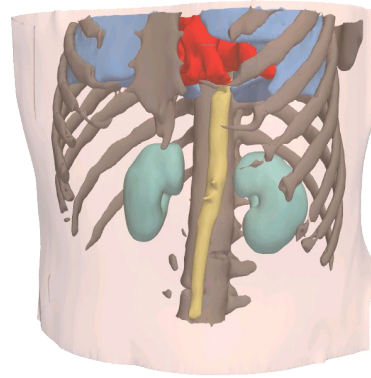
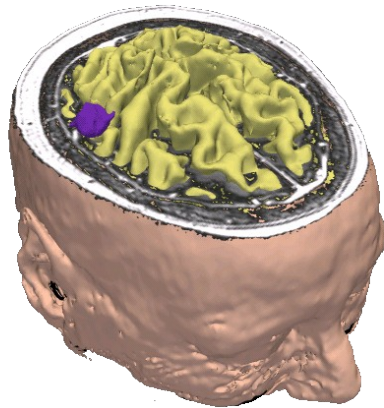




EMSegmenter Tutorial (Advanced Mode)



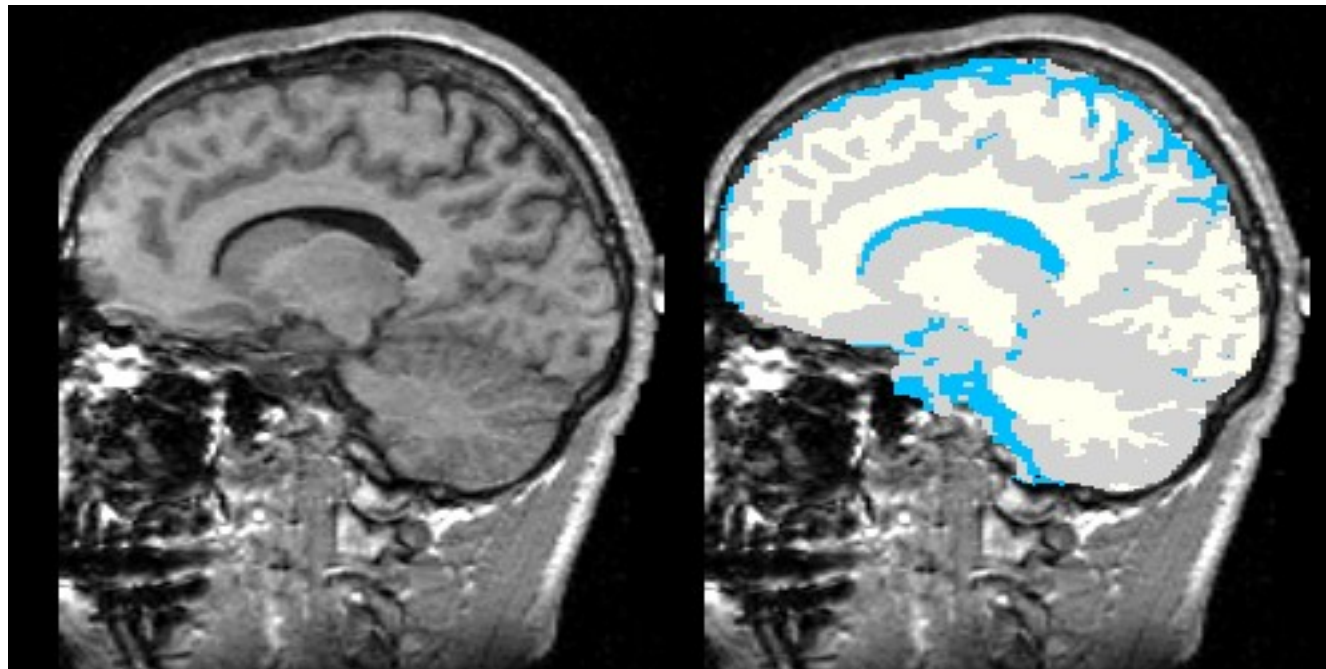
Dominique Belhachemi

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 .



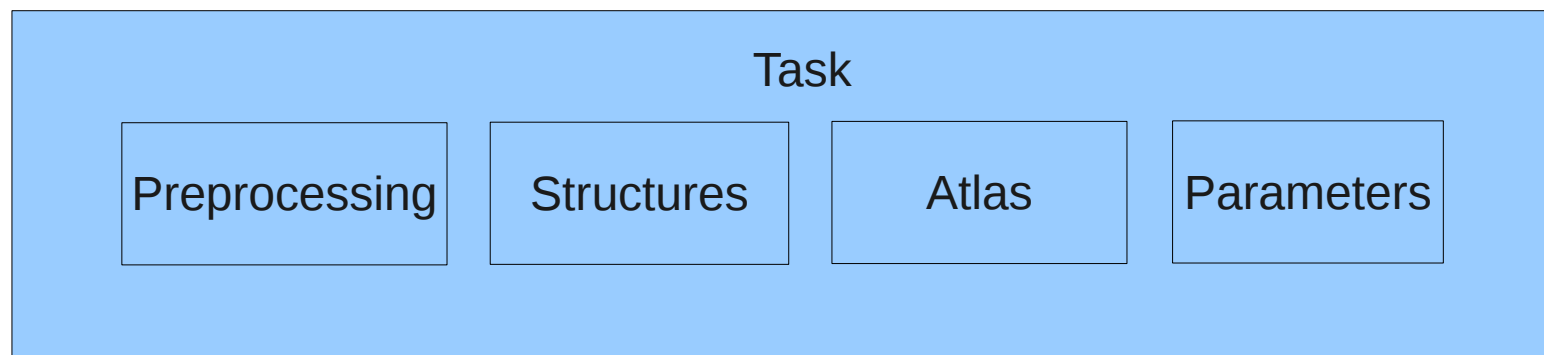
Before

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

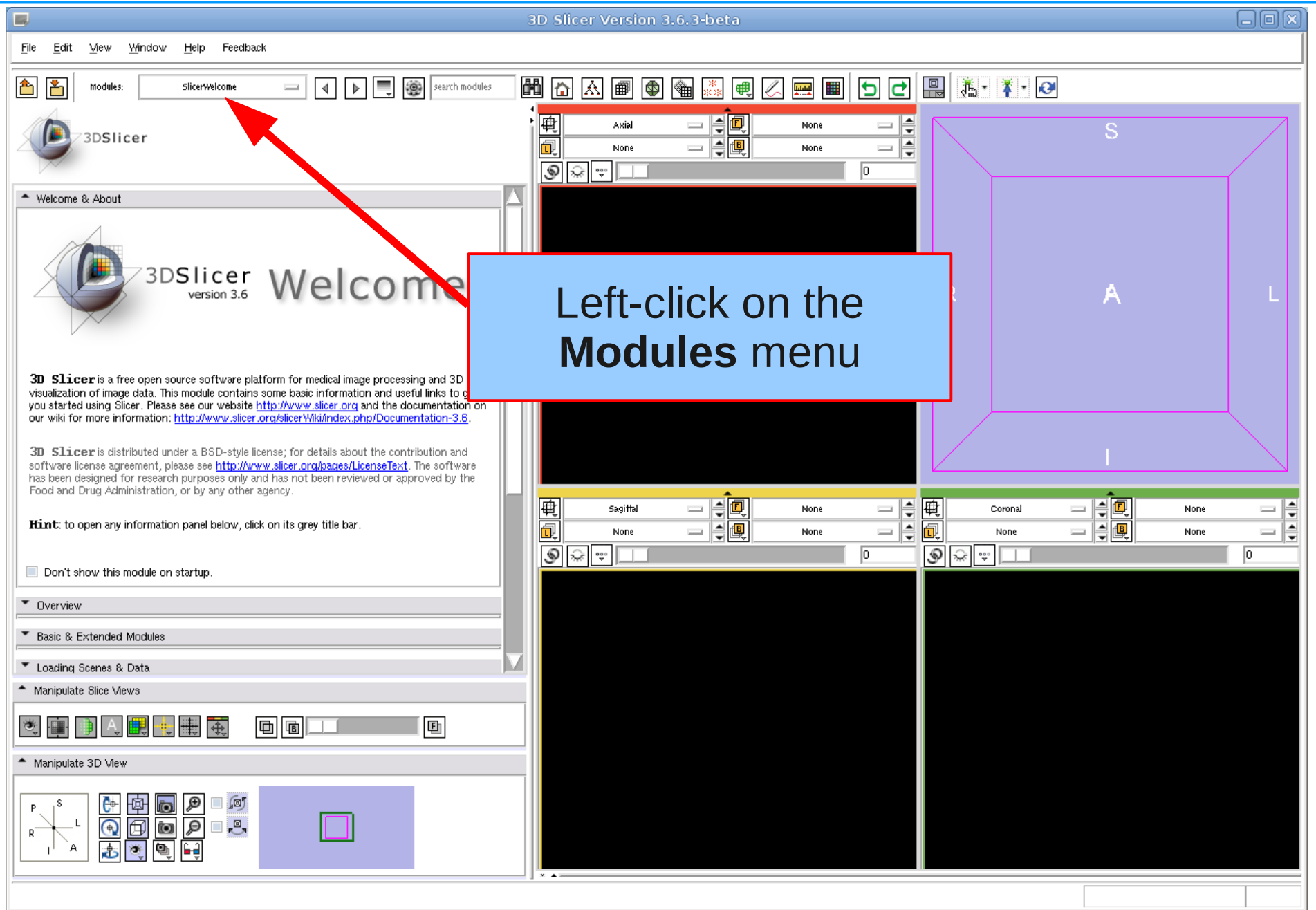
Step 1:

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





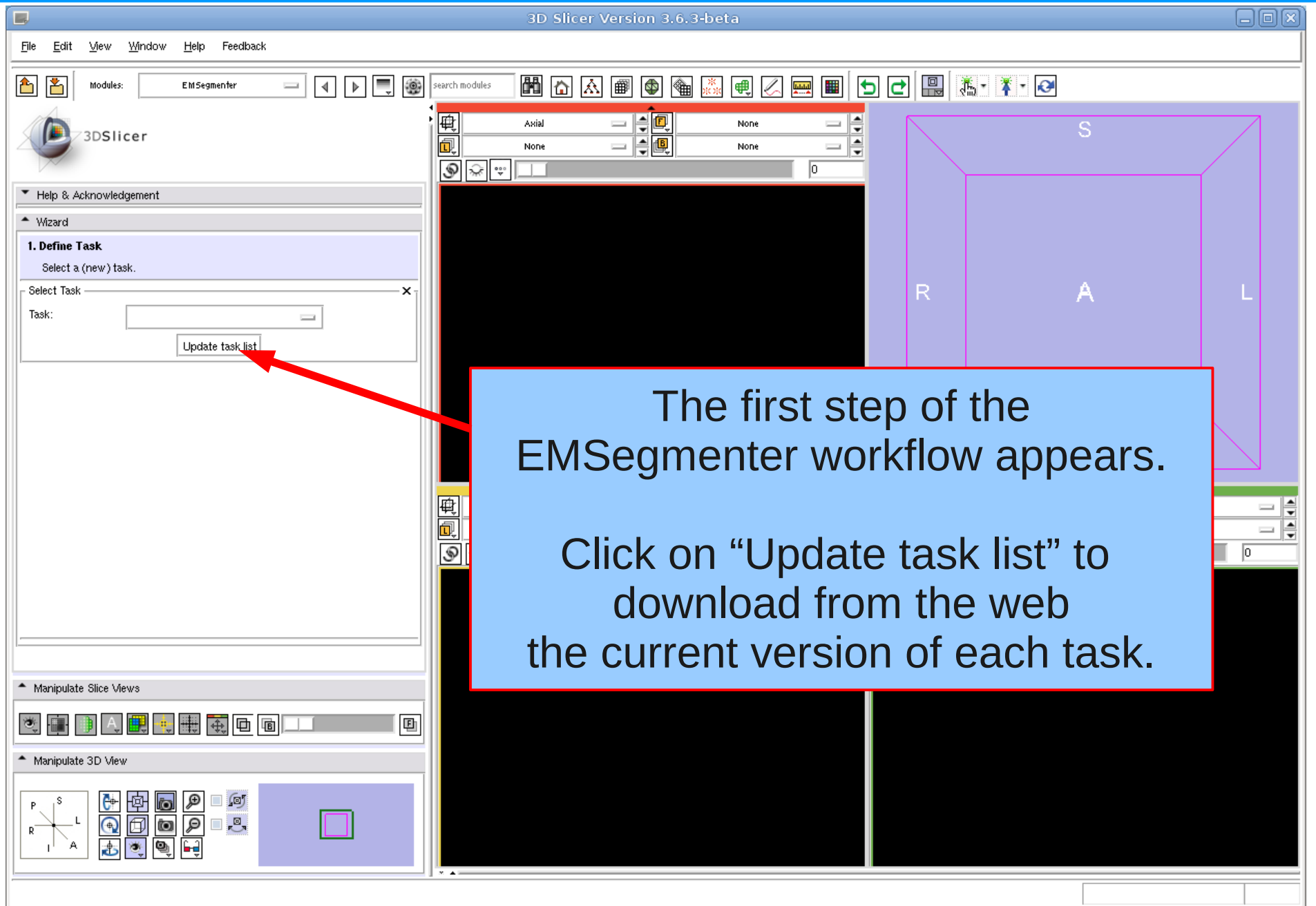
3DSlicer

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 segmented volume 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

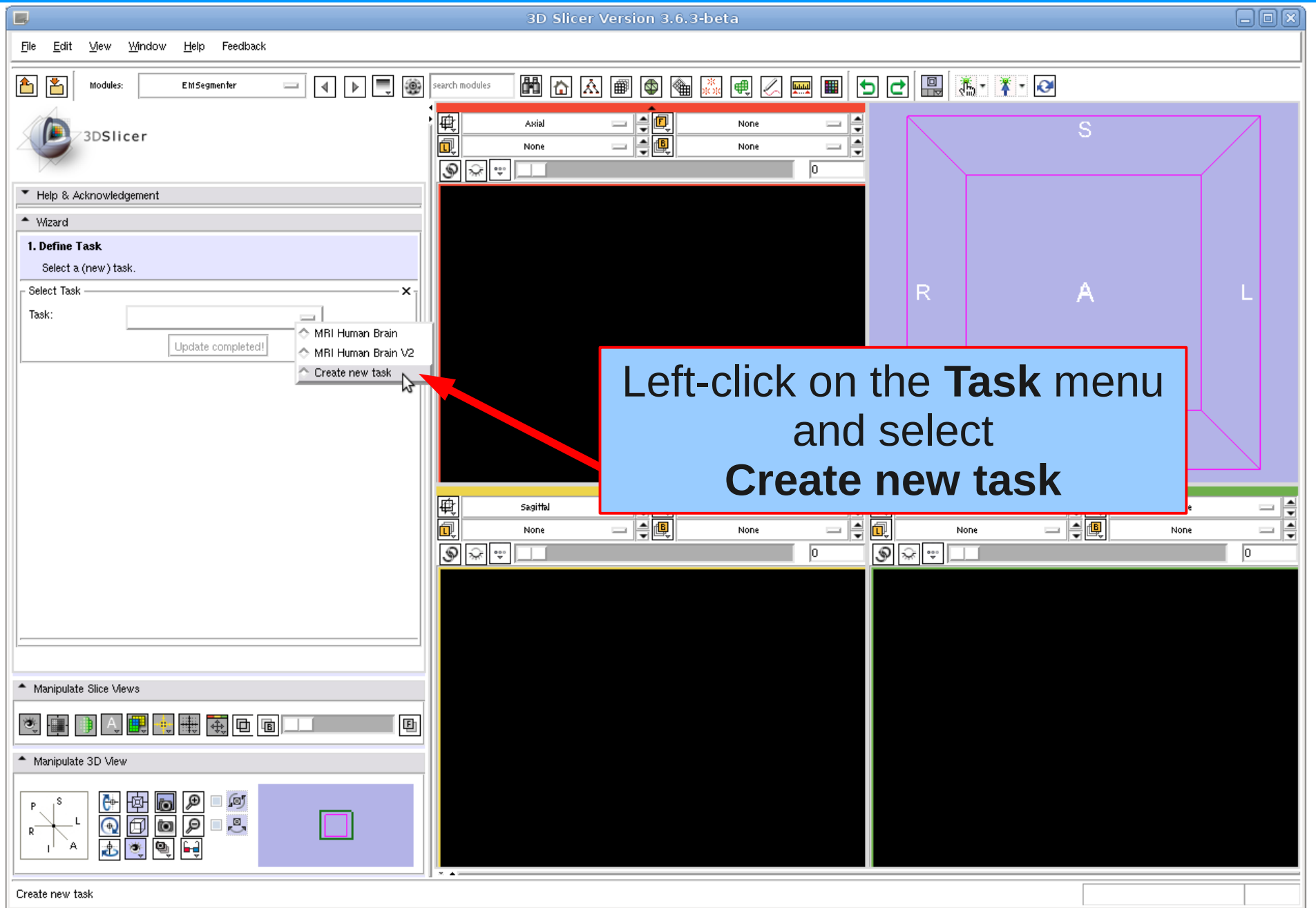


The first step of the EM Segmenter workflow appears.

Click on “Update task list” to download from the web the current version of each task.



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

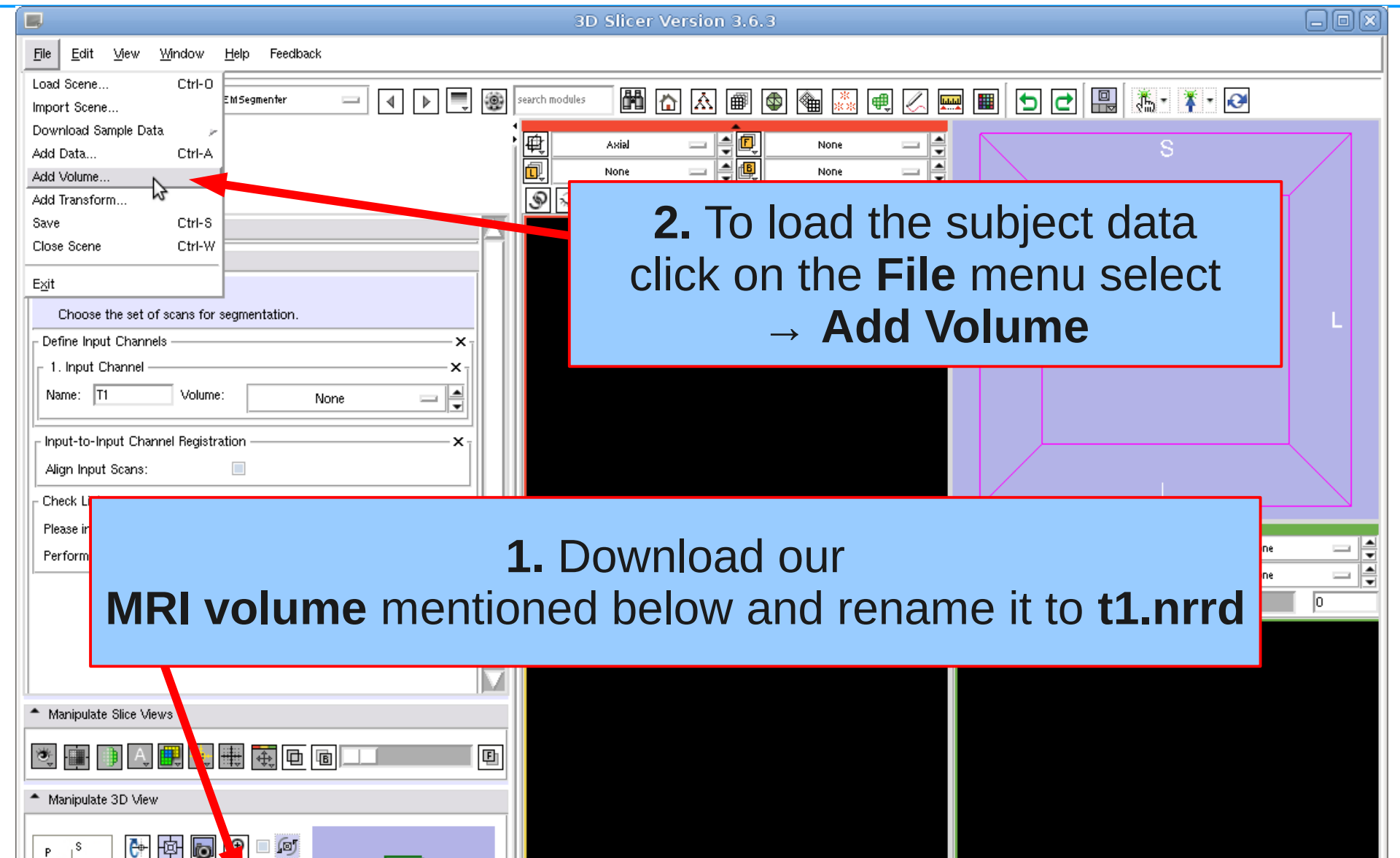
Manipulate Slice Views

Manipulate 3D View

P S R L I A



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: EM Segmenter

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

name Size Modified

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

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



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. The interface includes a menu bar, a toolbar, and various panels for slice manipulation and 3D view control.



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

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	Light Blue

Manipulate Slice Views

Manipulate 3D View

Sagittal None Coronal None

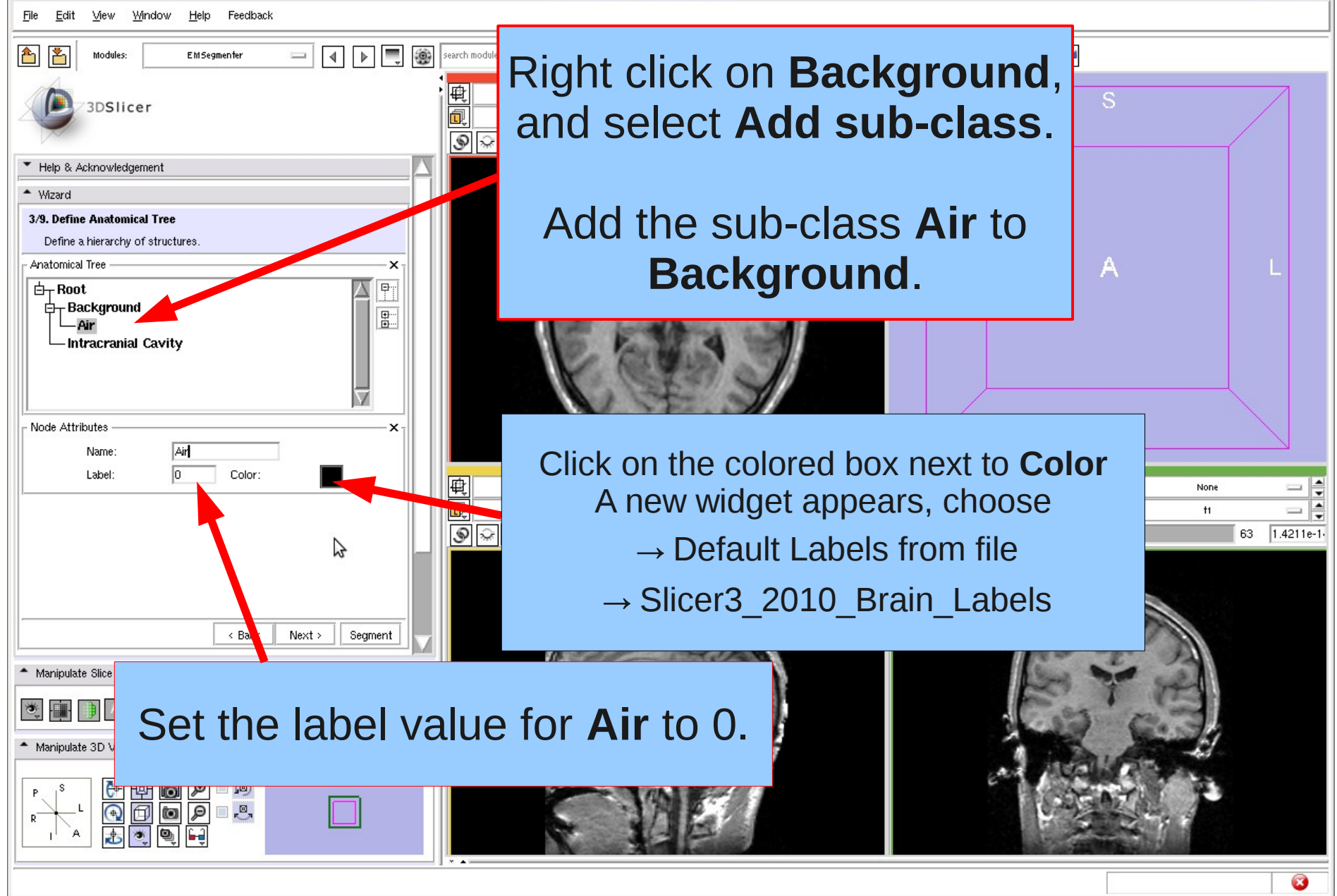
S A L I

The anatomical tree contains two components: Background and Intracranial Cavity



Define Anatomical Tree

3D Slicer Version 3.6.3



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.



Define Anatomical Tree

3D Slicer Version 3.6.3

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: 0
Color: [Black]

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

129 0

129 0

63 1.4211e-1

S L

Sagittal

Coronal

None

None

None

None

Add the **Skull** sub-class to Background, and set the label value for Skull to 0.



Define Anatomical Tree

3D Slicer Version 3.6.3

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: ■

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

None
H
63 1.4211e-1

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

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



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>



Define Atlas

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM Segmenter 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

Atlas Map

Class: Air

Select Probability Map:



Select Parcellation Map:

< Back Next >

Manipulate Slice Views



Manipulate 3D View



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

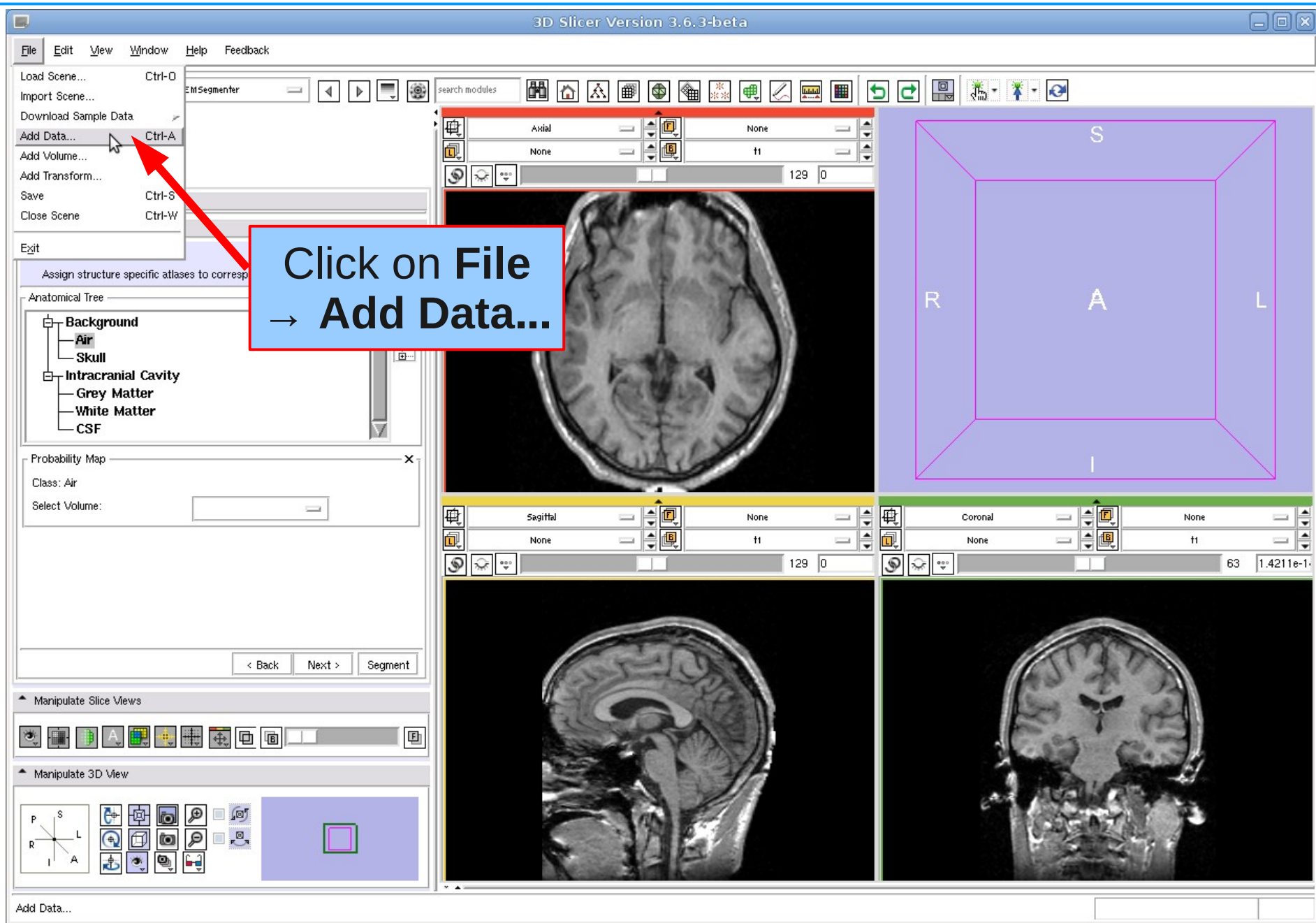
In this tutorial you only have to touch with **Select Probability Map**

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



3DSlicer

Load Atlas Data





3DSlicer

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 correspond to the anatomical tree

Anatomical Tree

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

Probability Map

Class: Air

Select Volume:

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

Click on **Add File(s)**

Browse to your Slicer3 install directory and from there to `./share/Slicer3/Modules/EMSegment/Tasks/MRI-Human-Brain/`

Select the six atlas data files and click **Open**

Add Data...



Load Atlas Data

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

Click **Apply**

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

The screenshot displays the 3D Slicer 3.6.3 interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. The main toolbar contains various icons for navigation and manipulation. On the left, the 'Anatomical Tree' panel shows a hierarchy: Background (Air, Skull) and Intracranial Cavity (Grey Matter, White Matter, CSF). The 'Atlas Map' panel shows 'Class: Air' and 'Select Parcellation'. The central viewer area is divided into four panels: a top-left axial slice, a top-right 3D perspective view with a purple bounding box and labels S, R, A, L, I, a bottom-left sagittal slice, and a bottom-right coronal slice. A blue text box with a red border is overlaid on the viewer, containing the text 'The loaded atlas data appear in the viewer.' Three red arrows point from this text box to the axial, sagittal, and coronal slice panels. The status bar at the bottom shows 'Slicer 3.6.3', 'Section of Biomedical Image Analysis, UPenn', and '31/65'.



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

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

Atlas Map

Class: Air

Select Probability Map: **atlas_air**

Select Parcellation Map:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

129 0

S

Sagittal None

Select **Air** in the anatomical tree.

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



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

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

Atlas Map

Class: Skull

Select Probability Map: atlas_skulneck

Select Parcellation Map:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

Select **Skull** in the anatomical tree.

Left-click on **Select Probability Map** and assign the probabilistic atlas **atlas_skulneck** to the **Skull** structure.



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

Axial None
None atlas_whitematter

129 0

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

Atlas Map

Class: Grey Matter

Select Probability Map: atlas_greymatter

Select Parcellation Map:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

S

Sagittal
None

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

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



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

Axial None
None atlas_whitematter

129 0

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

Atlas Map

Class: White Matter

Select Probability Map: atlas_whitematter

Select Parcellation Map:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

S

Sagittal
None

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

Left-click on **Select Probability Map** and assign the probabilistic atlas **atlas_whitematter** to the **White Matter** structure.



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

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**

Atlas Map

Class: CSF

Select Probability Map: atlas_csf

Select Parcellation Map:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

Click on Next

Select **CSF** in the anatomical tree.

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



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



3DSlicer

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**



Edit Registration Parameters

3D Slicer Version 3.6.3

Select Fast for the Affine Registration and the Deformable Registration.

Set Package to BRAINS

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 interface during the '6/9. Define Preprocessing' step. The 'Check List' section contains the following items:

- This task only applies to non-skull stripped scans!
- Should the EMSegmenter
 - register the atlas to the input scan ?
 - perform image inhomogeneity correction on input scan ?

The 'Next >' button is circled in red, and a blue callout box with the text 'Click on Next' is overlaid on the image. The main window displays MRI slices in Sagittal and Coronal views.



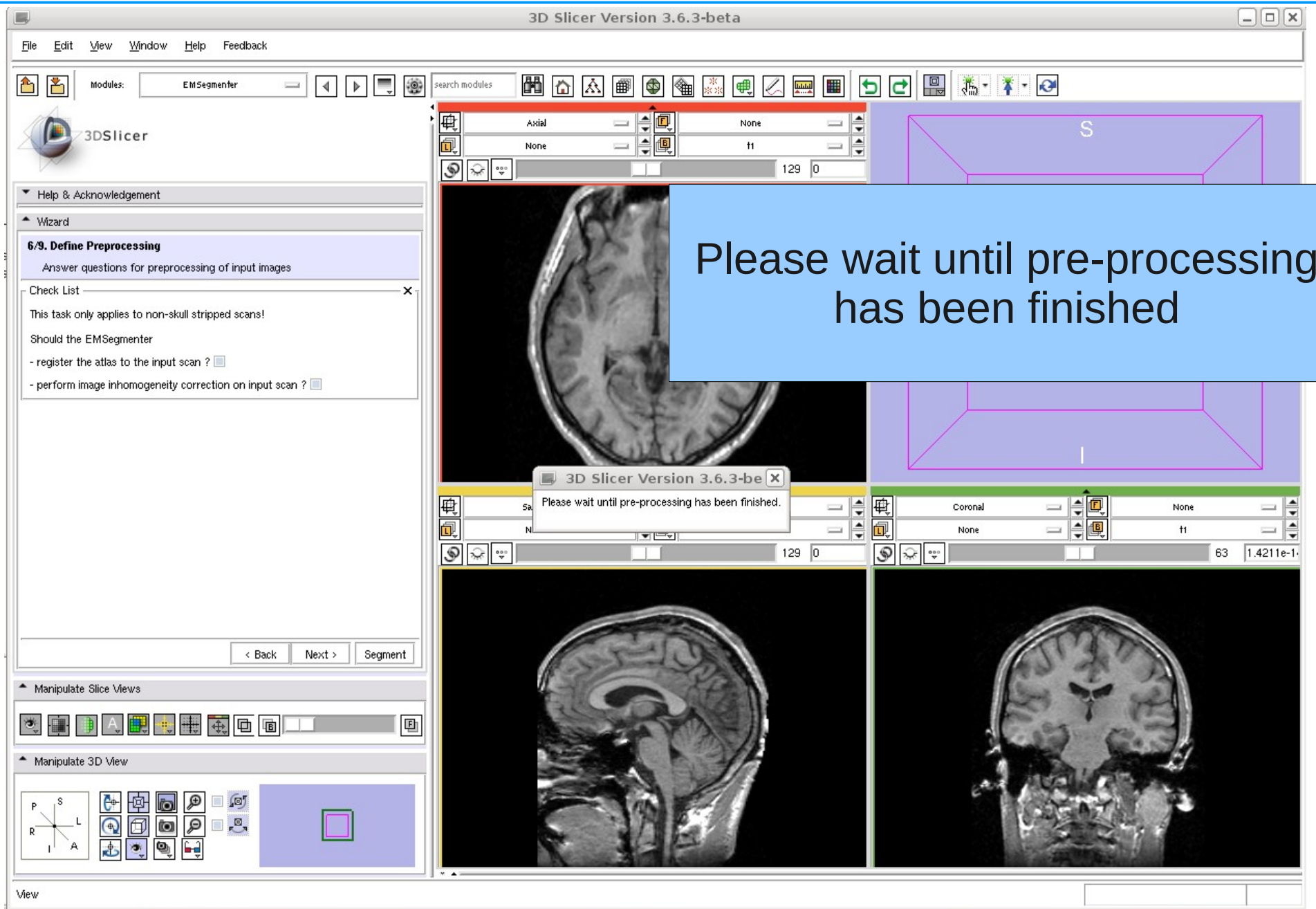
Define Preprocessing

The screenshot shows the 3D Slicer 3.6.3-beta interface. The 'EM Segmenter' module is selected in the 'Modules' panel. A wizard window titled '6/9. Define Preprocessing' is open, with a 'Check List' section containing the following text: 'This task only applies to non-skull stripped scans!', 'Should the EMSegmenter', '- register the atlas to the input scan ? ', and '- perform image inhomogeneity correction on input scan ? '. A dialog box titled 'Start Preprocessing of images?' is overlaid on the interface, asking 'Preprocessing of images might take a while. Do you want to proceed?' with 'Yes' and 'No' buttons. The 'Yes' button is highlighted by a mouse cursor. The main interface shows a 3D view of a brain slice and two 2D slice views (sagittal and coronal).

The EMSegmenter 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.



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.



3DSlicer

Edit Node-based Parameters

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

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

Basic | Stopping Conditions | Print | Advanced

Class Weight: 0 | Input Channel Weights

Atlas Weight: 0 | T1 0

Overview Of Class Weights

< Back | Next > | Segment

Manipulate Slice Views

Manipulate 3D View

Feedback

Per default all the EM Input Parameters are unspecified.



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

Atlas Weight: 1 T1 1

Alpha: 0.99

Overview Of Class Weights

Background	0.15
Intracranial Cavity	0

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S R L I A

Help

None

t1

63 1.4211e-1

129 0

S

L

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

Help

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

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



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: EM Segmenter

search modules

9/9. Define Miscellaneous Parameters

Define miscellaneous parameter for performing segmentation.

Define VDI

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 VDI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

< Back Next **Segment**

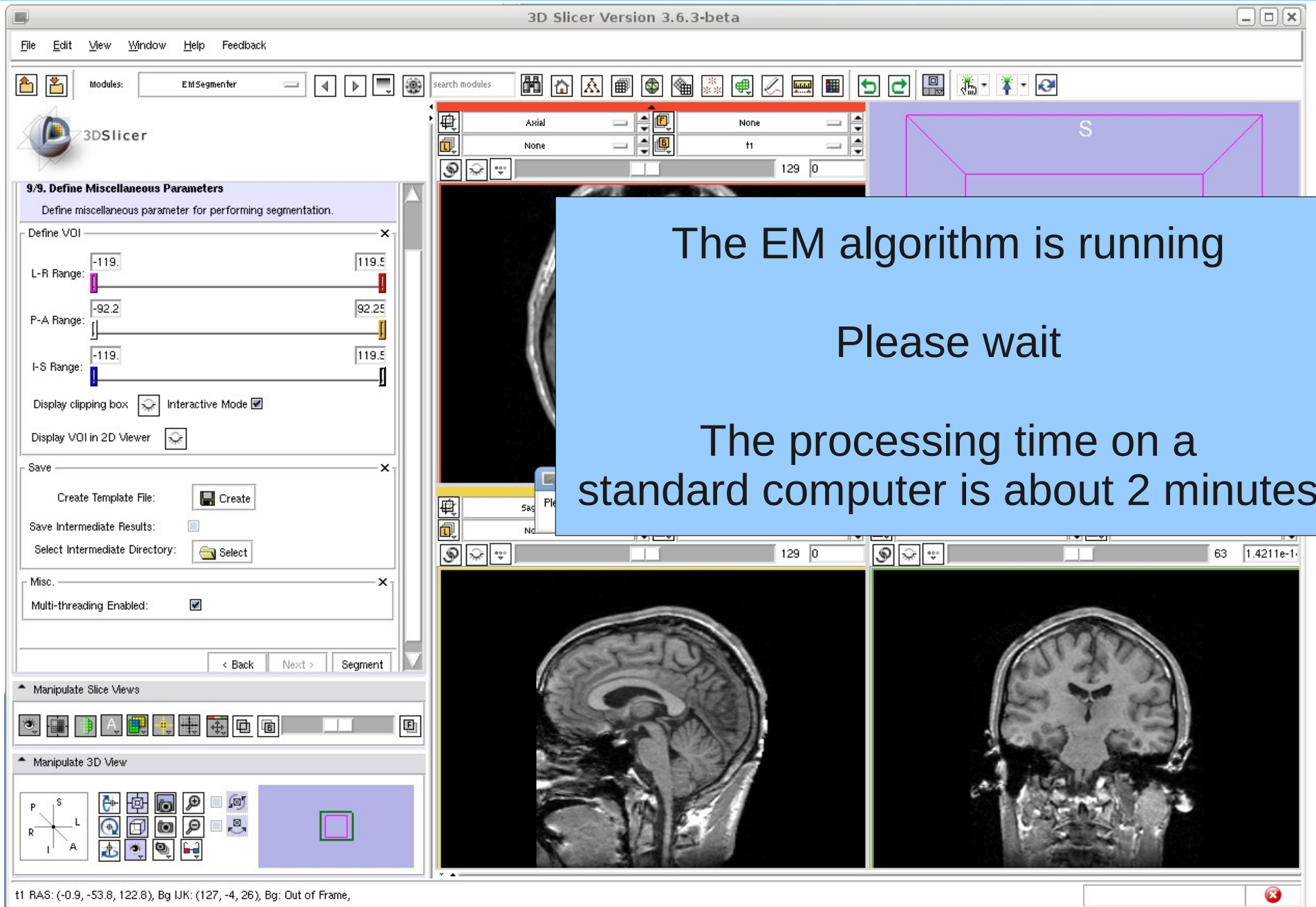
Manipulate Slice Views

Manipulate 3D View

Click on Segment

In the first run we don't specify a volume of Interest (VOI)

Run Segmentation



3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

9.9. Define Miscellaneous Parameters

Define miscellaneous parameter for performing segmentation.

Define VDI

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 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

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

The EM algorithm is running
Please wait
The processing time on a standard computer is about 2 minutes



3DSlicer

Results: Run Segmentation

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

Define miscellaneous parameter

White matter

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

Save Intermediate Results:

Select Intermediate Directory:

Misc.

Multi-threading Enabled:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

Grey matter

CSF

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)

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EML 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

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

Slicer 3.6.3



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

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: CSF

Class Weight: 0.25 | Input Channel Weights

Atlas Weight: 0.01 | T1

Overview Of Class Weights

Grey Matter	0.23
White Matter	0.52
CSF	0.25

Manipulate Slice Views

Manipulate 3D View

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

This process can be continued to get a better segmentation.

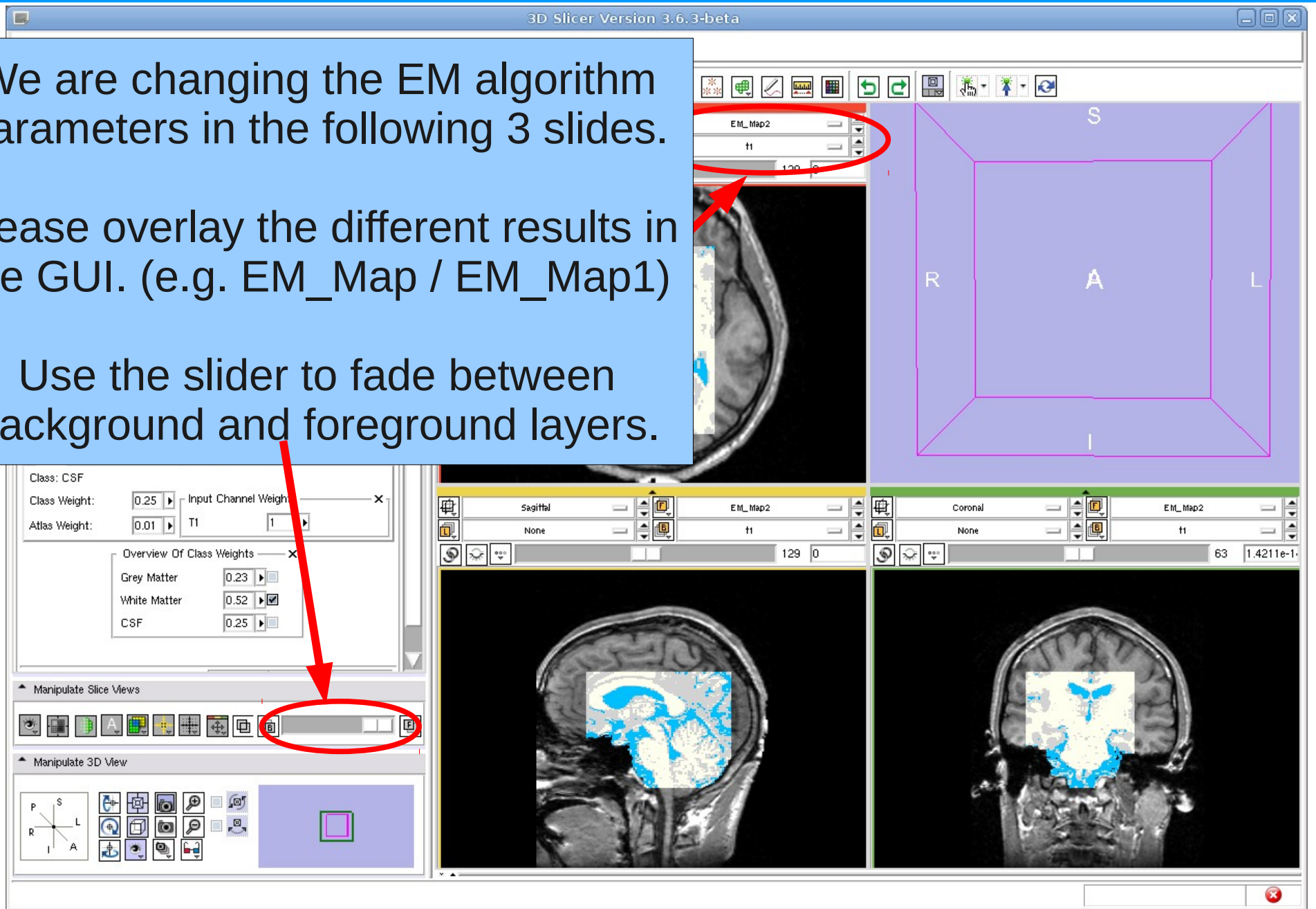


Compare Results

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 software interface (Version 3.6.3-beta) with the EM Segmenter module active. The 'Wizard' panel is open to the '8/9. Edit Node-based Parameters' step, where the 'Intracranial Cavity' class is selected. The 'Alpha' parameter is set to 0.1. The 'Overview Of Class Weights' shows Background at 0.15 and Intracranial Cavity at 0.85. The main window displays three views: Axial, Sagittal, and Coronal. Each view shows a brain MRI slice with a blue labelmap overlay. The labelmap is notably noisy and pixelated. A blue text box on the right side of the interface states: 'Effect: The labelmap Is less smooth'. The interface also shows various toolbars, a search bar, and a status bar at the bottom.



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

Atlas Weight: 0.1 | T1: 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.

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