

GUIDE: BrainResectionApp

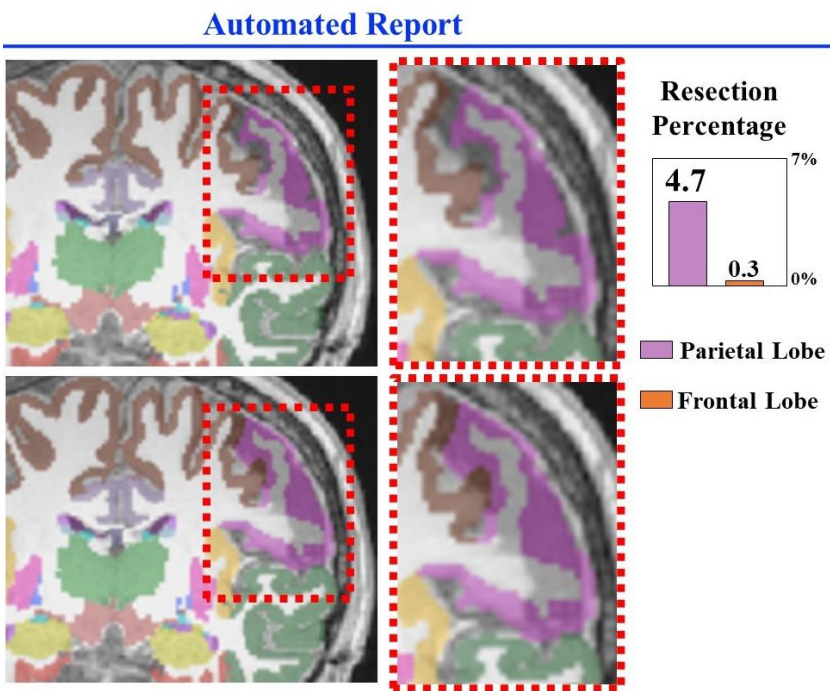
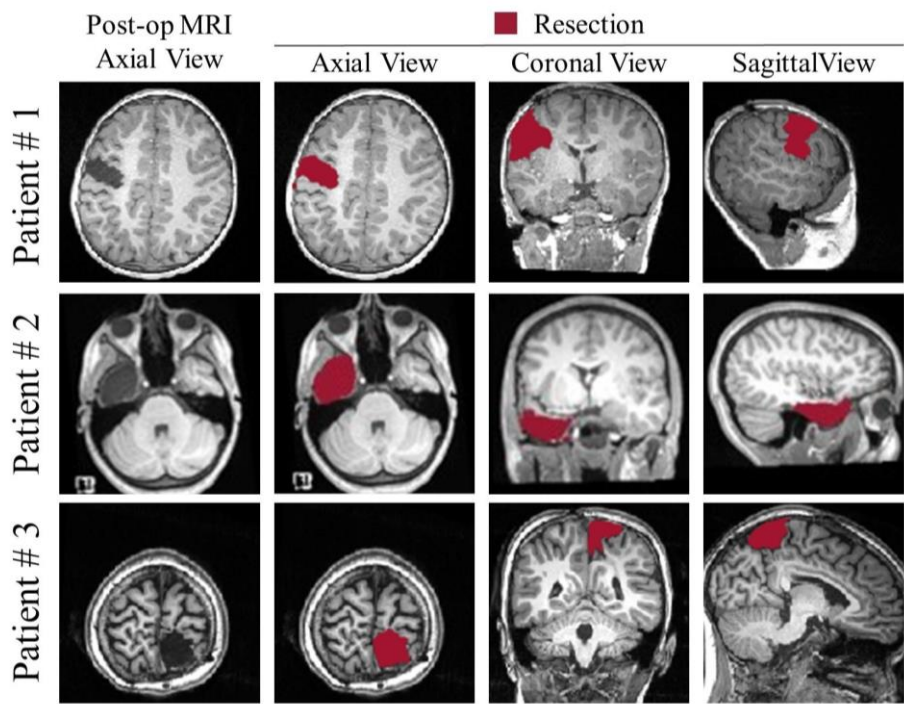
If you use our software for your data analysis, please cite: Billardello, R.; Ntolkeras, G.; Chericoni, A.; Madsen, J. R.; Papadelis, C.; Pearl, P. L.; Grant, P. E.; Taffoni, F.; Tamilia, E. Novel User-Friendly Application for MRI Segmentation of Brain Resection Following Epilepsy Surgery. *Diagnostics* 2022, 12 (4), 1017.

Reference: <https://www.mdpi.com/2075-4418/12/4/1017>

The latest version of the software is available at: <https://github.com/rbillardello/BrainResectionApp>

BrainResectionApp

BrainResectionApp is a MATLAB Graphical User Interface (GUI) for accurate delineation of the resected brain region within the patient's MRI space. It integrates a validated semi-automated segmentation pipeline based on a hybrid approach combining region growing algorithm on post-operative MRI with the patient-specific pre-operative mask. Designed to maximize user efficiency and the output accuracy, the GUI is focused entirely on segmenting the resection cavity, where parameter selection is simplified and kept to a minimum and where the user is only asked to place an initial seed anywhere in the cavity that he/she desires to accurately delineate. This GUI is also designed to extract the resection cavity volume and its neuroanatomical labelling.



Requirements

BrainResectionApp is an “Appdesigner” GUI. You can ensure that MATLAB Appdesigner tool is installed, and it is working on the machine by typing the command «appdesigner» in the command window.

Further information or download at:

<https://www.mathworks.com/products/matlab/app-designer.html>

Visualization functions of BrainResectionApp lean on Brainstorm toolbox. Please install the latest version of this toolbox at:

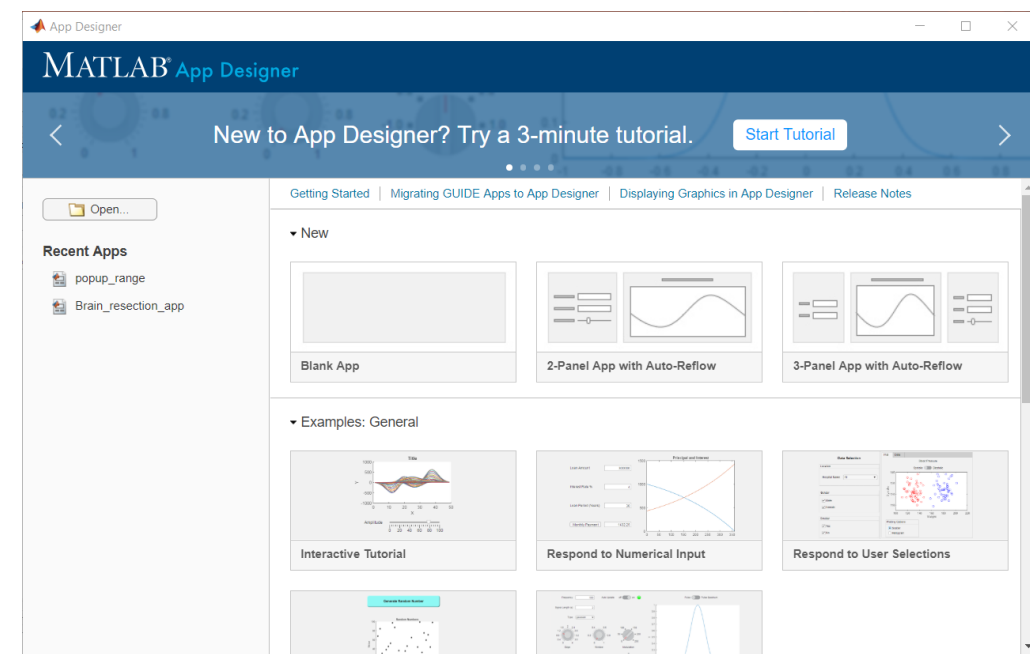
<https://neuroimage.usc.edu/brainstorm/>

Download all the files in

<https://github.com/rbillardello/BrainResectionApp> and store

them in a folder on you Computer.

- Launch Brainstorm
- Launch Brain_resection_app.mlapp

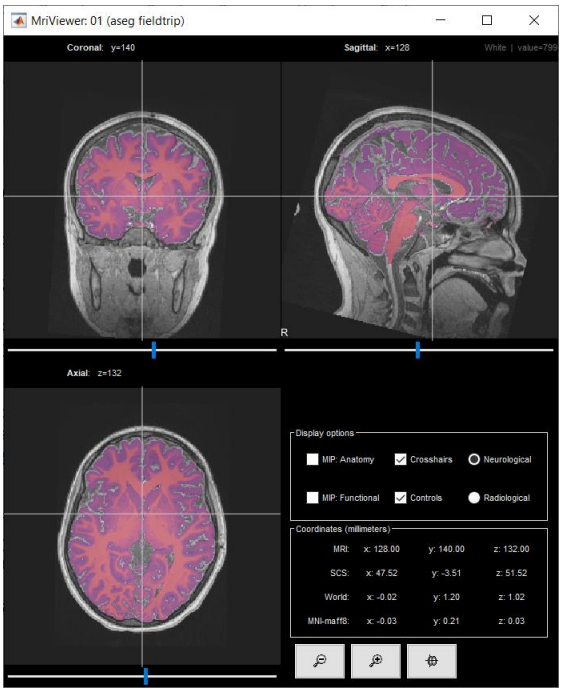
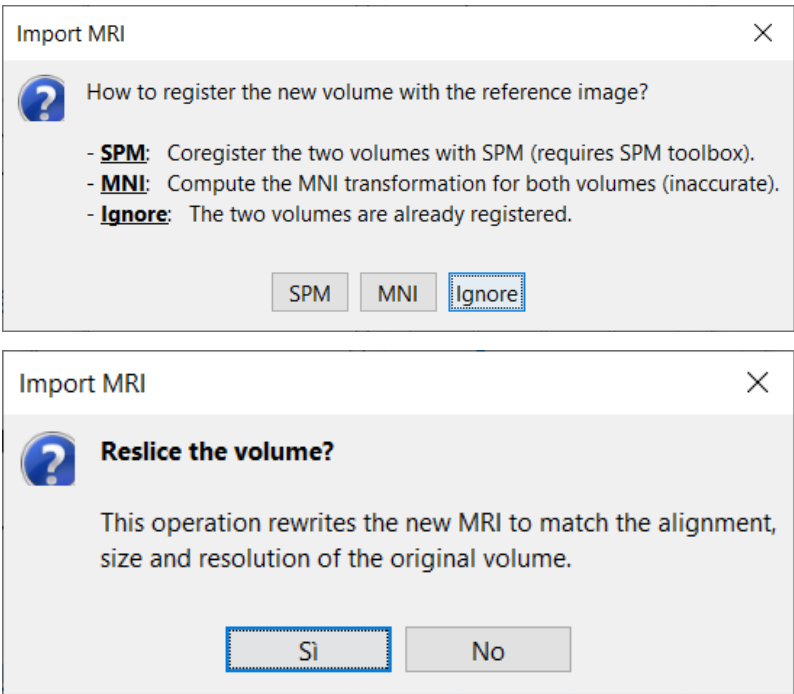
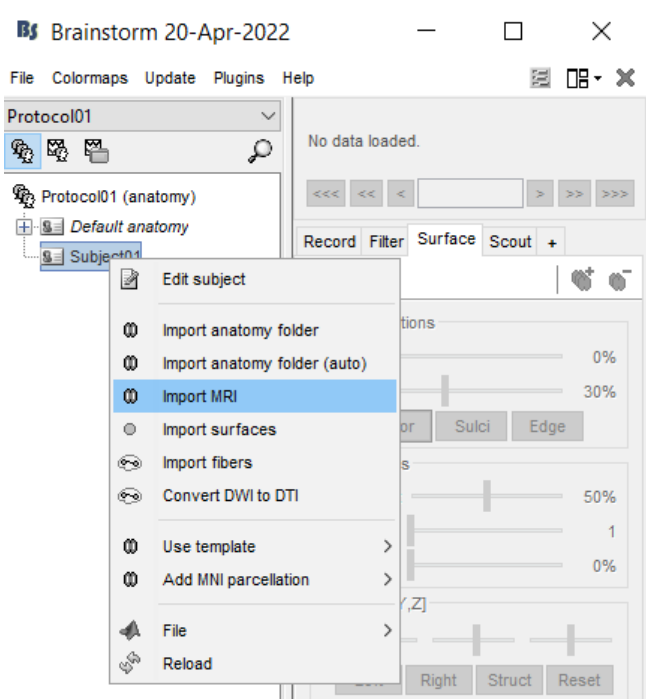


Preliminary MRI loading and co-registration

- To produce an accurate resection model, BrainResectionApp requires a pre-operative brain mask and a post-operative MRI, in a *.mat format.
- To obtain *.mat file, please load your MRI NIfTI files in Brainstorm, by right clicking on a subject in the protocol and then on “Import MRI”.
 - During the second import, the user is asked to co-register and to reslice the new volume, to the previously loaded one. Depending on these files, you may try different options to get the MRIs co-registered.

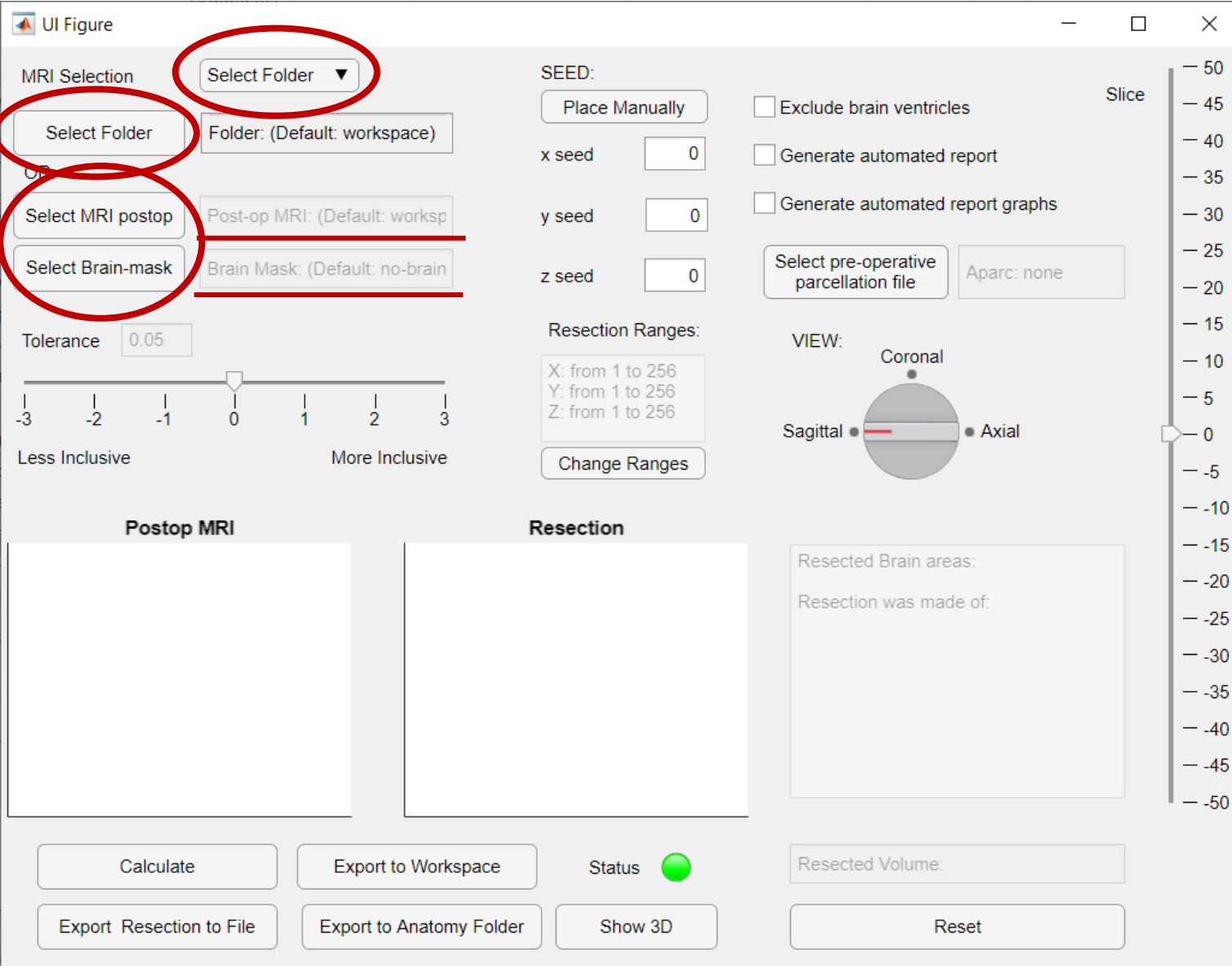
We suggest to:

1. Import the pre-operative MRI first, where no resection cavity is present.
2. Import the post-operative MRI, and co-register it to the pre-operative MRI.
3. Import the pre-operative brain mask, without co-registration.
4. Check the co-registration of the post-operative MRI and the brain mask. You can now start using BrainResectionApp.



*correctly co-registered post-operative MRI (grey-scale) and pre-operative brain mask (purple)

BrainResectionApp - 1: Selecting MRIs



Two methods:

- Select the Brainstorm folder of the patient where the MRIs (*.mat) are. Click «Select Folder» and select the patient's Brainstorm anatomy folder. The GUI will search for files named:

`subjectimage_MRI_postop`
`subjectimage_brainmask`

The GUI assumes that the brainstorm files have been renamed as "MRI_postop" and "brainmask" after being imported.

- Select the files separately, by clicking on "Select MRI postop" and then "Select Brain-mask". You can choose to load a *.mat or a *.nii file.

Note: if you choose the NIfTI format, ensure that MRIs are co-registered.

In both cases a popup window will appear to select the folder or the files. In both cases, the text fields will show the MRI names.

BrainResectionApp - 2: Tolerance selection

The screenshot displays the BrainResectionApp interface. A red circle highlights the 'Tolerance' slider, which is currently set to 0.05. The slider ranges from -3 to 3, with labels 'Less Inclusive' on the left and 'More Inclusive' on the right. The interface includes various input fields for MRI selection, SEED coordinates, and resection ranges. A 'VIEW' section shows a 3D brain model with 'Coronal', 'Sagittal', and 'Axial' views. A 'Slice' vertical scale on the right ranges from -50 to 50. At the bottom, there are buttons for 'Calculate', 'Export to Workspace', 'Export Resection to File', 'Export to Anatomy Folder', 'Show 3D', and 'Reset'. A 'Status' indicator shows a green light.

UI Figure

MRI Selection

Select Folder

Select Folder

Folder: (Default: workspace)

OR:

Select MRI postop

Post-op MRI: (Default: worksp

Select Brain-mask

Brain Mask: (Default: no-brain

Tolerance

0.05

-3 -2 -1 0 1 2 3

Less Inclusive

More Inclusive

SEED:

Place Manually

Exclude brain ventricles

Generate automated report

Generate automated report graphs

Select pre-operative parcellation file

Aparc: none

VIEW:

Coronal

Sagittal

Axial

Resection Ranges:

X: from 1 to 256

Y: from 1 to 256

Z: from 1 to 256

Change Ranges

Postop MRI

Resection

Resected Brain areas:

Resection was made of:

Calculate

Export to Workspace

Status

Export Resection to File

Export to Anatomy Folder

Show 3D

Resected Volume:

Reset

BrainResectionApp requires the definition of a single parameter, which can be adjusted accordingly to the desired result. This parameter is the Tolerance value, and you can change its value using the tolerance slide.

To be more inclusive (bigger resections) use higher tolerance values (slider to the **right**)

To be less inclusive (smaller resections) use lower tolerance values (slider to the **left**).

If you are not sure on the value to use, leave it at its default value.

BrainResectionApp - 3: Seed placement

The screenshot shows the 'UI Figure' window of the BrainResectionApp. The 'SEED:' section is highlighted with a red circle, containing a 'Place Manually' button and three input fields for 'x seed', 'y seed', and 'z seed', all currently set to 0. Below this, the 'Resection Ranges' are defined as X: from 1 to 256, Y: from 1 to 256, and Z: from 1 to 256. The 'VIEW:' section shows three radio buttons for 'Coronal', 'Sagittal', and 'Axial' views, with 'Sagittal' selected. The 'MRI Selection' section includes buttons for 'Select Folder', 'Select MRI postop', and 'Select Brain-mask', along with a 'Tolerance' slider set to 0.05. The 'Postop MRI' and 'Resection' sections are empty. The 'Status' is indicated by a green light. The 'Resected Volume' section is empty. The 'Reset' button is at the bottom right.

UI Figure

MRI Selection

Select Folder

Folder: (Default: workspace)

OR:

Select MRI postop

Post-op MRI: (Default: worksp

Select Brain-mask

Brain Mask: (Default: no-brain

Tolerance

0.05

Less Inclusive

More Inclusive

SEED:

Place Manually

x seed

0

y seed

0

z seed

0

Exclude brain ventricles

Generate automated report

Generate automated report graphs

Select pre-operative parcellation file

Aparc: none

VIEW:

Coronal

Sagittal

Axial

Resection Ranges:

X: from 1 to 256

Y: from 1 to 256

Z: from 1 to 256

Change Ranges

Postop MRI

Resection

Resected Brain areas:

Resection was made of:

Calculate

Export to Workspace

Status

Export Resection to File

Export to Anatomy Folder

Show 3D

Resected Volume:

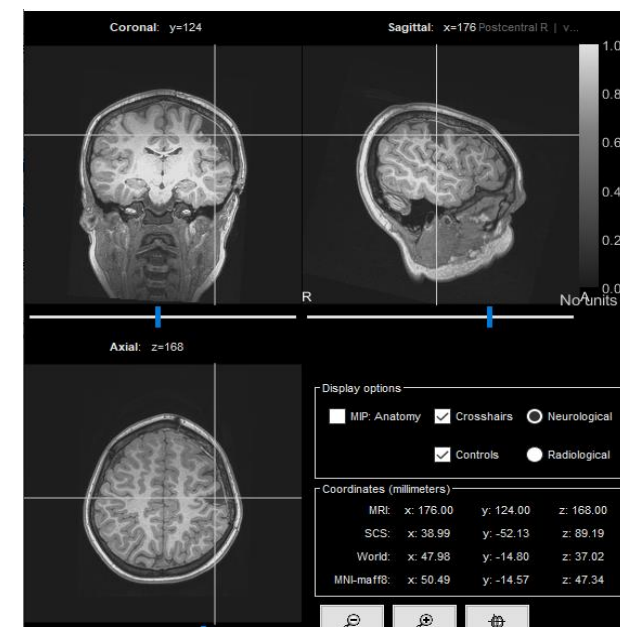
Reset

To place the seed (i.e. the point from which the resection model will start growing), change the x,y and z voxel coordinates by typing, or click «select Manually». This point can be placed anywhere within the resection cavity, but we also suggest to ensure that the selected point has low intensity.

If you pressed the «Select Manually Button», a 3D MRI viewer of the post-operative MRI will appear. If not, there may be a problem with the brainstorm protocol or Brainstorm might not have been opened. Scroll the 3D viewer until you see the resection and place the crosshairs in the middle of the resection. Then, click on the command window and press enter.

The coordinates will be updated automatically.

We suggest to write down the limits in which you expect the resection to be, so that you can click on «Change Ranges» and modify them.



BrainResectionApp - 4: Range Selection (optional)

UI Figure

MRI Selection Select Folder

Select Folder Folder: (Default: workspace)

OR:

Select MRI postop Post-op MRI: (Default: worksp

Select Brain-mask Brain Mask: (Default: no-brain

Tolerance 0.05

Less Inclusive More Inclusive

SEED:

Place Manually

☐ Exclude brain ventricles

☐ Generate automated report

☐ Generate automated report graphs

x seed 0

y seed 0

z seed 0

Select pre-operative parcellation file Aparc: none

VIEW: Coronal Sagittal Axial

Resection Ranges:

X: from 1 to 256

Y: from 1 to 256

Z: from 1 to 256

Change Ranges

Postop MRI

Resection

Resected Brain areas:

Resection was made of:

Calculate Export to Workspace Status Export Resection to File Export to Anatomy Folder Show 3D Reset

By clicking «Change Ranges», a popup window will appear, where the user can edit the resection ranges. This allows the definition a reduced ROI which could decrease the computational time or, in some cases, improve the performances. If not specified, resection ranges corresponds to the image dimensions (usually 256x256x256)

If the window does not appear, there may be a problem with the popup_window file, or it may be missing.

UI Figure

X start 145 X end 210

Y start 100 Y end 150

Z start 140 Z end 180

Save

BrainResectionApp - 5: Ventricles exclusion

The screenshot shows the BrainResectionApp interface. At the top left, there's a 'UI Figure' window. The main interface is divided into several sections. On the left, under 'MRI Selection', there are buttons for 'Select Folder', 'Select MRI postop', and 'Select Brain-mask'. Below these is a 'Tolerance' slider set to 0.05, ranging from -3 to 3, with labels 'Less Inclusive' and 'More Inclusive'. In the center, there's a 'SEED:' section with a 'Place Manually' button and input fields for 'x seed', 'y seed', and 'z seed', all set to 0. Below this is a 'Resection Ranges:' section with text indicating 'X: from 1 to 256', 'Y: from 1 to 256', and 'Z: from 1 to 256', and a 'Change Ranges' button. On the right, there are three checkboxes: 'Exclude brain ventricles' (checked), 'Generate automated report' (unchecked), and 'Generate automated report graphs' (unchecked). Below these are buttons for 'Select pre-operative parcellation file' and 'Aparc: none'. A 'VIEW:' section shows a circular diagram with 'Coronal', 'Sagittal', and 'Axial' views, with 'Sagittal' selected. A vertical 'Slice' scale on the far right ranges from -50 to 0. At the bottom, there are buttons for 'Calculate', 'Export to Workspace', 'Export Resection to File', 'Export to Anatomy Folder', 'Show 3D', and 'Reset'. A 'Status' indicator shows a green light. Two large empty boxes labeled 'Postop MRI' and 'Resection' are on the left. On the right, there are text areas for 'Resected Brain areas:', 'Resection was made of:', and 'Resected Volume:'.

The app allows the user to exclude the growth of the resection model over the brain ventricles. This can be particularly important in resections such as in the temporal lobectomy

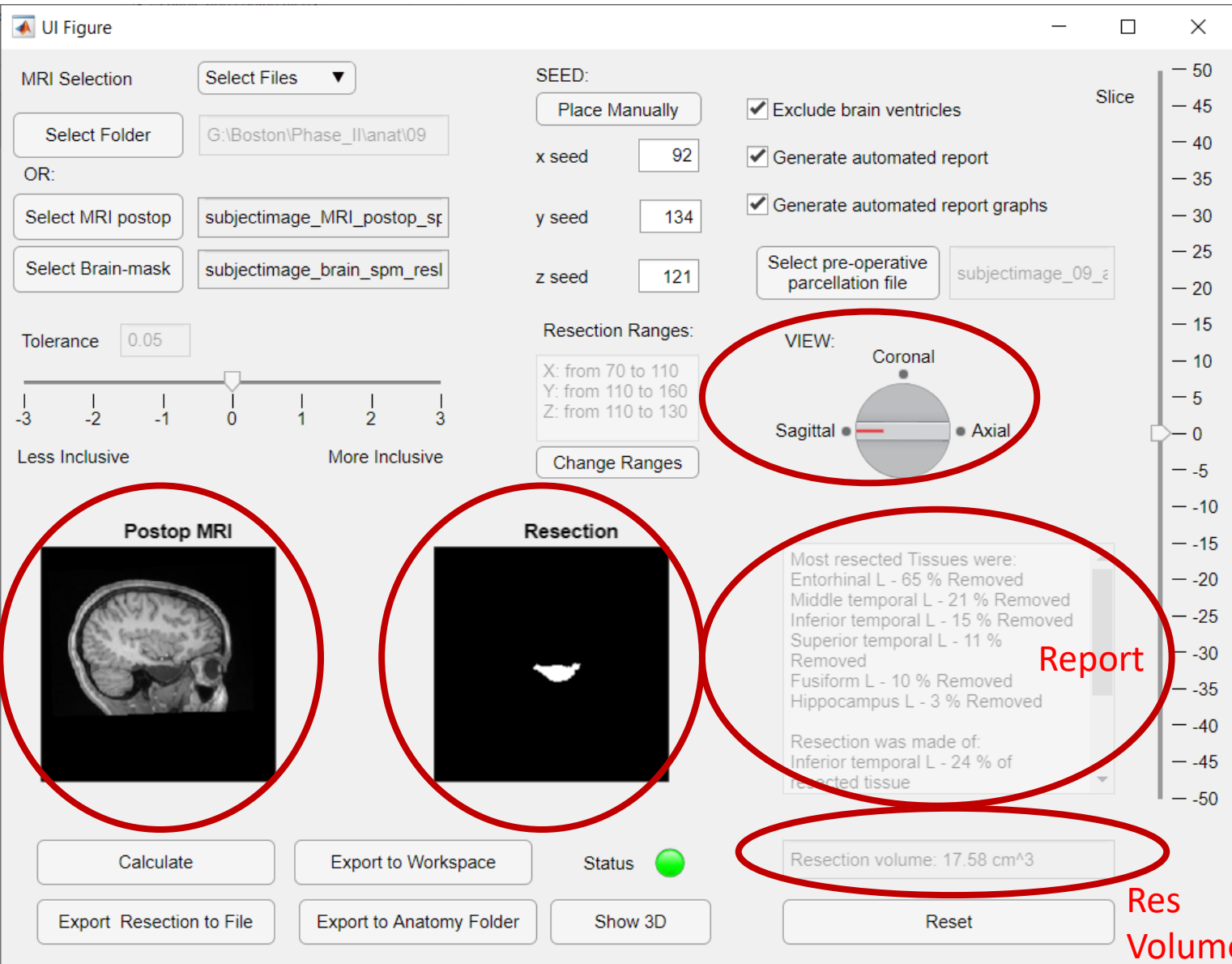
By selecting «exclude Ventricles», a popup window will appear for the user to select a preoperative segmentation or cortical parcellation file (if not already selected). Parcellations from Freesurfer, or segmentation files from SPM or Fieldtrip will work fine.

Select «Generate automated report» to get an anatomical report of the resection (you must select a preoperative cortical parcellation file if you have not already)

Select «Generate automated report graphs» to get graphs of the anatomical report (you must select a preoperative cortical parcellation file if you have not already)

To change the parcellation/segmentation file, click on «Select pre-operative parcellation file»

BrainResectionApp - 6: Results preview



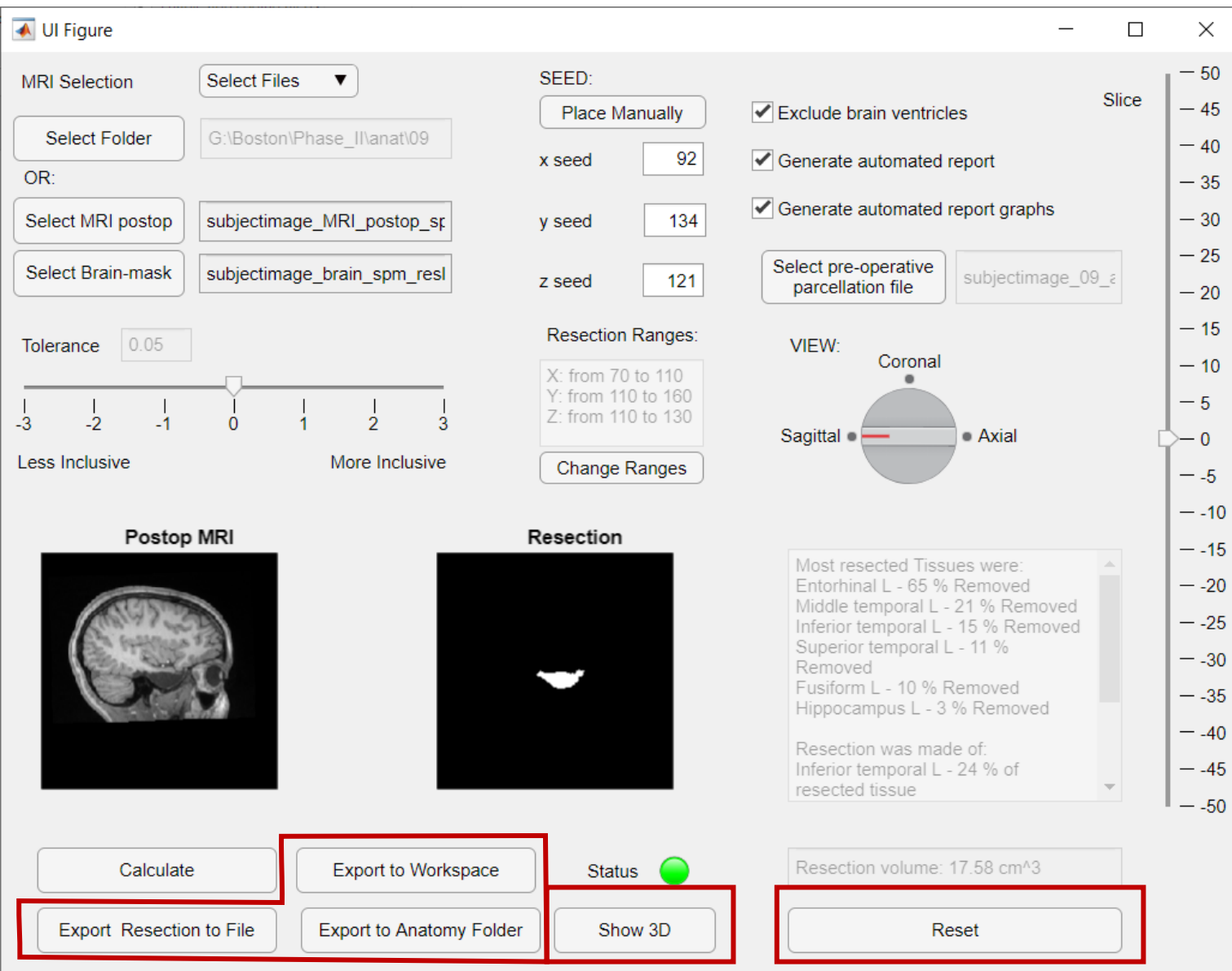
Click «Calculate» to have a preview of the output of the segmentation process. You will see the post-operative MRI (left), and the resection model (right). Use the «Slice» slider on the right to change slice, or the VIEW Knob to change the MRI view.

On the right of the resection, there will be the anatomical report, showing both the most resected tissues (Top), and what the resection is made of (bottom).

Below the anatomical report there will be the resection volume in cm^3 .

Res
Volume

BrainResectionApp - 7: Export the results



If you are satisfied from the results, you can export the model and other info to workspace by selecting «Export to workspace». You can choose to use the scs or the voxel coordinates

You can also export the *.mat file of the model by selecting «Export Resection to File». This is suggested when the resection model has to be inserted in a brainstorm protocol: in this case the user has to select the patient's anatomy folder*¹.

If you want to save the resection model in the exact same patient's folder as the post-operative MRI, you can also select «Export to Anatomy folder».

It is also possible to visualize the 3D model through the Brainstorm 3D MRI viewer, by clicking on «Show 3D»

Click the «Reset» button to clean all the results and start over

*1 - This option will by-pass the import of the resection model. Just right click on the patient in the Brainstorm window, and select "Reload"

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