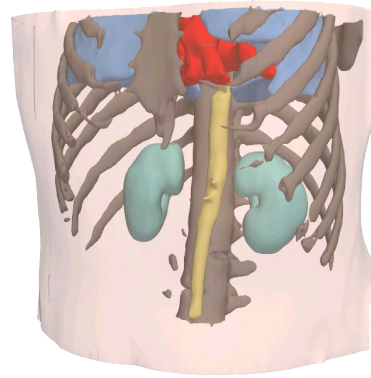
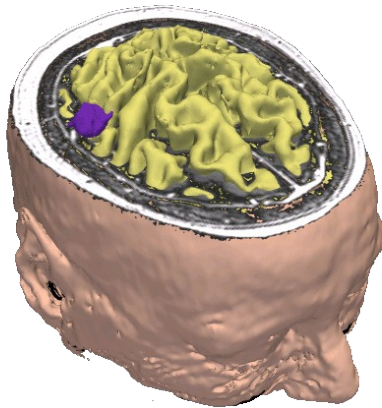




EMSegmenter Tutorial (Advanced Mode)



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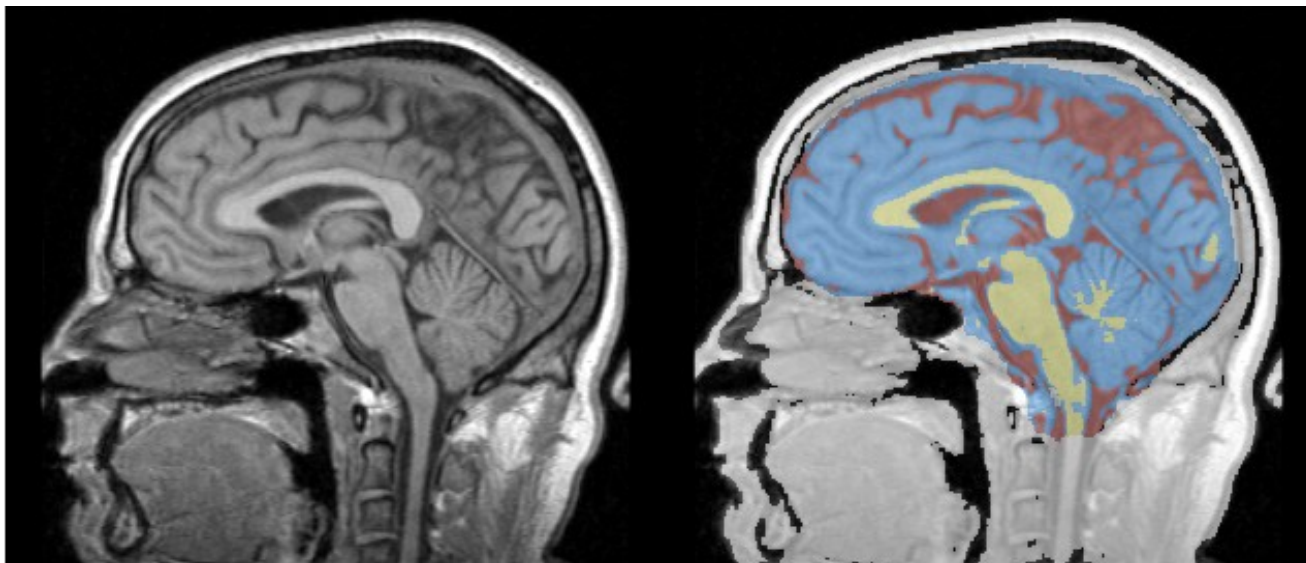


Overview

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 3.6.2 .

Before

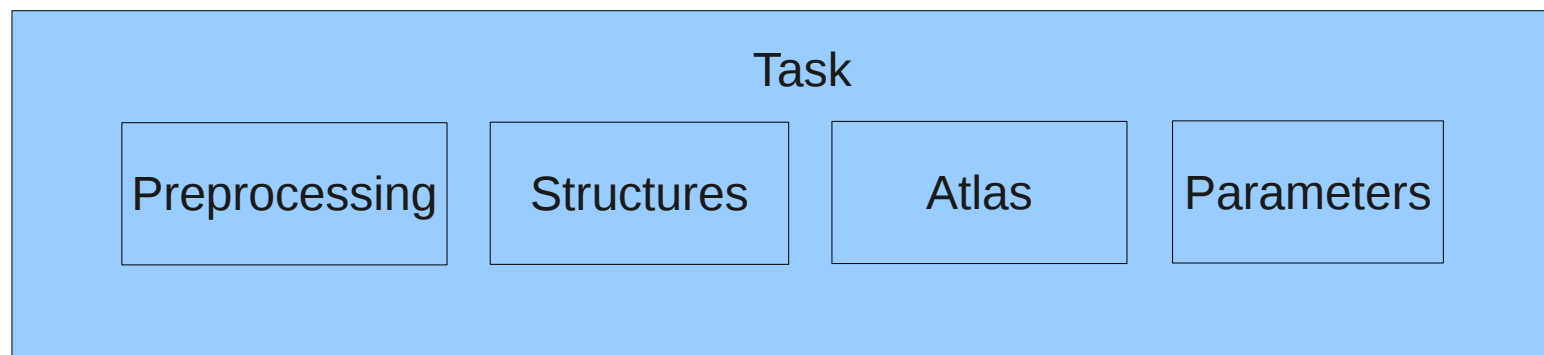


After



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

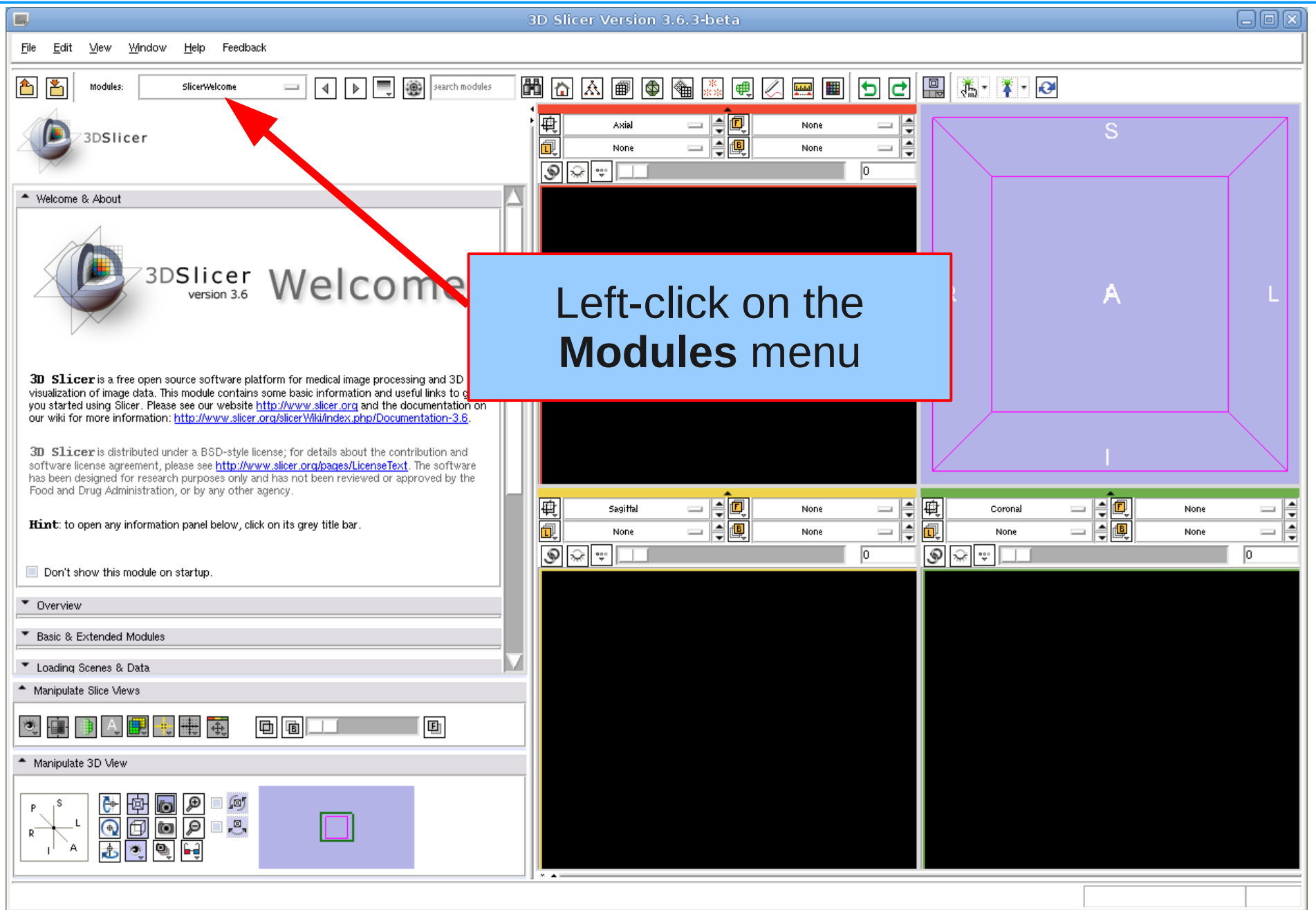
Step 1:

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

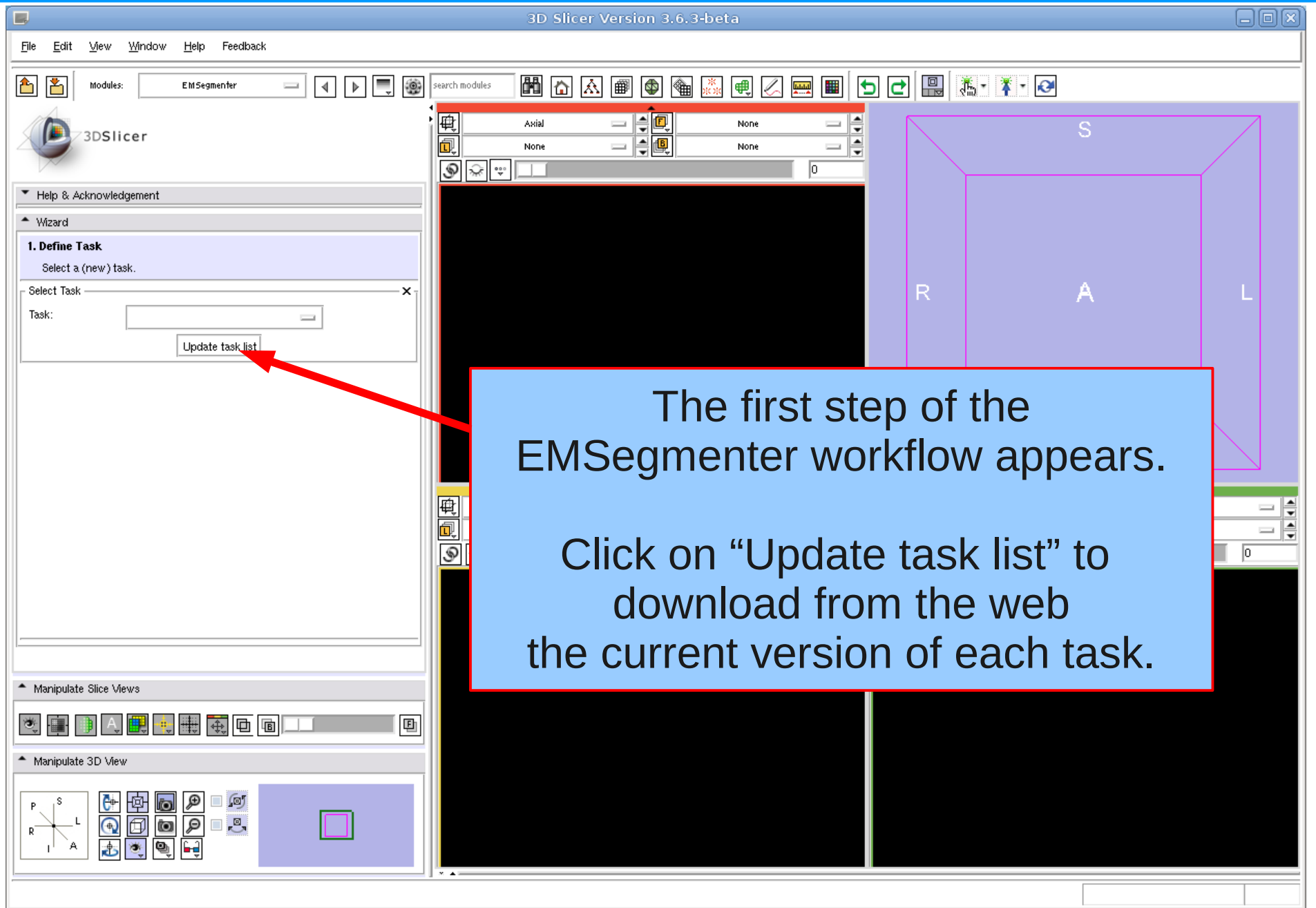
Select EMSegmenter Module

The screenshot shows the 3D Slicer Version 3.6.3-beta interface. On the left, the 'Modules' list is expanded to 'Segmentation', and the 'EMSegmenter' module is highlighted. A red arrow points from a blue callout box to the 'EMSegmenter' module. The main window displays three orthogonal views: Axial, Sagittal, and Coronal. The Axial view shows a purple rectangular region with labels 'S' (Superior), 'R' (Right), 'A' (Anterior), and 'L' (Left). The Sagittal and Coronal views show similar regions. The bottom status bar indicates the 'EMSegmenter' module is active.

Select Segmentation
→ EMSegmenter

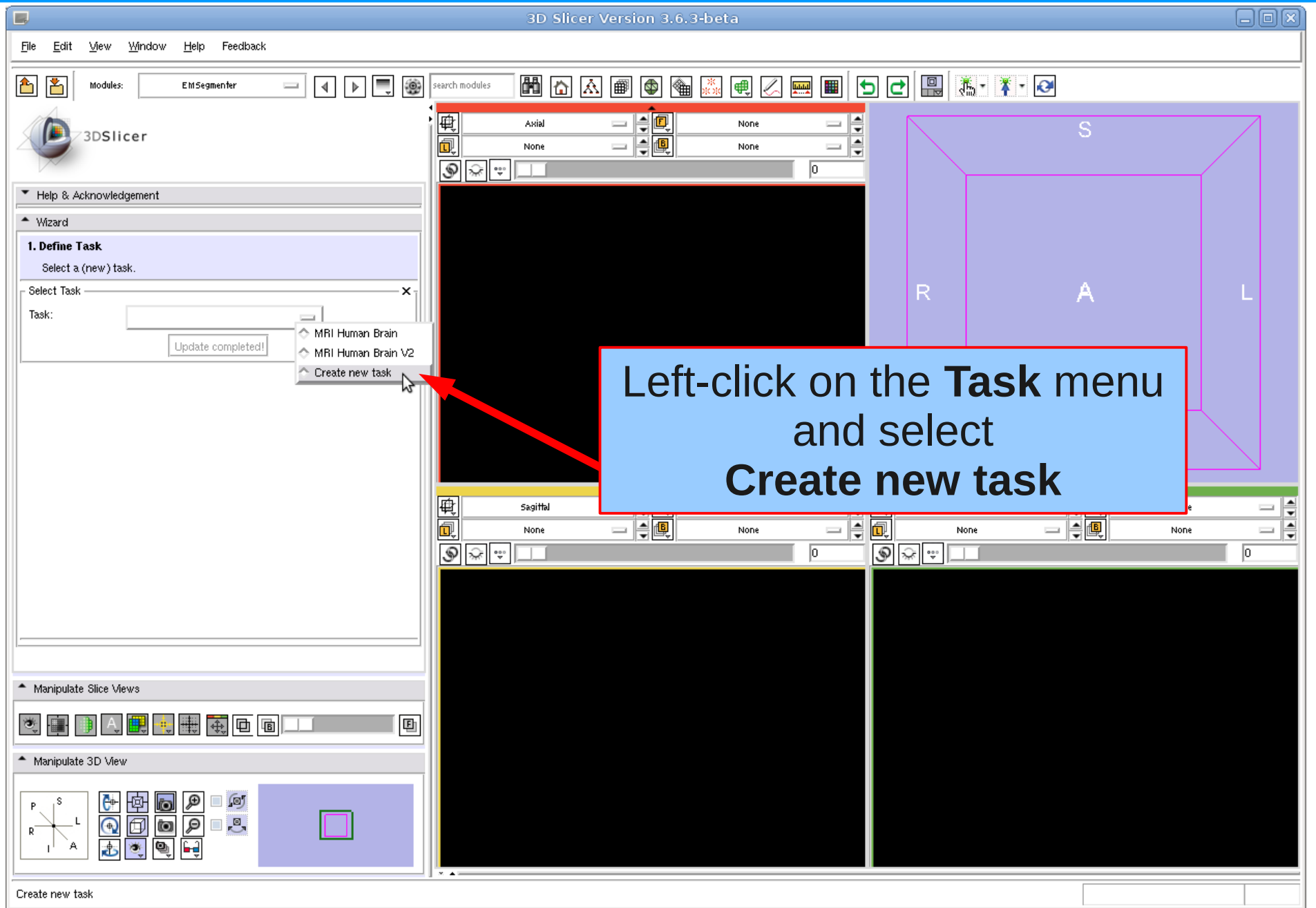


Update Task List





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]

Apply

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



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

Slice views: Axial, Coronal, Sagittal

Orientation: R, A, L, S, I



Add Subject Data

The screenshot shows the 3D Slicer 3.6.3-beta interface. The 'File' menu is open, and the 'Add Volume...' option is highlighted. A blue callout box with the text 'To load the subject data click on **Add Volume**' is positioned over the menu item. The interface includes a menu bar (File, Edit, View, Window, Help, Feedback), a toolbar with various icons, and a main workspace with four viewports: Axial, Sagittal, Coronal, and a 3D view. The 3D view shows a purple rectangular volume with axes labeled S (Superior), I (Inferior), R (Right), and L (Left). The 'Add Volume...' dialog box is partially visible at the bottom left.



Load Subject Data

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 segment

Define Input Channels

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

Add Volume

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

DICOM Information

Parse Directory Divide Subseries

Description	Value
-------------	-------

Recent Volumes: - Browse to CWD

Apply Cancel

Manipulate Slice Views

Manipulate 3D View

Add Volume...

Browse to the tutorial data set and select the file t1.nrrd



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

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

1. Input Channel

Name: T1 Volume: t1

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

Change the number of input channels?

Are you sure you want to change the number of input images?

Yes No

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S R L I A

To confirm click Yes



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 I



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

A new node appears



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

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

View

Change the node name to **Background**



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
 - Add sub-class
 - Delete sub-class

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

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 A L I

R S L I A

Rename the second sub-class
Intracranial Cavity

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



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
 - Background
 - Air
 - Intracranial Cavity

Node Attributes

Name: Air

Label: 0 Color: [Black]

Select colormap: L...s

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

Manipulate Slice Views

Manipulate 3D View

Edit

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

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

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



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
 - 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

3D Slicer interface showing a brain MRI scan with a purple box highlighting the skull region. The interface includes a menu bar, a toolbar, and a main view area with three orthogonal slices (Axial, Sagittal, Coronal). A red arrow points from the text box to the 'Skull' node in the Anatomical Tree.

Add the **Skull** sub-class to Background, and set the label value for Skull to 3.



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 4
- White Matter, label 8
- 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

Axial None
None t1

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

Probability Map

Class: Air

Select Volume:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

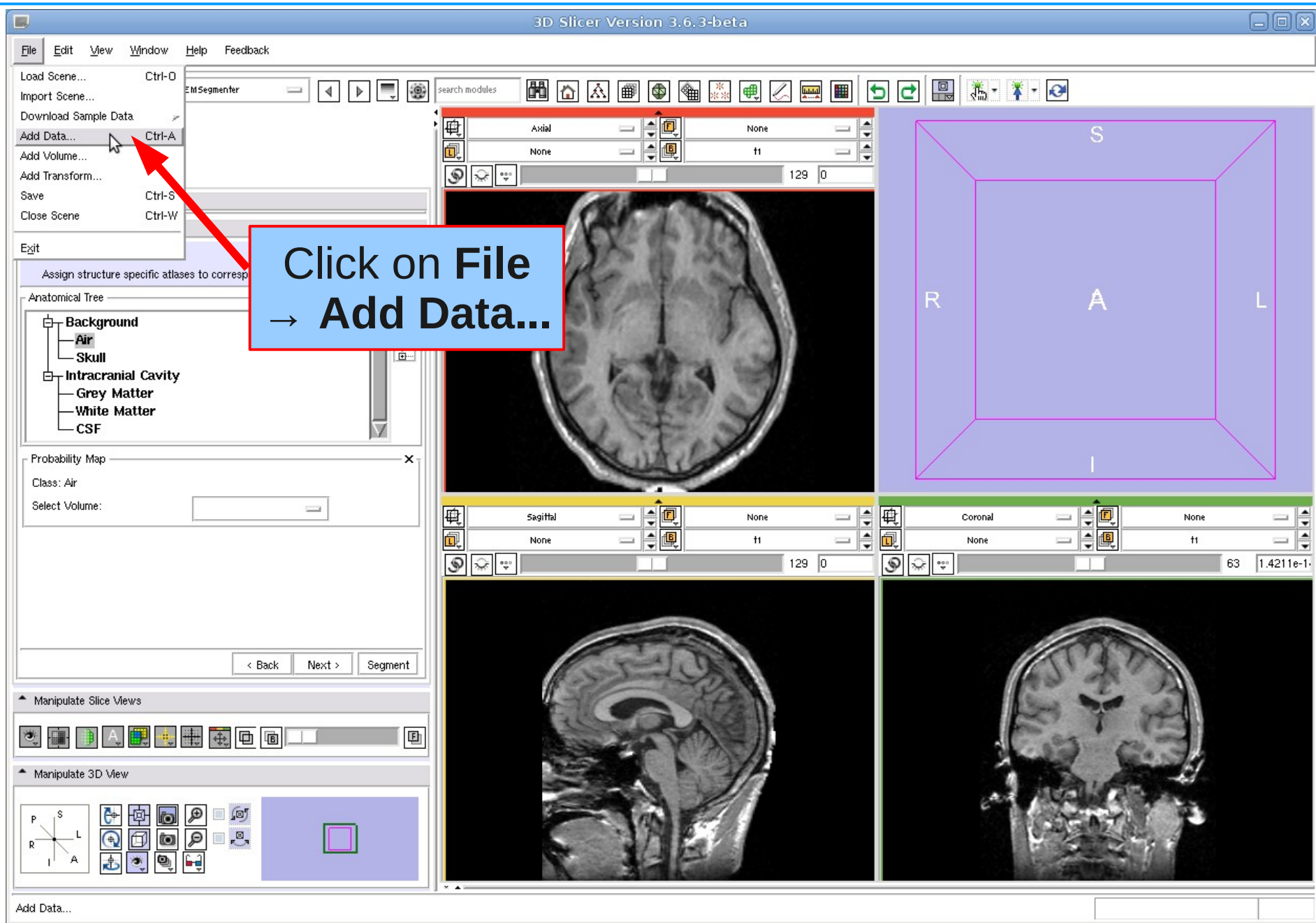
Edit

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



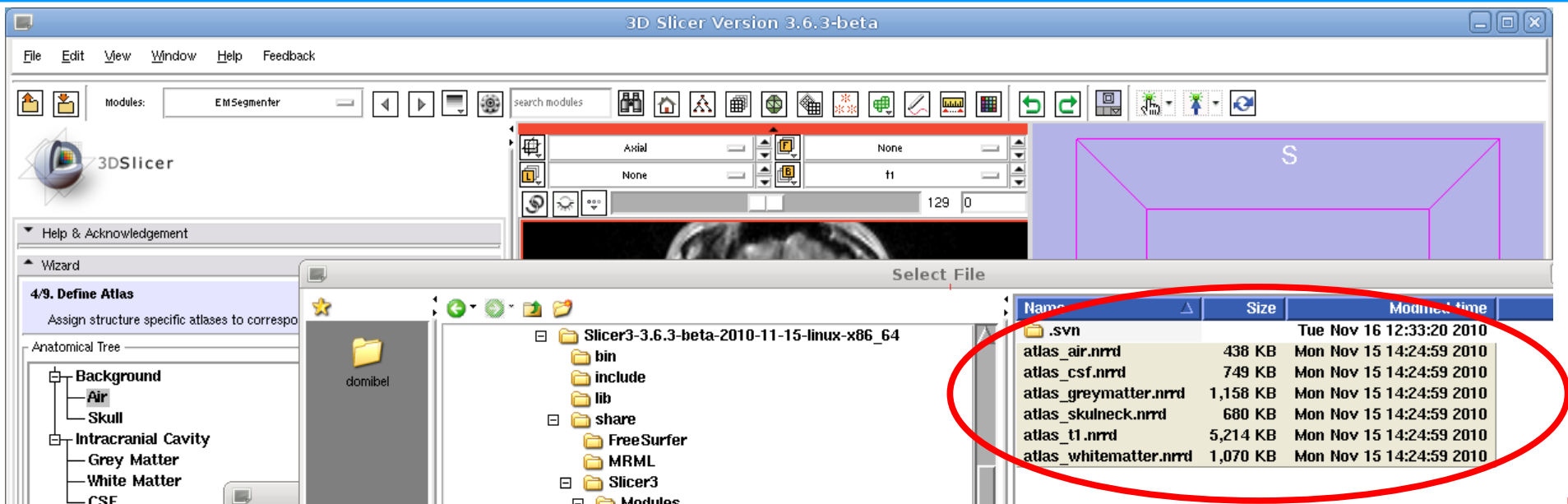
3DSlicer

Load Atlas Data





Load Atlas Data



Click on **Add File(s)**

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

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





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 checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_csf	<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 checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_skulneck	<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 checked="" type="checkbox"/>	/projects/sandbox/Slicer3/private-release-trunk/Sli...	Volume	atlas_whitematte	<input type="checkbox"/>	<input type="checkbox"/>	



Load Atlas Data

The screenshot displays the 3D Slicer Version 3.6.3-beta interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. The main toolbar contains various icons for file operations and viewing. The left sidebar features a 'Wizard' section with '4/9. Define Atlas' and an 'Anatomical Tree' showing a hierarchy: Background (Air, Skull) and Intracranial Cavity (Grey Matter, White Matter, CSF). A 'Probability Map' section is also visible. The central viewer area is divided into three panels: an axial view (top), a coronal view (middle), and a sagittal view (bottom). A red box highlights the axial view, with a red arrow pointing to it from a blue text box. The blue text box contains the text: 'The loaded atlas data appear in the viewer.' The coronal and sagittal views also show the loaded atlas data. The bottom right corner of the viewer area shows a small 3D view of the brain with a red box around it.

The loaded atlas data appear in the viewer.



3DSlicer

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

P S
R L
I A

Select **Skull** in the anatomical tree.

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



3DSlicer

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

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: White Matter

Select Volume: atlas_whitematter

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

File

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

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_whitematter** to the **White Matter** 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: CSF

Select Volume: atlas_csf

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

atlas_csf

Axial None

Sagittal None

None t1 63 1.4211e-1

S L

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



3DSlicer

Edit Registration Parameters

The screenshot shows the 3D Slicer software interface. The main window displays three orthogonal views of a brain MRI scan: Axial (top), Coronal (right), and Sagittal (bottom-left). The registration parameters panel on the left is titled "5/9. Edit Registration Parameters" and includes a "Wizard" section. The "Atlas-to-Input Registration Parameters" section is highlighted with a red circle, showing the "T1" input channel set to "atlas_t1". The "Affine Registration" section is set to "None", "Deformable Registration" is set to "None", and "Interpolation" is set to "Linear". A blue callout box with a red border is overlaid on the interface, containing the text: "Select atlas_t1 to assign the atlas to the input channel T1". The software title bar indicates "3D Slicer Version 3.6.3-beta".



3DSlicer

Edit Registration Parameters

3D Slicer Version 3.6.3-beta

File Edit View Window Help Feedback

Modules: EM Segmenter

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: **Accurate**

Deformable Registration: **Accurate**

Interpolation:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

View

Select Accurate for the Affine Registration and the Deformable Registration.

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 top menu bar includes File, Edit, View, Window, Help, and Feedback. Below the menu bar, there are icons for home, save, and a 'Modules' dropdown menu currently set to 'EMSegmenter'. The main window is divided into several panels. On the left, there is a 'Help & Acknowledgement' section and a 'Wizard' section. The 'Wizard' section is titled '6/9. Define Preprocessing' and contains a 'Check List' with the following items: '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 ? '. At the bottom of the wizard panel, there are buttons for '< Back', 'Next >', and 'Segment'. The 'Next >' button is circled in red. Below the wizard panel, there are sections for 'Manipulate Slice Views' and 'Manipulate 3D View'. The main window displays two MRI slices: a Sagittal view on the left and a Coronal view on the right. A blue callout box with the text 'Click on Next' is overlaid on the 'Next >' button. The status bar at the bottom shows 'File' and a red 'X' icon.



Define Preprocessing

The screenshot shows the 3D Slicer Version 3.6.3-beta interface. The 'EMSegmenter' 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 ?
- 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. A mouse cursor is pointing at the 'Yes' button. The background shows the 3D Slicer interface with a central 3D view of a brain slice and two smaller 2D slice views (sagittal and coronal) at the bottom.

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



Define Preprocessing

The screenshot shows the 3D Slicer software interface. The title bar reads "3D Slicer Version 3.6.3-beta". The menu bar includes "File", "Edit", "View", "Window", "Help", and "Feedback". The "Modules" section shows "EMSegmenter" selected. The "Help & Acknowledgement" panel is open to the "6/9. Define Preprocessing" step, which asks for preprocessing options for input images. A "Check List" section contains the following text: "This task only applies to non-skull stripped scans!", "Should the EMSegmenter", "- register the atlas to the input scan ?



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

The screenshot shows the 3D Slicer Version 3.6.3-beta interface. The 'EM Segmenter' module is active, and the '8/9. Edit Node-based Parameters' wizard is open. The 'Anatomical Tree' on the left 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. A blue text box is overlaid on the center of the interface, containing the text: 'Per default all the EM Input Parameters are unspecified.' The main view displays three MRI slices: a coronal slice at the top, a sagittal slice at the bottom left, and an axial slice at the bottom right. The coronal slice has a purple rectangular region of interest (ROI) with labels 'S' (Superior), 'I' (Inferior), 'R' (Right), and 'L' (Left). The axial slice has a purple ROI with labels 'S', 'I', 'R', and 'L'. The sagittal slice has a purple ROI with labels 'P' (Posterior), 'A' (Anterior), 'R', and 'L'. The interface also shows a 'Manipulate Slice Views' and 'Manipulate 3D View' section at the bottom left.



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: Background

Class Weight: 0.15 Input Channel Weights: x

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

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

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

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 Interested (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

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



3DSlicer

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 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 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 scan: Axial (top), Sagittal (bottom left), and Coronal (bottom right). The EM segmentation results are overlaid on the T1 volume, showing different tissue classes in various colors (blue, yellow, red, green). A blue callout box on the right states: "The results of the EM Segmentation are overlaid on the T1 volume." The left sidebar contains the "9/9. Define Miscellaneous Parameters" panel, which includes sliders for L-R, P-A, and I-S ranges, and checkboxes for "Interactive Mode" and "Multi-threading Enabled". The "Manipulate Slice Views" section at the bottom left has a red circle around the "EM Segmentation" icon. The top menu bar includes "File", "Edit", "View", "Window", "Help", and "Feedback".



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

the refine the segmentation result.



Volume Of Interest (VOI)

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 VOI

L-R Range: -41 62

P-A Range: -38 62

I-S Range: -14 46

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

Feedback

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

9/9. Define Miscellaneous Parameters

Define miscellaneous parameter for performing segmentation.

Define VOI

L-R Range: -41 62

P-A Range: -38 62

I-S Range: -14 46

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

Feedback

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: x

Atlas Weight: 0.01 | T1: 1

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.

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

Help

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

This process can be continued to get a better segmentation.

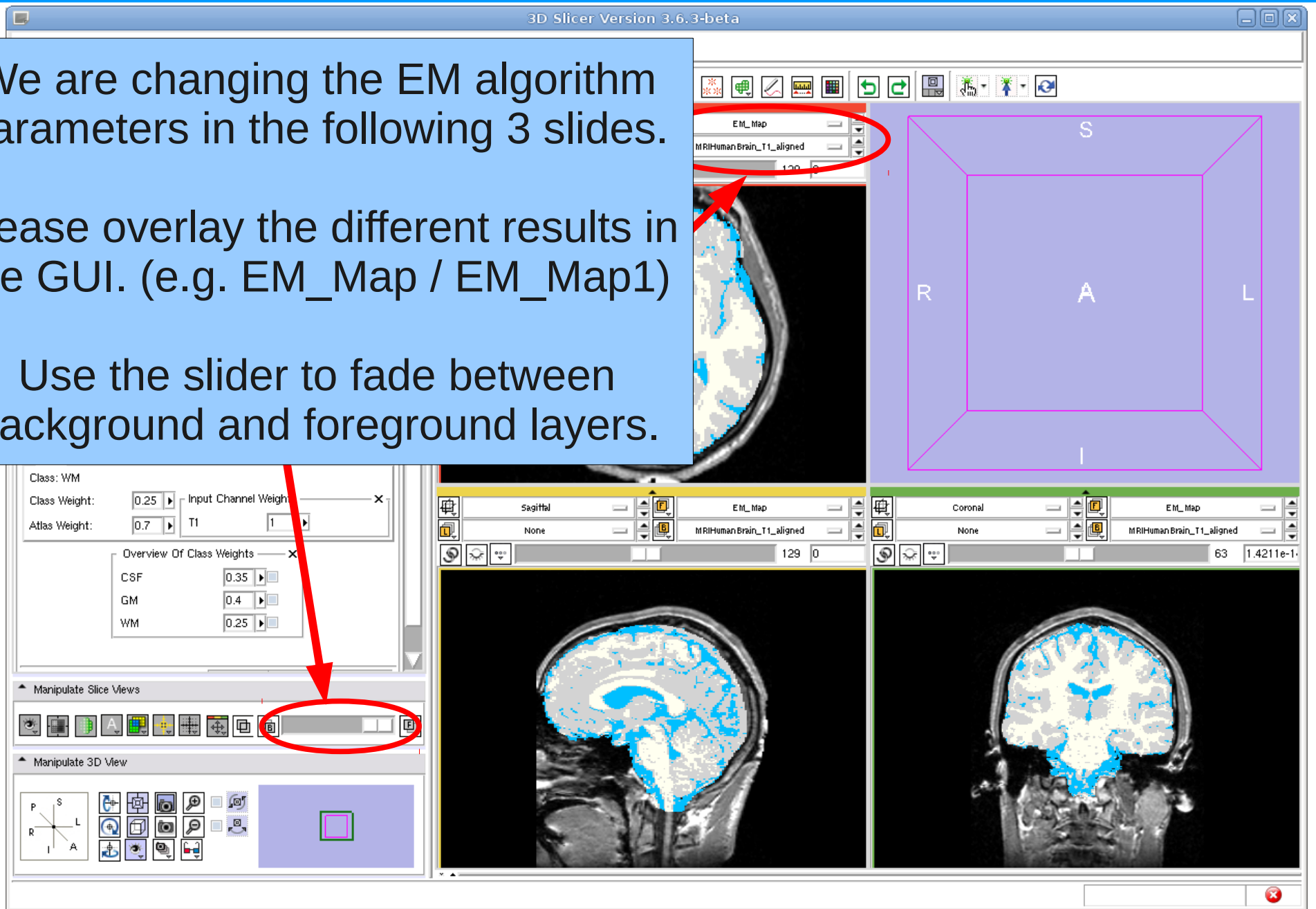


Compare Results

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 following components:

- Top Bar:** 3D Slicer Version 3.6.3-beta
- Menu Bar:** File, Edit, View, Window, Help, Feedback
- Toolbar:** Modules: EM Segmenter
- Left Panel:**
 - Help & Acknowledgement
 - Wizard: 8/9. Edit Node-based Parameters. Specify node-based segmentation parameters.
 - Anatomical Tree: Root, BG, ICC, CSF, GM, WM
 - Basic tab: Class: ICC, Class Weight: 0.85, Atlas Weight: 1, Alpha: 0.11
 - Overview Of Class Weights: BG (0.15), ICC (0.85)
- Center View:** Axial slice of a brain with a blue labelmap. A purple box highlights a region of interest.
- Right Panel:** Sagittal and Coronal views of the brain with blue labelmaps. A purple box highlights a region of interest.
- Bottom Panel:** Manipulate Slice Views and Manipulate 3D View controls.

Effect: The labelmap Is less smooth



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

- BG
 - AIR
 - Neck And Skull
- ICC
 - CSF
 - GM
 - WM

Basic | Stopping Conditions | Print | Advanced

Class: WM

Class Weight: 0.25 | Input Channel Weights: T1

Atlas Weight: 0.1

Overview Of Class Weights

CSF	0.45
GM	0.3
WM	0.25

< Back | Next > | Segment

Manipulate Slice Views

Manipulate 3D View

Effect: Finer white matter structures become visible



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

- Root
 - BG
 - ICC
 - CSF
 - GM
 - WM

Basic | Stopping Conditions | Print | Advanced

Class: WM

Class Weight: 0.2 | Input Channel Weights

Atlas Weight: 0.7 | T1 | 1

Overview Of Class Weights

CSF	0.15
GM	0.65
WM	0.20

Manipulate Slice Views

Manipulate 3D View

EM_Map2

MRIRHumanBrain_T1_aligned

129 0

S

Effect: Overestimation of grey matter

Sagittal

EM_Map2

MRIRHumanBrain_T1_aligned

129 0

Coronal

EM_Map2

MRIRHumanBrain_T1_aligned

63 1.4211e-1



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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