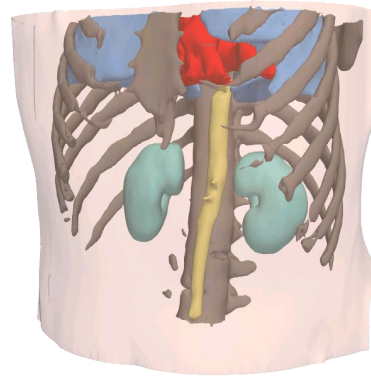
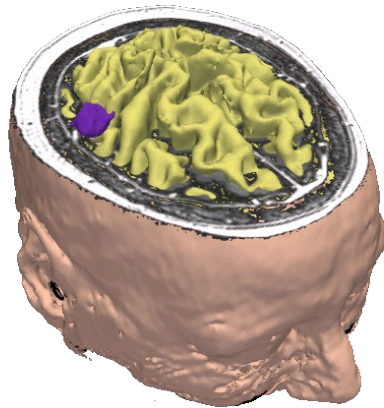




EMSegmenter Tutorial (End User Tasks)



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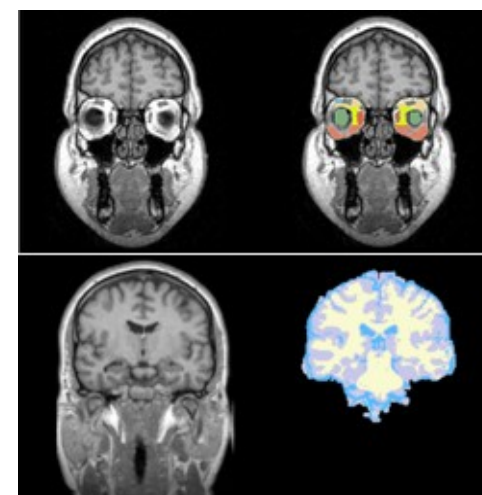
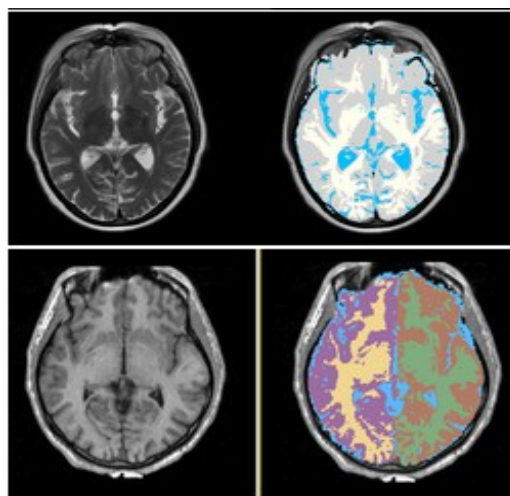
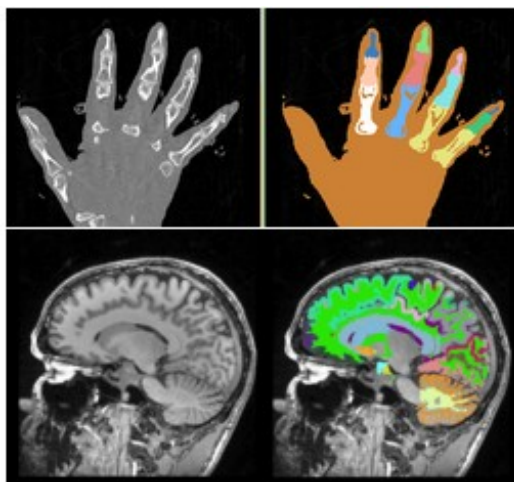
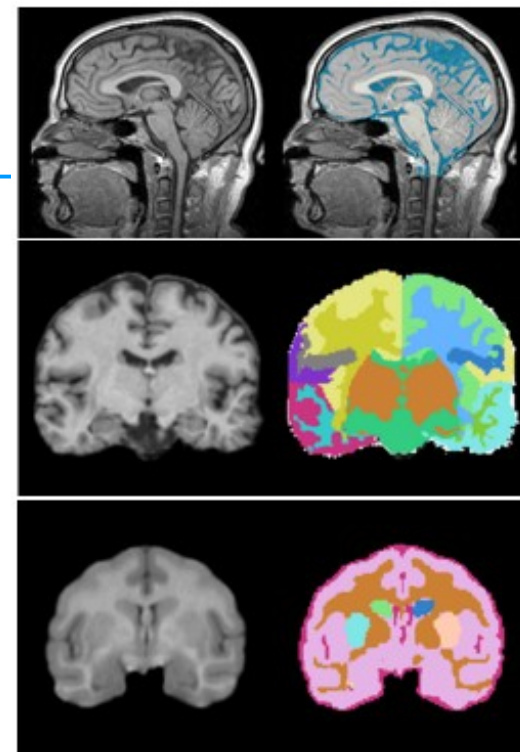


End User Tasks

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

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

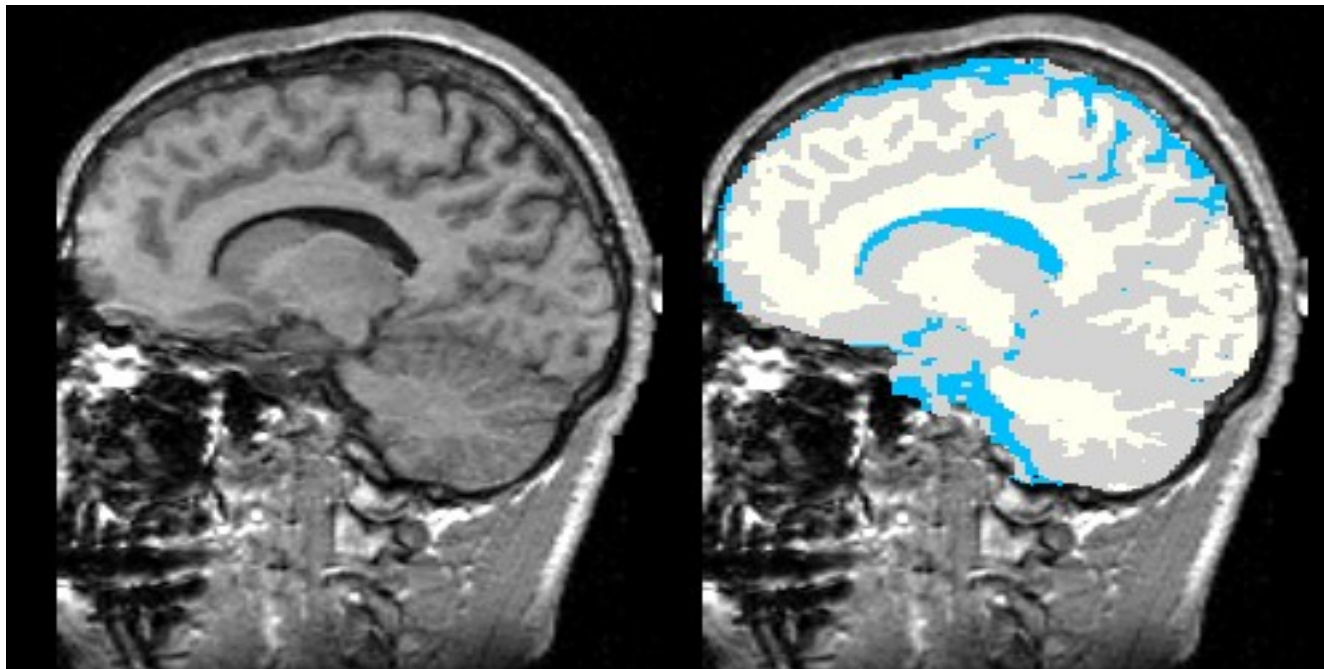
Preview: Slicer 3.6.4 or later



<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.



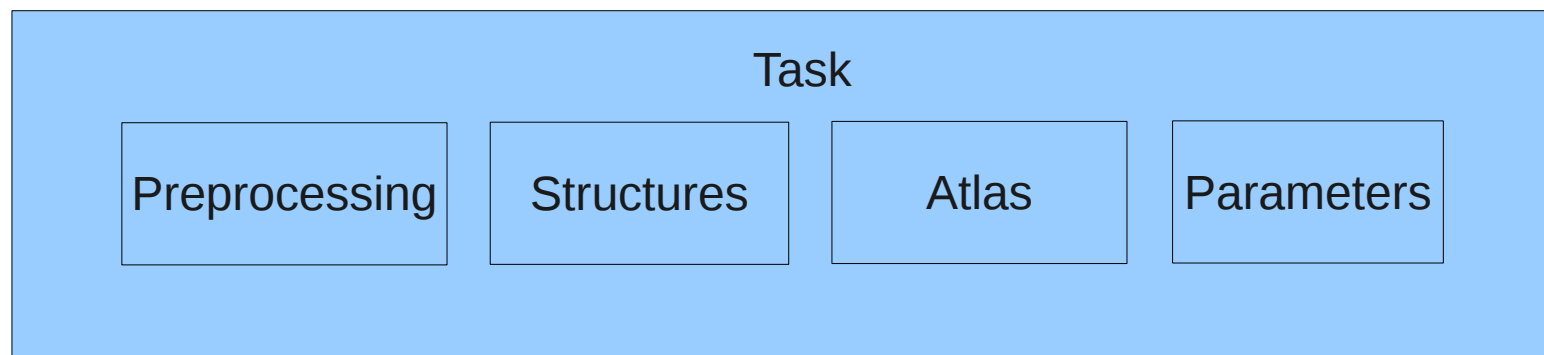
Before

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 3.6.3 interface. At the top, the title bar reads "3D Slicer Version 3.6.3". Below it is a menu bar with "File", "Edit", "View", "Window", "Help", and "Feedback". A "Modules" dropdown menu is open, showing "SlicerWelcome" and a search field. A red arrow points from a blue callout box to the "Modules" dropdown. The callout box contains the text "Left-click on the Modules menu". The main interface is divided into several panels: a "Welcome & About" panel on the left, a central "Overview" panel, and a right-hand panel with three viewports (Axial, Sagittal, Coronal) and a 3D view. The 3D view shows a purple rectangular volume with axes labeled S (Superior), A (Anterior), and I (Inferior). The "Modules" dropdown menu is currently set to "SlicerWelcome".

Left-click on the
Modules menu



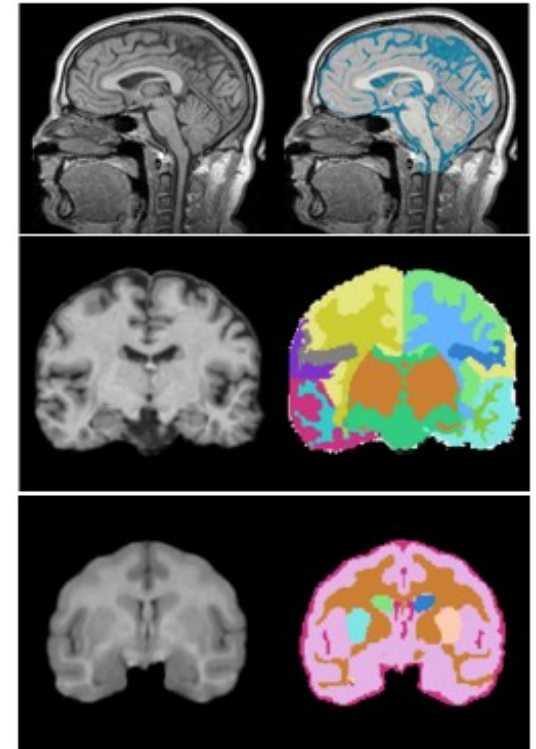
3DSlicer

Select EMSegmenter Module

The screenshot shows the 3D Slicer 3.6.3 interface. The 'Modules' menu is open, and the 'Segmentation' sub-menu is selected. Within the 'Segmentation' sub-menu, the 'EMSegmenter' module is highlighted with 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 interface shows a 3D view with a purple bounding box around a central region, and various toolbars and panels are visible.

Define task

Step 1: Define task



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



Update Task List

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EMSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

1. Define Task

Select a (new) task.

Select Task

Task:

Update task list

Axial None

None None

S

R A L

0

0

Manipulate Slice Views

Manipulate 3D View

P S

R L

I A

The first step of the EMSegmenter workflow appears.

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



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. A dropdown menu is open under 'Select Task', listing several options: 'Non Human Primate', 'MRI Human Brain Parcellation', 'MRI Human Brain' (which is highlighted and has a mouse cursor over it), 'test', and 'Create new task'. A red arrow points from a blue text box to the 'MRI Human Brain' option. The main 3D view area shows a purple brain slice with anatomical labels 'S', 'R', 'A', and 'L'. The status bar at the bottom left reads 'MRI Human Brain'.

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EITSegmenter

search modules

3DSlicer

Help & Acknowledgement

Wizard

1. Define Task

Select a (new) task

Select Task

Task:

- Non Human Primate
- MRI Human Brain Parcellation
- MRI Human Brain**
- test
- Create new task

Left-click on the **Task** menu and select **MRI Human Brain**

Sagittal

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.



3DSlicer

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

There is no default 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 and 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
-------------	-------

Centered Ignore File Orientation Label Map Single File

Name: MRIHumanBrain_T1_aligned

Apply Cancel

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

Remove Channel

Input-to-Input Channel registration

Align Input Scans:

< Back **Next >** Segment

Manipulate Slice Views

Manipulate 3D View

Assign the **Volume** MRIHumanBrain_T1_aligned.
Click **Next**



Define Input Channel

The screenshot shows the 3D Slicer 3.6.3-beta interface. The 'Define Input Channels' wizard is active, showing a single input channel named 'T1' with volume 't1'. A blue box with the text 'To confirm click Yes' is overlaid on the wizard. 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 highlighted. 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. Each node in the anatomical tree 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 spatial distribution of the structure of interest, which is the frequency of the structure which appears 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 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

File Edit View Window Help Feedback

Modules: EITSegmenter



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**

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

Set the registration **Package** to **BRAINS**

< Back Next > Segment

Click on **Next**



Define Preprocessing

Step 6: Further Specify Preprocessing

In the first step, we defined the type of preprocessing we wanted to perform. Now further specify the preprocessing by answering a set of questions related to the type of data we want 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. For the purpose of this tutorial please do not check either flag because pre-processing can be time consuming.

Click Next



3DSlicer

Define Preprocessing

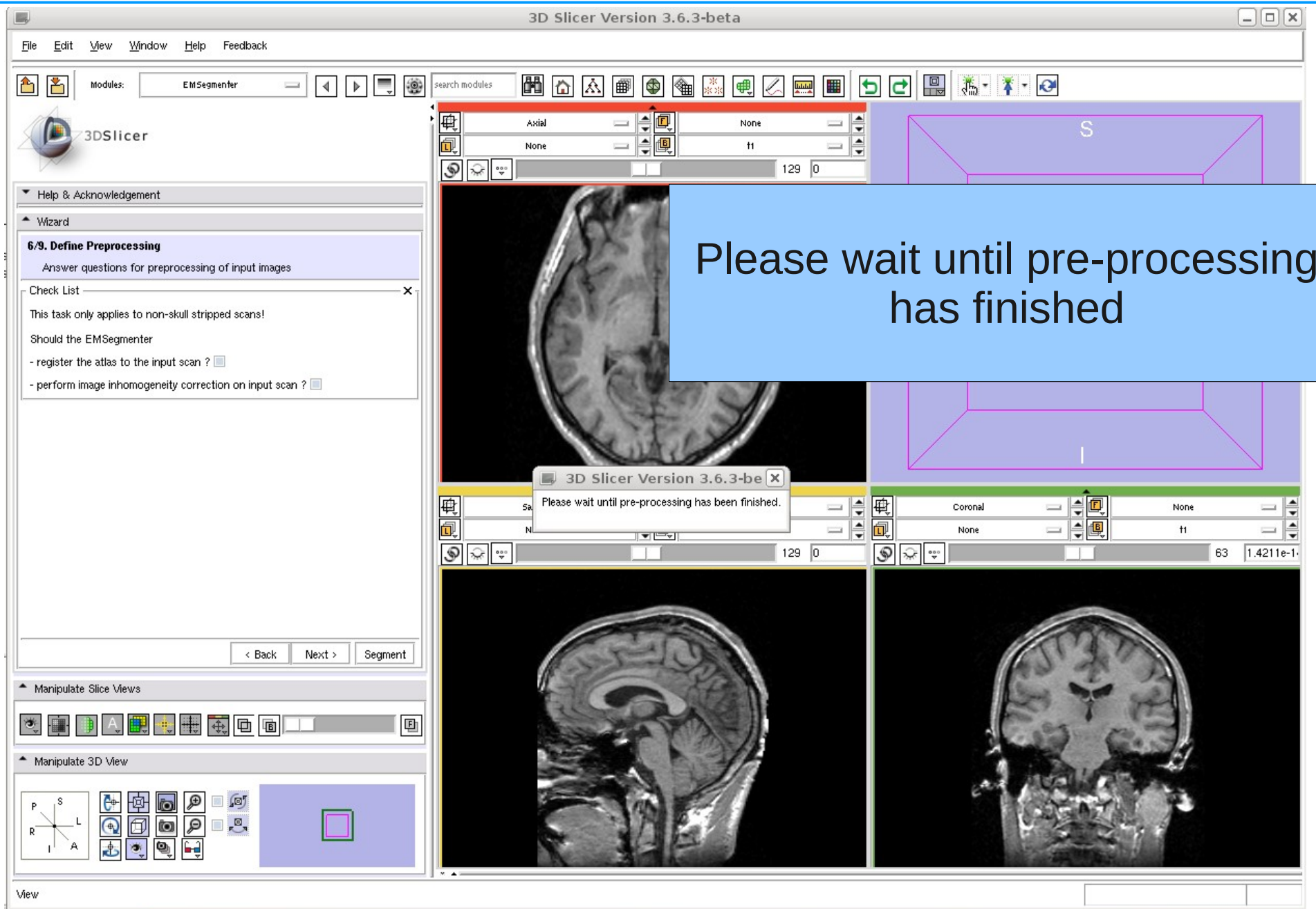
The screenshot shows the 3D Slicer 3.6.3 interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. The main toolbar contains various icons for navigation and manipulation. The left sidebar shows the 'EMSegmenter' module selected. A 'Wizard' panel is open, displaying '6/9. Define Preprocessing' with a 'Check List' that includes: '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 main view area shows three orthogonal slices: Axial, Sagittal, and Coronal. The bottom status bar displays 'MRIHumanBrain_T1_aligned RAS: (-112.2, -22.0, 0.0), Bg IJK: (8, 128, 47), Bg: 0.0'.

The EMSegmenter will perform some standard pre-processing.

Click **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 of the input scan.

This step can be skipped because the intensity distributions have been calculated during pre-processing.



Specify Intensity Distribution

3D Slicer Version 3.6.3

File Edit View Window Help Feedback

Modules: EITSegmenter

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 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 a given anatomical 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 defines the importance of the atlas (of Step 3) with respect to 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

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 parameters are already specified for all tree nodes.

Click 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: [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

Click Segment

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



Run Segmentation

The screenshot shows the 3D Slicer software interface with the EM Segmentation module active. The interface includes a menu bar (File, Edit, View, Window, Help, Feedback), a toolbar, and several panels. The left panel shows the 'EM Segmentation' module settings, including range sliders for L-R, P-A, and I-S, and checkboxes for 'Interactive Mode' and 'Multi-threading Enabled'. The bottom panel shows a 3D view of a brain slice with a purple bounding box. A blue text box is overlaid on the center of the interface, containing the text: 'The EM algorithm is running Please wait... The processing time on a standard computer is about 2 minutes'. The text box is semi-transparent and has a blue background.



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: Create
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
- 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: EMSegmenter

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 **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 **Segment**.



Result: Adjusting Parameters

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

Class	Weight
Grey Matter	0.23
White Matter	0.52
CSF	0.25

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

This process can be continued to get a better segmentation.

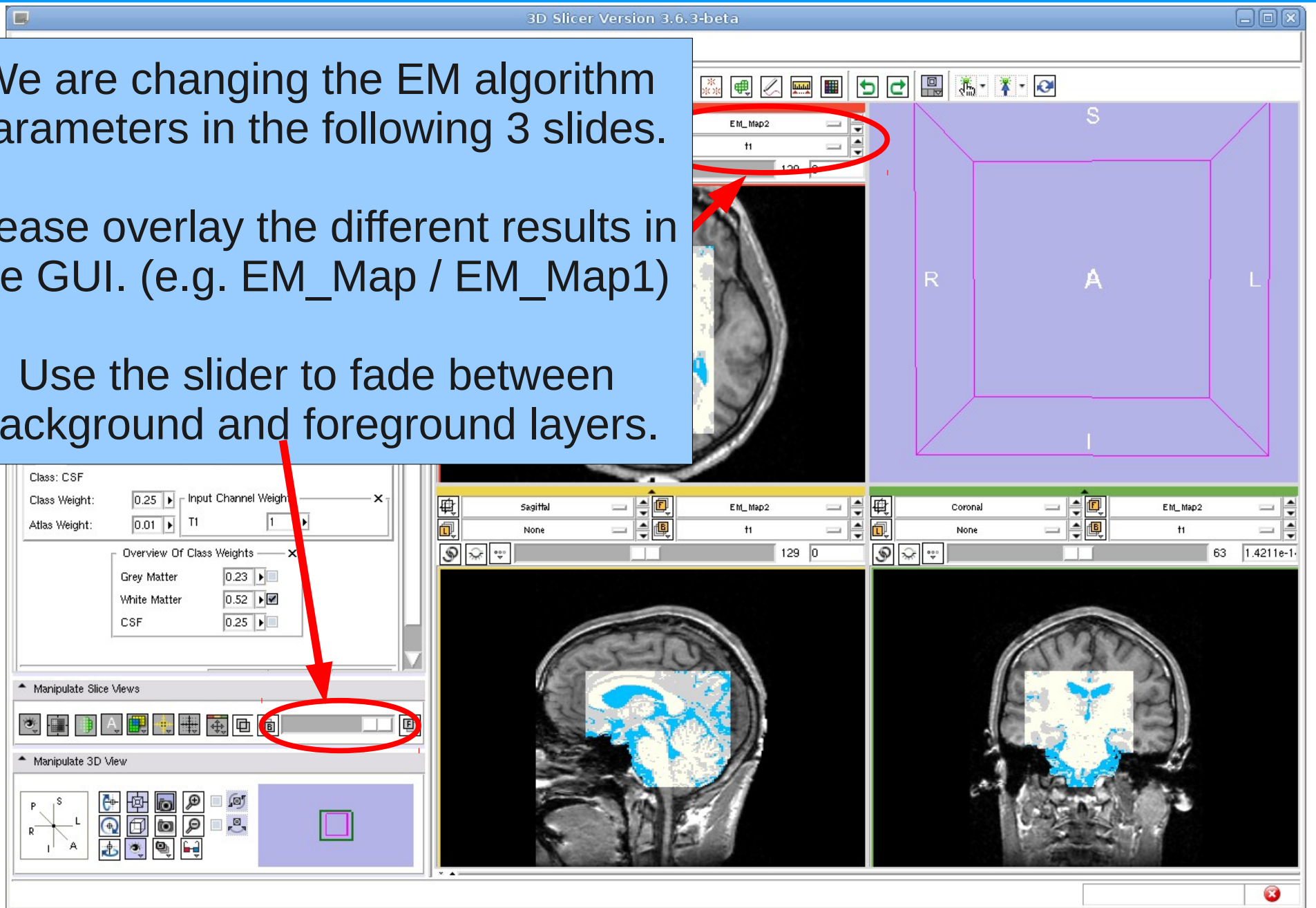


Compare Results

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 Version 3.6.3-beta interface. The 'Wizard' panel on the left is at step 8/9, 'Edit Node-based Parameters', for the 'Intracranial Cavity' class. 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 top toolbar shows the 'EM Segmenter' module is active.



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

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:

