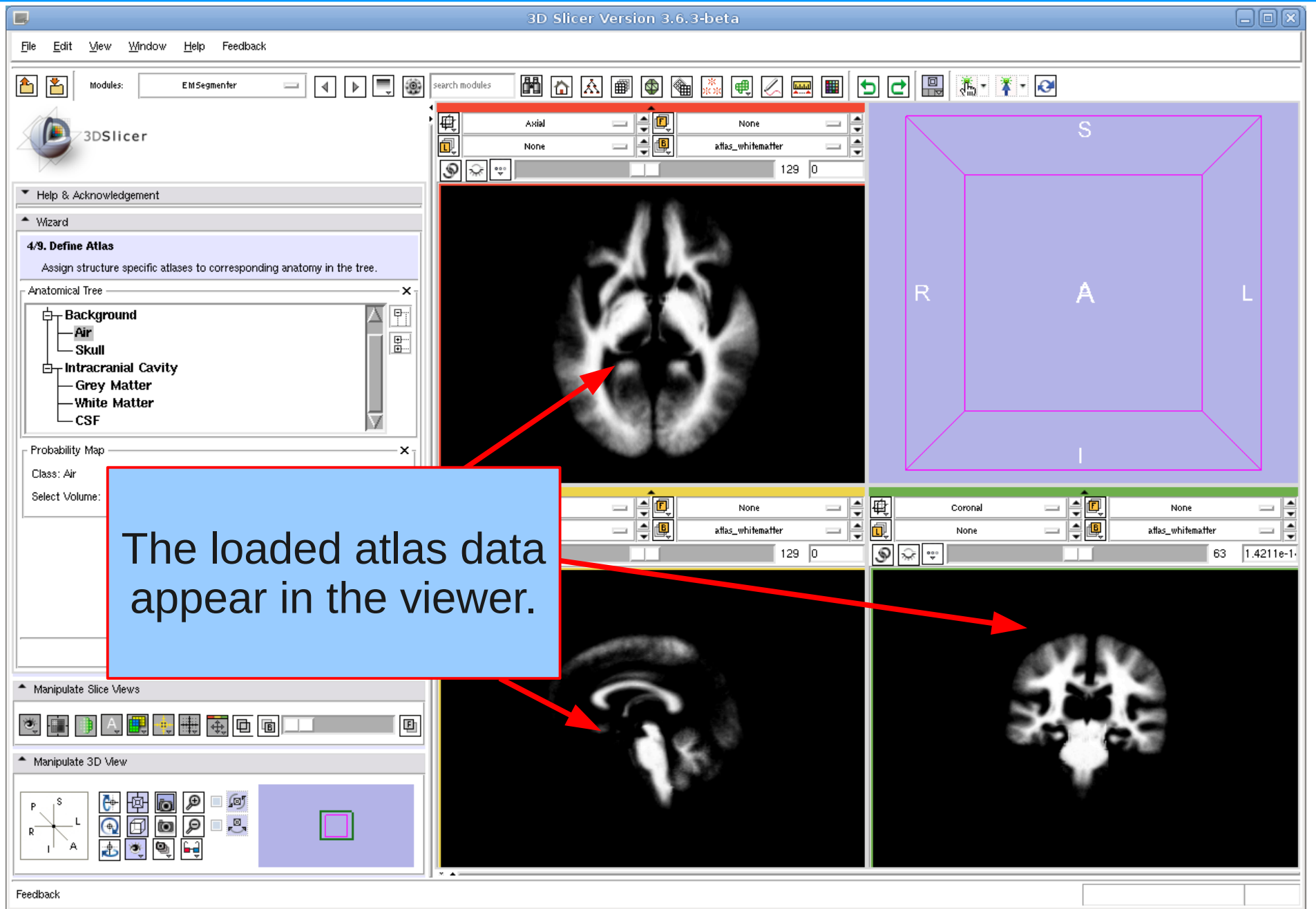
The screenshot shows the 3DSlicer interface with the 'Add Data' dialog box open. The dialog has several tabs: 'Clear Entries', 'Select All', 'Select None', 'Label', 'Label None', 'Centered All', 'Centered None', 'Fiber Bundle All', and 'Fiber Bundle None'. The 'Label None' tab is selected and circled in red. Below the tabs is a table with columns: 'Select', 'File', 'Type', 'Name', 'LabelMap', 'Centered', and 'FiberBundle'. The table contains six rows of atlas data, all with the 'LabelMap' checkbox unchecked. The 'Apply' button at the bottom right of the dialog is also circled in red. A blue callout box with a red border contains the text: 'Click on Label None to uncheck all LabelMap checkboxes' and 'Click Apply'. Red arrows point from the callout box to the 'Label None' tab and the 'Apply' button.

Select	File	Type	Name	LabelMap	Centered	FiberBundle
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_air	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_csf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_greymatter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_skulneck	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_t1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_whitematte	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



3DSlicer

Load Atlas Data





Define Atlas

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

4/9. Define Atlas
Assign structure specific atlases to corresponding anatomy in the tree.

Anatomical Tree

- Background
 - Air**
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Probability Map

Class: Air

Select Volume: atlas_air

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

File

Select **Air** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_air** to the **Air** structure.



Define Atlas

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

4/9. Define Atlas
Assign structure specific atlases to corresponding anatomy in the tree.

Anatomical Tree

- Background
 - Air
 - Skull**
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Probability Map

Class: Skull

Select Volume: atlas_skullneck

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

File

Select **Skull** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_skullneck** to the **Skull** structure.



Define Atlas

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

4/9. Define Atlas
Assign structure specific atlases to corresponding anatomy in the tree.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter**
 - White Matter
 - CSF

Probability Map

Class: Grey Matter

Select Volume: atlas_greymatter

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

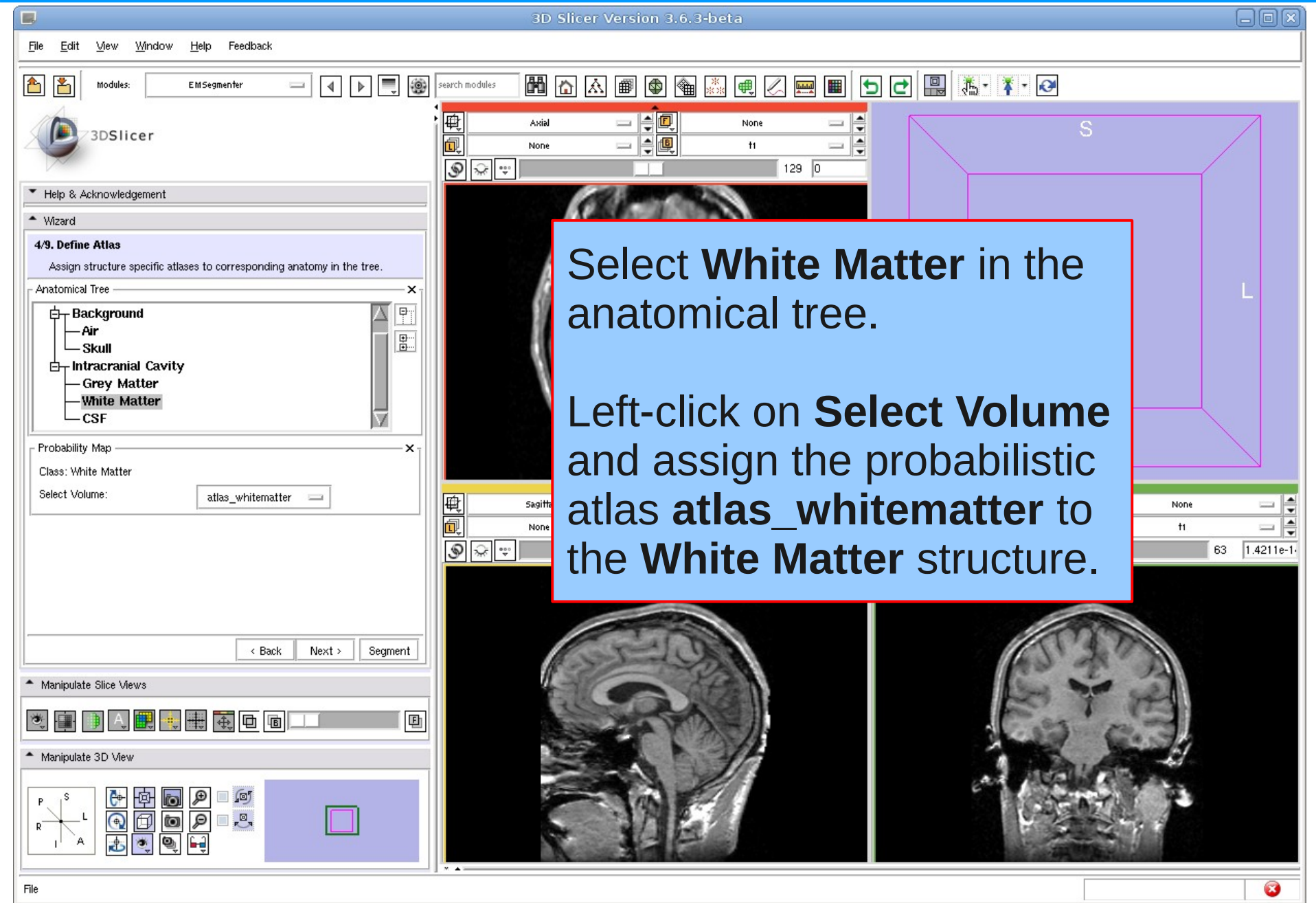
atlas_greymatter

Select **Grey Matter** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_greymatter** to the **Grey Matter** structure.



Define Atlas





Define Atlas

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

4/9. Define Atlas
Assign structure specific atlases to corresponding anatomy in the tree.

Anatomical Tree

- Background
- Air
- Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF**

Probability Map

Class: CSF

Select Volume: atlas_csf

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

atlas_csf

Select **CSF** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_csf** to the **CSF** structure.

Click on **Next**



Edit Registration Parameters

Step 5: Defining the Atlas to Image Registration

In general, the currently defined atlas has to be aligned to the subject scan. To do so, we define in this step the template, which in this case is a T1 scan, that the atlas is currently aligned to as well as the type of registration we would like to perform



Edit Registration Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

5/9. Edit Registration Parameters

Specify atlas-to-input scans registration parameters.

Atlas-to-Input Registration Parameters

T1: atlas_t1

Affine Registration: None

Deformable Registration: None

Interpolation: Linear

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

Window

Select **atlas_t1** to assign the atlas to the input channel **T1**



3DSlicer

Edit Registration Parameters

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM Segmenter search modules

3DSlicer

Help & Acknowledgement

Wizard

5/9. Edit Registration Parameters

Specify atlas-to-input scans registration parameters.

Atlas-to-Input Registration Parameters

T1

Affine Registration: **Fast**

Deformable Registration: **Fast**

Interpolation: Linear

Package: CMTK

Select **Fast** for the Affine Registration and the Deformable Registration.

< Back **Next** > Segment

Manipulate Slice Views

Manipulate 3D View

Click on **Next**



Define Preprocessing

Step 6: Further Specify Preprocessing

In the first step, we defined the type of preprocessing we wanted to perform. We now further specify the pre-processing by answering a set of questions further specifying the type of data we attend to segment. For example, in this tutorial we assume that the subject scan is already aligned to the atlas so that we skip the atlas to image registration during preprocessing.



Define Preprocessing

We note, that in this tutorial the subject data set is image inhomogeneity corrected and pre-registered to the atlas. Thus, the 'registration flag' and the 'inhomogeneity correction flag' are not checked. Please do not check for this tutorial as pre-processing can be time consuming.

The screenshot shows the 3DSlicer software interface. The main window is titled '6/9. Define Preprocessing' and contains a 'Check List' with the following items:

- register the atlas to the input scan ?
- perform image inhomogeneity correction on input scan ?

The 'Next >' button is circled in red. A blue callout box with the text 'Click on Next' is overlaid on the interface. The interface also shows various viewports and toolbars.



3DSlicer

Define Preprocessing

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

6/9. Define Preprocessing
Answer questions for preprocessing of input images

Check List

This task only applies to non-skull stripped scans!

Should the EM Segmenter

- register the atlas to the input scan ?
- perform image inhomogeneity correction on input scan ?

Start Preprocessing of images?

Preprocessing of images might take a while. Do you want to proceed ?

Yes No

< Back Next > Segment

Manipulate Slice Views

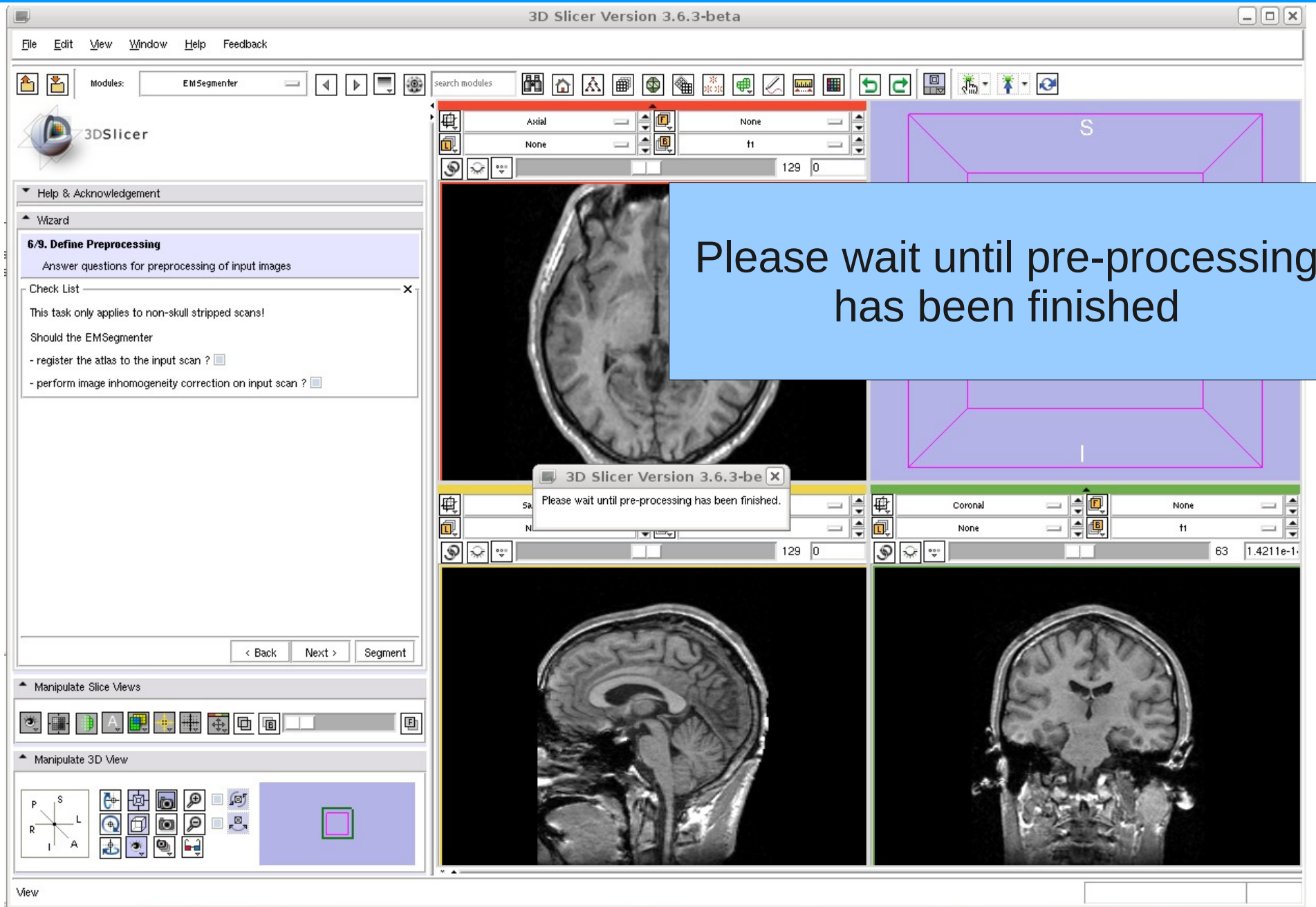
Manipulate 3D View

Feedback

The EM Segmenter will perform some standard pre-processing.
Click on **Yes** to confirm.



Define Preprocessing





Specify Intensity Distribution

Step 7: Specifying the Intensity Distribution

In this step, users further specify each anatomical structure by defining the intensity distribution that is typical for the structure in the input scan.

In this tutorial the step can be skipped as the intensity distributions have been calculated during the pre-processing.



3DSlicer

Specify Intensity Distribution

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

7/9. Specify Intensity Distributions

Define intensity distribution for each anatomical structure.

Anatomical Tree

- Root
 - Background
 - Air
 - Skull
 - Intracranial Cavity
 - Grey Matter
 - White Matter

Intensity Distribution | Manual Sampling

Class: Air

Specification: Manual

Mean: 1.612

Log Covariance: 0.6825

Reset Distribution

Plot Distributions

< Back | **Next >** | Segment

Manipulate Slice Views

Manipulate 3D View

Click on Next



Edit Node-based Parameters

Step 8: Define EM Specific Parameters

The EMSegmenter segments the input scans of Step 1 into the structure of interest of Step 2 by using an optimization algorithm called the Expectation Maximization Algorithm. This algorithm has specific parameters that influence the segmentation. In this tutorial we will specify:

- **class weights**, which define the relative importance of structure over other structure. This is useful if a structure is too dominant in the automatic segmentation. By lowering the weight, the structure will be less present in the corresponding automatic segmentation.
- **atlas weight**, which define the importance of the atlas (of Step 3) over the image data defined in Step 1. One might want to lower the weight if the intensity distributions clearly define each structure to be segmented.
- **Input Channel weight**, which defines the importance between the different input channels for the structure of interest. Since we only defined one input channel, this parameter should simply be set to 1.
- **Alpha**, which defines the smoothness of the segmentation. The alpha value has to be between 0 and 1. An alpha value of 1 produces fairly smooth segmentations while an alpha value of 0 generally results in noisy segmentations.



Edit Node-based Parameters

The screenshot shows the 3D Slicer 3.6.3-beta interface. The main window displays a brain MRI scan with three orthogonal views: Axial (top), Sagittal (bottom left), and Coronal (bottom right). A blue text box is overlaid on the Axial view, containing the text: "Per default all the EM Input Parameters are unspecified." The left sidebar shows the "EM Segmenter" module with the "8/9. Edit Node-based Parameters" wizard open. The "Anatomical Tree" shows a hierarchy: Root > Background > Air, Skull > Intracranial Cavity > Grey Matter, White Matter. The "Basic" tab is selected, showing "Class Weight" and "Atlas Weight" fields. The "Manipulate Slice Views" and "Manipulate 3D View" panels are also visible.



Edit Node-based Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
- Air
- Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: Background

Class Weight: 0.15 | Input Channel Weights: T1 | Atlas Weight: 1 | Alpha: 0.99

Overview Of Class Weights

Background	0.15
Intracranial Cavity	0

< Back | Next > | Segment

Manipulate Slice Views

Manipulate 3D View

Help

Left click on **Background** and Enter the following parameters:

- Class Weight 0.15
- Atlas Weight 1

We only defined one input channel, please set Input Channel Weights: T1: 1.0



3DSlicer

Edit Node-based Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity**
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: Intracranial Cavity

Class Weight: 0.85 | Input Channel Weights

Atlas Weight: 1 | T1 1

Alpha: 0.99

Overview Of Class Weights

Background	0.15
Intracranial Cavity	0.85

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

Help

Left click on **Intracranial Cavity**
And enter the following parameters:

- Class Weight 0.85
- Atlas Weight 1
- Input Channel Weights:
T1: 1.0



3DSlicer

Edit Node-based Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull**
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: Skull

Class Weight: 0.3 | Input Channel Weights

Atlas Weight: 1 | T1 1

Overview Of Class Weights

Air	0.7
Skull	0.3

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

Help

Enter the following parameters
for Air and Skull

Air: Class Weight: 0.7
Atlas Weight: 1.0
Input Channel Weight: 1.0

Skull: Class Weight: 0.3
Atlas Weight: 1.0
Input Channel Weight: 1.0



3DSlicer

Edit Node-based Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Wizard

8/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: Grey Matter

Class Weight: 0.45 | Input Channel Weights: T1

Atlas Weight: 0.01

Overview Of Class Weights

Grey Matter	0.45
White Matter	0.3
CSF	0.25

< Back | **Next >** | Segment

Manipulate Slice Views

Manipulate 3D View

Window

Click on Next

Enter the following parameters for GM, WM, and CSF

GM: Class Weight: 0.45
Atlas Weight: 0.01
Input Channel Weight: 1.0

WM: Class Weight: 0.3
Atlas Weight: 0.7
Input Channel Weight: 1.0

CSF: Class Weight: 0.25
Atlas Weight: 0.01
Input Channel Weight: 1.0



Run Segmentation

Step 9: Specify the Region of Interest and complete the Segmentation

This is the last step of the EMSegmenter wizard.

The Volume Of Interest (VOI) can be specified, and one can start the EM algorithm, which will segment the input channels by taking all the information entered in the previous steps into account .



Run Segmentation

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

9.9. Define Miscellaneous Parameters

Define miscellaneous parameter for performing segmentation.

Define VDI

L-R Range: -119.0 119.5

P-A Range: -92.2 92.25

I-S Range: -119.0 119.5

Display clipping box Interactive Mode

Display VDI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

< Back Next **Segment**

Manipulate Slice Views

Manipulate 3D View

View 1: Axial, None, t1, 129 0

View 2: Sagittal, None, t1, 129 0

View 3: Coronal, None, t1, 63 1.4211e-1

Click on Segment

The screenshot shows the 3D Slicer interface with the EMSegmenter module active. The 'Define Miscellaneous Parameters' panel is open, showing VDI ranges and checkboxes for 'Interactive Mode' and 'Multi-threading Enabled'. The 'Segment' button at the bottom of the panel is circled in red. A blue callout box with the text 'Click on Segment' is overlaid on the bottom right of the interface. The main window displays three orthogonal views of a brain MRI slice: Axial (top), Sagittal (bottom left), and Coronal (bottom right). The Axial view shows a purple rectangular clipping box with labels S (Superior), I (Inferior), R (Right), and L (Left). The Sagittal and Coronal views also show similar clipping boxes.



Run Segmentation

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

9/9. Define Miscellaneous Parameters

Define miscellaneous parameter for performing segmentation.

Define VOI

L-R Range: -119. 119.5

P-A Range: -92.2 92.25

I-S Range: -119. 119.5

Display clipping box Interactive Mode

Display VOI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

t1 RAS: (-0.9, -53.8, 122.8), Bg IJK: (127, -4, 26), Bg: Out of Frame

The EM algorithm is running
Please wait for a while.

3D Slicer Version 3.6.3-beta
Please wait until segmentation has been finished.



3DSlicer

Results: Run Segmentation

The screenshot displays the 3D Slicer interface with the EM Segmenter module active. The main window shows three orthogonal views of a brain T1 volume: Axial (top), Sagittal (bottom left), and Coronal (bottom right). The segmentation results are overlaid in blue. The software title bar indicates '3D Slicer Version 3.6.3-beta'. The left sidebar contains a 'Define miscellaneous parameter for performing segmentation' panel with sliders for L-R, P-A, and I-S ranges, and a 'Segment' button at the bottom. The 'Manipulate Slice Views' section at the bottom left has a red circle around the 'Show/Hide' icon. A blue text box on the right contains the text: 'The results of the EM Segmentation are overlaid on the T1 volume.'



Consecutive adjustment

As previously mentioned, one might want to adjust the parameters of Step 8 in order to improve the segmentation. We now adjust three parameters and show the impact on the segmentation. The following slides illustrate

- how to specify a volume of interest and
- how to adjust segmentation parameters that refine the segmentation result.



Volume Of Interest (VOI)

The screenshot shows the 3D Slicer software interface. The 'Define VOI' panel is highlighted with a red circle. It contains three sliders for L-R Range, P-A Range, and I-S Range. The 'Display VOI in 2D Viewer' checkbox is also highlighted with a red circle. The 'Segment' button is highlighted with a red circle. The 2D viewer shows a brain slice with a red VOI box. The 3D viewer shows a brain model with a red VOI box. The 'Segment' button is highlighted with a red circle.

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

Define miscellaneous parameter for performing segmentation.

Define VOI

L-R Range: -37 49

P-A Range: -58 54

I-S Range: -55 36

Display clipping box Interactive Mode

Display VOI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

< Back Next >

Manipulate Slice Views

Manipulate 3D View

To specify a smaller volume of interest, make it first visible by selecting the checkbox **Display VOI in 2D Viewer**, adjust the size of the VOI by moving the 'Range' slider, unselect the checkbox **Display VOI in 2D Viewer**, and click **Segment**.

Result: Volume Of Interest (VOI)

3DSlicer

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

Define miscellaneous parameter for performing segmentation.

Define VOI

L-R Range: -37 49

P-A Range: -58 54

I-S Range: -55 36

Display clipping box Interactive Mode

Display VOI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

Manipulate Slice Views

Manipulate 3D View

Only the VOI has been segmented.

Note that a smaller VOI leads to a faster segmentation.

For the next adjustment click on **Back**



Adjusting Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

3DSlicer

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: CSF

Class Weight: 0.25 | Input Channel Weights

Atlas Weight: 0.01 | T1

Overview Of Class Weights

Grey Matter	0.23	<input type="checkbox"/>
White Matter	0.52	<input checked="" type="checkbox"/>
CSF	0.25	<input type="checkbox"/>

< Back Next > **Segment**

Manipulate Slice Views

Manipulate 3D View

Feedback

Step 8/9. Edit Node-based Parameters:

We want to change the class weight for grey matter and automatically update the class weight for white matter.

To do so, select the checkbox next to white matter and change the class weight for grey matter to 0.23 .

Click on **Segment**.



Result: Adjusting Parameters

The screenshot shows the 3D Slicer software interface. The main window displays three orthogonal views of a brain MRI scan: Axial (top), Sagittal (bottom left), and Coronal (bottom right). Each view shows a segmentation of the brain tissue, with different colors representing different classes. The 'Wizard' panel on the left is open to the '8/9. Edit Node-based Parameters' step, showing the 'Anatomical Tree' with classes like Background, Air, Skull, Intracranial Cavity, Grey Matter, White Matter, and CSF. The 'Basic' tab is selected, and the 'Class: CSF' parameters are visible, including 'Class Weight' (0.25) and 'Atlas Weight' (0.01). The 'Overview Of Class Weights' table is also shown:

Class	Weight
Grey Matter	0.23
White Matter	0.52
CSF	0.25

A blue text box on the right side of the image contains the following text:

The result of the new segmentation based on the changed parameters appears.

This process can be continued to get a better segmentation.

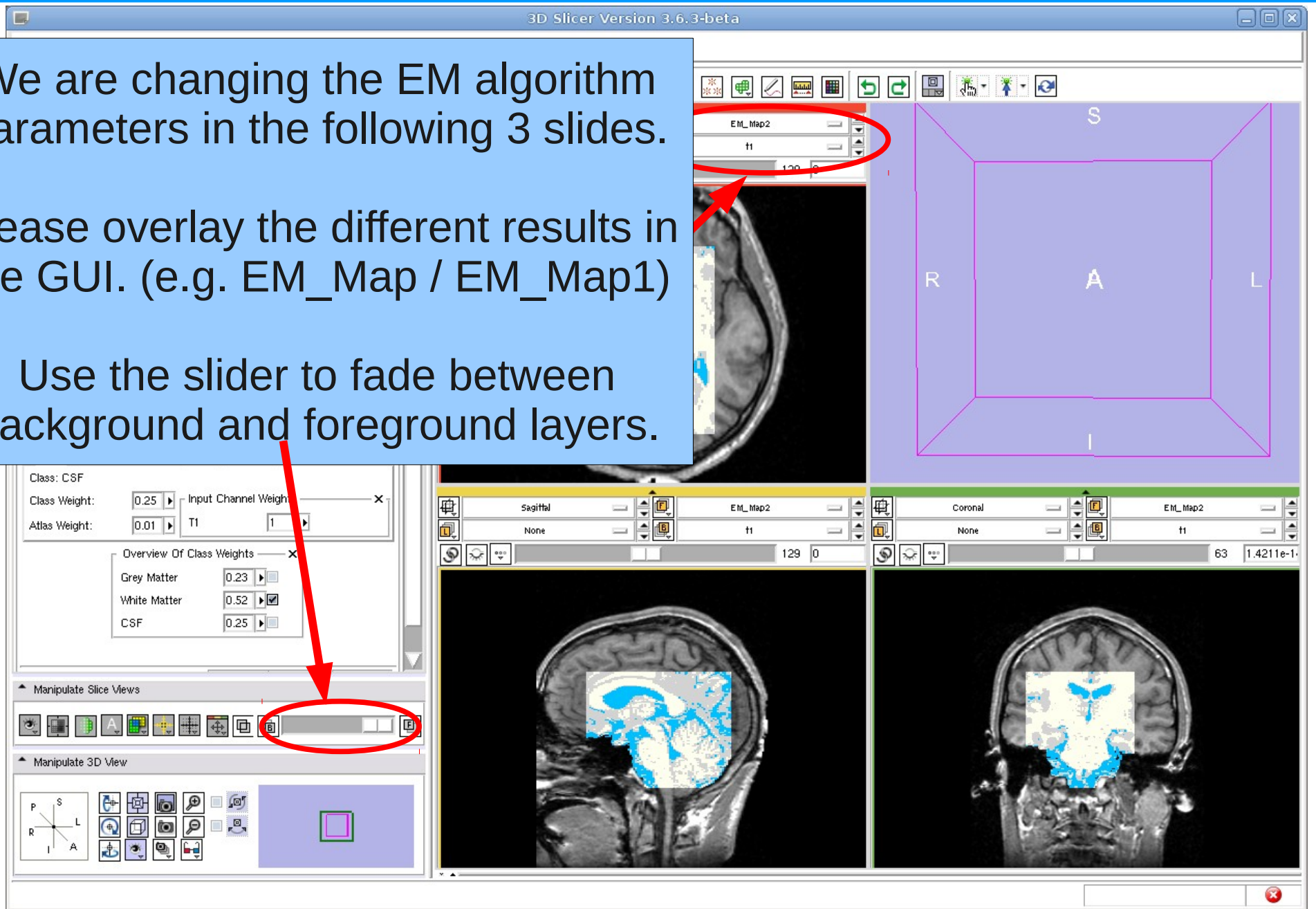


Compare Results

We are changing the EM algorithm parameters in the following 3 slides.

Please overlay the different results in the GUI. (e.g. EM_Map / EM_Map1)

Use the slider to fade between background and foreground layers.





Low ICC alpha value

The screenshot shows the 3D Slicer interface with the EM Segmenter module active. The 'Wizard' panel is open to the '8/9. Edit Node-based Parameters' step. The 'Anatomical Tree' shows the 'Intracranial Cavity' selected. The 'Basic' tab is active, showing the 'Class: Intracranial Cavity' with a 'Class Weight' of 0.85 and an 'Alpha' value of 0.1. The 'Overview Of Class Weights' shows 'Background' at 0.15 and 'Intracranial Cavity' at 0.85. The 'Manipulate Slice Views' and 'Manipulate 3D View' panels are also visible. The main window displays three views: Axial, Sagittal, and Coronal. The labelmap is shown in a noisy, pixelated style, indicating the effect of a low alpha value. A blue text box with the text 'Effect: The labelmap Is less smooth' is overlaid on the right side of the image.



Low white matter atlas weight

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM_Segmenter

search modules

3DSlicer

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: White Matter

Class Weight: 0.52 | Input Channel Weights: T1 | 1

Atlas Weight: 0.1

Overview Of Class Weights

Grey Matter	0.23
White Matter	0.52
CSF	0.25

< Back | Next > | Segment

Manipulate Slice Views

Manipulate 3D View

Effect: Finer white matter structures become visible



3DSlicer

High grey matter class weight

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM_Segmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

- Background
 - Air
 - Skull
- Intracranial Cavity
 - Grey Matter
 - White Matter
 - CSF

Basic | Stopping Conditions | Print | Advanced

Class: White Matter

Class Weight: 0.2 | Input Channel Weights

Atlas Weight: 0.1 | T1 | 1

Overview Of Class Weights

Grey Matter	0.65
White Matter	0.20
CSF	0.15

Manipulate Slice Views

Manipulate 3D View

Effect: Overestimation of grey matter



Further Info & Acknowledgments

EMSegmenter Wiki Page:

<http://www.slicer.org/slicerWiki/index.php/EMSegmenter-Overview>

The EMSegmenter technology behind was reported in:

K.M. Pohl et. A hierarchical algorithm for MR brain image parcellation. IEEE Transactions on Medical Imaging, 26(9), pp 1201-1212, 2007.

We thank the following institutions for their support:

