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# 1. Introduction

Welcome to **SURFdriver**, the surface reconstruction program. **SURFdriver** is a powerful tool for developing detailed morphological reconstructions of anatomical features using sequential image slices through the structure.

This manual will guide you through **SURFdriver's** interface, and explain the basics of anatomical reconstruction. For a simple interactive reconstruction demonstration, go through the "Y demo" included with this **SURFdriver** release. It will give you a hands-on demonstration of the reconstruction techniques outlined in this manual.

Before proceeding with the manual, take a moment to note the following terms used throughout the text:

1. **Vertex** - a point placed on a morphological structure you wish to reconstruct.
2. **Contour** - an outline or border drawn around structure that you wish to reconstruct. A contour consists of a set of vertices connected by lines.
3. **Slice** - the two-dimensional image, or anatomical section, from which you will outline a structure. For example, a slice is a single image from the Visible Human Data Set, or a single histological cross section.
4. **Object** - a single reconstructed morphological feature. Each **SURFdriver** data file contains a single object.
5. **Split/Join**- a branching within an object. This occurs when one contour branches into two or more (a split), or two or more contours come together to form one (a join).

# 2. Setting Up

**SURFdriver** requires at least 8 MB of RAM to run; however the size requirements depend on your images and objects. If your reconstructions cause memory errors, quit the program, click once on the **SURFdriver** icon, choose 'Get Info' from the File menu, and change the Preferred Size to a larger number. Do not set the size below 8 MB, as this may cause the program to quit unexpectedly. If you need to increase the size of the application, and your computer doesn't have enough physical RAM, try activating or increasing the virtual memory (set in the **Memory** control panel).

The image format used in **SURFdriver** is very important. **SURFdriver** accepts images only in the **PICT** format. However, if you have **QuickTime**® 3.0 or later, you will be able to import a variety of image formats into **SURFdriver** using automatic QuickTime translation. If you do not have **QuickTime**® 3.0, you can download it from the **Apple**® website at <http://www.apple.com>, or you can use your own graphics software to translate your images into **PICT** files.

The image files **must** be numbered in a particular way. The numbers must all have the same basic file name followed by a number at the end of the file name, and the numbering must represent consistent slice thicknesses. So if you had a series of images at 5 mm intervals, you could number them "picture1", "picture2", etc. Be sure **not** to have any leading zeros (i.e. picture 001, picture 002, etc). Files numbered in this way will **not** work. Also, there can **not** be any suffix extensions on the file names (i.e. picture1.jpg, picture2.jpg, etc). Files with suffixes will **not** work on the Macintosh version of **SURFdriver**.

If you are making your own PICT files, make sure that the images are all the same scale. If different slices are in different scales, the object will appear to constrict and swell along the reconstruction axis. If this consistency cannot be assured during input, the images should be scaled to the correct dimensions with a separate program before importing them into **SURFdriver**.

### 3. The Command Palette

**SURFdriver** is divided into seven functions. When you start up **SURFdriver**, you are presented with an option window, called the Command Palette, which looks like this:



Figure 1. The Command Palette. This is where all actions are initiated in **SURFdriver**.

You can select one of the seven functions by clicking on the appropriate button. The options, which are explained in detail in the following chapters, are:

<b>New Object:</b>	Create a new object
<b>Edit Object:</b>	Edit an existing object
<b>Surface Object:</b>	Process an existing object
<b>View Object:</b>	View a processed object
<b>Adjust Objects:</b>	Adjust image orientation using objects
<b>Volumetrics:</b>	Calculate volume and surface area
<b>Quit:</b>	Quit <b>SURFdriver</b>

### 4. New Object

To create a new object, begin by selecting the **New Object** button. You will be prompted for a PICT file name. Select the file number which contains the lowest slice number you intend to use (for example, if your object goes from slice 1200 to slice 1300, select file number 1200). This will be your base slice. You can later change the base slice to a smaller number if necessary (see under **View Object**).

The Slice Characteristics box, shown below, must now be completed correctly. This information is critical for reconstructing the image to the correct dimensions.

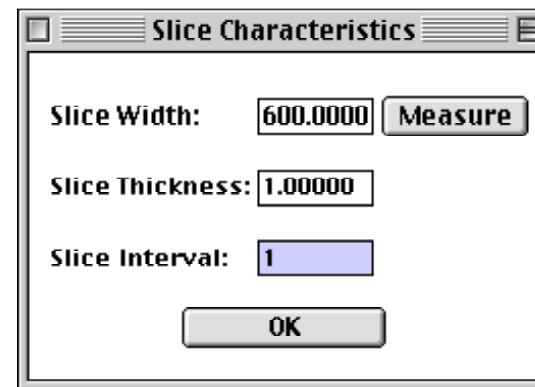


Figure 2. The Slice Characteristics box. Defines the parameters for your image files.

The **Slice Width** is the actual width of the entire slice, in units you choose. The default value of 600 represents the slice width for a Visible Male slice on the **SURFdriver VH+** CD, in millimeters. If you don't know the width of the slice, but you have a reference object of known length in one of the images (e.g., micron bar, centimeter scale), you can use the **Measure** button, located next to the **Slice Width** field.

To use the measure option, click the **Measure** button, and you will be prompted for a PICT file. Select the file that contains the reference object and the image will appear on the screen. Click and **hold** the mouse button at one end of the object, drag the mouse to the other end, then **release** the mouse at the other end. You will be prompted for the length of the line you just drew. Enter the appropriate value in your chosen units. The width of the entire slice (or measurement bar) will be automatically calculated and entered in the **Slice Width** box.

The **Slice Thickness** is the depth (in the same units as above) of each slice. Note that this number represents the thickness at which the sections were cut. Thus, if you are using slices 1.0 mm in thickness, and you are numbering every slice, but you are only using every 5th slice, the slice thickness should still be set to 1! The default of 1 represents the thickness of the Visible Male slices (the Visible Female setting is 0.333);

The **Slice Interval** is the interval between number slices you are using. Thus, if you are using every 5th numbered slice, the **Slice Interval** should be set to 5. Once you have filled in this window, click the OK button to continue.

## 4.1. The Slice Editing Screen

After completing the **Slice Info** box, your monitor will display a variety of windows (see next page for image). The large central window is the **Slice Editing** window; this is where the image of your first slice should appear. If it does not appear, refer to Chapter 2 (Setting Up), or to the troubleshooting section found at the end of the manual.

All of your vertex manipulations are done in the **Slice Editing** window, shown below. The green dots and lines represent vertices already placed on the object. Different colored dots represent different contours of the object (discussed later).

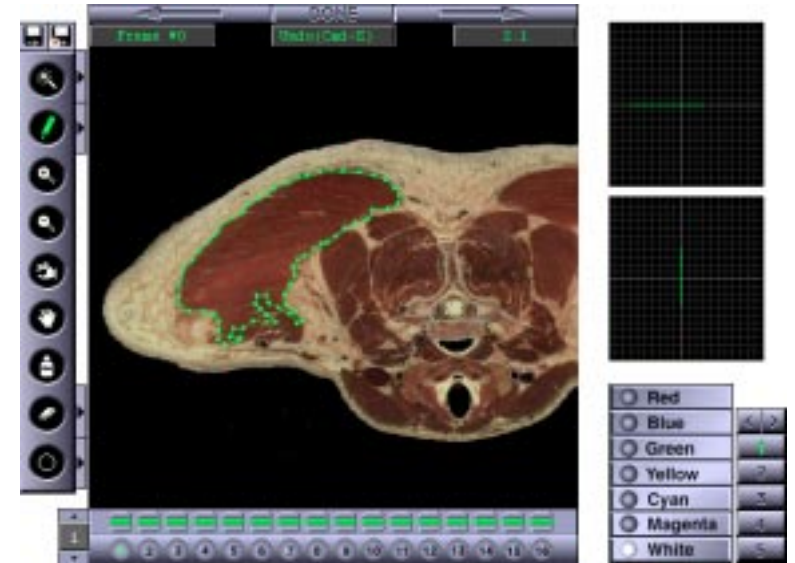


Figure 3. The Slice Editing window, containing a Visible Human image, and the associated palettes.

Above the **Slice Editing** window are the **direction buttons**, and the **DONE** button. The direction buttons allow you to move to the next slice (right arrow) or the previous slice (left arrow).

Inside the **Slice Editing** window itself are three buttons, the **Frame Number** `Frame #1783`, **Undo Button** `Undo(Cmd-Z)`, and the **Magnification** `1:1`. Clicking on the **Frame Number** allows you to jump to a specific slice number. Clicking on **Undo** reverses the last edit. Clicking on the **Magnification** button returns the magnification to 1:1.

## 4.2. The Tool Palette

The tools of the **Tool Palette** place and manipulate vertices in the **Slice Editing Window**. Each tool is described individually below.



### 4.2.1. Magic Wand Tool

The first tool represents the **Magic Wand** icon. This tool is the easiest way to contour an object. Simply click inside the object, and the **Wand** tool will estimate the desired contour.

The **arrow** button to the right of the **Wand** tool allows you to set the **threshold** and **density** of the vertices. The threshold controls the degree of variation in colors that the **Wand** will grab. A higher value allows more variation in color, and therefore grabs a larger region. The **density** value controls the number of vertices used to create the contour. A higher value results in more vertices.

To use the **Wand** tool, select the icon and set the density and threshold. Move the tool over the structure you wish to contour - near the edge often works best. Click and wait. If the computer was not able to identify a contour, it will inform you. Otherwise, a contour will appear. If the contour is not what you wanted, pressing the **Delete** key on your keyboard or clicking the **Undo** button will remove the points.

Clicking in slightly different locations will result in different contours, so try a few different places. Don't forget to alter the threshold if it appears to be getting too much or too little.

**Note!** If you only capture a portion of the object you were trying to contour, you can hold down the **Shift** key and click on the object again. This will **expand** the contour you have already made. This only works on the most recently contoured object. Also, if the new portion you capture is not connected to the first contour, the contour will not be expanded. If you get a contour that is **almost** right, you can always use the other tools of the **Tool Palette** to adjust the specific vertices that are incorrect, or remove extraneous ones.



### 4.2.2. Pencil Tool

Using the **Pencil** tool, you can **draw an outline** of the desired structure, and **SURFdriver** will place vertices along this path (contour sketching). Alternately, you can place **individual vertices** by clicking in the Slice Editing window. The **arrow** button to the right of the **Pencil** tool allows you to set the **density** of the vertices. The higher the value, the more vertices will be added.

It is **very important** that you place the vertices in a **clockwise** direction.

Note that if you wish to insert a point between two existing points, you must use the **Glue** tool (below).



### 4.2.3. Magnify/Demagnify Tools

These tools allow you to zoom in and out of the image. Select the tool and click anywhere in the Editing window to zoom in or out. You can zoom to 1:1 by clicking on the magnification button in the Image Editing window.



### 4.2.4. Move Vertex Tool

This tool is for moving incorrectly placed vertices. Simply click on or near the misplaced vertex, drag it to the new location, and release the mouse. You can also bring up this tool by holding down the **Control** key.



### 4.2.5. Glue/Eraser Tools

These tools allow you to insert and remove vertices. To insert between two points, select the **Glue** tool, and click between the two points. To delete a single point, click on the point with the **Eraser** tool. To delete a group of points, **click and drag** the **Eraser** - all points within the rectangle will be deleted. The arrow beside the **Eraser** allows you to delete all the points within a slice or contour.



#### 4.2.6. Scroll Image Tool



This tool allows you to move your magnified view around the image. You must be zoomed to at least 2:1 before this tool will work. Select the tool, then **click and drag** within the Image Editing window to scroll your view.

#### 4.2.7. Marker Tool



Use the marker tool to identify labels or points within the object. Clicking on the triangle to the right of the tool sets the radius of the marker. To delete a label, press the **Backspace** key while the marker tool is selected, or use the **Delete Vertex** tool.

### 4.3. The Trace Palette



It is sometimes useful to be able to see the contours of previous or following slices superimposed on the current slice. This can help in smoothing out objects and in finding obscured objects. The **Trace Palette** allows you to select the number of previous (or following) slice contours to show. The left arrow specifies previous slices, while the right arrow specifies following slices. To turn off the trace feature, deselect both arrows.

### 4.4. The Color Palette



This palette allows you to set the color of the entire object (not just one contour or slice). Click on the desired color, and the object will be rendered in this color during the viewing process. If you want different parts of the object to be in different colors, you must create each portion of the object in **separate object files**, then combine them in the viewer.



### 4.5. The Contour Palette







The Contour Palette has two functional units, the **Object Selector** and the **Contour Selector**.

The **Object Selector**, on the left, allows you to edit multiple objects simultaneously. Click the up arrow to go to a previous object, and the down arrow to go to the next object. Each object will be saved in a separate file.

The **Contour Selector** allows you to define different portions of a single object (splits and joins), and ensure that they all connect together correctly. The trick is to use a **separate contour** for each separate portion of the object. Different contours are selected by clicking on the numbers in the contour palette.

Number one  represents the first contour set, number 2  the second, and so on. The color of the number when selected is the same as the color of the contours it produces. When a certain contour is selected, all of the points added using the **Pencil** tool or the **Wand** tool would go into that contour.

The three lights  above each number represent the cap setting for that contour. Caps represent the end of an object. When you label a contour in a particular slice as capped, **SURFdriver** produces a cap, or lid, for that contour, at that slice, and ends the object at that point. The top of an object requires a top cap, while the bottom requires a bottom cap. Anything that isn't at the top or the bottom is uncapped. As you might guess, the top light  indicates a top cap, the bottom light  represents a bottom cap, and the middle light  indicates an uncapped contour. An object with no splits or joins would generally have a top cap for the first slice, a bottom cap for the last slice, and uncapped for all other slices. The tricky part is when we have splits or joins. An example might help to show how we handle these scenarios.

The example included in the demonstration folder is the **Y demo**. The sections of the **Y demo** represent a three-dimensional letter Y, cut into slices and named Y.1 through Y.20. In this object, the two "arms" of the Y join together in the middle to form the base of

the Y. The two "arms" must therefore be contoured separately. So for the first slice, you would contour the left arm in contour #1, then switch to contour #2 and contour the right arm. Both contours in the first slice would require a top cap.

Now we go to the second slice. Again, the left arm goes into contour #1, while the right arm goes into contour #2. This time, however, the contours are left as uncapped, because we are in the middle of the object.

This continues until we reach the place where the two contours become one. At this point we can only have one object, so the entire contour goes into contour #1. So contour #2 no longer exists. Does that mean we should have put a bottom cap onto contour #2 in the previous slice? No, because that would be telling **SURFdriver** that portion of the object ends in the previous slice, which it doesn't. It just joins with contour #1. So we leave it uncapped, and carry on contouring the base of the Y into contour #1. When we get to the last slice, we label it as a bottom cap. This will create the correct morphology for the object.

The main point to remember is that a **bottom cap** indicates the **end** of a contour, so if the contour is joining with another contour, no bottom cap is required. Similarly, a top cap indicates the very beginning of a contour, so if that contour is the result of a split, then no top cap is required.

Be sure to go through the **Y Demo**, which gives a practical demonstration of the discussion above.

## 4.6. Profile Windows

There are two additional windows shown in the top right corner of Figure 3. These are the profile windows. These two windows show successive object slices, from the X-axis and Y-axis, respectively. They are useful for overall object reconstruction, as well as for aligning slices. The current slice is shown in the middle axis of each window. Capped sections are indicated by a white line. Note that objects in the profile windows are not shown according to scale. They are there to help with contour alignment and slice navigation.

## 5. Surfacing an Object

After you have completed your contours and saved them as a file, you will have the option of surfacing the object immediately, adjusting the contours, or canceling and performing the surfacing later. The surfacing process connects the vertices and sections you have identified for the final object; therefore, if you have not finished defining an object, you may wish to defer the surfacing until later. Note, however, that you will not be able to view the object until you have surfaced it.

Before surfacing, you will be asked whether or not you wish to use **Skew Correction**. If the object you are creating is at a sharp angle on the Z-axis, skew correction will often result in better surface morphology. If the object is not at an angle on the Z-axis, it is generally better not to use **Skew Correction**.

You will also be asked to choose a **Stringency** level. The **Stringency** is the amount of effort **SURFdriver** will put into lining up consecutive slices. The default level of 75% is usually sufficient, and is **much** faster than using a **Stringency** of 100%. Increase the value to correct small alignment problems between slices; decrease the value to increase the surfacing speed.

## 6. Adjusting Objects

Sometimes the images you use to create your objects are not aligned properly, relative to one another. The slices may require translation and/or rotation to properly align the images. This is where the **Adjust Objects** function becomes useful.

To adjust a series of objects, select **Adjust Objects** from the main **Command Palette**. You will be prompted for object files. You will use these objects to align the layers. Load as many as you need. Note, however, that all of the objects must have been created using the same series of images.

When you have selected all of the desired object files, click **Cancel**, and the adjusting environment will appear. This includes the main adjustment window with control buttons, the tool palette, and the profile window.

The main **Adjustment Window** looks like the **Slice Editing** screen shown in Figure 3, except that the actual image file is not visible, only the contours of the objects you have loaded. In addition to the contours of the current slice, which are shown in white, the previous and following slices are also shown, in cyan and magenta respectively.

The profile window shows a three-dimensional view of the contours. Again, contours prior to the current slice are shown in white, contours of the previous slice are shown in cyan, and those of the following slice are shown in magenta.

## 6.1. Tool Palette

The **Tool Palette** contains the tools for translating and rotating each slice.



### 6.1.1. Slice Translation

To adjust the position of the current slice, select this tool. Then move your cursor to the main adjustment window, and press down with the mouse. Drag the contours until they are in the correct position, and then release the mouse. Use the contours of the previous and/or next slices to correctly position the slice.



### 6.1.2. Slice Rotation

To correct rotational problems, select this tool. Move the cursor to the main adjustment window, and drag the contours either clockwise or anti-clockwise, using the contours of the previous and/or next slices as a guide. You can set the center of rotation (the red cross hair) using the **Rotation Center** tool, below.



### 6.1.3. Copy Previous

Sometimes, a series of images in a row are all off by the same amount. In this case, you can simply adjust the first image, then go to the next slice and click this button. The image will be translated and rotated by the same amount as the previous image.



### 6.1.4. Reset Adjustments

This button returns the image to its original, unadjusted position. Simply click once on this tool to reset the image position.



### 6.1.5. Set Rotation Center

Use this tool to set the center of rotation for the rotation tool. Note that holding down the **Command** key performs the same function.



### 6.1.6. Magnify/Demagnify

These tools allow you to zoom in and out on the contours, permitting more accurate adjustment of small contours.

When you have finished with a slice, proceed to the next slice using the **direction buttons** above the main adjustment window. Typically, the best strategy for adjusting contours properly is to begin with the **second** slice. Adjust this slice to match the cyan (previous slice) contours. Then go to the third slice and repeat, until **all** slices have been adjusted.



After completing all adjustments, click the **Done** button. You will be asked if you wish to save your changes. If you click 'Yes', the changes will be saved to a special adjustment file, with the name corresponding to the image file names, followed by the suffix '.ADJ' - for example, if the objects were created using a series of images named "mouse1", "mouse2", "mouse3", etc., then the file would be named "mouse.ADJ". This file will reside in the same folder as **SURFdriver**, and must always be in same folder as **SURFdriver** in order to be used correctly.

This file will be used to adjust the contours for all future contours created using the same image files, which means you should only have to perform the adjustments for each slice once.

When you have saved the adjustment file, you will be notified that you will need to **re-surface all the objects**, which use these images. You can surface each one individually from the **Command Palette**; all of the adjustments will be applied, and the final objects will be correctly aligned.

## 7. Viewing an Object

After you have completed your contours and surfaced the object, the program will display the three-dimensional object. Sometimes, your contours may have been reconstructed in such a way that **SURFdriver** incorrectly surfaces the object, creating holes or other distortions in the object. This occurs primarily when two consecutive slices differ highly from one another. If this occurs, you should return to the **Object Editor**, and edit the object by either moving vertices to line up more closely, or by decreasing the slice interval to increase the resolution (see section 8).

Once **SURFdriver** has created the 3D object, the viewing environment will appear, and the object will appear in the **Rendering Window** (above). When you have just created an object, only that object will appear in the window. In the picture above, multiple objects are shown. This is possible by going back to the **Command Palette**, clicking the **View Object** button, and then selecting all of the objects you wish to load. This is also

achieved by saving a group of objects together as a Group file (see below).

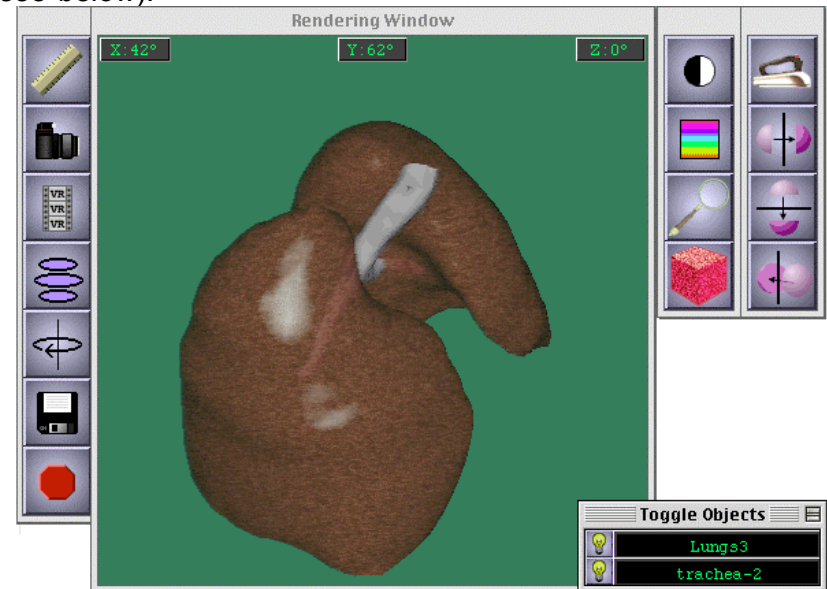
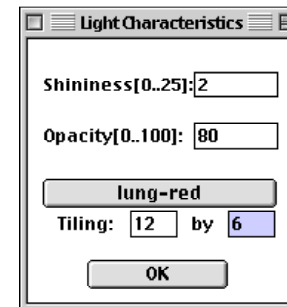



Figure 4 - The **SURFdriver** Rendering Window with associated palettes.



Clicking and dragging in the window can rotate the object. The individual objects are listed in the **Toggle Objects Palette**. Objects can be toggled visible or invisible by clicking on the buttons of this palette. You can set each object's appearance characteristics by clicking on the  button next to the object's name. This produces a dialog box as shown on the left.

A higher **Shininess** value gives the object more highlights. A higher **Opacity** value makes the object less transparent.

Clicking on the texture name (e.g. "lung-red") allows you to select a texture map for the object. The **Tiling** values allow you to set the number of horizontal and vertical repetitions of the texture map. This allows you to use small texture maps to cover a large object.

## 7.1. The Tool Palette

The tools in the rendering **Tool Palette** are described individually below:



### 7.1.1. Measuring Tool

This tool allows you to measure the distance between two points on the object(s). Click the measure button once to activate. Move the mouse to the Rendering Window and click somewhere on an object. A **green X** will appear, and the button will now be in the up position, with a number **2** over the ruler icon. Move the object(s) in the Rendering Window until you can see the location where you wish to place the second point. Click the tool button again, move the cursor to the Rendering Window, and click on the desired location. Another **X** will appear. A dialog box will report the distance between the two points. Units are the same as those used in the **Slice Characteristics** box. To perform another measurement, click on the tool again, and repeat as above.



### 7.1.2. Capture Tool

Takes a snapshot of the current image. The angles are not included. The size of the snapshot is the same as the current size of the window. Click the capture tool to snap the image, and a dialog box will prompt you for a file location.



### 7.1.3. QuickTime VR Tool

This button is for producing QuickTime VR objects. Click on this button, and select a file name. You can cancel the process by holding down the escape key (esc). See the on-line file 'Making QTVR Objects' for more information.



### 7.1.4. Frame Type

When dragging the three-dimensional object(s) on the screen, **SURFdriver** can either display the object as a wire frame (where only contours and caps are displayed), a simple box for each object, or a full framed object with every polygon outlined. Clicking on this tool selects between the three options.



### 7.1.5. Rotation Mode

When dragging the object(s), you can either use constrained rotation, where rotation is only in the X and Z directions (like a QuickTime VR object), or free rotation in all three axes. Constrained rotation is easier to control, but free rotation gives you more viewing options.



### 7.1.6. Save/Export

Allows you to either save the current object(s) as a fast loading file, or to export to **DXF** or **IGES** files. After clicking this button, you are asked to choose between **SURFdriver** and Export. Choosing **SURFdriver** saves multiple objects that can be stored together, and **lighting** conditions and **angles** are maintained. Choosing Export allows you to select from DXF, IGES Type I, or IGES Type II. The DXF option exports using 3Dface entities; the IGES Type I uses Plane (#128) entities; the IGES Type II uses B-spline (#144) entities.



### 7.1.7. Exit

Quits back to the Command Palette.

## 7.2. View Palette

The **View Palette** contains tools for adjusting the viewing conditions. The tools available are:



### 7.2.1. Contrast

Sets the degree of contrast between light and dark portions of the image. A higher value is a higher degree of contrast. The range is from 1 to 9, and the default value is 5. This tool affects all objects, regardless of whether they are visible or not.



### 7.2.2. Background

Sets the background color of the viewing window.



### 7.2.3. Magnify

Sets the magnification of the viewing window. The range is from 0% to 400%. Note that some polygons may be lost around the edges at higher magnifications.



### 7.2.4. Render Quality

Sets the rendering quality of the objects in the viewing window. The options are to view wire frame, no texture mapping, or full texture mapping.

## 7.3. Vertex Palette

Tools of the **Vertex Palette** are used to make changes to the vertices of the objects, including smoothing and axis flipping. These tools are:



### 7.3.1. Smoothing

The smoothing button reduces surface irregularities and results in a cleaner surface. There are three levels of smoothing, which are selected from a dialog box. If you want to undo smoothing, exit the viewer without saving, then re-open.



### 7.3.2. X-axis flip

Flips all vertices across the X-axis. Note that points are flipped across the **original** X-axis, not the X-axis of your current viewpoint.



### 7.3.3. Y-axis flip

Flips all vertices across the Y-axis. Note that points are flipped across the **original** Y-axis, not the Y-axis of your current viewpoint.



### 7.3.4. Z-axis flip

Flips all vertices across the Z-axis. Note that points are flipped across the **original** Z-axis, not the Z-axis of your current viewpoint.

## 8. Editing an Object

Once you have viewed an object, you may wish to make changes to the original object. To edit an object, return to the **Command Palette**, and press the **Edit Object** button. You will be prompted for a file to edit. Locate the desired object file - remember, **you can't edit group files** (saved in the viewer), only the original object files. You will then be asked to locate the associated **PICT** files.

**NOTE:** If you wish to start at an earlier slice to include more of the object, select the earlier slice at this time. The program will automatically line up the vertices with the correct slices.

If you already know the slice you wish to start editing, you can select that PICT number and again the program will jump to the correct position.

After you have selected the desired PICT file, the **Slice Characteristics** box will reappear. Normally, you will not need to change the contents of this box. However, if you made a mistake in the **Slice Width** or **Slice Height**, you can change it now.

**NOTE:** Changing the Slice Interval can be destructive. If you had a previous slice interval of 5, and you change it to 10, every second slice will be lost. **IT WILL NOT RETURN LATER IF YOU CHANGE THE SLICE INTERVAL BACK TO 5.** If your previous slice interval was 5, and you change it to 3, the program will attempt to line up slices as closely as possible to the new numbering scheme. For example, if you started at slice 100 with a slice interval of 5, you would be entering data on slices 100, 105, 110, 115, etc. Changing the interval to 3 would result in slices 100, 103, 106, 109, 112, 115, etc. So slice 100 would get the data from the previous slice 100; slice 103 would be empty; slice 106 would get slice data from 105; slice 109 would get 110; 112 would be empty; and 115 would get 115. Generally, when changing the slice thickness, it is advisable to save the result under a new file name.

When you are finished with the **Slice Characteristics** box, the editing window will appear, and you can perform the desired changes.

## 9. Volumetrics

The **Volumetrics** function allows you to calculate the volume and surface area of a **SURFdriver** object file.

**Note** that volumetrics can only be performed on single object files. You cannot perform the volumetrics function on the **SURFdriver** fast file format (i.e., **.sdf** files).

To perform a volumetric calculation on your object, click on the **Volumetrics** button, and select a **SURFdriver** object file. Choose an export file; this is where the volumetric information will be saved.

Once **SURFdriver** has completed its calculations, quit out of the program and double-click on the newly created file to view the calculated information.

The volumetrics file is divided into sections, one per slice. Each slice section contains the slice number, the z-coordinate of the slice relative to the top of the object, and a series of contour sub-sections, one for each contour on that slice.

Each contour sub-section contains the contour number, the length of the line making up the contour, and the surface area enclosed by the contour vertices.

At the end of the file is the total surface area and volume for the object.

## 10. Frequently Asked Questions

**When I'm in View Mode, I sometimes want to make changes without seeing the fully rendered result right away. Is there any way to stop SURFdriver from rendering?**

Yes. In **View Object** mode holding down the Shift key, or turning the Caps Lock on, prevents **SURFdriver** from rendering the 3D image. Instead, only the frame is shown. These keys only work before the program has started rendering. If **SURFdriver** has already started rendering, you can use the Escape key (esc) to abort rendering.

**I'm missing certain slices, or I have slices that are unusable. Is there any way to skip a slice?**

Yes. When entering slice data, if you come across a slice that is particularly poor, or the objects are difficult to distinguish, you can leave the slice completely blank. **SURFdriver** will simply connect the vertices of the previous slice with the next slice. Note that if you leave out one contour for a particular slice, you must leave out all other sections as well for that slice. Note that you can skip as many slices as you want, although the smoothness of the final rendered object may be affected.

**Is there any way to use objects created with SURFdriver with another 3D program?**

Yes. You can export **SURFdriver** objects as either a DXF or an IGES file, two common 3D format used by many 3D programs. To export as DXF, choose "**View Object**" from the main command palette. Load only the object(s) you wish to export. Once the object has been rendered, click on the disk (save) icon in the tool palette. Choose the **Export** option, then choose DXF, IGES Type I, or IGES Type II, and give the exported file a new name.

**I want to send a SURFdriver object to another person who has SURFdriver. What's the best format to use?**

If you just want them to be able to see the object in **SURFdriver**, you should save the object in the Group File Format, because adjustments you make to slice positions are not saved in the regular object format. To save a Group File, go into the **View Object** mode, and select all of the objects you wish to save. Set the lighting and angle as desired. Then click on the disk icon. Choose the **SURFdriver** format, and select a name for the new group file.

**When I try to view my object, nothing shows up in the viewing window. Why is this happening?**

First make sure that you have surfaced the object. If the object has never been surfaced, there will be nothing to render. If the object has been surfaced, make sure you have sufficient memory. Also check your settings in the **Slice Characteristics** window - you may have accidentally flattened your image by entering incorrect values.

**No image is showing up in my Editing window.**

Make sure you have sufficient free memory to load the image. Also make sure the image has been saved as a PICT file. If your first image appears, but no successive ones appear, make sure you have numbered your files correctly. If your files are number image001, image002, etc., then remove the redundant zeros (i.e. image1, image2, etc). Check the **Slice Characteristics** window and make sure the **Slice Interval** is set correctly. If you have **SURFdriver VH**, make sure that **File Sharing** is turned off on your computer.

**My question isn't answered here.**

Try checking the **SURFdriver** website FAQ page, located at <http://www.surfdriver.com/support.html>, or send your questions to [support@surfdriver.com](mailto:support@surfdriver.com)

## 11. Appendix - Y demo

The files in **Y Demo Folder** demonstrate a simple three-dimensional object reconstructed from slices. It is included to give you a series of simple images with which you may practice object reconstruction. Please read the manual before going through this exercise.

Begin by running **SURFdriver**, and selecting the **View Object** button. Load up the file named 'Y fast'. This is a so-called **Group File**, even though there is only one object in it. This type of file is not editable, only viewable; however, it loads quickly, and can be saved with a particular angle and specified light properties.

Now click the exit button (the stop sign), returning you to the Command palette. Click the 'View Object' button again, but this time select the file marked 'Y'. The same image will appear, but it will take more time to load. This is an Object file, and it is fully editable, assuming the PICT files used to create it are available. They are contained in the same folder, and are labeled **Y.1** to **Y.20**

Click the exit button again, and then click the **Edit Object** button from the Command palette. The Slice Info window will give the Slice Width as 500, Slice Thickness as 50 and Slice Interval as 1. Click OK, and the first slice will appear, with the contours already added. Go through the slices up to number 11, where the two arms of the Y become one. Note that, after this juncture, only one contour is labeled (contour #1, in green).

Now click **DONE**, and return to the Command palette. We'll now go through reconstructing a 3D object. We'll make a few mistakes along the way, just to see the possible errors that can occur.

Click the **New Object** button from the Command palette. You will be prompted for a PICT file - go into the Y Demo Folder, and select the file named 'Y.1'. Now the Slice Info window will appear, with the values Slice Thickness = 600, Slice Width = 1, Slice Interval = 1. These are the default values for the Visible Human data set. Leave them at these values for now (mistake #1). Click OK.

The first slice will now appear in the editing window (if it doesn't, refer to Section I of the manual). Choose the **Wand** tool from the Tool palette (it's the one at the top). Make sure you are on contour #1. Leave the cap setting in the **Contour Palette** (the bar across the bottom of the screen) in the middle, on **uncapped** (mistake #2). Click with the **Wand** button on the circle on the left. A green ring will appear around the circle. Now click on number 2 in the Contour Palette to change the current contour to 2. Click in the right circle, and a red ring will appear around it. You've finished your first slice!

Click on the right arrow below the Image Editing screen to advance to the next slice. Click in the left ring with the **Wand** tool. Oops! A red ring appeared! Mistake #3. We forgot to set the contour back to #1. Hit the backspace key on your keyboard, and the whole ring will disappear. Click on number 1 on the Contour Palette to get back to contour #1, then click again in the left circle. Now a green ring appears. Much better. Click number 2 in the Contour Palette to set the contour number to 2, and click in the right circle to produce a red ring. Note that you don't need to do the contour numbers in order - you could have done the right circle with contour #2 first, then done the left circle with contour #1 after.

Continue through the slices, ensuring that you keep the contour numbers associated with the same circle at each slice, until you reach slice #11. Here, you have only one contour, as the two have merged. The remainder of the slices can all be done with one contour. Generally, when two slices merge, you continue on with the smaller contour number. So, set the contour number to 1, click on the circle (producing a green ring), and carry on through the slices up to slice number 20. We'll leave contour #1 at slice 20 set to **uncapped** (i.e. the middle button) (mistake #4).

Click the **DONE** button, and choose a name and location for your object file. The 3D object will be constructed while you wait, and when complete, it will appear in the rendering window.

So there it is. It looks awful! First of all, it's white (mistake #5). Second of all, it's completely flat. That's mistake #1 showing up - we didn't set the ratio of the slice width to the slice thickness properly. We need to go back and edit the object file.



Click the stop sign. Back at the Command Palette, choose **Edit Object**. You will be prompted for an object file - find your object file and click Open. Now you will be asked to locate the PICT file named 'Y.1' - locate that file, and click OK. You will get the Slice Info screen again. This time, fill in the Slice Width to 500, and the Slice Thickness to 50. The slice interval is correct as 1; after all, our sample data slices are numbered consecutively, and we want to use every one of them. Now we've corrected mistake #1. Click OK to get to the Image Editing screen. Click on the Blue Color button. That's mistake #5 corrected. Click DONE, and save (you can give it the same name if you like, or a new name).

Back at the Command Palette, choose **View Object**, and take a look at your file. Much better! It's the right shape now, and the color is right, too. Click in the Rendering Window, and rotate the Y until you are looking at it from above. Uh-oh! You can see right into the arms of the Y - the ends aren't sealed. Same goes for the base. Those are mistake numbers 2 and 4. We didn't set the caps on the top and bottom. Click the stop sign, and go back to the **Edit Object** button. Click OK on the Slice Info window (that's set right now) and get to the Image Editing screen.

You should be on slice #1 now. Above the number 1 in the Contour Palette, click on the top button (i.e. **top capped**). Do the same for the top button above contour number 2. Now both tops of the Y are capped. Click on the **Frame #** button, then type in 20 and press Return. You will jump to slice #20. Click the bottom button above contour #1 (**bottom capped**) - that will cap off the base of the Y. Click done, give it a name and save. View the object.

The image looks much better now - no holes! Experiment with the **contrast** and **shininess** if you want. There's no point in changing the **opacity** here - there's only one object, so it will just appear to get darker if you set the OPACITY at anything other than 100%.

When the light is set the way you want it, and you've got a view you like, you can click the disk button. This will save the image as a 'group file'. Give it a new name (if you give it the same name as your object file, it will erase it, and you won't be able to edit any

more) and click **Save**. Now you can load up the object quickly and it will come up at the same angle and lighting as before!

Try experimenting with the other tools if you want. Try saving a Snapshot, or, if you've got time and you've downloaded the 'Make QTVR OBJECT' program from Apple, try making a QuickTime VR object.

If you want to see how **SURFdriver** will do with less data, Edit your object file, then go to the Slice Info window, and change the Slice Interval to 2. This will erase the data from every second slice, and you will only be able to edit every second slice within the Image Editing window. Save the file with a new name, and View it. The advantage of using fewer slices is that the image will draw faster, and the file will be smaller. The disadvantage is that the contour starts to get rough, and the true shape of the object gets distorted. With half the slices, the image is noticeably deformed if you look at it from above or below. If you set the Slice Interval to 3 or larger, the distortions will get worse, and eventually **SURFdriver** may not be able to create a 3D image at all.

When you reconstruct your own 3D object, try to find a balance between speed/size and integrity of image. This will be different for each object you work with. Large objects in the Visible Human data, the skull for example, might only require using every 10th slice; a small structure like a cochlea may require using every single slice. Experimentation will be required until you begin to develop a feel it.

If you've got slice data ready to go, start experimenting with it. Remember to convert all images to PICT files before attempting to use them with **SURFdriver**.

## 12. SURFdriver End User's Agreement

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