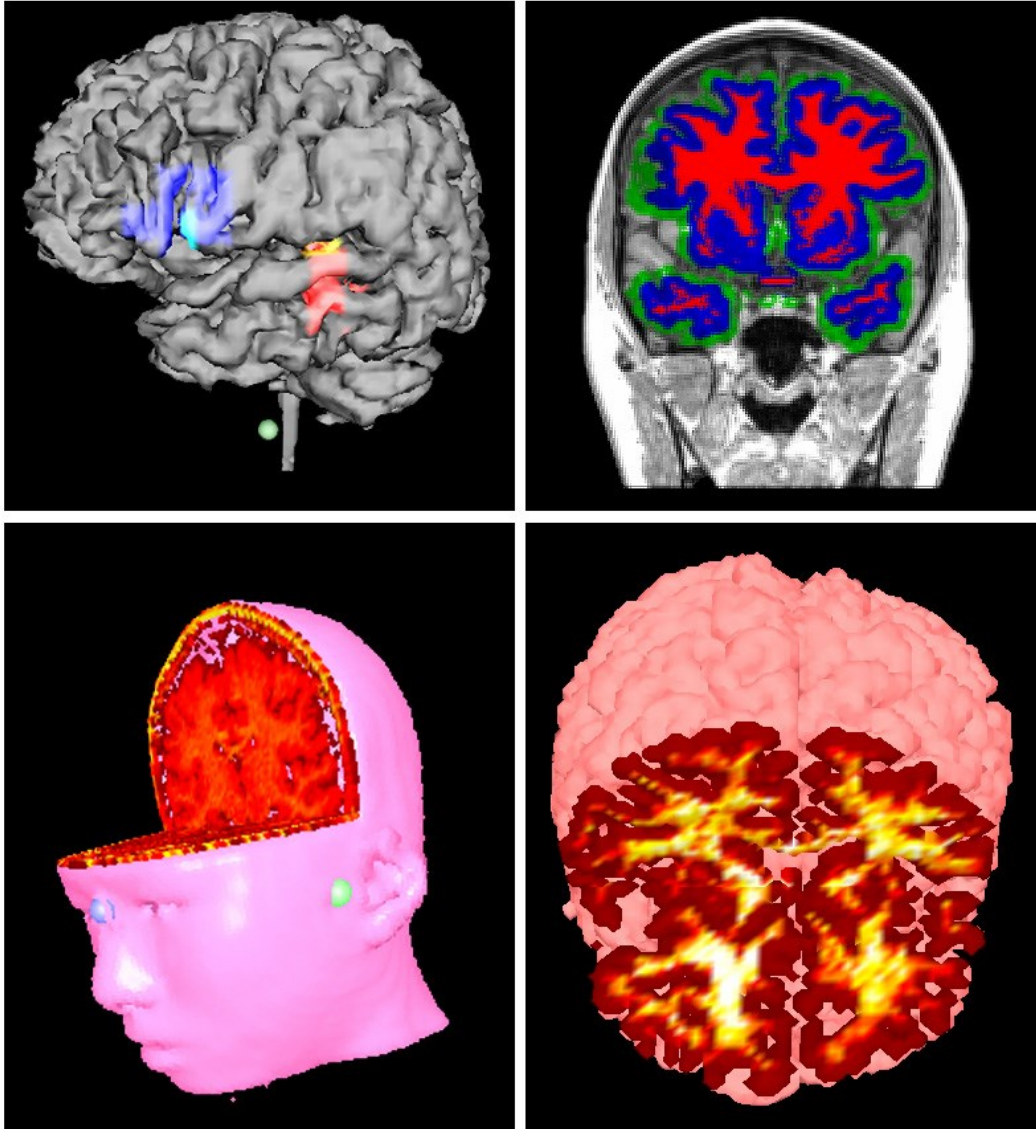


# Segmentation Toolbox

## Software Guide



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Features and specifications of this software program are subject to change without notice. This manual contains information and images about segmentation, its user interface, GUI and its other signal processing algorithms, publications that are protected by copyright.

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Thank you.

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### *Warnings and Cautions*

This software supports gray scale images. Structural image data include magnetic resonance imaging (MRI) and computed tomography (CT) are typically gray scale image in nature.

If you use software to convert a DICOM (Digital Imaging and Communications in Medicine) series containing oblique slices with a slice plane that is not orthogonal to the scan direction, the result will be a distorted image. The severity of distortion will depend on the angle of the oblique scan. Such a distorted image should not be used for analysis.



## Preface

This guide describes the operation of the MRI/CT segmentation. The segmentation toolbox is one of the core windows for separating various tissues in MRI/CT. It is used as the primary tool to view structural abnormality for academic or clinical purposes. The main window is also often used to launch other windows such as segmentation toolbars.

## Intended Audience

This guide is intended for persons responsible for structural MRI/CT data. The guide assumes the reader is familiar with standard MRI/CT procedures. In addition, this guide assumes the reader is familiar with the Windows operating systems.

## References

This document assumes familiarity with many terms related to computer operations and neurophysiology. There is also wide use of acronyms.

## Document Structure

Documents are generally provided in both Microsoft Word® format and Adobe® Acrobat® PDF (Portable Document Format). All editions are distributed on Flash Driver, CD or websites with the related software, and include bookmarks and hyperlinks to assist navigating the document. Please feel free to send your critiques, corrections, suggestions and comments to: BrainX@live.com.

## Conventions

**Numeric:** Numeric values are generally presented in decimal but in special circumstances may also be expressed in hexadecimal or binary. Hexadecimal values are shown with a prefix of 0x, in the form 0x3D. Binary values are shown with a prefix of 0b, in the form 0b00111101. Otherwise, values are presumed decimal.

**Units:** Units of measure are given in metric. Where measure is provided in imperial units, they are typically shown in parenthesis after the metric units. Magnetic signal strength is given in Teslas (T), the SI unit of flux density (or field intensity) for magnetic fields, also known as the magnetic induction. Typical signal strengths in MEG measurements are in the order of pT (picoteslas =  $10^{-12}$ ) or fT (femtoteslas =  $10^{-15}$ ).

## Changes from Previous Releases

If you used the software before, please read the ReadMeFirst file for late changes that did not make it into this manual and for a list of new functions or options, changes, additions, bug fixes, and known bugs for the application. You can open this file from the main window's Help > New Features menu.

## Segmentation in MR/CT images

Segmentation, such as Brain segmentation in magnetic resonance images, is the delineation of anatomical structures. For example, outlines of brain structures can be drawn on images to indicate the extents of those structures. In general, this is a very difficult and time-consuming process. This software focuses on brain segmentation although the methods are generalizable and can be used in other segmentation.

General segmentation of the brain involves defining anatomical structures by "primary" borders, corresponding to signal intensity transitions at brain-CSF or gray-white matter interfaces, or by "secondary" borders, which are knowledge-based anatomic subdivisions within a gray or white matter field that are not defined unambiguously by signal intensity transitions.

The completely manual method for segmentation would be to draw the desired borders directly onto the raw image. This would take too much time and be prone to errors, especially due to fatigue.

Iso-intensity contours can be used to outline structures. The user can pick an intensity by pointing to a pixel that seems to be on the border of a structure or the intensity can be chosen by hand or by using a histogram.

The brightness and contrast can be adjusted so that the user can better understand the information in the image. The user will also benefit from seeing how the current slice fits in the 3D context of the rest of the data. One way of presenting this would be in the "cardinal" views: coronal, sagittal, and axial.

## Professional Multi-Window Segmentation

The **Professional Segmentation** has at least three Windows. The three windows allow user to separate different tissue with marks in three views. It seems easier to do segment in 2D images because 2D image in the main window is exactly similar to traditional X-ray film; the only difference is that a 2D image in segmentation window is more flexible and editable.

**Hint:** double click on the top bar of the dialog will maximize or restore the window.  
The menus are same as the Standard Segmentations.

The important functions in segmentation are "Undo", "Clean Marks" and "Show Marks". The Undo will help you to correct a mistake. If you deleted some areas by mistake, you can use Undo to rescue the previous data.

The Clean Marks will clean all marks you made and restore all the images to original states. Therefore, with Clean Marks, you can do it again from the very first step. Generally speaking, a beginner will use this function very often.

Please pay special attention to the Show Marks function. This function allows users to hide or show all marks. According to our experience, different technicians or different CT and MRI machines acquire different gray scale images. Therefore, it is hard to say which gray scale is bone or brain or something else. However, human eyes can tell you the different tissue. You may use this function to check the original image and the pseudo-color to ensure you have extracted the right tissues.

When you finish your work, go to file and exit. This menu provides some basic functions for segment. It may be same as some buttons on the toolbars. You can use any one and take your favorite; it is just a matter of taste.

**Hint:** click right mouse button will also show popup menu, this menu has the similar functions as the fixed menu at the top of the window. You can take any way you like.

### Standard One-Window Segmentation

The Standard Segmentation Window allows users to separate different tissue with marks in 2D images. It seems easier to do segment in 2D images because 2D image is exactly similar to traditional X-ray film; the only difference is that a 2D image is more flexible and editable.

Hint: double click on the top bar of the dialog will maximize or restore the window.

Please note that the popup menu and the attached menu may have the same functions. For example, the view menu has the similar functionality with the popup view menu. They both work well. You can pick your favorite way to use those functions. Though Standard Segmentation has only one window, however, user can view 3 planes by two mouse clicks (e.g. Select View Menu->Axial, the view will be set to axial). Specifically, the menu Axial will change the view to axial view; Coronal will changes the view to coronal view; and Sagittal will change the view to sagittal view.

The segmentation functions can be accessed through the menus. Some menus will launch toolbars to facilitate the segmentation. The menus in segmentation dialog have the following groups.

#### Menu File

When you finish your work, go to file and exit.

#### Menu Edit

This menu provides some basic function for segment. It may be same as some buttons or toolbars in the segmentation function. The two ways are provided so as to meet the need of various users.

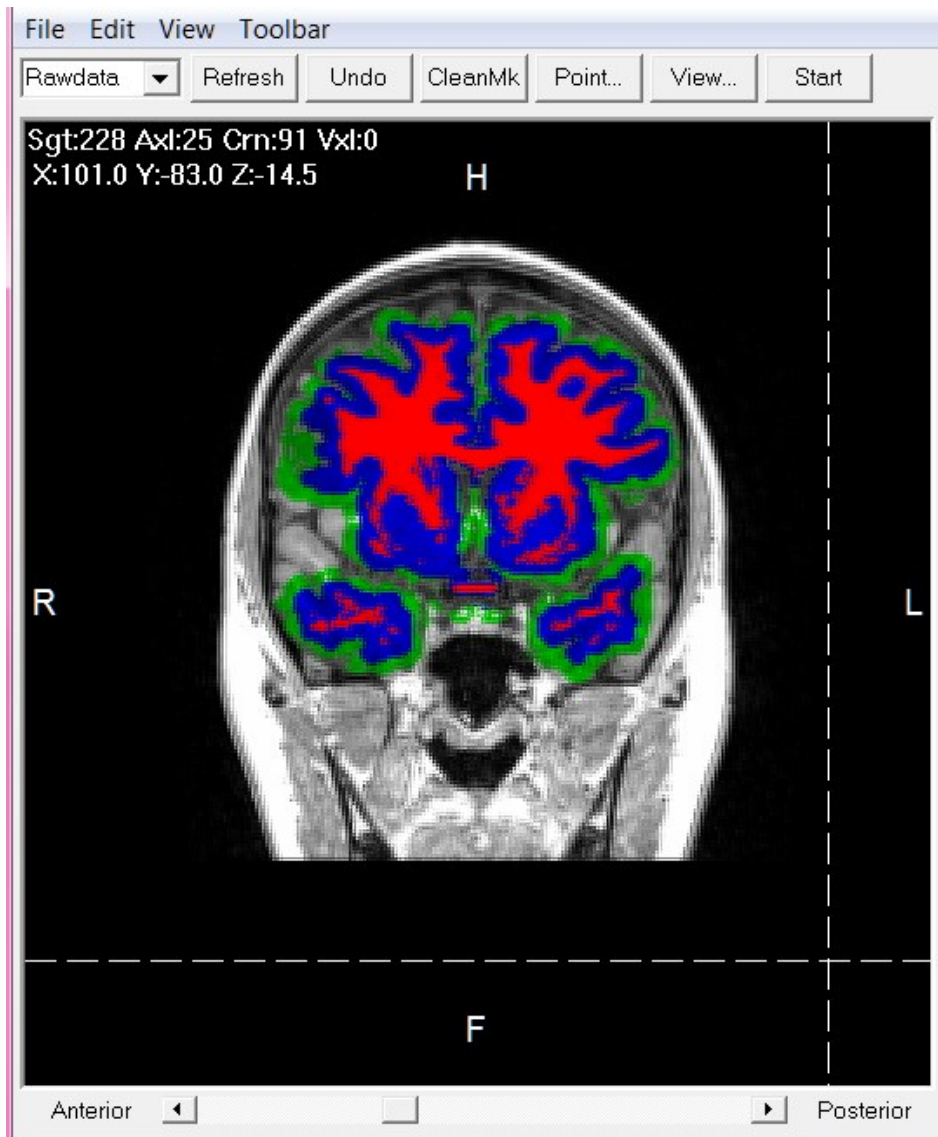


Figure 1. Standard Segmentation Dialog. The information of the image can be hidden and the view can be changed through the view Menu.

### Menu View

This menu provides some basic functions for defining the 2D display.

### Menu Toolbar

This menu allows users to select all toolbars for segmentation. The detailed functions about each toolbars are discussed in the segmentation sections.

### **Menu Function (this function has been moved to main frame)**

*Since this program is provided for three-dimensional integration of structural and functional images, the Function menu provides an access for users to manipulate the functional data.*

## **Menu Edit**

The Edit menu has the most commonly used functions.

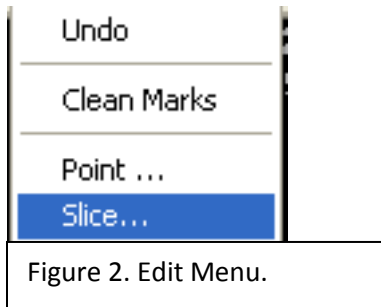


Figure 2. Edit Menu.

### **Undo**

It returns the segmented data to the previous one.

### **Clean Marks**

It cleans all marks (Mark1, red; Mark2, blue; Mark3, green). This function allows users to start a new segmentation process from the very beginning.

### **Point**

It changes the segmentation mode to “Point”. In this mode, users press the left mouse button; the information of the current location on the 2D image will be showed at the left up corner. Here is the meaning of the words.

Sgt: sagittal

Axl: axial

Crn: coronal

The unit of the first line is pixel; the unit of the second line is mm.

### **Slice**

It changes the segmentation mode to “Moving Slice”. In this mode, when users press the left mouse button and move up/down, the 2D image will shift one by one.

Please note that, if the mouse has a middle button, rotating the middle button will produce the same effect. Users can use either way.

The left up corner will show the current slice number and the moving directions.

## Menu View



Figure 3. View Menu.

The View Menu allows users to change the display.

### View

It changes the segmentation mode to “View”. In this mode, when users press the left mouse button and move, the brightness and contrast of the image’s display will change.

Please note that, in this mode, the cursor will change as “eye”.

### Settings

It shows the display control dialog. User can change all the parameters.

### Axial

It shows the 3D image’s axial view.

### Sagittal

It shows the 3D image’s sagittal view.

### Coronal

It shows the 3D image’s coronal view.

**Image Info...**

It shows or hides image information.

**Image Dir...**

It shows or hides image direction or orientation.

**Segmentation: Menu Toolbar**

All the segmentation functions are listed in this menu. The software program itself has used three kinds of marks, which named as Mark 1 (red), Mark 2 (blue) and Mark 3 (green). Users can use the three marks for segmentation or data analysis.

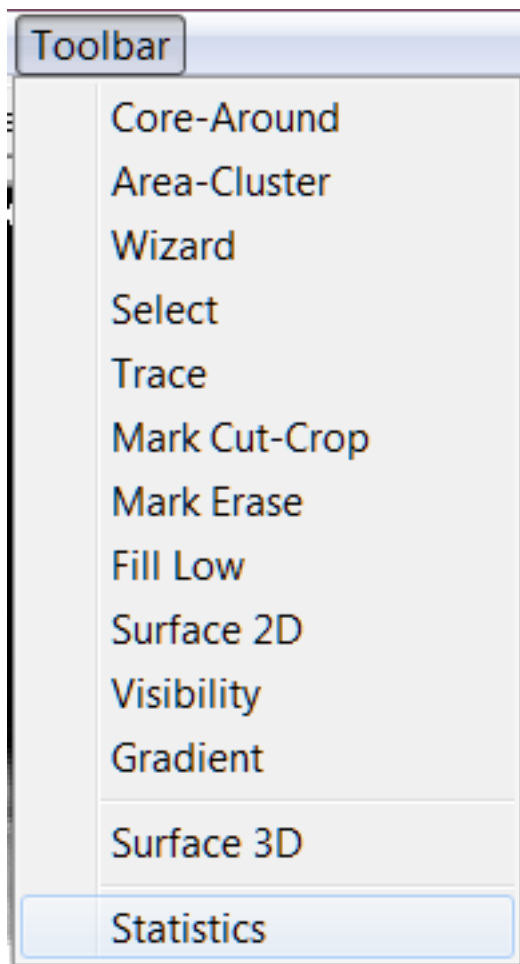


Figure 4. Tool Bar Menu.

**Core-Around**

It is commonly used for separating tissues with three marks in all slices (3D). You pick or select a core area; the software will find the connected tissues and expand the selection according to the voxel values and the spatial connections.

**Area-Cluster**

This function allows for select an area in 2D image and the software will automatically search for the cluster according to the voxel values and the spatial connections. This menu provides users a way to mark each slice individually with three kinds of Marks.

**Wizard**

It provides users optimized ways to separate tissues.

**Select**

To select an area or region, this is the right function to use.

**Trace**

Trace menu shows a toolbar with four kinds of pens for trace various tissues.

**Mark Cut-Crop**

It provides the function for cutting or cropping three kinds of mark in 2D or 3D images. Users can cut or crop Mark1, Mark2 and Mark3 simultaneously.

**Mark Erase**

It provides the function for users to clean each kind of mark.

**Fill Low**

This function is specifically provided for users to extract low gray scale tissue.

**Surface 2D**

It allows users to mark 2D surface in various direction.

**Visibility**

It allows users to separate tissue according to the visibility of voxel values.



### **Gradient**

It allows users to separate tissue according to the gradient of voxel values with a spatial distance.

### **Surface 3D**

It allows users to mark 3D surface in various direction.

### **Statistic**

This function is specifically provided for calculating the marked points.

### **Popup Menu**

The popup menu is the combination of all menu attached to the window. The functions in the popup menu are same to that in the window menu. The design of the pop-up menu is to enable easier access to those functions in the main window. Please refer to the menu explanation for details.

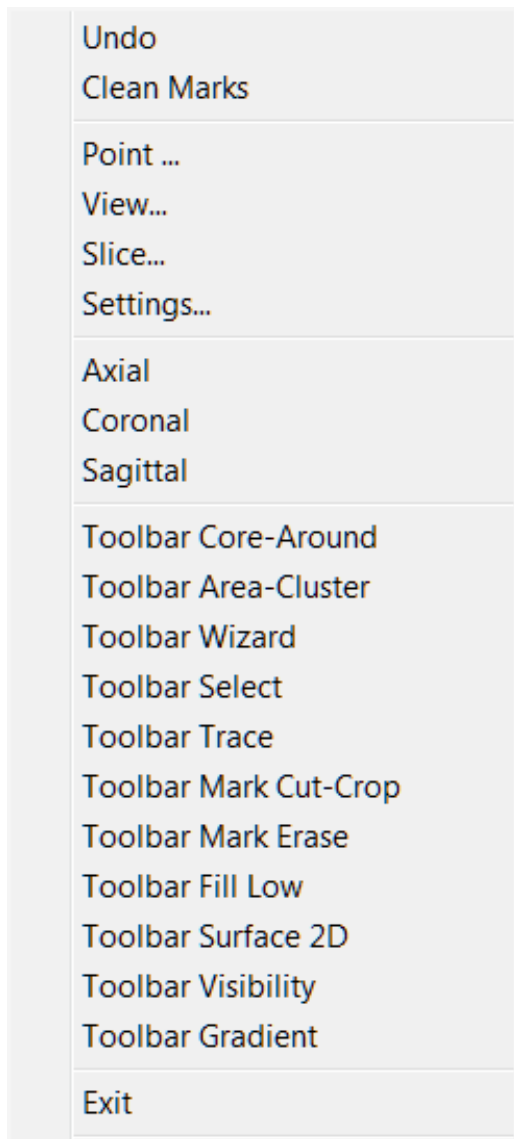


Figure 5. Tool Bar Menu.

## Overview of Segmentation Toolbar

This guide describes the various graphical elements that are used in segmentation of structural images such as MRI and CT used throughout the software applications.

The goal of segmentation is to visualize one or more specific tissues we are interested in. Therefore, identify the interesting tissues is first step. The interesting tissues can be find in 2D and or 3D image. Since films, 2D images, are routinely used for clinical purposes, we designed more than ten toolbars for 2D images.

To visualize one or more specific tissue in 3D is not easy because almost all diagnostic images are gray scale and the computer cannot separate different tissue with just the gray scale

value, for example, the human brain. For this purpose, pseudo-colors are introduced in segmentation. In our software package, use Marks to encode the images. Although this program can support about 256 marks or codes or pseud colors for segmentation, the nearly fixed build-in colors are three: which named as Mark 1 (red), Mark 2 (blue) and Mark 3 (green). Users can use the three marks for segmentation.

To separate interesting tissues from other tissues, the above toolbars are provided to accomplish the task by using various algorithms. As we mentioned before, this images can be marked and the marks will be assigned with color, user can easily identify the relationship between various tissues. Please refer to the specific discussion about the toolbar for the usage of the toolbars.

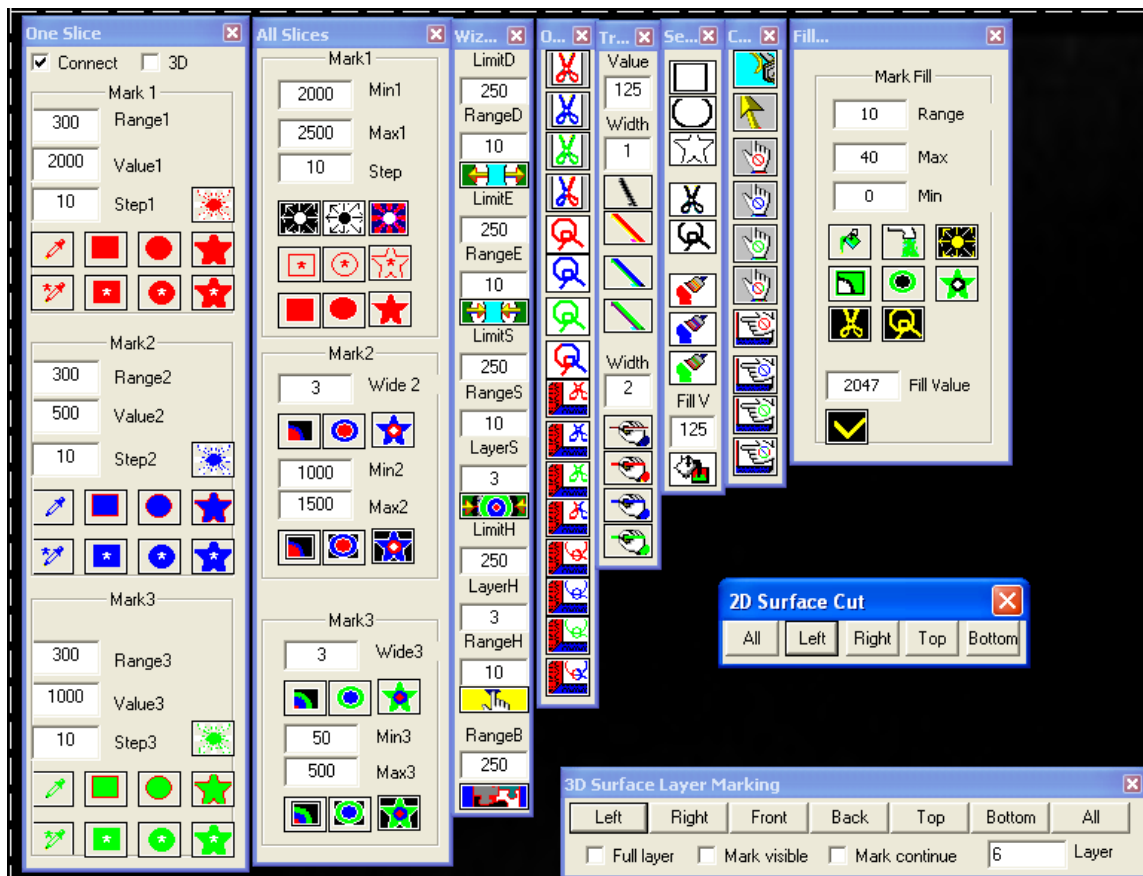


Figure 6. Over View of Toolbars for Image Segmentation.

## Core-Around Toolbar

The Standard Segmentation Toolbar is designed for separating tissues intermingled or surrounded.

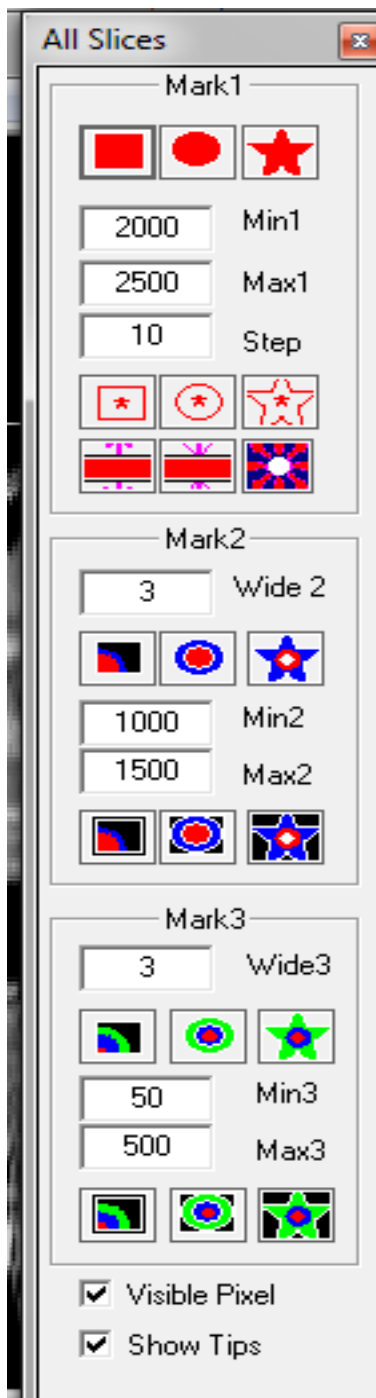


Figure 7. Core-Around Toolbar for Segmentation.

Please note the differences between Match and Find. Match let you to select the region of interest (ROI) and then the software will automatically find the match tissue. Thus the area you selected is critical, for example, if you are going to extract the brain white matter, you have select the exact area that you believe it is brain white matter. I have to remind you that the

computer is stupid some times; it only finds what you told. The Find function will find the matched area throughout the entire slices or volume data, so it will take a while if your computer is old and slow.

The Find function will mark the selected area; this function is also called “seed”, because when you marked some area, then you can dilate it. For example, you mark the vessel, and then just dilate it; the program will delineate the vessel. If you have two monitors or a larger monitor, watch how the vessel becomes alive. If there is nothing happening, poor guy, your MRI or CT is not contrast enhanced (please don't bite your technicians' head off, try next time).

Actually, the Min (minimum) and Max (maximum) values indicate what gray scales you have selected with the Find function. These two values are also used by the Match and Dilate functions, so you can manually change them if you know the range of gray scale for matching and dilation.

Match Border let you to select the region of interest (ROI) and then the software will automatically find the border of the area you have already selected using Match Area (If you have not selected Mark1 or red points, go back to do it). Thus the area you selected is critical, for example, if you are going to extract the brain gray matter, you have selected the exact area that you believe it is brain gray matter, which is considered to around the white matter. I have to remind you that the computer is stupid some times; it only finds what you told. The Find Border function will find the matched area throughout the entire slices or volume data, so it will take a while if your computer is as old as I have.

## Mark1

In Mark1 group, all parameters are used for defining Mark1. The Min1 and Max1 indicate the minimum and maximums values used for segmentation for Mark1. The Step indicates how many scales will be expanded or shrunk.



The three buttons allows user to use rectangle, ellipse and polygon to find the Min1 and Max 1 values and mark the selected region, and then search and mark the similar tissues.



The three buttons allows user to use the user defined Min1-Max1 values to mark the rectangle, ellipse and polygon areas.



It is used to shrink the gray scale range for Mark1 (red). Please pay attention to the Min1 and Max1, they should be changed; and the amount of changes should be same as the step. The range of the Min1 and Max1 should be decreased.



It is used to expand the gray scale range for Mark1 (red). Please pay attention to the Min1 and Max1, they should be changed; and the amount of changes should be same as the step. The range of the Min1 and Max1 should be increased.



It is used to find Mark1 (red). You may extend the Min and the Max values and then click this button. It is handy when you selected an area and would like to rescan that area by extend the two values and dilate it.

## Mark2

In Mark2 group, all parameters are used for defining Mark2 (blue). Mark2 is supposed to surround the Mark1 (red). In other words, Mark2 is the border of Mark1. The Wide2 indicates how wide the Mark2 will be. The Min2 and Max2 indicate the minimum and maximums values used for Mark2.



The three buttons are designed to use rectangle, ellipse and polygon to find the value of the selected areas and then mark the border (Mark2, blue) around Mark 1. In other words, the selected areas will be marked, and similar tissues around the Mark1(red) will be searched. Please pay attention to the Min2 and Max2, they should change accordingly.



Those three buttons are used to find the marched border (Mark2, blue) using the Min2 and Max2. Please note that only matched pixel will be marked in the region selected by the rectangle, ellipse and polygon.

## Mark 3

In Mark3 group, all parameters are used for defining Mark3 (green). Mark3 is supposed to surround the Mark2 (blue). In other words, Mark3 is the border of Mark2. The Wide3 indicates how wide the Mark3 will be. The Min3 and Max3 indicate the minimum and maximums values used for Mark3.

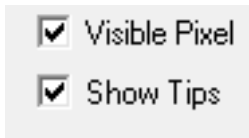


The three buttons are designed to use rectangle, ellipse and polygon to find the border (Mark3, green). The selected areas will be marked, and similar tissues around the Mark2(blue) will be searched. Please pay attention to the Min3 and Max3, they should change accordingly.

Those three buttons are used to find the marched border (Mark3, green) using the Min3 and



Max3. Please note that only matched pixel will be marked in the region selected by the rectangle, ellipse and polygon.



Hint: The Toolbar may show tips about how to use the functions whenever user moves mouse on to a button. You may turn of the feature by uncheck the “Show Tips”.

### Area-Cluster Toolbar

The Area-Cluster Segmentation Toolbar is designed for separating tissues in all situations. By default, segmentation will find the similar tissue, which is connected. To get the best results, the segmentation will be done on one slice, 2D. However, 3D is useful if the tissues have distinct gray scale ranges.

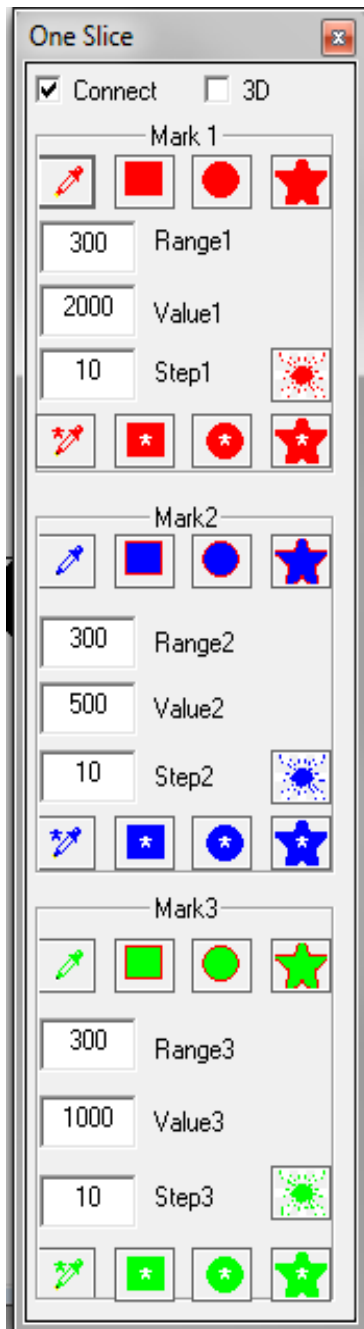


Figure 8. Area-Cluster Toolbar.

In the following segmentation, buttons are commonly used. The buttons change the editing mode. For example, Pick Button will change the mode to picking mode. In picking mode, clicking the left mouse will pick up the voxel value of the point, which the cursor pointed and mark the points within the range (the range is calculated according to the picked value and the Range).



The find button takes the Range and the value to mark the points with the certain range (the range is calculated according to the Value and the Range). Therefore, the Find button is different from the Match button by taking the input value and range into check if selected pixels are matched.

Please note that, picking is a point, but selecting with rectangle, ellipse and polygon is an area.

## Mark1

In Mark1 group, all parameters are used for defining Mark1 (red). The range1 indicate the range used for search Mark1. The Valume1 indicates the current value defined for Mark1. The Step1 indicates how many scales will be expanded or shrunk.



It is used to dilate the gray scale range for Mark1 (red). Please pay attention to the value, it should be changed.



The four buttons allows user to use point, rectangle, ellipse and polygon to mark the selected point or region and find the similar tissues.



The four buttons allows user to use point, rectangle, ellipse and polygon to find the matched point or selected region. Be careful, if there is no match, there will be no mark.

## Mark2

In Mark2 group, all parameters are used for defining Mark2 (blue). The range2 indicate the range used for search Mark2. The Value2 indicates the current value defined for Mark2. The Step2 indicates how many scales will be expanded or shrunk.



It is used to dilate the gray scale range for Mark2 (blue). Please pay attention to the value, it should be changed.



The four buttons allows user to use point, rectangle, ellipse and polygon to mark the selected point or region and find the similar tissues.



The four buttons allows user to use point, rectangle, ellipse and polygon to find the matched point or selected region. Be careful, if there is no match, there will be no mark.

### Mark3

In Mark3 group, all parameters are used for defining Mark3 (green). The range3 indicate the range used for search Mark3. The Value3 indicates the current value defined for Mark3. The Step3 indicates how many scales will be expanded or shrunk.



It is used to dilate the gray scale range for Mark3 (green). Please pay attention to the value, it should be changed.



The four buttons allows user to use point, rectangle, ellipse and polygon to mark the selected point or region and find the similar tissues.



The four buttons allows user to use point, rectangle, ellipse and polygon to find the matched point or selected region. Be careful, if there is no match, there will be no mark.

### Wizard Toolbar

The wizard toolbar has several optimized segmentation functions. It is commonly used with other tools.



Figure 9. Wizard Toolbar.

## Dilate



This function will dilate the marked points (Mark1).

LimitD: the value used for dilating.

RangeD: the range used for dilating.

**Erode**

Erode will shrink the marked voxels or points.

LimitE: the value used for eroding.

RangeE: the range used for eroding.

**Shelling (Surface Peel)**

It peels the surface and keeps the center, or erodes shell.

LimitS: the value used for peeling.

RangeS: the range of the peeling.

LayerS: how many layers (depth) will be peeled.

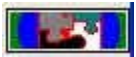
**Wash (Watershed Hole)**

This function will wash hole (make a hole bigger so as to softly separate two kinds of tissues).

LimitH: the value used for washing hole.

LayerH: how many layer of the wall of the hole with be washed or erode off.

RangeH: the range of the hole washing.

**Edge (Find border)**

This function will find the edge of two groups of tissue. The edge is defined according to the voxel value. It is very useful if you would like to cut off the connection of different tissues. The edit box on the up side of the button is the threshold of edge. The threshold is the difference between two neighbor points. The higher the value is, the narrower the border is.

RangeB: the value used for defining the border of two tissues. The border is the edge of two tissues.

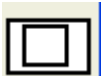
**Selection Toolbar**

The selection toolbar is designed to cut, crop, and mark and fill a selected region.



Figure 10. Selection Toolbar.

## Rectangle



It allows user to select a rectangle region. Pressing this button will change the segmentation mode. Please note the cursor which will indicate it.

## Ellipse



It allows user to select an ellipse region. Pressing this button will change the segmentation mode. Please note the cursor, which will indicate it.

## Polygon



It allows user to select a polygon region. Pressing this button will change the segmentation mode. Please note the cursor, which will indicate it.

### Cut



It cuts the selected region.

### Crop



It crops the selected region.

### Mark1



It mark the selected region as Mark1 (red)

### Mark2



It marks the selected region as Mark2 (blue).

### Mark3



It marks the selected region as Mark3 (green).

### Fill



It fills the selected region with the above defined “Fill V” value.

## Trace Toolbar

This is a powerful toolbar for tracking neuron fiber and vessel. It has three groups of functions: one is to write or delete the value; one is to mark pixels and one is to clean marked pixels.



Figure 11. Trace Toolbar.

### Width

it define how big the pen will be, or how many pixels it will work on at each time point. The smaller the number is, the smaller the paint area is.

### Writing Pen



It will write the defined value to the pin pointed pixel. It will let you paint one area. The edit box on the up side of the button is the size of the paint pen.

### Mark1 Pen



It will mark the traced pixels as Mark1 (red).

## Mark2 Pen



It will mark the traced pixels as Mark2 (blue).

## Mark3 Pen



It will mark the traced pixels as Mark3 (green).

## Erase Pen



It will erase the traced pixels. It let you cut or delete or erase a small area or even one point. It is necessary for extracting complex tissue, such as brain.

## Erase Mark1



It will erase traced Mark1 if the pixels have.

## Erase Mark2



It will erase traced Mark2 if the pixels have.

## Erase Mark3



It will erase traced Mark3 if the pixels have.

## Mark Cut-Crop Toolbar

The operation toolbar is designed to cut and crop marked pixels and voxels. It allows user to cut or crop regions with specific marks. Pressing this button will change the segmentation mode. Please note the cursor which will indicate it. This toolbar is designed to cut and/or crop the marked region. There are two big groups: 2D cut-crop and 3D cut-crop. If you did some wrong, for example you cut your red heart out when you are interested in it, don't panic, try the Undo function by click you right mouse button, it works well to rescue you.



The Crop function is exactly the opposite of the Cut function. It keeps the marked points and cut other stuff. This function is also called “isolate”, because when you click it, only pseudo color will stay there, other pixels are deleted. If you did some wrong, don’t panic, try the Undo function by click you right mouse button.



Figure 12. Mark Cut-Crop Toolbar.

### 2D Cut Mark1 (red)



It will cut all the Mark1 (red) in the 2D image. If you did some wrong, for example you cut your red heart out when you are interested in it, don’t panic, try the Undo function by click you right mouse button, it works well to rescue you.

### 2D Cut Mark2 (blue)



It will cut all the Mark2 (blue) in the 2D image. If you did some wrong, for example you cut your red heart out when you are interested in it, don't panic, try the Undo function by click you right mouse button, it works well to rescue you.

### 2D Cut Mark3



It will cut all the Mark3 (green) in the 2D image.

### 2D Cut Marks



It will cut all the Marks (red, blue and green) in the 2D image.

### 2D Crop Mark1



It will crop all the Mark1 (red) in the 2D image.

### 2D Crop Mark2



It will crop all the Mark2 (blue) in the 2D image.

### 2D Crop Mark3



It will crop all the Mark3 (green) in the 2D image.

### 2D Crop Marks



It will crop all the Marks (red, blue and green) in the 2D image.

### 3D Cut Mark1



It will cut all the Mark1 (red) in the 3D image.

### 3D Cut Mark2



It will cut all the Mark2 (blue) in the 3D image.

### 3D Cut Mark3



It will cut all the Mark3 (green) in the 3D image.

### 3D Cut Marks



It will cut all the Marks (red, blue and green) in the 3D image.

### 3D Crop Mark1



It will crop all the Mark1 (red) in the 3D image.

### 3D Crop Mark2



It will crop all the Mark2 (blue) in the 3D image.

### 3D Crop Mark3



It will crop all the Mark3 (green) in the 3D image.

### 3D Crop Marks



It will crop all the Marks 1-3 (red, blue and green) in the 3D image.

## Mark Eraser Toolbar

This toolbar is designed mainly for erasing marks. It has three groups of functions: (1) Undo and return selection mode; (2) Clean marks on 2D image; (3) Clean marks on 3D image.



Figure 13. Mark Eraser Toolbar.

## Undo



If you made a mistake, pressing this button will return the image back one step, therefore, correct the mistakes.

## Select



It will change the segmentation mode to selection.

## Clean Mark 1(red)



It cleans Mark1 (red) in the 2D image.

## Clean Mark 2(blue)



It cleans Mark2 (blue) in the 2D image.

## Clean Mark 3(green)



It cleans Mark3 (green) in the 2D image.

## Clean All 2D Marks (red, blue and green)



It cleans all Marks (red, blue and green) in the 2D image.

## Clean 3D Mark 1 (red)



It cleans Mark1 (red) in the 3D image.

## Clean 3D Mark 2 (blue)



It cleans all Mark2 (blue) in the 3D image.

## Clean 3D Mark 3 (green)



It cleans all Mark3 (green) in the 3D image.

### Clean All 3D Marks (red, blue and green)



It cleans all Marks (red, blue and green) in the 3D image.

### Low-Fill Toolbar

This toolbar is designed mainly for extracting or separating low gray scale tissues. In image processing term, it marks the pixels with a unique mark (Mark 4, typically yellow). Generally speaking, it is used for fluid or low-density tissue.

The range indicates the difference between min and max. The min and max indicate the minimum and maximum values for filling. Please note that the minimum value is commonly set as 0, which means the lowest value in the tissue imaging.

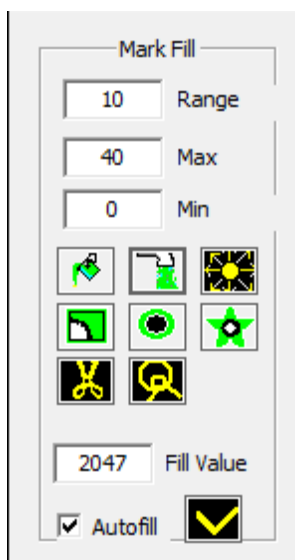


Figure 14. Low-Fill Toolbar.

### Select Fill-Low



It will fill the pointed region according to the range of pixel value by marking the pixels if the value < than the threshold. This is mark 4.

### Fill-Low Value Pixels



Similar to the “Autofill”, It replaces the voxel values with the provided “fill value”.

### Dilate-Low Value Pixels



It dilates the filling area.

### Dilate Low-Value Pixels



It fills the selected rectangle, ellipse or polygon areas with low-filling marks.

### Cut Low-Value Pixels



It cuts the filled area.

### Crop Low-Value Pixels



It crops the filled area.

### Fill Low-Value Pixels



It replaces the filled region with the “Fill Value”.

## Visibility Toolbar

The visibility toolbar is designed to cut visible and non-visible voxels, whose gray-scale value below or above the threshold for viewing, in the image data. It also provides easy access to cut voxels hidden or covered by other voxels.

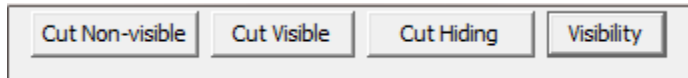
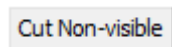


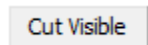
Figure 15. Visibility Toolbar.

### Cut Non-visible



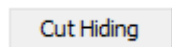
It cuts the voxels which are not visible due low-gray scale values.

### Cut Visible



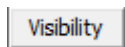
It cuts the voxels which are visible as their gray scale values are in the visible range.

### Cut Hiding



It cuts voxels hidden or covered by other voxels.

### Visibility



It shows the window for adjusting parameters for showing images.

## Gradient Toolbar

The gradient toolbar is designed to segment voxels according to the gradient or height of two or more neighbor voxels. The distance between neighboring voxels is typically more than 1.



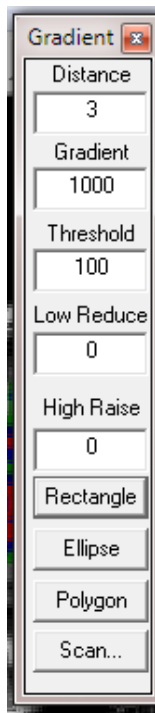
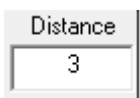


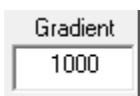
Figure 16. Gradient Toolbar.

### Distance



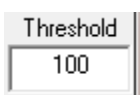
It defines the spatial distance of neighboring voxels.

### Gradient

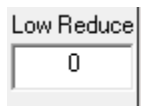


It defines Gradient or difference of voxel values among voxels, typically between highest - lowest voxels.

### Threshold



It defines minimum value (threshold) for watershed or erase.

**Low-Reduce**

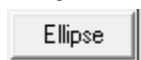
It defines the reduction value of the voxels meet the requirements.

**High-Raise**

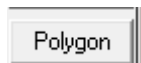
It defines the raise value of the voxels meet the requirements.

**Rectangle**

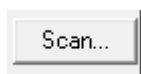
It selects a rectangle area to define the Gradient, Threshold and Low-Reduce values.

**Ellipse**

It selects an ellipse area to define the Gradient, Threshold and Low-Reduce values.

**Polygon**

It selects a polygon area to define the Gradient, Threshold and Low-Reduce values.

**Scan**

It finds and operates on voxels which meet the requirements to segment edges.

**3D Surface-Mark Toolbar**

Mark Layer will let you mark the surface of any volume data. It is very useful when you would like to check the tissue from outside, like skin, to the deeper area, like brain material. You can mark layer with 1 to entire volume data according to your purposes.

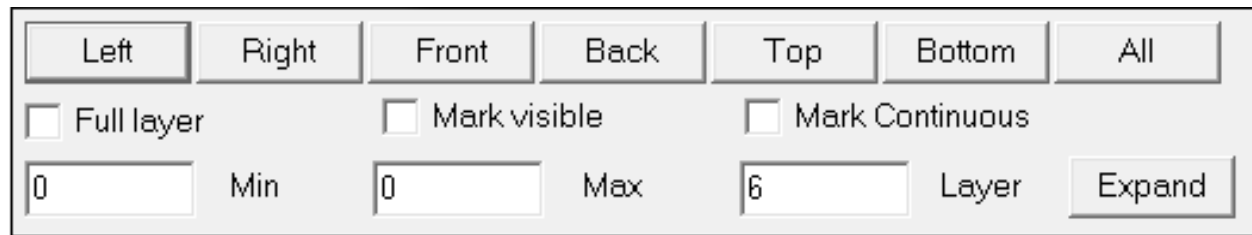


Figure 17. 3D Surface-Mark Toolbar.

### Left



It marks the surface voxels on the left side.

### Right



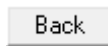
It marks the surface voxels on the right side.

### Front



It marks the surface voxels on the frontal direction.

### Back



It marks the surface voxels on the back direction.

### Top



It marks the surface voxels on the top.

### Bottom



It marks the surface voxels on the bottom.

### All



It marks the surface voxels in all directions.

**Full Layer**

If this check box is checked, the mark action will mark all layers.

**Mark visible**

If this check box is checked, only the visible points will be marked.

**Mark continue**

This check box will let the mark action continue even if a point has been marked by other actions. It is used by professional user.

**Layer**

It indicates how deeper the mark action will go from the outside, such as skin. This is an important parameter in analysis the surface.

**Hint:** In volume rendering, there are more points than what you see, some points are hidden because we would like you to see the internal structure. You can use the View Control ( in volume section) to adjust the threshold of hiding.

**2D Surface-Cut Toolbar**

The 2D Surface-Cut toolbar is designed to cut the surface voxel (out-layer) in 2D images.

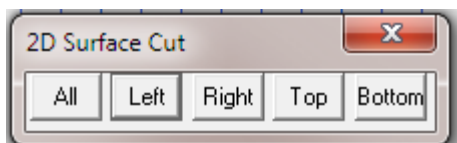


Figure 18. 2D Surface Cut.

**All**

It cuts the surface voxels in all directions.

### Left



It cuts the surface voxels on the left side.

### Right



It cuts the surface voxels on the right side.

### Top



It cuts the surface voxels on the top.

### Bottom



It cuts the surface voxels on the bottom.

## 3D Surface-Cut Toolbar

The 3D Surface-Cut toolbar is designed to cut the surface voxel (out-layer) in 3D images. The number of layers can be defined according to the inputs from users.



Figure 19. 3D Surface Cut.

### Left



It cuts the surface voxels on the left side.

## Right

Right

It cuts the surface voxels on the right side.

## Front

Front

It cuts the surface voxels on the frontal direction.

## Back

Back

It cuts the surface voxels on the back direction.

## Top

Top

It cuts the surface voxels on the top.

## Bottom

Bottom

It cuts the surface voxels on the bottom.

## All

All

It cuts the surface voxels in all directions.

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