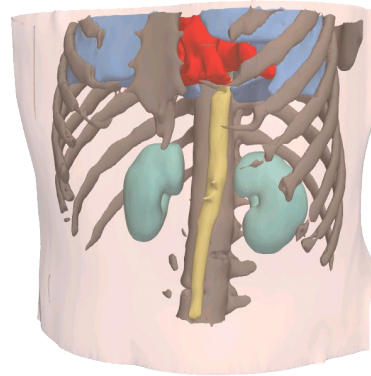
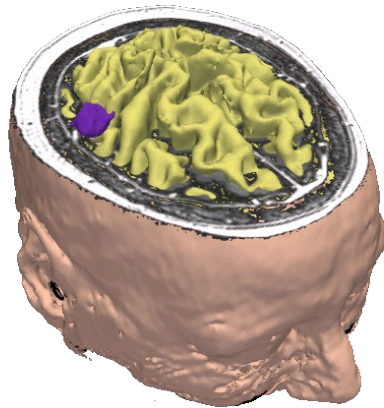




EMSegmenter Tutorial (End User Tasks)



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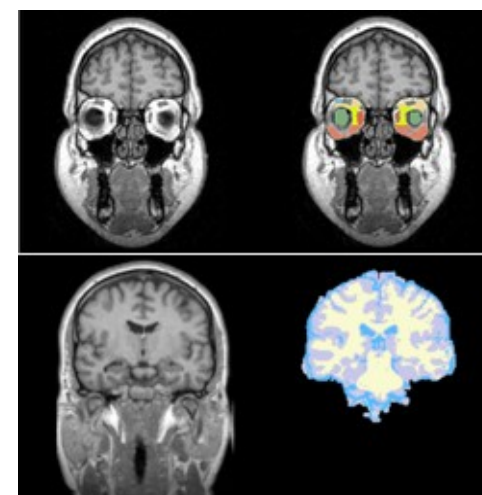
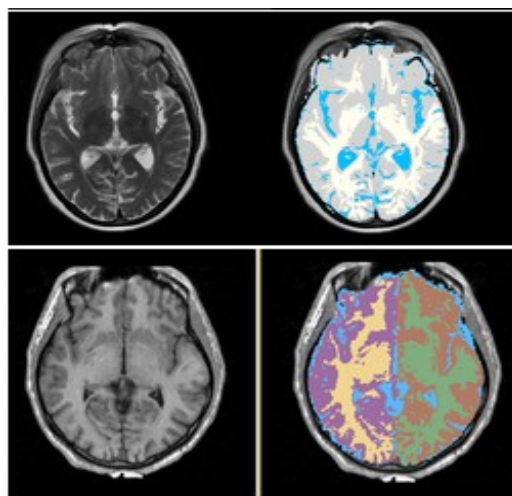
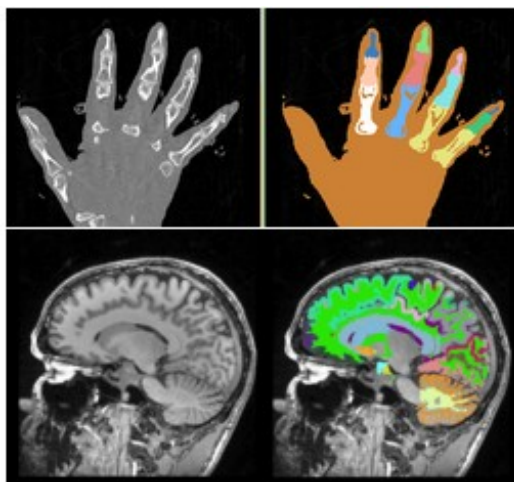
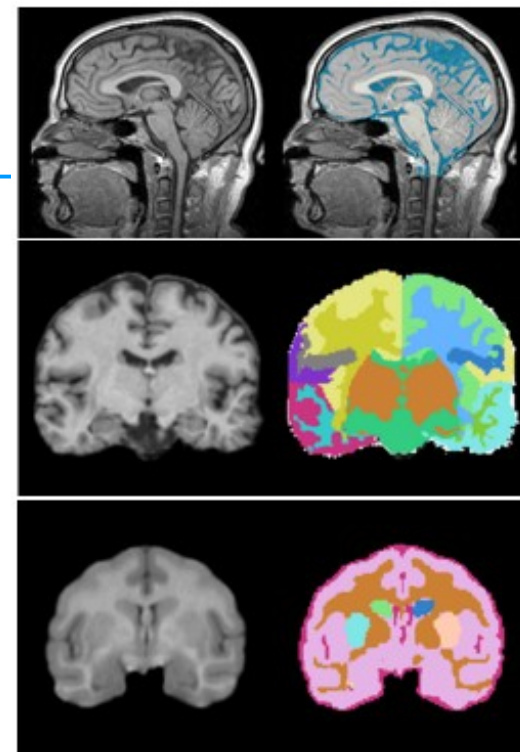


End User Tasks

This tutorial is based on **Slicer 3.6.3** .

The goal of this tutorial is to make the user familiar with the different uses cases in the EMSegmenter.

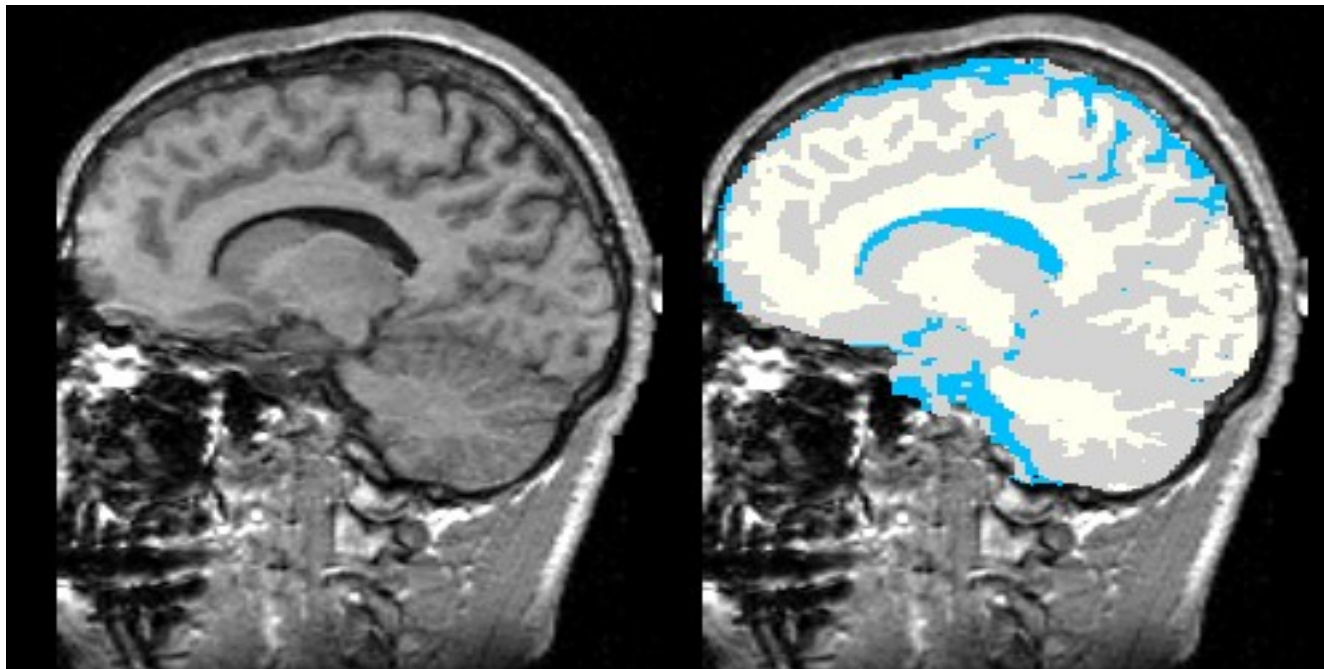
Pre-view: Slicer 3.6.4 or later



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

Overview

We will segment the clinical T1 scan shown below into **grey matter**, **white matter**, and **cerebrospinal fluid** using the **MRI Human Brain** task.



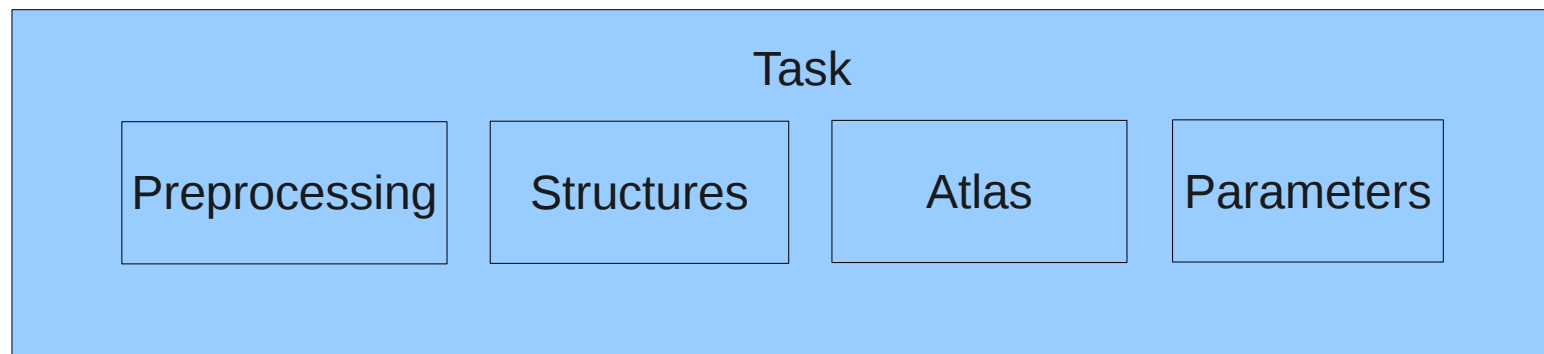
Before

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 to perform a segmentation:

Step 1: Select task

Step 2: Define input volume

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



3DSlicer

Select EMSegmenter Module

The screenshot shows the 3D Slicer Version 3.6.3 interface. A red arrow points to the 'Modules' menu in the top toolbar, which currently displays 'SlicerWelcome'. A blue callout box with a red border contains the text 'Left-click on the Modules menu'. 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), A (Anterior), and L (Lateral). The left sidebar contains a 'Welcome & About' panel with the 3DSlicer logo and version 3.6, and a 'Manipulate Slice Views' panel with icons for slice manipulation.



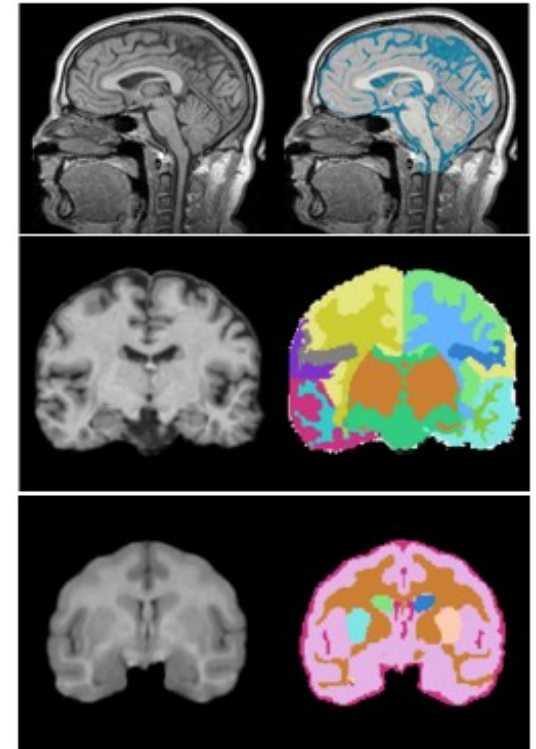
3DSlicer

Select EMSegmenter Module

The screenshot displays the 3D Slicer 3.6.3 interface. On the left, the 'Modules' list is open, with 'Segmentation' selected. A sub-menu is visible, listing various segmentation modules, with 'EMSegmenter' highlighted by a mouse cursor. 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 shows a 3D view of a brain slice with a purple bounding box and labels 'S', 'R', 'A', and 'L'. The 'EMSegmenter' module is also visible in the bottom status bar.

Define task

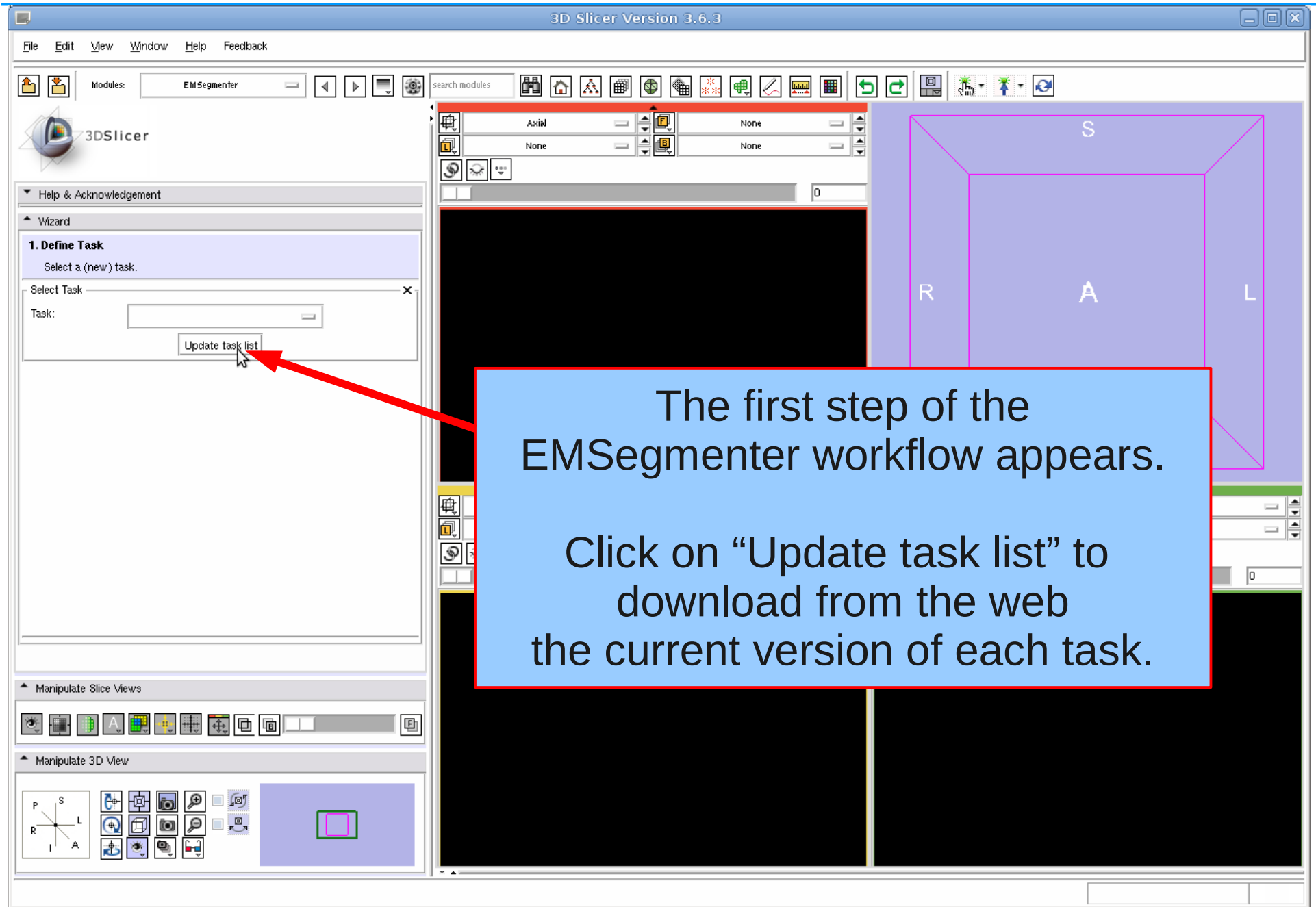
Step 1: Define task



In this step the user can choose between multiple pre-defined tasks.



Update Task List





3DSlicer

Select Task

The screenshot shows the 3D Slicer 3.6.3 interface. The 'Wizard' panel on the left is open to the '1. Define Task' step. Under 'Select a (new) task', a dropdown menu is open, listing several options: 'Non Human Primate', 'MRI Human Brain Parcellation', 'MRI Human Brain', 'test', and 'Create new task'. The 'MRI Human Brain' option is highlighted, and a red arrow points to it from a blue callout box. The callout box contains the text: 'Left-click on the Task menu and select MRI Human Brain'. The main 3D view area shows a purple brain slice with anatomical labels 'S' (Superior), 'R' (Right), 'A' (Anterior), and 'L' (Left). The status bar at the bottom left indicates 'MRI Human Brain'.



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 assigning it to the single input channel.



Load subject volume

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

2/9. Define Input Channels

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

Define Input Channels

1. Input Channel

Name: T1 Volume: **None**

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S R L I A

Axial None MRIHumanBrain_T1_aligned 129 0

Sagittal None MRIHumanBrain_T1_aligned 129 0

Coronal None MRIHumanBrain_T1_aligned 63 1.4211e-1

R A L

Per default there is no Volume selected



3DSlicer

Load subject volume

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Load Scene... Ctrl-O
Import Scene...
Download Sample Data
Add Data... Ctrl-A
Add Volume...
Add Transform...
Save
Close Scene Ctrl-W
Exit

EMSegmenter

search modules

Axial None
None None

S

1. Download our **MRI volume**
http://www.slicer.org/slicerWiki/images/c/cd/MRIHumanBrain_T1_aligned.nrrd

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

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

Define Input Channels

1. Input Channel

Name: T1 Volume: None

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

Add Volume...



3DSlicer

Load Subject Data

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

3DSlicer

Help & Acknowledgement

Wizard

2/9. Define Input Channels

Name the input channels and channels

Define Input Channels

1. Input Channel

Name: T1 Volume:

Add Channel Remove Channel

Input-to-Input Channel Registration

Align Input Scans:

Manipulate Slice Views

Recent Volumes: - Browse to CWD

Manipulate 3D View

None RAS: (-1.0, 193.3, -116.6)

Add Volume

Name	Size
MRIHumanBrain_T1_aligned.nrrd	5,214 KB

DICOM Information

Parse Directory Divide Subseries

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

Apply Cancel

Centered Ignore File Orientation Label Map Single File Name: MRIHumanBrain_T1_aligned

Browser file list:

- ./
- .ure
- bin
- boot
- data
- dev
- etc
- home
- lenny-chroot
- lib
- lib32
- lib64
- lost+found
- media
- mnt

Browse to your download location,
select **MRIHumanBrain_T1_aligned.nrrd**,
And click on **Apply**.



Define Input Channel

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

2/9. Define Input Channels

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

Define Input Channels

Input Channel

Name: T1 Volume: MRIHumanBrain_T1_aligned

Add Channel Remove Channel

Input-to-Input Channel registration

Align Input Scans:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S R L I A

S R A L

S R A L

Assign the **Volume** MRIHumanBrain_T1_aligned.
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 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 anatomical structures we want to segment can be defined. A tree data structure stores the those information where 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

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

3/9. Define Anatomical Tree

Define a hierarchy of structures.

Anatomical Tree

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

Node Attributes

Name:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

The anatomical tree exists already

Click on Next



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 frequency the structure appeared at each image location in a given set of scans.



3DSlicer

Define Atlas

3D Slicer Version 3.6.3

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

- Root
 - BG
 - AIR**
 - Neck And Skull
 - ICC
 - CSF
 - GM

Atlas Map

Class: AIR

Select Probability Map: atlas_air

Select Parcellation Map:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

The probability maps and parcellation maps are already assigned to the tree nodes

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

File Edit View Window Help Feedback

Modules: EITSegmenter

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: Linear

Package: BRAINS

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S L R I A

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

Set the registration **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.



3DSlicer

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 with the 'Define Preprocessing' wizard active. The 'Next >' button is circled in red. A blue callout box with the text 'Click on Next' is overlaid on the interface. The main window displays MRI brain slices in Sagittal and Coronal views.



3DSlicer

Define Preprocessing

The screenshot shows 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. The left sidebar shows the 'Wizard' section with '6.9. Define Preprocessing' selected. Below this, a 'Check List' is visible with 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 ?

A dialog box titled 'Start Preprocessing of images?' is open in the foreground, displaying a warning icon and the text: 'Preprocessing of images might take a while. Do you want to proceed?'. It has 'Yes' and 'No' buttons.

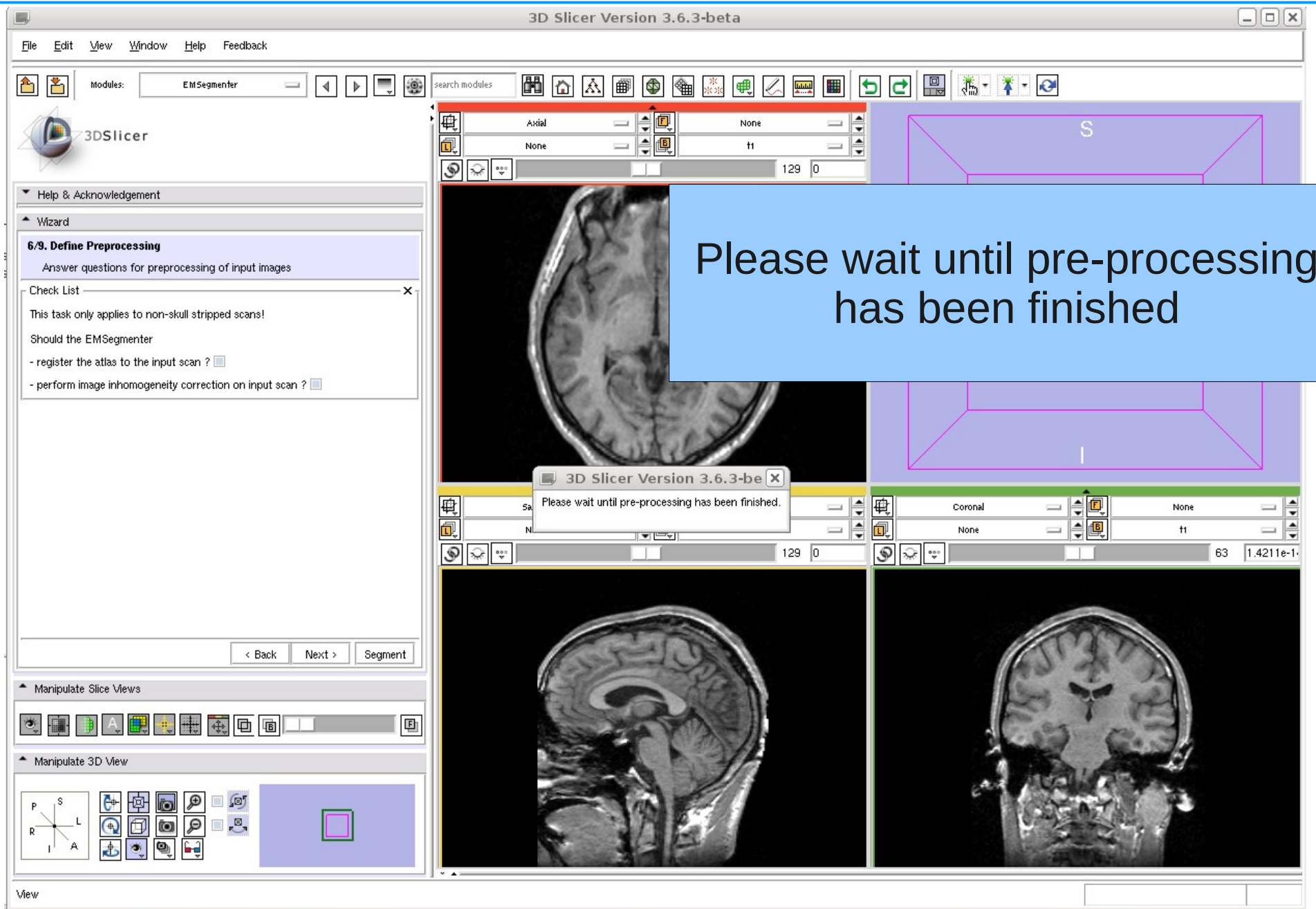
The main window displays three orthogonal views of a brain MRI scan: Axial, Sagittal, and Coronal. The EMSegmenter module is active, and the 'Start Preprocessing of images?' dialog box is overlaid on the interface.

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

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

7/9. Specify Intensity Distributions

Define intensity distribution for each anatomical structure.

Anatomical Tree

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

Intensity Distribution Manual Sampling

Class: AIR

Specification: Manual

Mean: 1.612

Log Covariance: 0.6625

Reset Distribution

Plot Distributions

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

Intensity Distribution values have been calculated during the pre-processing step.

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 chosen 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

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

8/9. Edit Node-based Parameters

Specify node-based segmentation parameters.

Anatomical Tree

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

Basic | Stopping Conditions | Print | Advanced

Class: AIR

Class Weight: 0.7 | Input Channel Weights

Atlas Weight: 1 | T1: 1

Overview Of Class Weights

AIR	0.7
Neck And Skull	0.3

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

Best known standard parameter are already specified for all tree nodes.

Click on Next



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 .



3DSlicer

Run Segmentation

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

3DSlicer

L-R Range: [] []
P-A Range: [-92.2] [92.2E]
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:

Postprocessing

Subparcellation enabled:
Minimum island size: [1]

Misc.

Multi-threading Enabled:

< Back Next > **Segment**

Manipulate Slice Views

Manipulate 3D View

Segment

Segment

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

Click on Segment



Run Segmentation

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

Axial None

None None MRHumanBrain_T1_aligned_pos

129 0

3DSlicer

L-R Range: [Slider]

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:

Postprocessing

Subparcellation enabled:

Minimum island size: 1

Misc.

Multi-threading Enabled:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

S

Sagittal

None

129 0

63 1.4211e-1.

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



Results: Run Segmentation

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

Axial EM_Map
None MRIHumanBrain_T1_aligned_pos

L-R Range: 129 0
P-A Range: -92.2
I-S Range: -119. 119.5

Display clipping box Interactive Mode
Display VOI in 2D Viewer

Save
Create Template File:

Save Intermediate Re
Select Intermediate

Postprocessing
Subparcellation enabled:
Minimum island size: 1

Misc.
Multi-threading Enabled:

< Back Next > Segment

Manipulate Slice Views

Manipulate 3D View

White matter

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

File Edit View Window Help Feedback

Modules: EM Segmenter

search modules

EM_ROI1
MRIHumanBrain_T1_aligned_pos

129 0

L-R Range: -38.2 27.75
P-A Range: -35.1 44.53
I-S Range: [slider]

Display clipping box Interactive mode

Display VOI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Postprocessing

Subparcellation enabled:

Minimum island size: 1

Misc.

Multi-threading Enabled:

< Back Next >

Manipulate Slice Views

Manipulate 3D View

P S
R L
I A

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)

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EM_Segmenter

search modules

3DSlicer

L-R Range: [Slider]

P-A Range: -38.2 [Slider] 27.75 [Slider]

I-S Range: -35.1 [Slider] 44.53 [Slider]

Display clipping box Interactive Mode

Display VOI in 2D Viewer

Save

Create Template File:

Save Intermediate Results:

Select Intermediate Directory:

Postprocessing

Subparcellation enabled:

Minimum island size: 1 [Slider]

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

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

P S
R L
I A

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

This process can be continued to get a better segmentation.

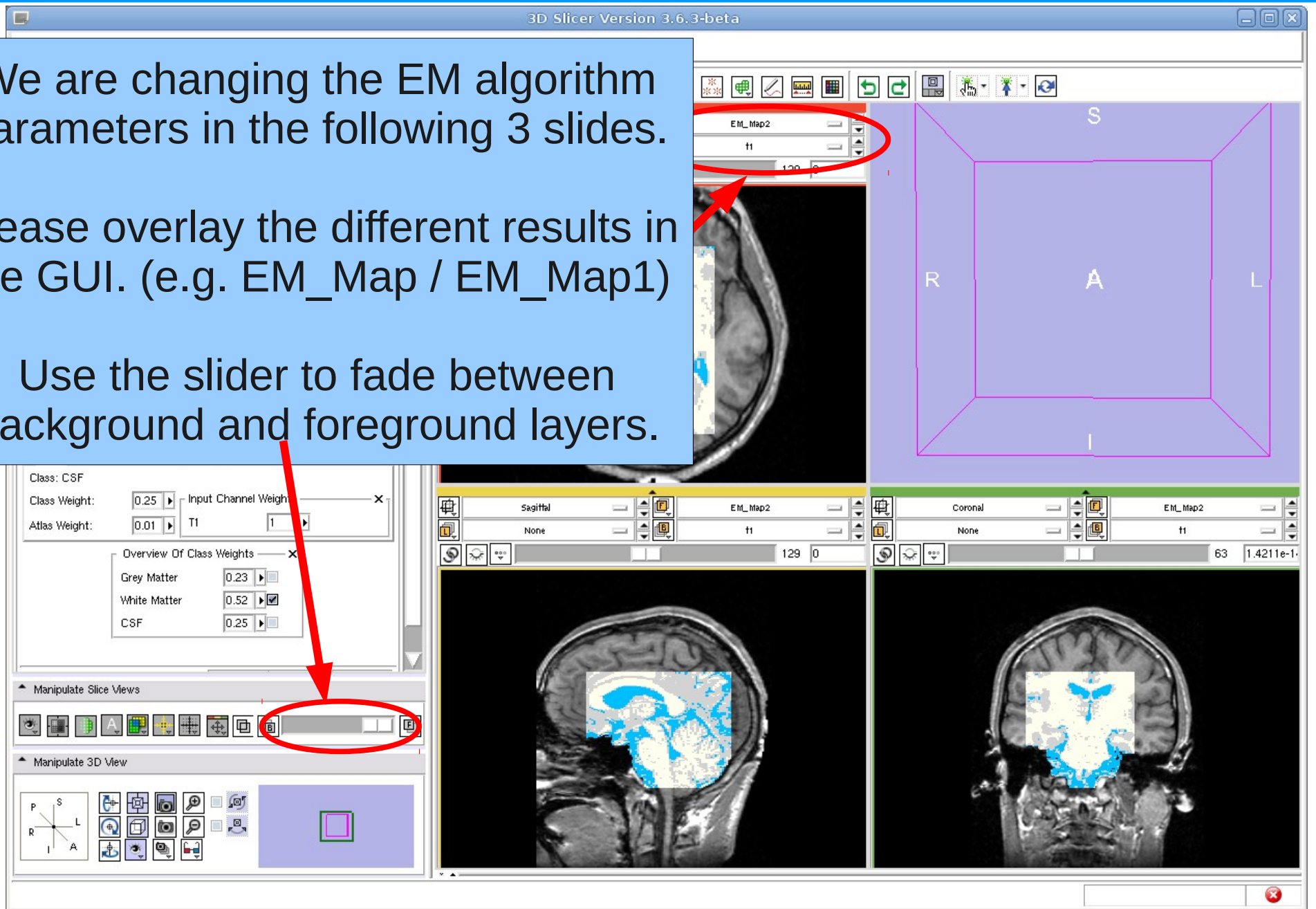


Compare Results

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:

- Wizard Panel (8/9. Edit Node-based Parameters):**
 - Anatomical Tree: Background, Air, Skull, Intracranial Cavity (expanded to show Grey Matter, White Matter, CSF).
 - Class: Intracranial Cavity
 - Class Weight: 0.85
 - Atlas Weight: 1
 - Alpha: 0.1
 - Input Channel Weights: T1 (1)
 - Overview Of Class Weights: Background (0.15), Intracranial Cavity (0.85)
- Viewports:** Axial, Sagittal, and Coronal views of a brain MRI slice. Each view shows a blue labelmap overlaid on the grayscale MRI. The labelmap is notably noisy and pixelated.
- UI Elements:** Top menu bar (File, Edit, View, Window, Help, Feedback), toolbar, and various control panels for view manipulation.

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

- 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:

