MNI-Display - Program for Display and Segmentation of Surfaces and Volumes

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Contents

1 Introduction

`MNI-Display` is a program originally designed to display and manipulate three dimensional objects, mainly human cortical surfaces and sulcal curves. It has since evolved to include volume display and segmentation of MRI, PET, etc., and a variety of other features. The user interface is a non-standard menu oriented system, based on keystrokes and mouse selection.

2 Running `MNI-Display`

`MNI-Display` runs on Silicon Graphics (SGI), DEC Alpha, Sun Microsystems, and Linux workstations. The command syntax is:

```
Display  [file1]  [file2]  ... [filen]
```

where each file is one of:

Volume:	contains an MRI, PET, or other 3D volume, and ends in `.mnc` ,
3D object:	contains 3D surfaces, lines, or other objects, and ends in `.obj` ,
Tags:	contains a list of 3D points, such as those chosen from a volume, and ends in `.tag` .

2.1 MRI Files at the MNI

The following are the standard available datasets:

Normal MRI	305 normal brains in the files: `/avgbrain/brain/autoreg/filename.mnc` , and
Average MRI	the average of the 305 brains in the file: `/avgbrain/brain/images/norm_avg_305_mri256.mnc` or a lower resolution version in `/avgbrain/brain/images/norm_avg_305_mri.mnc` .

Note that the above files are generally compressed. If the file ends in .gz, then it is compressed and the full name of the file, including the .gz, must be specified to `MNI-Display` .

3 `MNI-Display` Windows

Figure 1 shows the four windows used by `MNI-Display` (three of which are created when the program is run):

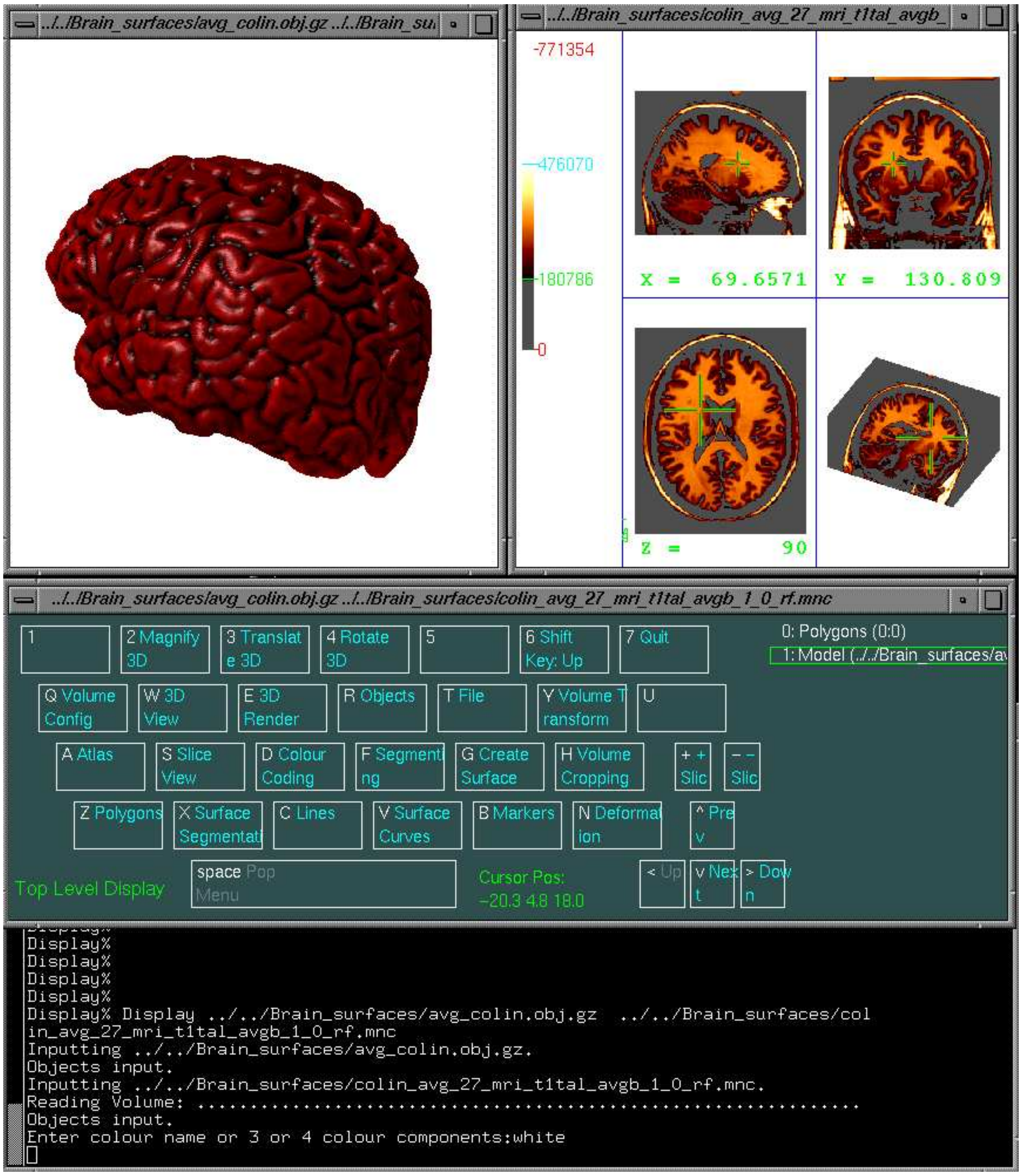

Figure 1: top left: 3D window, top right: slice window, centre: menu window, bottom: text entry window.

3D window:	contains the 3D objects, such as surfaces, lines, and markers,
slice window:	shows up to 4 views of slices through one or more volumes (if volumes are loaded),
menu window:	shows the current menu configuration,
text entry:	this is the shell window or xterm from which `MNI-Display` was run and in which all text must be typed, e.g. filenames, numerical parameters, etc.

4 Menu and Interaction System

The menu window (centre in Figure 1) represents the layout of the left side of the keyboard. A menu entry is selected by hitting the corresponding key in any of the 3 `MNI-Display` windows (not the text window) or pointing to the entry in the menu window with the mouse and clicking the left button. The space bar or middle mouse button in the menu window will pop back one level in the menu. If the display of a menu entry is "grayed out" (in a less visible colour), then this signals that the entry is not valid in the current context and cannot be selected. In the remainder of this document the following convention will be used to refer to menu selection: **View**/**Reset** means select the `View` menu, then select the `Reset` button from within the view menu. Whenever text must be typed, such as in prompts for filenames, size and width parameters, etc., the mouse must be moved to the text entry window and the values typed, followed by the return key. Some menu items cannot be selected by the mouse because the mouse must be used to point to the object of the action, usually one of the 4 volume slices in the slice window. In these cases, the mouse must be positioned on the relevant slice in the slice window and the keyboard character corresponding to the menu entry pressed. When the user is prompted to type in a colour, either the name of a colour, such as `red` , `yellow` , or `pink` , or a numerical red-green-blue colour, such as `0.3 0.7 0.7` (or `0.3 0.7 0.7 0.5` for a semitransparent colour) may be typed in.

4.1 Menu Window

The menu window contains the representation of the partial keyboard, the name of the currently selected menu in the lower left, and the object hierarchy. All objects loaded and created in `MNI-Display` , with the exception of volumes are displayed in the object hierarchy. The arrow keys are used to move around in this hierarchy and to select the current object. Also, clicking on an object in the 3D window or on the name of the object in the menu hierarchy with the left mouse button will make it the current selection.

4.2 3D Window

The 3D window shows three dimensional objects such as surfaces and lines, with lighting and camera control. In the 3D window, the following mouse operations are available:

Left Button:	Selects a position on an object.
Middle Button:	Rotates, translates, or magnifies the 3D view, depending on the current mode selected from the view 3D menu.

4.3 Slice Window

The slice window displays slices of the loaded volumes, with various colour coding options. For each loaded volume, the slice window carries around another volume of the same size as the loaded volume, which is referred to as the **label volume**. This functions as a coloured overlay for storing and displaying the results of manual segmentation of the volume. In the slice window, the following mouse operations are available:

Left Button:	Sets the position of the 4 slices.
Middle Button:	Moving the mouse up or down while holding down the middle button changes the current volume slice position.
Right Button:	Paints a region of the current volume slice with the current brush size.
Alt-Left Button:	While holding down the `shift` , `ctrl` , or `alt` key, the left button translates the position of the slice within the viewport.
Alt-Middle Button:	While holding down the `shift` , `ctrl` , or `alt` key, holding down the middle button and moving the mouse up or down changes the magnification of the current slice.
Alt-Right Button:	While holding down the `shift` , `ctrl` , or `alt` key, holding down the right button erases regions of the labels.
Colour Bar:	The limits of the colour bar for the current volume can be moved by pressing the left mouse button on the bar near the desired limit. Pressing the middle button on the colour bar will allow both limits to be moved simultaneously.

Figure 2: Top level menu

5 Complete Menu Reference

The following is a complete listing of every menu selection, with a short description of each. Since this program is also partly a research tool, a few selections are not relevant to most users, and will simply be described as not for general use. Fig. 2 shows the top level menu that is presented upon program start up, or after popping the menu to the top level.

5.1 Current Object Menu

The 3D graphics objects, visible in the 3D window, are also presented in a hierarchical form in the menu window, as a tree structure with each element of the tree being the name of a 3D graphics object. There are 4 keys that can be used to navigate through the list, where the currently selected object is always displayed with a surrounding box:

Up Arrow Sets the current object to the one before the current object.

Down Arrow Sets the current object to the one after the current object.

Left Arrow Sets the current object to the one above the current object.

Right Arrow Sets the current object to the one below the current object, if the current object is a model.

5.2 File Menu

File / **Load File** Prompts for a filename and loads the file. If it is a volume file (ends in `.mnc`), then the slice window is opened, if not already opened.

File / **Save File** Prompts for a filename and saves to the file the current object, or all objects under the current object, if it is a model object. This selection cannot be used to save a volume file (`.mnc`)

File / **Load Labels .mnc** Prompts for a filename and loads the file as the label volume for the current slice window volume. The label volume need not have the same sampling or extent as the volume on top of which it is being loaded. This does not clear the current labels, unless the label file is exactly the same size and sampling as the underlying volume.

File / **Save Labels .mnc** Prompts for a filename and saves the label volume of the current volume. The labels are cropped to the smallest size possible.

File / **Load Labels .tag** Prompts for a filename and loads the tags file into the current label volume. Note that it does not clear the current label volume, so the resulting labels are the union of the current labels and the loaded tags. Also, it does not check that this is a valid label file, e.g., whether sizes match.

File / **Save Labels .tag** Prompts for a filename and saves the current label volume as a tag file. For large regions this may create very large ascii files, and it may be more efficient to save as `.mnc` .

File / **Save Markers as .tag** Prompts for a filename and saves any markers at or under the current object to the file in tag file format.

File / **Save Colour Map** Prompts for a filename and saves the label colour map of the current volume as an ascii file, with a default suffix of `.map` . The label colour map is defined by **Colour Coding** / **Set Paint Lbl Colour**.

File / **Load Colour Map** Prompts for a filename and loads the current label colour map as an ascii file, with a default suffix of `.map` .

File / **Load UserDef ColCode** Prompts for a filename and loads the current user defined colour map as an ascii file, with a default suffix of `.ccd` . It automatically switches the colour coding mode to user defined, in order to reflect the new map loaded from the file. Each line in file contains a position and a colour. The first position in the file must be 0, the last must be 1, and the intermediate ones must be monotonically increasing. The colours may be specified as 3 or 4 space separated values in the range 0 to 1, or as one of the predefined colour names. For instance, the gray colour scale is equivalent to a file with two lines, the first being **0 black**, the second being **1 white**.

File/**Save 3D Window** Prompts for a filename and saves the image contents of the 3D window to the file, in .rgb format. Before doing this, make sure the window is up to date and not in the process of drawing.

File/**Save Slice Window** Prompts for a filename and saves the contents of the slice window to the file, in .rgb format. Before doing this, make sure the window is up to date and not in the process of drawing.

File/**Save Slice Image** If the mouse is pointing to one of the four slice viewports, prompts for a filename and saves the contents of the slice viewport to the file, in .rgb format. Before doing this, make sure the window is up to date and not in the process of drawing.

File/**Load Poly Visib.** Not for general use.

File/**Save Poly Visib.** Not for general use.

File/**Save Bintree** Not for general use.

File/**Load Bintree** Not for general use.

5.3 Slice Menu

+ Slice Changes the current slice to the next slice.

- Slice Changes the current slice to the previous slice.

Slice/**Curr Volume** If more than one volume is loaded, then this button increases the current volume index. For many operations, the current volume is used as the target volume. This button allows selection of which of the multiple loaded volumes to perform subsequent operations on.

Slice/**Reset Slice View** If the mouse is in the slice window and is pointing to one of the 4 slices, then the view for that slice is reset and resized to fit the viewport.

Slice/**Toggle Slice Visib** If the mouse is in the slice window and is pointing to one of the 4 slices, then the visibility of that slice for the current volume is toggled.

Slice/**Box Filter Volume** Prompts for 3 box filter widths and another specifier. If the specifier is the character “w”, then the filter widths are assumed to be in world coordinates, otherwise it is assumed to be voxel coordinates. The current volume is resampled using a box filter, creating another volume.

Slice/**Resample Volume** Prompts for 3 size parameter and resamples the current volume to the given size, creating another volume. Creates a volume with a smaller number of voxels by box filtering. It is preferable to use **Slice**/**Box Filter Volume**, which maintains the number of voxels.

Slice/**Create 3D Slice** Creates a rendering of the slice pointed to by the mouse, in the 3D window.

Slice/**Recompute Histogram** Creates a histogram of values in the current volume, which is displayed in the slice window near the colour coding bar. If the mouse is pointing to a slice in the slice window, then a histogram of that slice only of the current volume is displayed.

Slice/**Histogram of Label** Same as **Slice**/**Recompute Histogram**, but only includes values which are in labeled (segmented) regions.

Slice/**Slice DblBuf:** Toggles between single and double buffer mode for the slice window. Single buffer mode provides maximum colour resolution, but flashes when updating. Double buffer mode has less colour resolution but updates smoothly. Single buffer mode is generally only used when taking snapshots of the window, where maximum colour resolution is desirable.

Slice/**Toggle Plane Visib** This menu selection toggles the visibility of the cross section plane in the 3D window.

Slice/**Set Current Arb. View** Each of the four slices can be oriented to an arbitrary angle. By pointing to one of the slices and selecting this menu option, the user can set the current arbitrary view, which is the one that the following slicing commands operate on.

Slice/**Toggle Slice Crs-Sect** Turns on and off the cross section visibility in the three views which are not the current arbitrary view.

Slice/**Rotate Slice** After selecting this entry, the middle mouse button in the 3D window will control rotation of the arbitrarily oriented slice, updating the current view slice in the slice window.

Slice/**Pick Slice Angle** Instead of rotating the slice in the 3D window, the orientation of the current view slice can be chosen from within the slice window. After selecting this menu entry, the left mouse button selects a position on one of the other slices. The line through the slice cursur and this position is used to define the slice plane of the current view slice.

Slice/**Toggle Slice Anchor** Turns on and off the anchoring of the current view slice to pass through the cross section of the current slice view. This is used to constrain a slice plane to pass through a given vector.

Slice / **Print Origin** Prints the cursor location in world space to the text window.

Slice / **Print Plane Normal** Prints the world space normal of the slice currently under the mouse.

Slice / **Type In Origin** Prompts the user to type in a world space x, y, and z, and moves the cursor to this point.

Slice / **Type In Plane Normal** If the mouse is pointing to one of the four slices, prompts the user to type in a world space x, y, and z, and orients the slice plane to this normal.

Slice / **Visible:** Makes only one volume visible, cycling through all loaded volumes as the button is pressed. Whichever volume is made visible is set to the current volume.

Slice / **Vol Opacity:** Prompts the user for an opacity value and sets the opacity of the current volume.

Slice / **Increm Update:** Toggles the incremental update mode of the slice window. When it is on, the slice window incrementally updates the slice window. This is useful when the slice window takes long to update, such as with cached volumes or in trilinear interpolation mode.

5.4 Volume Config Menu

Volume Config / **Delete Volume** Brings up a submenu that allows the user to delete the current volume.

Volume Config / **Nearest Neighbour** Sets the filter type of the current volume slice under the mouse to nearest neighbour (this is the default).

Volume Config / **Linear Int Filter** Sets the filter type of the current volume slice under the mouse to linear interpolation between the two nearest slices.

Volume Config / **Box Filter** Sets the filter type of the current volume slice under the mouse to a box filter.

Volume Config / **Triangle Filter** Sets the filter type of the current volume slice under the mouse to a triangle filter.

Volume Config / **Gaussian Filter** Sets the filter type of the current volume slice under the mouse to a gaussian filter.

Volume Config / **Filter Width** Prompts the user for the current volume slice filter full width half max. Only applies to box, triangle, and gaussian filters.

Volume Config / **Share Labels** Switches back and forth between sharing label volumes across volumes which have identical sampling, and giving each a separate label volume. The default is yes, so that users can paint one set of labels on top of several similar volumes, such as T1 and T2 volumes of the same patient.

Volume Config / **Interp:** Toggles interpolation of displayed slices among nearest neighbour (default), trilinear, and tricubic. The latter two take a long time to update, several seconds, and it is best to switch to incremental update (**Slice** / **Increm Update:**).

5.5 Volume Cropping Menu

This menu allows the user to specify a subregion of a volume and to create new volumes that are cropped to this region.

Slice / **Volume Cropping** / **Visibility:** Toggles the visibility of the volume crop box in the slice planes. Note that the position of the volume crop box is relative to the current volume, so changing the current volume will change the appearance of the crop box.

Slice / **Volume Cropping** / **Reset Crop Position** Resets the volume crop box to the entire volume of the current volume.

Slice / **Volume Cropping** / **Pick Crop Edge** After pressing this selection, an edge, a corner, or the entire crop box in the slice window can be moved by pressing the left mouse button and dragging to the desired position.

Slice / **Volume Cropping** / **Set Crop Source** Prompts the user to type in the name of the file which will be cropped according to the crop box.

Slice / **Volume Cropping** / **Crop and Load** Crops the current crop filename with the current crop box volume limits, and loads the cropped file.

Slice / **Volume Cropping** / **Crop to File** Prompts for a filename and creates the cropped volume as this file, without loading it.

5.6 Colour Coding Menu

Colour Coding / **Spectral** Selects the spectral colour coding method for the current volume.

Colour Coding / **Gray Scale** Selects the gray scale colour coding method for the current volume.

Colour Coding / **Hot Metal** Selects the hot metal colour coding method for the current volume.

Colour Coding/**Red** Selects the red colour coding method for the current volume.

Colour Coding/**Green** Selects the green colour coding method for the current volume.

Colour Coding/**Blue** Selects the blue colour coding method for the current volume.

Colour Coding/**Arb Colour (Over)** Selects the colour coding method for the current volume, where the scale ranges from black through to the current over colour, which can be any valid colour.

Colour Coding/**UserDef ColCode** Selects the colour coding method for the current volume, where the scale is defined by the user as any piecewise linear function. At present the only way to specify this function is through the **File**/**Load UserDef ColCode** function.

Colour Coding/**Contour** Selects the rarely used contour colour coding method for the current volume.

Colour Coding/**Range** Prompts the user to type in the lower and upper colour coding limits for the current volume. These may be the same, which results in a binary thresholded volume coloured by the under and over colour. The upper limit may be a smaller number then the lower limit, which results in an inverted colour map,

Colour Coding/**Under Colour** Prompts the user to type in the colour for values in the current volume below the low limit.

Colour Coding/**Over Colour** Prompts the user to type in the colour for values in the current volume above the high limit.

Colour Coding/**Label Ratio** Prompts the user to type in the intensity of the coloured labels superimposed on the current volume slices ($0 <= value <= 1$).

Colour Coding/**Show Labels** Toggles between showing the label volume superimposed on the current volume or not showing it.

Colour Coding/**Set Paint Lbl Colr** Prompts for a label value and a colour, and sets the displayed colour of this label for the current volume.

Colour Coding/**Num Labels** Prompts for the number of labels desired, and recreates the current label volume with this number. Depending on the number of labels, the volume may be a byte, short, or long valued volume. Note that this effectively clears the current label volume.

Colour Coding/**Colour Code Object** Changes the colours of the current object in the 3D window according to the current colour coding parameters of the loaded volumes.

5.7 Segmenting Menu

This menu contains all the controls for modifying the current label volume, which is overlaid on the current volume. At each voxel in the current volume, there is an associated integer value, which is stored in the current label volume. Segmenting consists of painting regions of a label volume to change the values from the default of 0. When the right mouse button is pressed over a slice in the slice window, the current paint label value is painted into the label volume of the most recently loaded visible volume. If the `control` key or `shift` key is held down at the same time, erasing will be performed, by storing the value 0.

Segmenting/**Clear All Labels** Sets all labels of the current volume to 0. Provides a cancel/confirm submenu.

Segmenting/**Set Paint Label** Sets the current label used for painting, where 0 erases. If the mouse is positioned over a voxel that has a non-zero label when this menu item is selected, then the current label is set to that value. Otherwise, the user is prompted to type in an integer label, between 0 and 255 (or higher if the number of labels has been changed).

Segmenting/**XY Radius** Prompts for the in-slice brush radius used in painting on the volume slices (right mouse button). Any voxel which intersects the brush is painted. A radius of zero is therefore paints any voxel the mouse is in. This gives the most fine control over painting.

Segmenting/**Out-Plane Radius** Prompts for the brush radius in the direction perpendicular to the slice plane. This defaults to zero, for slice-by-slice painting. If this is non-zero, then a ellipsoidal brush is used, and updating the display is a little slower because all slice views are updated as painting is performed.

Segmenting/**Undo** Provides a one-level undo, which, in certain cases, may be used to reset the state of the labels to before the previous operation. If the previous operation on the labels was a load from file, or a 3D operation such as 3D fill, the undo cannot be performed.

Segmenting/**Label Voxel** Sets the label of the voxel underneath the mouse to the current paint label.

Segmenting/**Clear Voxel** Sets the label of the voxel underneath the mouse to 0.

Segmenting/**Label Slice** Sets the label of the entire slice pointed to by the mouse to the current paint label.

Segmenting/**Clear Slice** Sets the label of the entire slice pointed to by the mouse to 0.

Segmenting/**Set Threshold** Prompts for a minimum and maximum volume value, and uses these limits for subsequent segmentation operations. When painting with the right mouse button, only voxels whose values are within this range are affected. Operations such as dilation, erosion, and 2D and 3D filling are also affected by the current threshold. By default, there is no segmenting threshold, which can be explicitly specified, if desired, by a max value which is less than the min value.

Segmenting/**Label Fill** If the mouse is pointing to a voxel which is within the selected segmenting range and which has a label not equal to the current paint label, then all similarly labeled voxels on this slice connected to the starting voxel are assigned the current paint label, by a flood fill algorithm.

Segmenting/**Label Fill No Thrs** Same as **Segmenting**/**Label Fill**, except ignoring the threshold. If the mouse is pointing to a voxel has a label not equal to the current paint label, then all similarly labeled voxels on this slice connected to the starting voxel are assigned the current paint label, by a flood fill algorithm.

Segmenting/**Clear Fill** If the mouse is pointing to a voxel which is within the selected segmenting range and which has a nonzero label, then all similarly labeled voxels on this slice connected to the starting voxel are assigned the paint label 0, by a flood fill algorithm.

Segmenting/**Connectivity** Toggles between using 8(26)-neighbour and using 4(6)-neighbour connectivity in 2D(3D) operations such as fill, dilate, and erode.

Segmenting/**Erode 3D** Prompts the user for a label range which corresponds to outside the labels of interest, and erodes regions of the current paint label which are neighbouring the typed-in label range. Typically the user will type in “0 -1” to specify all labels which are not equal to the current paint label.

Segmenting/**Dilate 3D** Prompts the user for a label range which corresponds to outside the labels of interest, and dilates regions of the current paint label which are neighbouring the typed-in label range. Typically the user will type in “0 -1” to specify all labels which are not equal to the current paint label.

Segmenting / **Copy from Rt/Sup/Ant** If the mouse is pointing to a slice in the slice window, then the labels of the neighbouring slice are copied to this slice. For transverse slices, the neighbour is the slice just superior to this one. For coronal slices, the neighbour is the slice just anterior to this one. For sagittal slices, the neighbour is the slice just to the right of this one.

Segmenting / **Copy from Lt/Inf/Pos** If the mouse is pointing to a slice in the slice window, then the labels of the neighbouring slice are copied to this slice. For transverse slices, the neighbour is the slice just inferior to this one. For coronal slices, the neighbour is the slice just posterior to this one. For sagittal slices, the neighbour is the slice just to the left of this one.

Segmenting / **Fill 3D** If the mouse is pointing to a voxel which has a label which is not equal to the current paint label and is within the threshold, then all similarly labeled voxels in the entire volume which are connected to this one are assigned the current paint label. This may take a few seconds to a minute.

Segmenting / **Calculate Volume** Calculates the total volume of all voxels which have the current paint label. This takes a few seconds to perform.

Segmenting / **Change Labels** Prompts for a source and destination label value, as well as a volume value minimum and maximum value. All voxels which have the source label value and are within the specified value range are changed to have the destination label. If the maximum value specified is less than the minimum value, then this range is ignored, and the operation simply changes all occurrences of the source label to the destination label.

Segmenting / **Fast Update** Toggles between updating only the slice on which the mouse is painting or all slices, in order to provide a speed tradeoff. By default, fast update is on, which results in fast painting.

Segmenting / **Cursor Follows** Toggles the mode where the slice cursor follows the mouse during painting. This results in slower update speeds, but all slice views show updated labels as painting progresses, which may be helpful for detail work.

5.7.1 Translate Labels

This is a submenu which may be used to translate the labels by integral voxel increments.

Segmenting / **Trans ^** Moves all labels one voxel in the upwards direction of the slice pointed to by the mouse. May take a minute to perform.

Segmenting / **Trans v** Moves all labels one voxel in the down direction of the slice pointed to by the mouse. May take a minute to perform.

Segmenting/**Trans <** Moves all labels one voxel in the left direction of the slice pointed to by the mouse. May take a minute to perform.

Segmenting/**Trans >** Moves all labels one voxel in the right direction of the slice pointed to by the mouse. May take a minute to perform.

Segmenting/**Big Translate** Prompts for 3 voxel offsets and moves all labels by this amount. May take a minute to perform.

5.8 Create Surface

This menu is used to create surfaces from the current volume and/or label volume. Surfaces created from this menu may subsequently have their appearance smoothed by the use of **Polygons**/**Compute Normals** or **Polygons**/**Average Normals**. During all surface extractions, the surface is displayed in the 3D window as it is being created, and all program operations are still functional. Note that the currently set crop limits from the Volume Cropping menu are used to constrain the range of the surface extraction.

Create Surface/**Volume Isosurface** Prompts for a value, then starts extracting a polygonal isosurface from near the slice cursor, using a variation of the 3D contouring algorithm called marching cubes.

Create Surface/**Volume Bin-Isosurf** Prompts for two values, specifying a volume value range, then starts extracting a polygonal isosurface from near the slice cursor. This differs from **Create Surface**/**Volume Isosurface**, in that voxels are classified as in or out and the isosurface points are exactly half way between an inside voxel and outside voxel. Typically, this is only useful for segmented volumes, otherwise the user should use **Create Surface**/**Volume Isosurface**, which results in a smoother surface.

Create Surface/**Volume Voxelate** Prompts for two values, specifying a volume value range, then creates a voxelated surface. A voxelated surface is one composed entirely of rectangular faces of voxels, the boundaries between inside voxels and outside voxels, as defined by the value range specified.

Create Surface/**Label Bin-Isosurf** Same as **Create Surface**/**Volume Bin-Isosurf** except operates on the label volume. For instance, if the user has painted a region with label 1, then to create a 3D isosurface of this region, select this menu option, and type in “1 1” for the min and max values. Note that as the user paints and erases labels, the 3D surface will update to reflect the changes.

Create Surface/**Label Voxelate** Same as **Create Surface**/**Volume Voxelate** except it operates on the label volume. For instance, if the user has painted a region with label 1, then to create a 3D voxelated surface of this region, select this menu option, and type in “1 1” for the min and max values.

Create Surface / **Extracting** If a surface extraction is in progress, this button toggles the extraction process on and off. This allows suspension and resumption of surface extraction.

Create Surface / **Reset Surface** Cancels the current surface extraction, if any is in progress, deleting the extracting surface. This must be selected before starting another surface creation.

Create Surface / **Make Permanent** If a surface extraction is in progress, the currently extracted surface is made a permanent member of the 3D object hierarchy, and the extraction terminated.

Create Surface / **Set Invalid Lbl Range** Modifies the surface extraction so that any voxels with label values with the specified range, which the user types in, are not used for the surface extraction. Defaults to the range (0, -1), which indicates that no voxels are invalid.

5.9 Atlas Menu

This menu controls the display of the Talairach atlas overlaid on the the slice views. The colour atlas book by Talairach and Tournoux has been scanned into a digital format and can be overlaid on any volume for reference and comparison purposes.

Atlas / **Atlas State** Toggles between displaying scanned images of the Talairach Atlas Book superimposed on the volume slices. The first time this is pressed there will be a delay of about 2 minutes while the data is read in.

Atlas / **Set Opacity** Prompts for the opacity of the atlas. A value of 1 will not show the volume slice through the atlas, while values closer to 0 will show a more transparent atlas on top of the volume.

Atlas / **Set Tolerance X** Sets the distance from the current sagittal slice that atlas pages must be within in order to be displayed.

Atlas / **Set Tolerance Y** Sets the distance from the current coronal slice that atlas pages must be within in order to be displayed.

Atlas / **Set Tolerance Z** Sets the distance from the current transverse slice that atlas pages must be within in order to be displayed.

Atlas / **Flip X** Flips the sagittal atlas pages around the X axis.

Atlas / **Flip Y** Flips the coronal atlas pages around the Y axis.

Atlas / **Flip Z** Flips the transverse atlas pages around the Z axis.

Atlas / **Set Transparent Threshold** Not for general use.

5.10 3D View Menu

3D View/**Magnify 3D** Sets the mode where the middle mouse button and left/-right movement in the 3D window magnify the view. Once the 3D view menu is chosen, this button will usually be available, even after popping out of the 3D view menu.

3D View/**Translate 3D** Sets the mode where the middle mouse button and movement in the 3D window translate the objects in the view. Once the 3D view menu is chosen, this button will usually be available, even after popping out of the 3D view menu.

3D View/**Rotate 3D** Sets the mode where the middle mouse button and movement in the 3D window rotate the objects in a virtual trackball fashion. Once the 3D view menu is chosen, this button will usually be available, even after popping out of the 3D view menu.

3D View/**Front View** Selects a view of the front of the objects.

3D View/**Back View** Selects a view of the back of the objects.

3D View/**Left View** Selects a view of the left side of the objects.

3D View/**Right View** Selects a view of the right side of the objects.

3D View/**Top View** Selects a view of the top side of the objects.

3D View/**Bottom View** Selects a view of the bottom side of the objects.

3D View/**Left Tilted View** Selects a view of the left side of the objects, tilted forward.

3D View/**Right Tilted View** Selects a view of the right side of the objects, tilted forward.

3D View/**Reset View** Resets the view to a top view.

3D View/**Fit View** Without changing the view direction, magnifies the objects to just fit inside the window. Useful when the user desires to see the full extent of all objects.

3D View/**Parallel/Perspective** Toggles between a parallel and perspective view of the 3D objects.

3D View/**Film Loop** Creates a movie of the 3D window. Prompts for a filename prefix, an axis index (0-2), and a number of frames. The objects are spun around the specified axis, saving a separate frame to file for each increment.

3D View/**Front Plane** Not for general use.

3D View/**Back Plane** Not for general use.

3D View/**Toggle Stereo** Not for general use.

3D View/**Eye Width** Not for general use.

3D View/**Pick View** Not for general use.

5.11 Objects Menu

This menu operates on the objects in the 3D window, which also have textual representations in the Menu window, in the form of the object hierarchy, which consists of lines, polygons, markers, and collections of these, called `models` . Generally, object operations apply to the currently selected object which is the one which has a green rectangle around its textual representation in the menu hierarchy. Selection of the current object can be performed by using the arrow keys to navigate the hierarchy, or by clicking on the desired object text in the Menu window. A second click on a model object will descend a level to the set of objects contained in the model. Another way to select the current object is to click on its image in the 3D window.

Objects/**Delete Object** Puts up a confirm/cancel submenu to allow the user to delete the current object. If the current object is a model, the model and all objects it contains are deleted.

Objects/**Change Colour** Prompts for a new colour for the current object.

Objects/**Change Surface Prop** Prompts for an ambient coefficient (0–1), a diffuse coefficient (0–1), a specular coefficient (0–1), a specular exponent (0–100 or so), and an opacity (near 0 is transparent, 1 is fully opaque). The currently selected object is assigned these lighting parameters.

Objects/**Invisible** Turns the current object invisible.

Objects/**Visible** Turns the current object visible.

Objects/**Toggle Visible** Toggles the visibility of the current object.

Objects/**Next Visible** Turns the current object invisible, and advances to the next object, making it visible.

Objects/**Prev Visible** Turns the current object invisible, and advances to the previous object, making it visible.

Objects/**Create Model** Creates a model at the current position in the hierarchy. This is useful for grouping objects into a single file.

Objects/**Change Model Name** Prompts for a name and assigns this to the currently selected model in the object hierarchy.

Objects/**Cut Object** Cuts the currently selected object out of the object hierarchy and adds it to the cut buffer.

Objects/**Paste Object** Copies the entire cut buffer to the current position in the object hierarchy, and clears the cut buffer.

Objects/**Flip Object** Mirror images the current object around the $X = 0$ plane.

Objects/**Scan Object to Volume** Causes the intersection of the current object with the volume to be displayed in the slice window, by assigning the current paint label to any voxel which is touching the object. Works for polygons, lines, and markers.

Objects/**Show Vertices** Not for general use.

5.12 3D Render Menu

Render/**Change Background** Prompts for a colour to set the background colour of the 3D window and slice window.

Render/**Wireframe or Shaded** Toggles the display mode of the current model between a wireframe rendering and a solid, shaded rendering. The default is wireframe.

Render/**Gouraud or Flat** Toggles the display mode of the current object between a flat or smooth shading. The default is smooth (Gouraud).

Render/**Lights** Toggles the lights on and off. If lights are off, all objects are coloured uniformly.

Render/**3D DblBuf** Toggles the double buffer mode of the 3D window. If double buffering is on, the window is smoothly updated, but the colour resolution may be poor. When double buffering is off, the colour resolution improves, but the 3D window flickers when updated. When taking snapshots, turn off double buffering so as to get the best colour resolution. This option is only available on IRIS/GL versions of the program.

Render/**Marker Labels** Toggles the display of the text labels of the markers in the 3D window.

Render/**Set # Curve Segments** Not for general use.

Render/**2 Sided** Not for general use.

Render/**Backface** Not for general use.

5.13 Markers Menu

Markers/**Create Marker** If the mouse is in the slice window over a volume pixel, a marker is created at that location. Otherwise, it is created at the current cursor position.

Markers/**Chg Marker Pos** If the current object is a marker, then changes the marker's position in a manner similar to **Markers**/**Create Marker**.

Markers/**Default Size** Prompts the user to type in the default marker size in real world units, typically millimetres.

Markers/**Default Label** Prompts the user to type in the default marker label string.

Markers/**Default Colour** Prompts the user to type in the default marker colour.

Markers/**Default Structure Id** Prompts the user to type in the default structure id.

Markers/**Default Patient Id** Prompts the user to type in the default patient id.

Markers/**Default Type** Prompts the user to type in the default marker type, of which only cube is supported.

Markers/**Chg Marker Size** Prompts the user to type in the new size of the current marker, if the current object is a marker.

Markers/**Chg Marker Label** Prompts the user to type in the new label of the current marker, if the current object is a marker.

Markers/**Chg Marker Type** Prompts the user to type in the new type of the current marker, if the current object is a marker.

Markers/**Chg Structure Id** Prompts the user to type in a structure id. If the current object is a marker, then it is assigned this structure id. If the current object is a model, then all markers underneath this object are assigned this structure id.

Markers/**Chg Patient Id** Prompts the user to type in a patient id. If the current object is a marker, then it is assigned this patient id. If the current object is a model, then all markers underneath this object are assigned this patient id.

Markers/**Move to Marker** If the current object is a marker, sets the 3D cursor and the volume position to the position of the marker.

Markers/**Move Cursor Home** Moves the 3D cursor to the origin, which should be 0, 0, 0 in Talairach space. This is useful for making slides with the cursor as a reference to AC-PC.

Markers/**Delete Object**/☐ This is the same as the **Objects**/**Delete Object**, duplicated in this menu for convenience.

Markers/**Classify Markers** Attempts to group markers by relative proximity, generating a different colour and structure id for each group.

Markers/**Segment Thresh** Prompts for and sets the distance threshold which determines if two markers are close enough to belong to the same group. Default is 1.5.

Markers/**Pick Modify Marker** Allows the user to draw a rectangle on the 3D view of the markers and change all the markers within the rectangle to the default settings. This is done by pressing and holding the left button, sweeping out a rectangle, and when the left button is let go, the defaults are copied to the markers.

Markers/**Defaults -> Current** Copies the default marker values to the current object, if it is a marker.

Markers/**Defaults -> Many** Copies the default marker values to all markers which have the same patient id and structure id as the current object, if it is a marker.

5.14 Polygons Menu

Polygons/**Compute Normals** Computes normals for the current polygon, for use in displaying a smooth lighted surface in the 3D window.

Polygons/**Average Normals** A second way to compute normals for a polygon, which results in smoother shading. Prompts for a number of iterations and a ratio value between 0 and 1. The normals for the polygon are computed using the **Polygons**/**Compute Normals** algorithm, then the iterations are performed. Each iteration consists of smoothing each polygon vertex normal with its neighbour vertex normals, based on the ratio value. A value of 0 causes no change in each iteration, where a value of 1 sets each vertex normal to the average of its neighbour vertex normals. Typically, use the values “5 1” for this selection.

Polygons/**Set Line Thickness** Prompts for a line thickness value used in displaying the current polygons in wireframe mode. Default value is 1.

Polygons/**Make Tetrahedral Ellipsoid** Prompts for 3 numbers for the centre, 3 numbers for the radii, and an integer for the number of triangles, and creates an triangulation of an ellipsoid. The resulting polygon is a subdivision of a tetrahedron, an octohedron, or dodecahedron, depending on the number of triangles specified, which will be rounded to an appropriate multiple of 4 times either 4, 8, or 20.

Polygons / **Make Quad Ellipsoid** Same as **Polygons** / **Make Tetrahedral Ellipsoid** except that the resulting polygons consist of triangles and quadrilaterals defined by lines of longitude and latitude, and rather than specifying the number of items composing it, the user specifies the number of intervals around and up the ellipsoid.

Polygons / **Separate Polygons** Causes individual polygons in the current polygons object not to share common vertices, which has the visual effect of causing the object to be flat shaded.

Polygons / **Coalesce Polygons** Causes individual polygons in the current polygons object to share common vertices, which results in the object appearing to be more smoothly shaded.

Polygons / **Subdivide Polygons** Not for general use.

Polygons / **Create Bintree** Not for general use.

Polygons / **Reverse Polygons** Not for general use.

Polygons / **Reverse Normals** Not for general use.

Polygons / **Smooth Polygon** Not for general use.

5.15 Surface Curves Menu

This menu is used to draw curves on surfaces, for the purposes of delineating sulci and gyri, or for drawing regions on the surface which can then be coloured.

Surface Curves / **Start Surf Curve** Enters curve drawing mode. Any left mouse click on the surface in the 3D window will define a point on the surface. Subsequent points on the surface are connected by a line of shortest distance along the surface. The first mouse click will cause precomputation of neighbours in the polygons which may take several seconds.

Surface Curves / **End Surf Curve** Exits from curve drawing mode.

Surface Curves / **Close Curve** When in curve drawing mode closes the curve by connecting the end of the curve with the start of the curve.

Surface Curves / **Pick Line Point** Picks the closest point on a line to the point under the mouse, and adds it to the current surface curve.

Surface Curves / **Reset Curves** Clears the current curve.

Surface Curves / **Permanent Curve** Copies the current curve permanently into the object hierarchy.

Surface Curves / **Curve Weight** Prompts the user to type in a curvature weight. A value of -100 will tend to make surface curves follow sulci, and a value of 0 (default) makes it just choose shortest path along the surface. Generally, this parameter has not been very successful, and it is best to leave it at 0.

Surface Curves / **Set Crv'tre Limits** Prompts the user for a minimum and maximum curvature and constrains subsequent curves to follow paths along the surface to stay within these surface curvature limits. Generally, this is not used.

5.16 Surface Segmentation Menu

This menu is used for segmenting the surface into various coloured regions or to make parts of the surface invisible. It is still experimental and is therefore not for general usage.