vlab Tools
Reference Manual

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Contents

1 Introduction

This manual describes the *tools* that exist within *vlab*. Each tool is used to interactively manipulate a specific type of data file. The following tools are currently available:

- a panel manager (*panel*) - to control parameter values embedded in a text file
- a colormap editor (*palette*) - to edit the 256 color triplets in a colormap file (`.map`)
- a material editor (*medit*) - to edit the material properties of colors in a material file (`.mat`)
- two surface editors - to define bicubic surfaces consisting of Bézier patches: *bezieredit* provides functionality to join patches with various levels of continuity, while *stedit* can display and edit a texture on the surface patch. Both use the same file format to describe the surface.
- a contour editor (*cuspy*) - to define B-spline curves in 2D space.
- a function editor (*funcedit*) - to graphically define functions of one variable.
- a utility to organize a set of contours or functions in a single file (a *gallery*), and call the appropriate editor.
- a timeline editor (*timeline*) - to order a set of functions over time.
- a basic text editor (*vlabTextEdit*) that can communicate changes with the other tools to keep data in sync.

Each tool includes Preferences, that can be used to customize default settings. The tools are designed to produce and/or edit files used by the *vlab* modeling programs *cpfg* and *lpfg*.

See the *Vlab Framework* manual for a general description of the components of *vlab*, including how the tools are used within the framework.

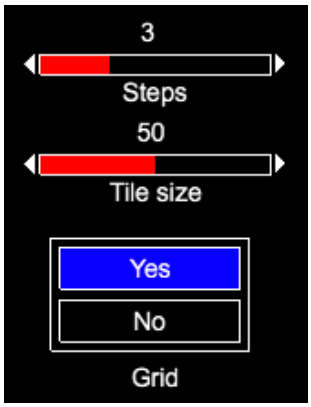


Figure 1: Example of a panel with two sliders, two buttons, and a label defining the button group.

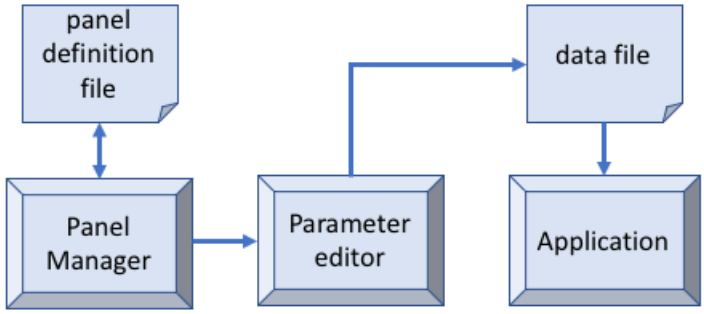
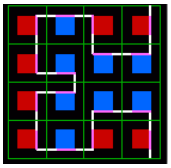


Figure 2: Communication flow from the Panel Manager to an application.

2 Panel manager (*panel*)



See object: HilbertPanels

The Panel Manager is used to create a panel with sliders and buttons (Figure 1) in *edit* mode, and output the results of manipulating the panel components in *execute* mode. The output is sent to *stdout* where it can be piped to an editor that will update a data file (Section 11.2). This makes it possible to control parameters embedded in a data file and, therefore, graphically manipulate any application that reads its parameters from a file. The communication flow is shown in Figure 2.

The command line for the panel manager is defined as:

`panel [-rmode` *mode*`]` *panelfile*

where *mode* is the refresh mode for outputting slider values:

- `triggered` or `trig` to output the slider's value when the mouse is released
- `continuous` or `cont` to output the value as a slider is moved (every slider value)

The refresh mode can also be set from the Panel Manager menu (Section 2.1.2).

2.1 Using a panel (Execute mode)

When the Panel Manager is opened, it is in execute mode, ready for the user to manipulate the components as read from the *panelfile*.

2.1.1 Manipulating sliders and buttons

Sliders. To manipulate a slider, left-click and hold within the slider outline, and move the mouse left (to decrease) or right (to increase) the value. Alternatively, click on the arrow at either end of the slider to decrement (left arrow) or increment (right arrow) the value by 1.

Buttons. Left-click on a button to activate it. There are several types of buttons:

- A *monostable button* will turn on (send value 1) and change colour when pressed, and turn off (send value 0) and return to the original colour when released.
- A *toggle button* will switch between on and off states (and colours) each time it is clicked.
- A *button group* is a set of mutually exclusive toggle buttons (as in the example in Figure 1). When any button is clicked, it is switched on and sends a user-defined message (Section 2.2.3). All other buttons in the group are switched off.

2.1.2 The panel menu

The panel menu is activated by right-clicking anywhere within the panel. The menu items are:

Menu item	Description
Pages	Select a specific panel page, if there are multiple pages. Otherwise this item will not be present.
Reset	Reread the panel definition file to restore all controls to their default values, and output all the values (Section 2.3).
Broadcast	Output all current values (Section 2.3).
Edit	Open the panel editor window and switches to edit mode (Section 2.2).
Save as default	Set the default value of each control to its current value.
Refresh mode	Set the mode for outputting slider messages: Triggered = when the mouse is released Continuous = as a slider is moved (every slider value)
Exit	Output the null character (end-of-file) to terminate the parameter editor (Section 11.2), and close the panel.

2.2 Panel edit mode

The interactive editor used to create or modify the panel specification file is invoked by selecting Edit on the pop-up menu. It provides:

- a separate Panel Editor window that interacts with the panel, and
- a grid over the panel to aid with alignment.

The Panel Editor window is divided into three main sections (Figure 3): the upper section contains items that can be added to a panel; the middle section is for aligning items on the panel; and the lower section defines characteristics of the panel itself. See Section 2.2.1 for more information on selecting and editing items.

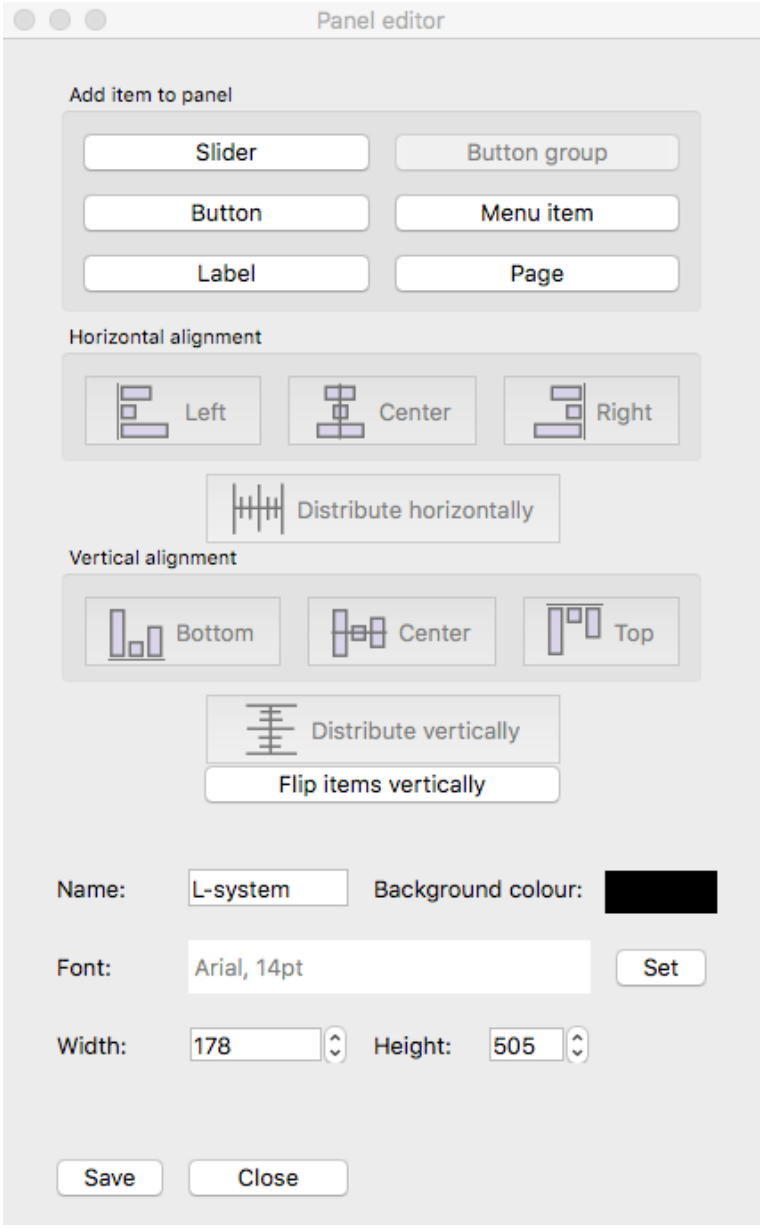


Figure 3: The Panel Editor.

There are also new options on the pop-up menu.

Main item	Sub-item	Description
Edit options	Edit item	Edit the selected item on the panel by invoking its editor (Sections 2.2.2 to 2.2.4). This can also be done by double clicking on the item.
Edit options	Clone item	Copy and paste the selected item on the same panel page.
Edit options	Copy item Paste item	Copy and paste the selected item in two steps. This allows the copied item to be pasted on another page on the panel.
Edit options	Delete item	Delete the selected item. There is no warning, and no undo, for this function.
Edit options	Edit page	Edit the page characteristics.
Edit options	Delete page	Delete the page.
Edit options	Snap to grid	Align the bottom left corner of the selected item with the nearest grid intersection. Buttons within a group will not snap to the grid, but the button group itself will.
Execute		Return to *execute* mode.
File	Load	Open another panel specification file.
File	Reread	Reread the current panel from the panel specification file, overwriting any changes made since the panel was last saved.
File	Save	Save all changes to the panel specification file. This can also be done using the Save button at the bottom of the Panel Editor window.
File	Save as...	Save all changes to a new file. This new file will be used in all subsequent Save commands.

See Section 2.4 for details of the panel specification file

2.2.1 Editing panel items

It is possible to move, edit, copy, and delete existing items on the panel, either graphically or using the Edit options on the pop-up menu.

To select items Left click on an item to select it: a dashed yellow rectangle indicates the selected item. To select several items at once, either click and drag to encompass all the items, or click on the first item then hold the Shift key down and click on each of the remaining items. This will extend the dashed yellow rectangle around all of the items. Note that clicking on the first and last item does NOT select the items in between.

To move items Once selected, items can be moved by left-clicking anywhere within the yellow rectangle and dragging.

To align items The Snap to grid menu item aligns a selected item with the nearest grid intersection. When several items are selected, the middle section of the Panel Editor is also enabled (see Figure 3). Use these functions to align the selected group of items horizontally or vertically. Note that the Flip items vertically function is always available. It flips ALL the items on the panel page, regardless of the items selected.

To add a new slider, button, or label Click on the appropriate button in the Panel Editor window. The new item will appear in the middle of the panel, and its Editor window will pop up (see the slider example in Figure 4). In addition to the dashed yellow rectangle indicating that the new item is selected, there will also be a solid yellow rectangle around the item indicating that this is the

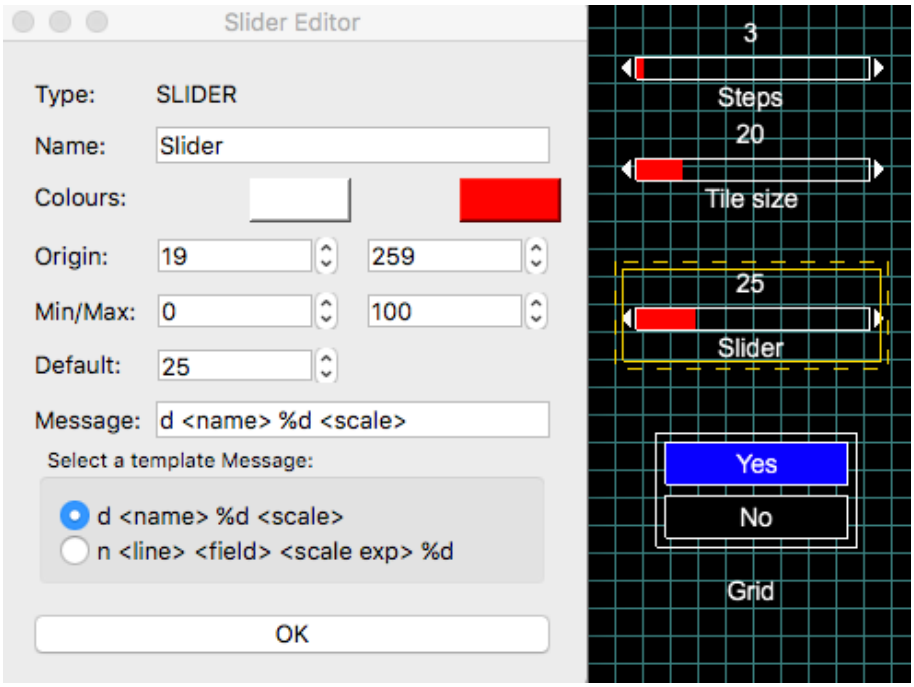


Figure 4: The Slider Editor with the new slider on the panel. The buttons have been moved from their position in Figure 1 to make room for the new slider.

item whose parameters are seen in the associated Editor window. Note that since the new item is positioned in the middle of the panel, other items may need adjusting to make room for it.

2.2.2 Sliders

Sliders are used for data parameters that can range between a set of numbers. The fields on the Slider Editor (Figure 4) are:

Fields	Description	Default
Name	The label below the slider	Slider
Colours	The outline and name colour (left) and the slide colour (right)	White / Red
Origin	The position of the slider with respect to the top left corner of the panel. Normally the slider is positioned graphically - manual adjustments are only needed for very precise positioning.	
Min/Max	The minimum and maximum values for the slider.	0 - 10
Default	The default value for the slider, used when the panel is initially invoked, and when Reset is selected from the menu. The slider will also be set to this value when the OK button is clicked.	5
Message	The message that will be output when this slider is activated. The template messages follow the standards used by the data file editor *awkped* (Section 11.2). Selecting a template populates this field, which can then be edited to replace the <> parameters as required.	d <name> %d <scale>

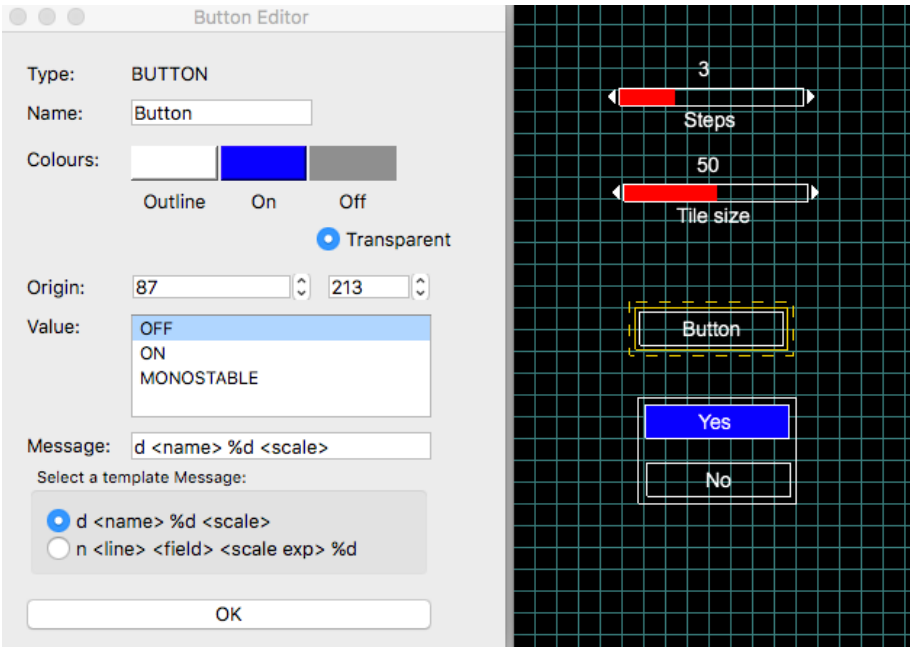


Figure 5: The Button Editor and a new button on the panel. The Yes/No buttons have been moved from their position in Figure 1 to make room for the new button.

2.2.3 Buttons

Buttons can be used for parameters with two values. The fields on the Button Editor (Figure 5) are:

Fields	Description	Default
Name	The label within the button.	Button
Colours	The Outline, On, and Off colours of the button.	white / blue / black
Transparent	When this radio button is set, there is no Off colour: the button is transparent. (The color in the editor is set to grey.)	
Origin	The position of the button with respect to the top left corner of the panel. Normally items are positioned graphically - manual adjustments are only needed for very precise positioning.	
Value	The initial setting of the button. (The rest state of a MONOSTABLE button is always off.)	OFF
Message	The message that is output when the button is activated. The template messages follow the standards used by the data file editor *awkped* (Section 11.2). Selecting a template populates this field, which can then be edited as required.	d <name> %d <scale>

If there are multiple buttons on the panel with the same label, the Panel Manager will automatically add `%Copy1`, `%Copy2`, etc to the end of the name (Figure 6). The percent sign and all text following it are not displayed on the panel itself, but make the Name unique (as required in the panel specification file). This text may be edited.

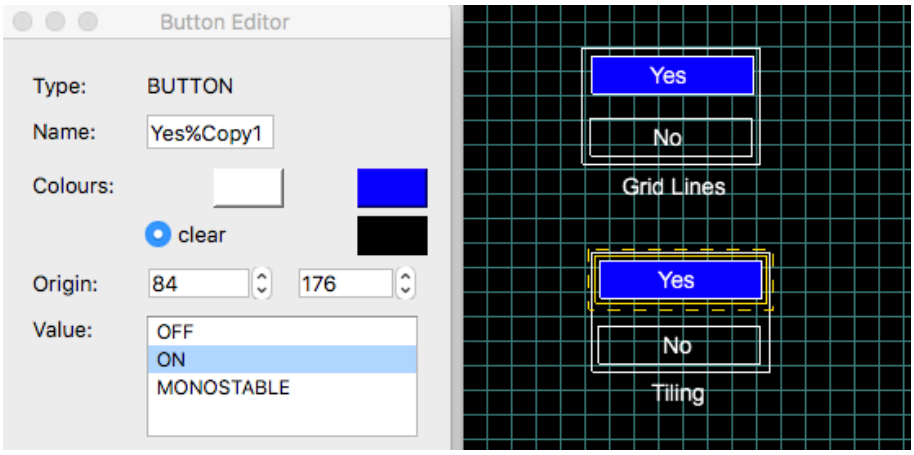


Figure 6: An example of non-unique button labels on a panel. The second Yes button has %Copy1 appended to its Name field in the Button Editor. This is not displayed on the button, but is used to distinguish this button from the one above.

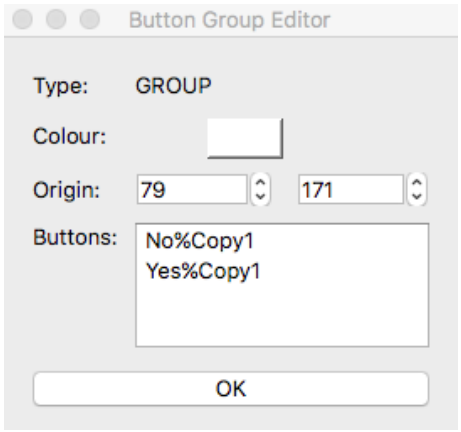


Figure 7: The Button Group Editor for the second set of buttons in Figure 6.

2.2.4 Button groups

To create a set of mutually exclusive toggle buttons (where only one button can be "on"), select a group of adjacent buttons: click on the first button, then hold down the Shift key and click on each of the other buttons in the group. Note that clicking on the first and last buttons will NOT include the buttons in between.

Selecting multiple buttons will enable the Button group function on the Panel Editor. Click it to open the Button Group Editor (Figure 7). To use the currently selected buttons, simply click OK. To edit the group later, double click on the group to open the editor. The fields on the Button Group Editor are:

Parameter	Description	Default
Colour	The outline colour for the group	white
Origin	The position of the group with respect to the top left corner of the panel. Normally items are positioned graphically - manual adjustments are only needed for very precise positioning.	
Buttons	The names of the buttons that are part of the group.	

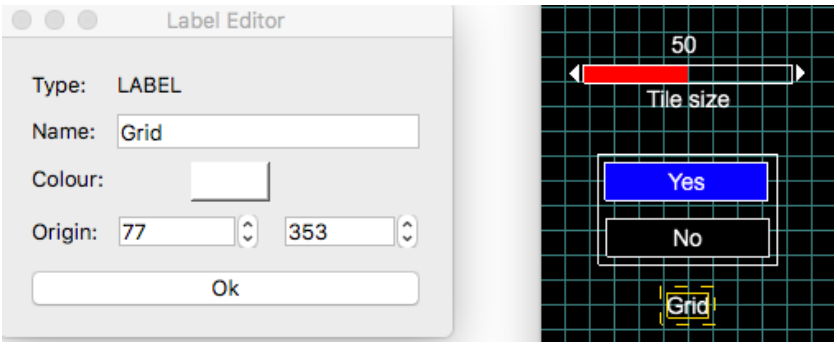


Figure 8: The Label Editor for a label defining a button group.

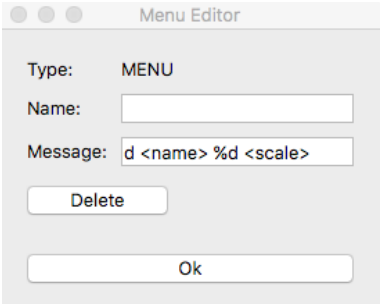


Figure 9: The Menu Editor used to add, update, and delete items for the panel's menu.

2.2.5 Labels

Labels can be used to add text anywhere on the panel. They are often used to label a Button Group. The fields on the Label Editor (Figure 8) are:

Field	Description	Default
Name	The text of the label	Label
Colour	The colour of the text	white
Origin	The position of the label with respect to the top left corner of the panel.	

2.2.6 Menu items

User-defined menu items can be added to the panel menu, where they will appear as subitems of the Custom messages menu item. (This menu item is only displayed if user-defined items have been added.)

Items are added using the Menu item function on the Panel Editor. There are only two fields on the editor, as well as a Delete button to remove an existing menu item (Figure 9):

Menu item	Description	Default
Name	The menu item name	
Message	The message that is output when the menu item is selected. The template message is the standard one used by the parameter editor (Section 11.2), but the %d field always returns 0.	d <name> %d <scale>
Delete	Delete this menu item. If it is the last user-defined menu item, Custom messages will be removed from the pop-up menu as well.	

To edit an existing custom menu item, select it from the pop-up menu (Figure 10).

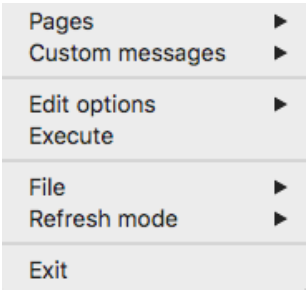


Figure 10: If the panel has multiple pages, they are listed at the top of the menu under Pages. Additional menu items are listed under Custom messages.

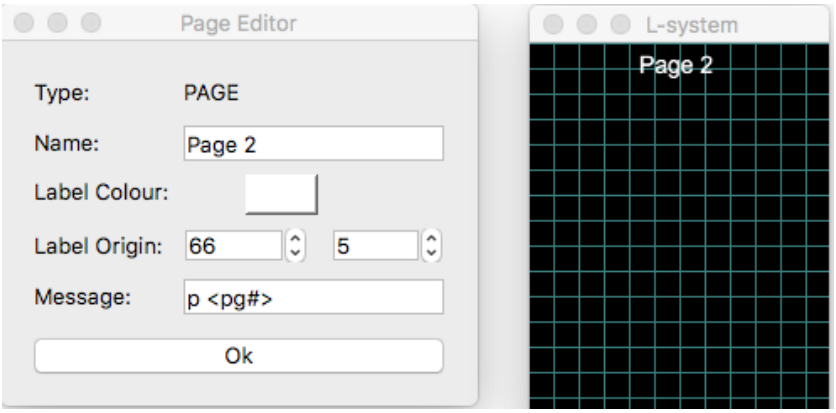


Figure 11: The default page and Page Editor when a second page is added to the panel.

2.2.7 Pages

A panel may consist of several pages, only one of which is displayed at any given time. If there are multiple pages, the list of pages will appear at the top of the pop-up menu (Figure 10).

To add a new page Click the Page function on the Panel Editor to open the Page Editor (Figure 11). The fields in the editor are:

Menu item	Description	Default
Name	The label at the top of the page.	Page n
Label Colour	The colour of the page label	
Label Origin	The location of the page label with respect to the upper left corner of the page	
Message	The message that is output when this page is selected.	p <pg#>

To edit a page Use the Pages menu item to navigate to the desired page. Either double click on the page label, or select Edit page from the pop-up menu under Edit options. This will display the Page Editor.

To delete a page Select Delete page from the pop-up menu under Edit options. This will return to the first page of the panel. Note there is no warning: the page is immediately deleted, and there is no undo.

2.2.8 Panel characteristics

The general characteristics of the panel are defined in the bottom section of the Panel Editor. The fields are:

Fields	Description
Name	The name of the panel window.
Background colour	The colour of the panel background.
Font	The font to be used for labels on the panel. To change the font, click the Set button.
Width Height	The width and height of the panel. These can also be adjusted graphically by clicking and dragging the edges of the window.

2.3 Panel output

The message associated with an item is output when the item is activated on the panel, or when Broadcast is selected from the pop-up menu (Section 2.1.2). The message is sent to *stdout*, where it can be input into the parameter editor, *awkped* (Section 11.2), and used to update values in a parameter file. This provides a mechanism for graphically changing parameters in an experiment.

Messages are output verbatim from the Message field associated with an item, with the exception of %d, which is used as follows:

- For sliders, %d is replaced by the displayed value.
- For buttons, the following %d values are output depending on the button type:
  - *Toggle button* - The %d is replaced with 1 when button is on, and 0 when off.
  - *Monostable button* - Two messages are output: %d is replaced with 1 when the button is pressed, and 0 when it is released.
  - *Button group* - The message associated with the button that has been turned on is output, replacing %d with 1. There is no message for the button(s) that are turned off.
- For all other items (pages and menu items), the %d parameter is always replaced by 0, if used.

See Section 11.2.2 for more information on using panel messages to update parameter files.

2.4 The panel specification file

The panel is read and saved from/to a text file using the File commands on the popup menu in edit mode (Section 2.2).

The specification file itself begins with a panel header, followed by blocks of lines defining each of the components of the panel, beginning with the page specification block (if more than one page is present), and then each of the components on the page. Each line of the file consists of a keyword, followed by a colon, and the associated value(s). For example, a panel header would be as follows:

```
target: View file
panel name: Viewing
background: 0,0,0
size: 178 505
font: Arial,14,-1,5,50,0,0,0,0,0
```

The keywords used in each block are described below.

2.4.1 Panel header

Keyword	Description	Panel Editor field
`target`	The name of the data file to be edited with this panel. This is for information only.	
`panel name`	The name of the panel, as seen in the panel window's title bar.	Name
`background`	The RGB components making up the background colour of the panel, separated by commas.	Background colour
`size`	The width and height of the panel, specified as two numbers separated by a space.	Width Height
`font`	The font to be used for labels throughout the panel.	Font

2.4.2 Page

Keyword	Description	Page Editor field
`type`	`PAGE`	Type
`name`	The page label.	Name
`color`	The RGB components of the label colour, separated by commas	Label Colour
`origin`	The x and y coordinates of the label with respect to the upper left corner of the panel, specified as two numbers separated by a space.	Label Origin
`message`	The message to be sent when this page is activated.	Message

2.4.3 Slider

Keyword	Description	Slider Editor field
`type`	`SLIDER`	Type
`name`	The label below the slider.	Name
`colors`	Two sets of RGB colours: one for the outline and name, and the second for the slider. The RGB components are separated by commas, with a space between the two sets of colours.	Colours
`origin`	The x and y coordinates of the slider with respect to the upper left corner of the panel, specified as two numbers separated by a space.	Origin
`min/max`	The minimum and maximum values of the slider.	Min/Max
`value`	The value of the slider when the panel opens.	Default
`message`	The message to be sent when the slider is activated.	Message

2.4.4 Button

Keyword	Description	Button Editor field
`type`	`BUTTON`	Type
`name`	The label within the button.	Name
`tricolor`	Three sets of RGB colours: the button outline, the "on" colour, and the "off" colour. The RGB components are separated by commas, with a space between each set.	Colours
`origin`	The x and y coordinates of the button with respect to the upper left corner of the panel, specified as two numbers separated by a space.	Origin
`value`	The setting of the button when the panel is opened: 0 = OFF 1 = ON 2 = MONSTABLE	Value
`message`	The message to be sent when the button is activated.	Message

2.4.5 Button group

Keyword	Description	Button Group Editor field
`type`	`GROUP`	Type
`color`	The RGB components of the group outline colour, separated by commas.	Colour
Button name 1 *Button name 2* ...	The name of each button in the group, one per line. The buttons must be defined before the group itself.	Buttons
`ENDGROUP`	To end the list of buttons.	

2.4.6 Label

Keyword	Description	Label Editor field
`type`	`LABEL`	Type
`name`	The text of the label.	Name
`color`	The RGB components of the label colour, separated by commas.	Colour
`origin`	The x and y coordinates of the label with respect to the upper left corner of the panel, specified as two numbers separated by a space.	Origin

2.4.7 Menu item

Keyword	Description	Menu Editor field
`type`	`MENU`	Type
`name`	The text of the menu item.	Name
`message`	The message to be sent when the menu item is selected.	Message

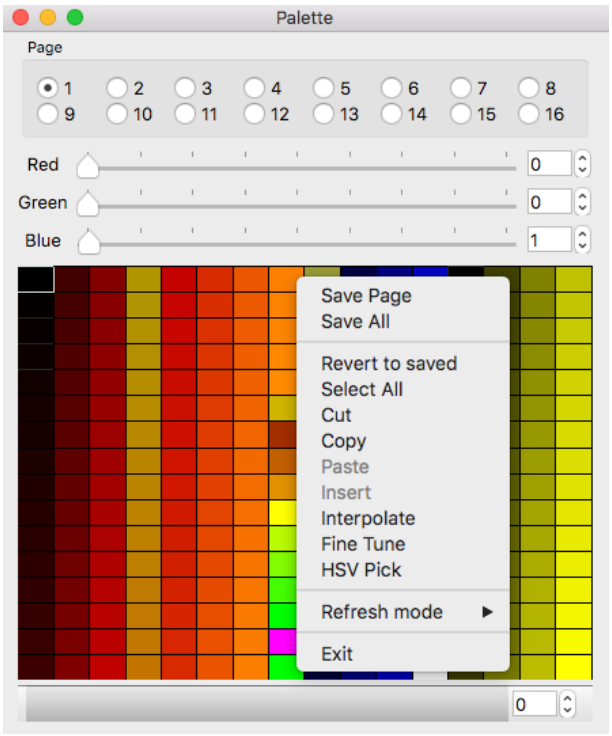
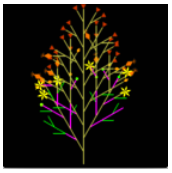


Figure 12: Example of the *palette* window and its pop-up menu. The selected color is outlined in white and its color number is indicated in the bottom right corner. The pop-up menu is displayed by right-clicking within the grid of colors.

3 Colormap editor (*palette*)

The *cpfg* and *lpfg* programs use either a colormap file, or a materials file (Section 4) to specify the colors in a simulation. The colormap file is a binary file that defines 256 colors in triplets of three bytes, one for each of the R, G, and B components of the color. Thus the file has exactly 768 bytes.

The colormap file is created and edited with the *palette* program (Figure 12). The command line syntax is:



See object: Mycelis Schematic

`palette [-rmode` *mode*`] [-m`*npage*`]` *filename*`.map`

where `-rmode` specifies the refresh mode (see the Refresh mode menu item in Section 3.2), and `-m` is used to define "pages" of colors. Each page is a separate 768-byte colormap file, and *npage* specifies the order (page number) in which the files will be opened and displayed. The page numbers range from 1 to 16, as seen at the top of the *palette* window (Figure 12). For example, to open three colormap files as three separate pages within *palette*, the command line would be:

`palette -m1` *filename1*`.map -m2` *filename2*`.map -m3` *filename3*`.map`

3.1 The color grid

The 256 colors in the *palette* grid are numbered column-wise from 0 to 255 (i.e. the first column represents colors numbered 0-15, the second column 16-31, and so on). To select a color, left-click on its cell. Its current RGB values will be displayed as positions on the sliders above the grid, as well as numbers in the field to the right of each slider. The color can be changed by

- manipulating the sliders,
- entering new numbers in the associated fields,
- using the up and down arrows next to a field to increase or decrease its value, or
- selecting the Fine Tune or HSV Pick menu item (see below).

It is also possible to select a range of colors by left-clicking on the first color, and holding the button down while dragging the mouse.

3.2 The *palette* menu

The menu items on the pop-up menu are defined as:

Menu item	Description
Save Page	Save the current page. If the page was not specified on the command line, it will be saved as `default`n`.map`, where n is the page number.
Save All	Save all pages. Any page that was created and/or modified but was not specified on the command line will be saved as `default`n`.map`, where n is the page number.
Revert to saved	Reread the file(s) specified on the command line, and update the grid with the colors specified in the file(s).
Select All	Select all the colors on the grid.
Cut	Cut the selected color(s). The remaining colors will be moved up, leaving blank (black) cells at the end of the color list (beginning at the bottom of the rightmost column).
Copy	Copy the selected color(s).
Paste	Paste the previously cut or copied color(s) at the selected cell. The current color(s) will be overwritten with the cut/copied values.
Insert	Insert the previously cut or copied color(s) at the selected cell. The current color(s) will be moved down; the color(s) at the end of the color list (beginning at the bottom of the rightmost column) will be removed.
Interpolate	Create a gradient of colors across the selected cells, by interpolating between the color in the first cell and the color in the last cell.
Fine Tune	Display a widget (Figure 13) for finely adjusting the red, green, and blue components of the selected color(s), as well as their overall brightness (value).
HSV Pick	Dispay a widget (Figure 14) for manipulating all components of the color in HSV or RGB space.
Refresh mode	Set the mode for refreshing the colormap file: Explicit = when the Save Page or Save All menu item is selected. This is the default. Triggered = as the mouse is released, when changing a color value with a slider. Continuous = continuously update as the slider changes a color value.
Exit	Close the *palette* application.

Figure 13: The *palette* widget for fine-tuning a color, or range of colors.

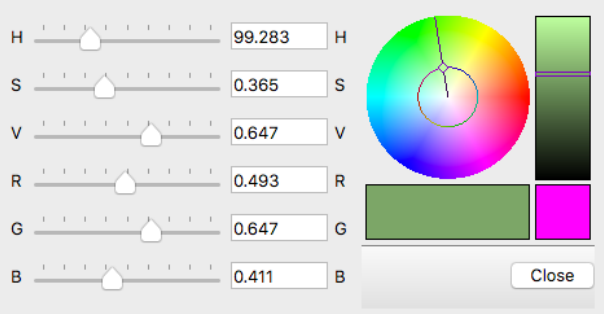


Figure 14: The *palette* widget for defining all the components of a color. Use the sliders or update the values for each component, or use the wheel to select a color and the rectangle to the right to select the brightness (value). The rectangle below the wheel displays the selected color, while the square beside it displays the original color. Return to the original color by clicking on the square.

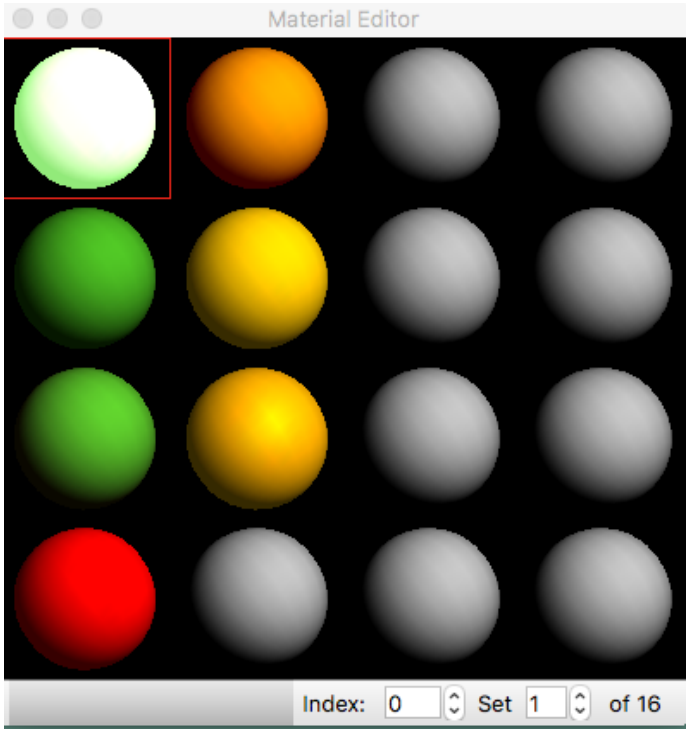


Figure 15: An example of the main *medit* window with 4 colors defined. The currently selected color is outlined in red.

4 Material editor (*medit*)

The *cpfg* and *lpfg* programs use either a colormap file (Section 3) or a materials file to specify the colors in a simulation. The material file specified the optical properties of up to 256 materials using the parameters of the Phong shading model: the ambient, diffuse, specular, and emissive colors, as well as shininess and transparency. It is a binary file that is created and edited by the *medit* program. The command line syntax of *medit* is:

See object: Monopodial Spiral

`medit [-rmode` *mode*`]` *filename*`.mat`

See Section 4.3.1 for a description of Refresh mode (the `-rmode` option).

It is possible to open several materials files simultaneously by listing multiple filenames on the command line. Each file is opened in a separate window.

4.1 The *medit* window

When *medit* is invoked a window is displayed containing 16 spheres (Figure 15). This is the default number of materials defined on each page. The page number is specified at the bottom of the window in the Set field. The number of materials displayed on a single page can be changed on the View menu (Section 4.3.4).

The materials are numbered down the columns, beginning with zero. For example, in the 4x4 window in Figure 15, the first column of materials are numbered 0-3, the second column 4-7, etc. The selected material is outlined in red, and its materials number is displayed in the Index field at the bottom of the window.

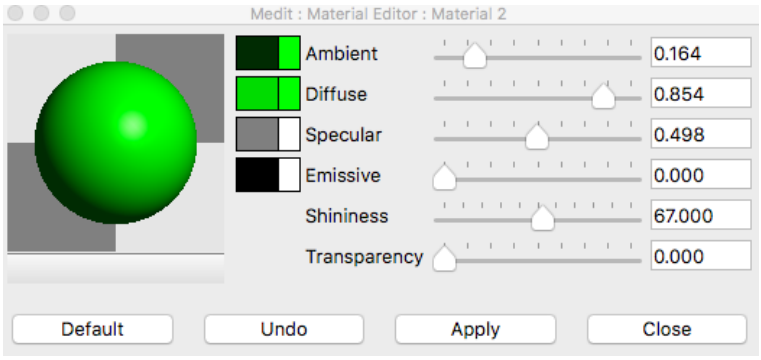


Figure 16: An example of the Material Editor widget. To change colors, click the rectangle to the left of Ambient, Diffuse, Specular, or Emissive. This will open the Colour Pick widget (Figure 17) for the attribute.

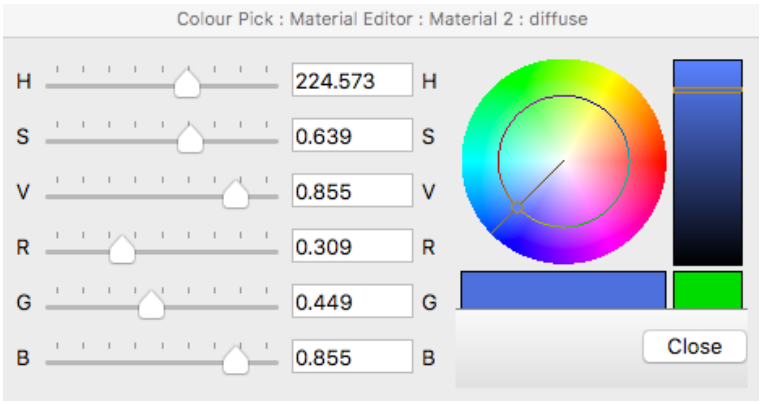


Figure 17: An example of the Colour Pick widget which is displayed when the rectangle to the left of the Ambient, Diffuse, Specular, or Emissive attribute is selected in the Material Editor widget (Figure 16). The original color is shown in the small rectangle above the Close button. Changes made here are immediately reflected in the Material Editor widget.

A material can be selected by clicking on it with the mouse, or by changing the value in the Index field. Ranges of materials can also be selected with the mouse, by clicking on the first material and dragging the mouse to the last material in the range. There are also options on the Edit menu (Section 4.3.3) for selecting ranges of colors.

4.2 Changing the material

To change the attributes of a material, double-click on the associated sphere, or select M-Edit from the pop-up menu (Section 4.3.1). This will open the widget in Figure 16. Click on the rectangle to the left of Ambient, diffue, Specular, or Emissive to open the Colour Pick widget (Figure 17) for the attribute.

4.3 The *medit* menus

The main functions of *medit* are found on the pop-up menu which is invoked by right-clicking in the *medit* window. These functions, along with less commonly used functions, are also available on the menu bar.

4.3.1 The pop-up menu

The *medit* pop-up menu contains the following options:

Menu item	Description
Save	Save the current material definitions to the file. This is only required when Refresh mode = Explicit (see below).
Save As...	Save the current material definitions to a new file.
Revert to Saved	Re-read the material definitions from the file, overwriting any changes made within *medit* since the last time the file was saved.
M-Edit	Open a widget (Figure 16) to edit the selected material.
Cut	Cut the selected material(s). The remaining materials will be moved up, leaving blank materials at the end of the last page.
Copy	Copy the selected material(s).
Paste	Paste the previously cut or copied material(s) at the selected cell. The current material(s) will be overwritten with the cut/copied values.
Insert	Insert the previously cut or copied material(s) at the selected cell. The current material(s) will be moved down; the material(s) at the end of the last page will be removed.
Interpolate	Create a gradient of colors across the selected materials, by interpolating between the color of the first material and the color of the last material.
Set to Default	Set the current material to the default attributes: grey with Ambient = 0.2. This is the same as clicking the Default button in the dialog box.
Refresh mode	Set the mode for refreshing the materials file: Explicit = only when the Save command is selected. This is the default. Triggered = when a material attribute is changed, and the mouse is released. Continuous = as a material attribute is changed (all values of a slider as it is moved with the mouse).

4.3.2 The File menu

The functions available on the File menu are:

Menu item	Description
New	Close the current file (a dialog box will be displayed if changes have been made), and open a new *medit* window with default values for all materials.
New Window	Open a new *medit* window, without closing the old one. The default file name for the new window is noname.mat.
Load...	Close the current file, and open the file selected in the dialog box.
Load New Window...	Open a new *medit* window for the file selected in the dialog box, without closing the old one.
Save Save As... Revert to Saved	See the pop-up menu (Section 4.3.1).

4.3.3 The Edit menu

The functions available on the Edit menu are:

Menu item	Description
M-Edit Copy Paste Insert Interpolate Set to Default	See the pop-up menu (Section 4.3.1).
Select Range...	Select a range of materials by providing the index of the first material and either the number of materials, or the index of the last material.
Select All in Page	Select all the materials displayed in the window.
Select All	Select all 256 materials available in the material file, including materials not displayed on the current page.

4.3.4 The View menu

The functions available on the View menu are:

Menu item	Description
New Page Prev Page First Page	Move between pages of materials, similar to changing the Label field at the bottom of the *medit* window.
xs - 1x1 sm - 4x4 md - 8x8 lg - 16x16	Change the number of materials displayed on each page.
Enter/Exit Full Screen	Enter and exit full screen mode.

4.4 The materials file

The file produced by the material editor has the extension `.mat`. It is a binary file that contains one or more 15-byte records of the form:

```
struct materialrecord
{
unsigned char id;
unsigned char transparency;
unsigned char ambient[3];
unsigned char diffuse[3];
unsigned char emission[3];
unsigned char specular[3];
unsigned char shininess;
};
```

The parameters are defined as:

Parameter	Description
`id`	The material number
`transparency`	The transparency applied to all material components, where 0 = no transparency, and 255 = full transparency.

Parameter	Description

`ambient`
`diffuse`
`emission`
`specular`
	The RGB values of the respective material components.

`shininess`	A value in the range [0,128] that defines the shininess of the material.

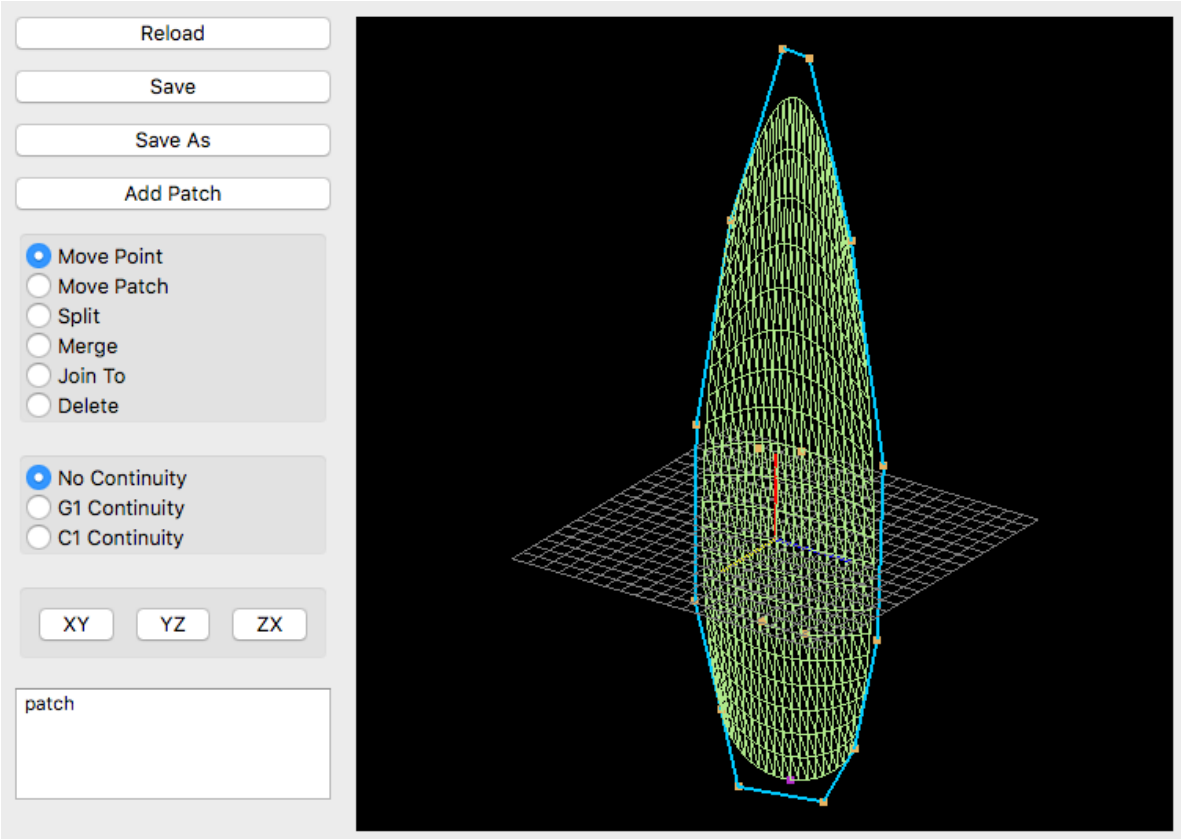


Figure 18: An example of the *bezieredit* window.

5 Surface editor (*bezieredit*)

See object:
LeafPosition

The surface editor defines a bicubic surface consisting of Bézier patches. The patches can exist separately, or can be joined with various degrees of continuity. All work is done in a single window. The surface can be rotated around the x and y axes to view it from any angle. It is edited by manipulating the control points of the Bézier patches. The points always move in the plane of the screen.

The command line syntax is:

```
bezieredit [filename]
```

When invoked, the *bezieredit* window is displayed with a view of the surface on the right, and a control panel on the left (Figure 18).

5.1 Viewing the surface

5.1.1 Manipulating the view

The image can be manipulated with the left mouse button and control keys:

- To rotate the image, use the Shift key
- To zoom in and out, use the Command key
- To pan left/right/up/down, use the Alt key

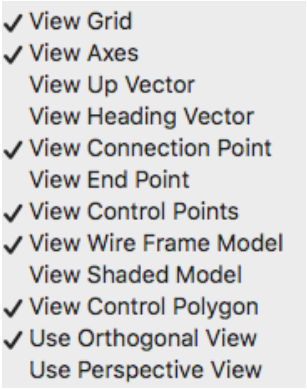


Figure 19: An example of the *bezieredit* pop-up menu.

The three buttons labeled XY, YZ and ZW on the control panel will make the respective plane parallel to the screen, corresponding to the front, side, and top views of the surface.

5.1.2 View elements

Use the pop-up menu (Figure 19), invoked by clicking the right mouse button in the surface view, to show/hide various elements of the view. Note that:

- Up Vector and Heading Vector are attached to the connection point.
- View Wire Frame Model and View Shaded Model are mutually exclusive: selecting one disables the other.
- Use Orthogonal View and Use Perspective View are also mutually exclusive.

5.1.3 Highlighting patches

Each patch is assigned a name, which is displayed in the box above the Help button on the control panel. When a surface has multiple patches, it is often convenient to highlight a particular patch. Clicking on a patch name will change its color, making it more visible. The highlighting does not affect the underlying data.

5.2 Manipulating the surface

5.2.1 Adding a patch

Use the Add Patch button on the control panel to create a new patch. The patch will be in the xy-plane, and approximately the same size as the current surface. A default patch name will be inserted into the list on the left. To change the name, double click on it. Note that the name must NOT contain any spaces.

5.2.2 Editing modes

The functionality of the left mouse button for manipulating the surface depends on the editing mode selected on the control panel, using the set of radio checkboxes below the Add Patch button:

Button	Description
Move Point	Move a single point by clicking and dragging it. The point is moved in the plane parallel to the screen. See Section 5.2.4 for details on manipulating a point that is occluded.
Move Patch	Move a patch by clicking and dragging one of its control points.
Split	Split patches by selecting a point on an edge or corner shared by the patches. The patches can then be moved apart using Move Patch.
Merge	Merge two patches by selecting a control point on the corner or edge of one patch and then selecting any point on the second patch. Be sure to select the Continuity constraints (Section 5.2.3) before merging. The two patches will be merged based on the point selected on the first patch only: the corresponding edge or corner of the second patch will be selected automatically. For example, if the first selected point is on the right edge of the patch, the left edge of the second patch will be merged with it. Likewise, the upper-left corner of the first patch will always join to the lower-right corner of the second patch. The points that become the shared edge or corner are the interpolated values of the original values of the points from the first and second patches.
Join	Join two patches by selecting a control point on the corner or edge of one patch and then selecting any point on the second patch, similar to Merge. However, instead of interpolating the positions of the points along the shared edge or corner, the positions of the second patch are used. This will maintain the shape of the second patch when no continuity is enforced (Section 5.2.3). If continuity is enabled, the second patch's interior points may be modified somewhat, but the edges will be preserved.
Delete	Delete a patch by selecting any control point on it.

5.2.3 Continuity constraints

When continuity is enabled, all patch manipulation occurs under the specified continuity constraints. Control points will be modified automatically as needed to ensure that the constraints are retained around the edited points. The continuity constraints are:

Button	Description
No Continuity	No constraints enforcing smoothness are present.
G1 Continuity	Geometric continuity constraints are enforced.
C1 Continuity	Algebraic continuity of the first derivative is enforced.

5.2.4 Sticky points

In some cases a point to be manipulated may be occluded by the image. The solution is to define it as a "sticky point" by double-clicking on it in any view where it is visible. The point will change color to indicate that it is now defined as a sticky point. When the sticky point is occluded by other points, it can be selected by clicking on the area where it is known to be. It can then be dragged as required. The point can be returned to normal by double-clicking on it again, or by selecting a new sticky point.

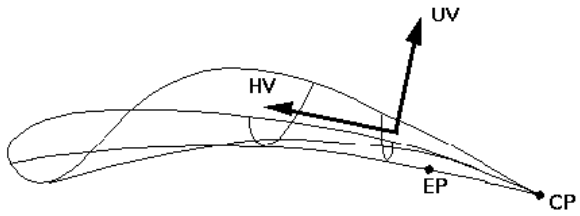


Figure 20: The geometric parameters in the header of a surface file: CP = contact point; EP = end point; HV = heading vector; UV = up vector.

5.3 Updating the surface specifications

The three buttons at the top of the control panel are used to update the surface specifications in the editor, or in the file:

Button	Description
Reload	Re-read the surface specification file, overwriting the current surface.
Save	Save the current surface to the file.
Save As	Save the current surface to a new file. A dialog box will be displayed to enter the new file name.

5.4 The *bezieredit* specification file

The file output from *bezieredit* has the following format, where x, y and z are real values, i and j are integers, and the remaining variables are text strings.

The header section of the file contains parameters that apply to the surface as a whole. See Figure 20 for a visual representation of the geometric parameters. These turtle references are pertinent to the surface's integration into models generated by *cpfg* and *lpfg*.

Parameter	Description
x_{min} x_{max} y_{min} y_{max} z_{min} z_{max}	The minimum and maximum values of the x, y, and z coordinates of the surface as a whole.
`CONTACT POINT X:`x `Y:`y `Z:`z	The point at which the surfaces connects to the turtle.
`END POINT X:`x `Y:`y `Z:`z	The point where the turtle is positioned after drawing the surface.
`HEADING X:`x `Y:`y `Z:`z `UP X:`x `Y:`y `Z:`z	The heading and up vectors of the surface, matched to the corresponding vectors of the turtle to determine the orientation of the surface.
`SIZE:` x	The scaling parameter giving the size, in surface units, to be considered as equivalent to the default unit length associated with the `F` symbol/module in *cpfg* and *lpfg*.

The header is followed by groups of 9 lines, each describing one component patch. Each group contains the following parameters:

Parameter	Description
patchname	The name used to identify the patch.
`TOP COLOR:` i `DIFFUSE:` x `BOTTOM COLOR:` j `DIFFUSE:` y	The color and diffuse lighting coefficients for either side of the patch. If the values are zero, the current parameters associated with the turtle are used.

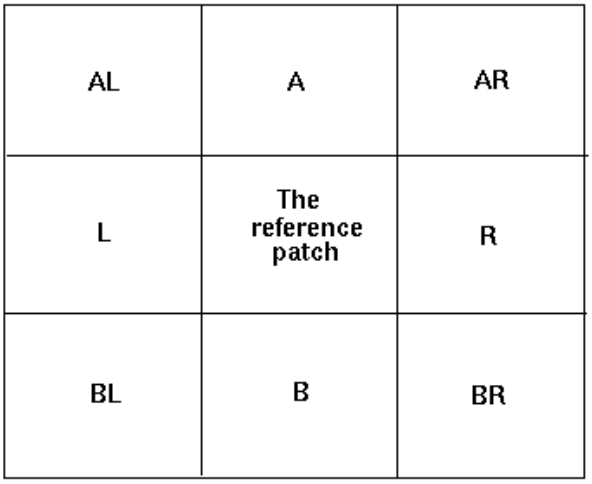


Figure 21: The abbreviations used to define the neighbours of a specified (reference) patch.

Parameter	Description
`AL:` *patch1* `A:` *patch2* `AR:` *patch3* `L:` *patch4* `R:` *patch5* `BL:` *patch6* `B:` *patch7* `BR:` *patch8*	The patch neighbourhood information. The patch arranglement is illustrated in Figure 21: `AL` = above left; `A` = above; `AR` = above right; `L` = left; `R` = right; `BL` = bottom left; `B` = bottom; and `BR` = bottom right. If there is no neighbouring patch, the tilde ($\sim$) symbol is used.
$x_{11}\ y_{11}\ z_{11}\ x_{12}\ y_{12}\ z_{12}\ x_{13}\ y_{13}\ z_{13}\ x_{14}\ y_{14}\ z_{14}$ $x_{21}\ y_{21}\ z_{21}\ x_{22}\ y_{22}\ z_{22}\ x_{23}\ y_{23}\ z_{23}\ x_{24}\ y_{24}\ z_{24}$ $x_{31}\ y_{31}\ z_{31}\ x_{32}\ y_{32}\ z_{32}\ x_{33}\ y_{33}\ z_{33}\ x_{34}\ y_{34}\ z_{34}$ $x_{41}\ y_{41}\ z_{41}\ x_{42}\ y_{42}\ z_{42}\ x_{43}\ y_{43}\ z_{43}\ x_{44}\ y_{44}\ z_{44}$	The patch control points. Each line represents one row of four points.

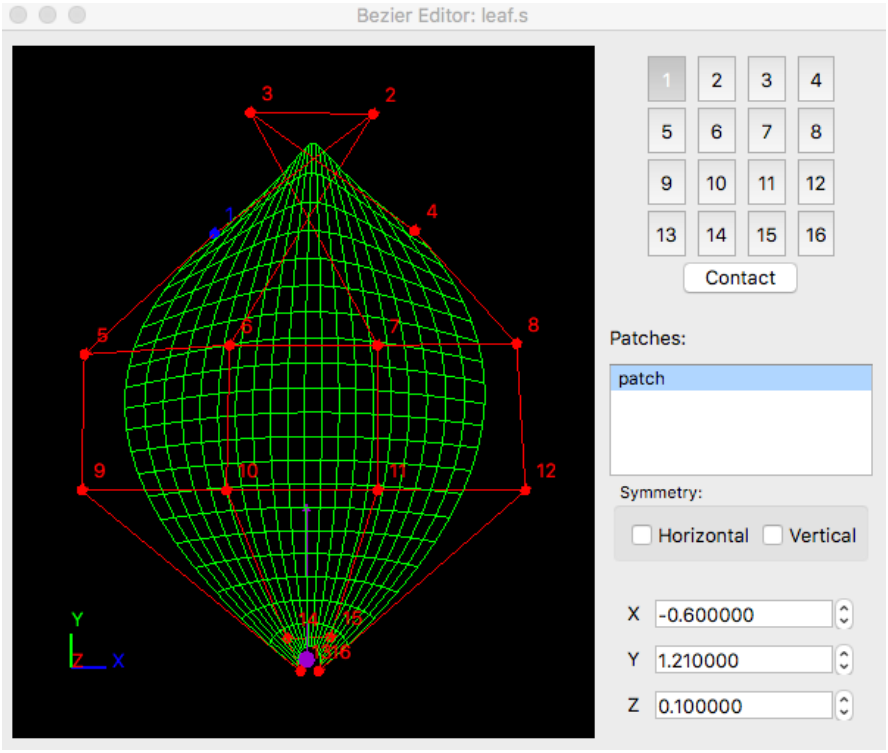


Figure 22: An example of the Bezier Editor window in *stedit* when only a surface file is included on the command line with the `-bezier` option.

6 Surface & texture editor (*stedit*)

See object: Monopodial-Maple

The surface and texture editor, *stedit*, provides slightly different functionality than *bezieredit* (Section 5). It uses the same file format to define a bicubic surface, but is designed for a single Bézier patch[1] with functionality to distort and place a texture on the patch.

The patch is defined in the Bezier Editor window; the texture in the Texture Distorter window. The texture can also be displayed on the patch in the Bezier Editor window.

There are several command line options, depending on whether the surface and/or texture should be invoked:

Command line	Description
`stedit -bezier` *surfacefile*	Open the Bezier Editor, and display the patch defined in *surfacefile*.
`stedit -bezier` *surfacefile texturefile*	Open the Bezier Editor, and display the patch defined in *surfacefile* superimposed with the texture image in *texturefile*.
`stedit -warp` *texturefile*	Open the Texture Distorter window, and display the texture defined in *texturefile*.
`stedit -both` *surfacefile texturefile*	Open both the Bezier Editor window and the Texture Distorter window, with the texture superimposed on the patch in the Bezier Editor window.

[1] *stedit* can display multiple patches (with the texture placed separately on each patch), and manipulate the control points of each patch, but it does not include the *bezieredit* functionality to manage the connections between the patches.

In addition, the command line can also include the `-rmode` option to set the refresh mode (see the Refresh mode menu item in Section 6.1.3).

6.1 The Bezier Editor window

The main *stedit* window, Bezier Editor, can be invoked with or without a texture. When *stedit* is invoked with the surface file only (using the `-bezier` option), the Bezier Editor window will display the surface and its control points (Figure 22).

6.1.1 Manipulating the view

The mouse can be used for most basic manipulations of the view:

Action	Description
Rotate	Click the left mouse button and drag
Pan	Hold the Shift key down, click the left mouse button and drag
Zoom	1. Hold the Alt key down, click the left mouse button and drag 2. Use the scroll wheel or middle button on the mouse 3. Use a two finger gesture on the mouse pad

Other view operations are available on the menus (see Section 6.1.3).

6.1.2 Editing points

There are several options for selecting and editing the control points and contact point:

- Hold the Command key down, and click and drag with the left mouse button. (See the Lock Rotations menu item in Section 6.1.3, to click and drag without using the Command key.)
- Select the point using the buttons on the side bar.
- Adjust the x, y and z coordinates of the point using the X, Y and Z fields at the bottom of the side bar.
- Click the Horizontal or Vertical checkbox under Symmetry on the side bar, to symmetrically move opposite control points. Note that the symmetry is *with respect to the contact point*, so may have unintentional results.
- Select Edit > Contact Point on the menu bar (Section 6.1.3) for more detailed editing of the contact point.

6.1.3 The Bezier Editor menus

Pop-up menu The main functions associated with the surface are available on the pop-up menu which is invoked by right-clicking anywhere in the window. Some of these functions are also available on the menu bar, as indicated below:

Menu item	Description	Menu bar
Lock Rotation	Locks the current rotation in place, allowing the left mouse button to be used to select control points directly, without the use of the Command key.	View
Transform > Flip	Turn the surface 180° around a Horizontal or a Vertical axis at the contact point, or flip the Z coordinate of each point (Depthwise) to the opposite side of the contact point.	Edit

Transform > Translate...	Open a dialog box to enter the x, y and z increments to apply to all control points. Note that the contact point is NOT translated.	Edit
Transform > Rotate...	Open a dialog box to enter the x, y and z coordinates of the point around which to rotate the surface, and the angle of rotation.	Edit
Transform > Scale...	Open a dialog box to enter the x, y and z factors for scaling the surface. Clicking the Uniform checkbox will sync the scaling across all three axes.	Edit
Reset view	Return the view to the XY plane.	View
Center	Center the control points in the window. This function centers a single patch only.	View
Center at Contact	Move the surface such that the contact point is in the centre of the window.	View
Reload	Reread the surface from the surface file. A dialog box will be displayed to confirm that the surface should be reverted to the most recently saved version.	File
Refresh mode	Set the refresh mode to Explicit, Triggered or Continuous. The default is Explicit.	File
Quit	Exit the program. A dialog box will be displayed if changes have been made but not saved.	Stedit

Menu bar There are several functions available on the menu bar, in addition to the ones noted above:

Menu bar	Menu item	Description
File	New	Close the current window (after checking whether to save changes), and open a new Bezier Edit window with a default square surface.
File	Save	Save the current characteristics of the surface to the surface file. This is only required when the refresh mode is set to Explicit.
File	Save As...	Save the current characteristics of the surface to a new file. A dialog box will be displayed to enter the new file name, which will be used with subsequent Save commands.
File	Open	Close the current window (after checking whether to save changes), and open a new surface file. A dialog box will be displayed to select the file.
Edit	Undo / Redo	Undo / redo the previous action taken.
Edit	Contact Point...	Open a dialog box to adjust all the characteristics of the contact point: its position (Contact Point), End Point, Heading Vector, Up Vector, and Size.
View	Wireframe	Toggle between a wireframe and shaded representation of the surface. The shade surface may be textured (Section 6.1.4).
View	Reset view	Resets the view after panning, zooming, and/or rotating.
View	Resize	Change the radius of the circles representing control points, the width of the lines between control points, the width of wireframe lines, and/or the number of wireframe subdivisions.
View	Color	Change the color of each component in the window, or Reset all colors to the default values.

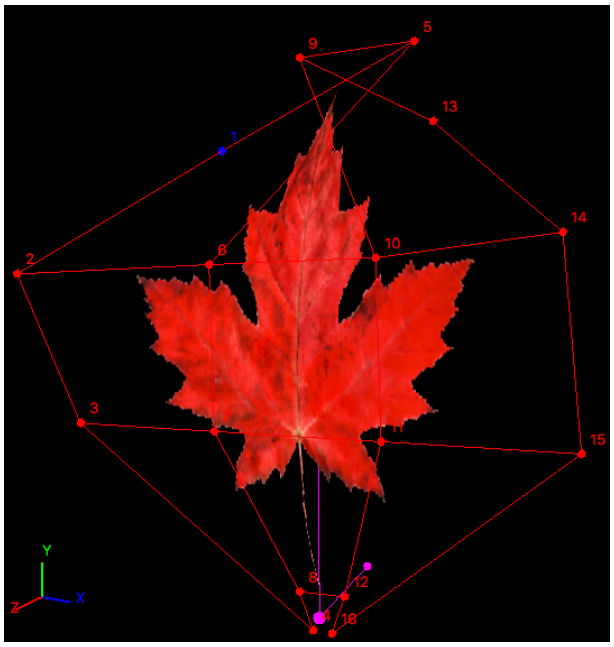


Figure 23: A view of a Bezier Editor surface with a texture superimposed.

6.1.4 Viewing a texture

There are two options for displaying a texture on the surface:

- Include the texture filename after the surface file on the command line with the `-bezier` option. The control points can be used to manipulate the underlying surface, but the texture itself cannot be manipulated.
- Use the command line option `-both` to open both the Bezier Editor window and the Texture Distorter window (Section 6.2). Changes to the image in the Texture Distorter window will be reflected in the Bezier Editor window.

In both cases the texture is displayed in the Bezier Editor rather than the surface (Figure 23). To see the surface instead, select View > Wireframe from the menu.

6.2 The Texture Distorter window

An *stedit* texture is an image file in PNG, JPG, or TIFF format that can be superimposed on the surface defined in the Bezier Editor window. The Texture Distorter provides functionality to warp the image to better fit the surface. It can be invoked separately with the `-warp` command line option, or in conjunction with the Bezier Editor window using `-both`.

6.2.1 Manipulating the control points

When the image is first displayed, there are default control points in each corner (Figure 24). The image is distorted by clicking on and dragging the existing control points with the left mouse button. More control points can be added by holding down the Command key and left-clicking on the location for a new control point.

To hide/show the control points and lines, hold the Command key down and tap the '1' key for control points, and the '2' key for lines.

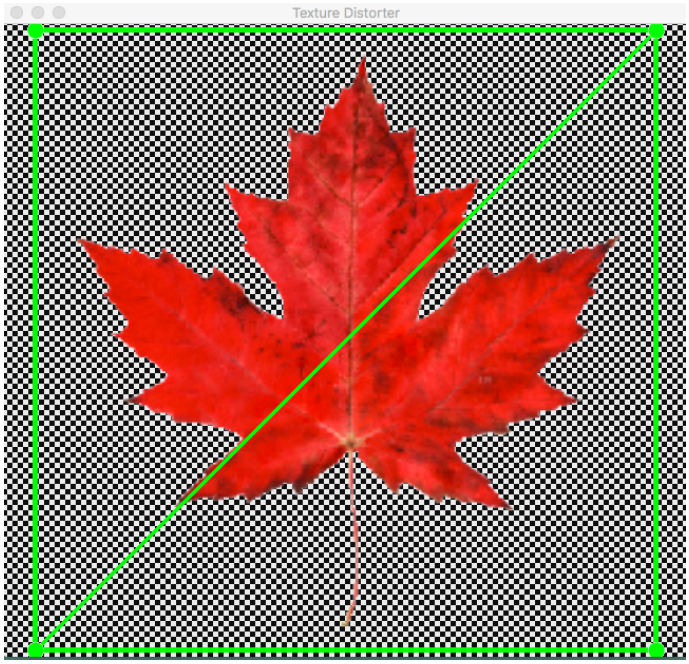


Figure 24: The *stedit* Texture Distorter window displaying the same texture as Figure 23. Note that many images used as textures, including this one, have a transparent background. This is indicated by a checkerboard pattern.

The distorted image can be temporarily captured (and the control points reset to the default four) using the Edit > Capture menu item. This allows the image to be manipulated further and reset to the captured state using Edit > Reset to capture.

When the distorted image is saved and re-opened later, the default four control points will be displayed again. If the manipulated control points are needed later, they should be saved in a DTX file using the File > Control points > Save menu item. This will open a dialog box to enter a filename to store the current set of control points. Then, when the image is re-opened at a later time, the control points can be retrieved using File > Control points > Open.

6.2.2 The Texture Distorter menus

Pop-up menu The main functions associated with the texture image file are available on the pop-up menu by right-clicking anywhere in the window. Some of these functions are also available on the menu bar, as indicated below:

Menu item	Description	Menu bar
Resize image	Distort the image by altering its height or width. A dialog box is displayed to enter the new values.	Edit
Rotate CW	Rotate the image clockwise.	Edit
Rotate CCW	Rotate the image counter-clockwise.	Edit
Flip Horizontal	Display a mirror image of the texture.	Edit
Flip Vertical	Flip the texture upside down.	Edit
Save Texture	Save the current view of the texture to *texturefile*.	File > Texture
Reload	Reread the image from the texture file.	File

Refresh mode	Set the refresh mode to Explicit, Triggered or Continuous. The default is Explicit.	File
Quit	Exit the program. A dialog box will be displayed if changes have been made but not saved.	Stedit

Menu bar There are several functions available on the menu bar in addition to the ones noted above:

Menu bar	Menu item	Description
File	Texture > Save As...	Save the displayed image to a new file. A dialog box will be displayed to enter the new file name, and this new file will be used with subsequent Save commands.
File	Texture > Open	Close the current window (after checking whether to save changes), and open a new image file. A dialog box will be displayed to select the file.
File	Control points > Save	Save the current control points into a DTX file. This provides a means of setting the control points the next time the texture file is opened (rather than using the default control points). A dialog box will be displayed if a control point file has not previously been opened or saved.
File	Control points > Save As...	Save the current control points to a new DTX file. A dialog box will be displayed to enter the new file name.
File	Control points > Open	Set the control points based on the information in a DTX file. A dialog box will be displayed to select the file. This file will be used for subsequent Control points > Save commands.
Edit	Undo / Redo	Undo or redo control point operations.
Edit	Capture	Reset the control points to the default four (one in each of the four corners), and temporarily save the current version of the image.
Edit	Reset to capture	Return the image to the version saved with the Capture command.
View	Reset	Reset the view to display the control points and connecting lines (if they were turned off with the View > Show option).
View	Show	Turn on/off the display of the control points and connecting lines.
View	Resize	Change the size of the control points and/or the width of the connecting lines. A dialog box will be displayed to enter the new value.
View	Color	Change the color of components in the window, or reset to the default values.

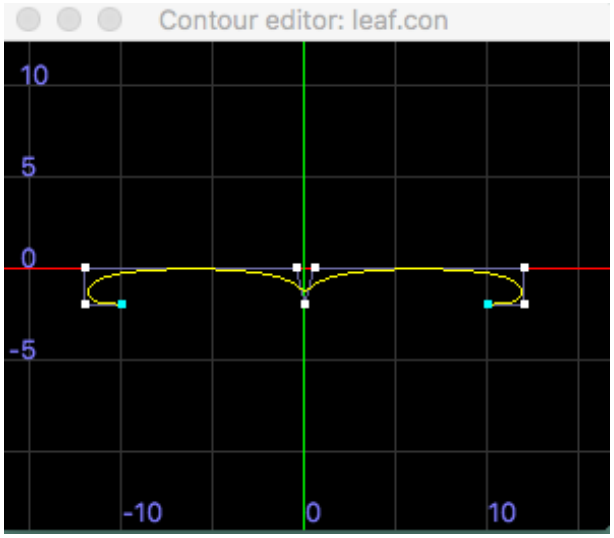


Figure 25: An example of the *cuspy* window.

7 Contour editor (*cuspy*)

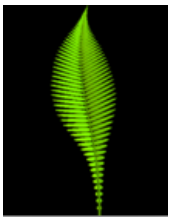
The contour editor, *cuspy*, is a utility for editing B-spline contours in 2D space. The curve may be open or closed.

The command line for invoking the editor is:

```
cuspy [-rmode mode] [filename]
```

If *filename* is not specified, a default contour of four control points is created, approximating a circle about the origin. The `-rmode` option sets the refresh mode (see Section 7.3). When invoked, the window in Figure 25 is displayed.

Contours defined by *cuspy* can also be grouped using *gallery* (Section 9).



See object:
FernLeaf

7.1 Manipulating the view

Use the menu (Section 7.3) to show/hide elements of the view (points, line segments, curve, limits), and the mouse and keyboard to:

- Zoom in and out (Alt key). It is also possible to zoom with the scroll wheel on the mouse, or with two fingers on a mouse pad.
- Pan (Shift key)

7.2 Manipulating the contour

The shape of the contour is manipulated by moving the control points. The actions related to control points all use the left mouse button. They are:

Action	Description
Move	Select and drag the control point.
Add	Hold down the Command button, and click at the desired location.
Change multiplicity	Double click on the control point. The color of the point will change. Double-clicking on a point with a multiplicity of 3 (the maximum) will reset it to multiplicity 1.
Translate all	Hold down the Command button, and use the arrow keys to move the entire contour. For larger steps, hold the Shift key down as well.
Delete	Hold down the Shift and Command buttons, and click on the point to be deleted.

7.3 The *cuspy* menus

Cuspy has both a pop-up menu, invoked by clicking on the window with the right mouse button, and a menu bar. Both contain the same actions. The following table lists the actions in the order given on the pop-up menu, and indicates where they can be found on the menu bar.

Action	Description	Menu Bar
Save	Save the current contour to the file. This is only needed when Refresh mode = Explicit (see below).	File
Save as...	Save the current contour to a new file. A dialog box will be displayed to enter the new file name.	File
Revert to saved	Reload the contour from the file, overwriting any changes made since the contour was last saved.	File
Load background image	Load an image to be displayed in the background. This makes it possible to define a contour to match an image. By default the image is displayed with the lower left corner at the origin, and is scaled such that the top of the image is at $y = 1$. It can be moved using the arrow keys.	File
Closed	Create a closed contour by assuming the last control point connects to the first one.	View
View points	Display/hide the control points.	View
View segments	Display/hide the line segments connecting the control points.	View
View curve	Display/hide the contour curve.	View
View axes	Display/hide the lines representing the x and y axes.	View
Edit name...	Update the name of the contour in the specification file.	File
Edit number of samples...	Change the number of samples that will be precomputed by *cpfg* or *lpfg* when using this contour.	File
Refresh mode	Set the mode used to refresh the file: Explicit = only with the Save command (default). Triggered = when the mouse button is released. Continuous = as a change is being made (all values as the mouse is moved).	

7.4 The contour specification file

The contour editor has been enhanced several times, resulting in several versions of the specification file. (See earlier versions in Section 7.5.) The editor will read all versions of the file, but will update the file to the latest version when saving.

The latest version of the contour specification file has the following format:

Parameter	Description
`cver 1 3`	The latest version of the file.
`name:` *name*	The name of the contour.
`background:` *filename* `backgroundXY:` *bx by*	Parameters added when the background image in *filename* is loaded (see the Load background image menu item). *bx* and *by* are world coordinates of a translation vector displacing the bottom left corner of the image from the origin.
`points:` *n1 n2*	The number of distinct control points, *n1*, and the sum of their multiplicities, *n2*.
$x_1\ y_1\ z_1\ m_1$ $x_2\ y_2\ z_2\ m_2$ $x_3\ y_3\ z_3\ m_3$ ... $x_{n1}\ y_{n1}\ z_{n1}\ m_{n1}$	The *x, y,* and *z* coordinates of each control point, and its multiplicity, *m*. The *z* coordinate is set to zero by *cuspy*, although non-zero values can also be interpreted by *cpfg* and *lpfg*.
`type:` *type*	The type of contour: `or` = open contour `cr` = closed contour
`samples:` *n*	A generalized cylinder generated by *cpfg* or *lpfg* will have *n* sides when drawn with this contour. If this parameter is not included, the default value is 8.

The control points of contours specifying the cross-section of a generalized cylinder to be generated by *cpfg* or *lpfg* should be specified in consistent order, because interpolation between clockwise and counter-clockwise contours will result in a twisted cylinder.

Note that if a contour includes some singularity (e.g. a cusp created by having three control points at the same location), the normals calculated by *cpfg* or *lpfg* may produce unexpected results.

7.5 Obsolete Contour Editor formats

The following file formats may exist in old objects within *vlab*. The files can still be read by the contour editor, but will be saved using the latest format.

None of these earlier versions has a `samples` parameter. The default value of 8 is used.

Version 1.2 does not include the background image parameters, but has two additional *type* values, `oe` and `ce`, for open and closed contours with endpoint interpolation. These types have been deprecated. The format of the file is:

`cver 1 2`
`name:` *name*
`points:` *n1 n2*
$x_1\ y_1\ z_1\ m_1$
$x_2\ y_2\ z_2\ m_2$
$x_3\ y_3\ z_3\ m_3$
...
$x_{n1}\ y_{n1}\ z_{n1}\ m_{n1}$
`type:` *type*

Version 1.1 has different `type` values: `open` and `closed`. The format of the file is exactly the same as Version 1.2, except for the version number: `cver 1 1`.

Version 1.0 has an entirely different format. It begins with a single header line followed by the x, y, and z coordinates of each point:

n *dim type*
x_1 y_1 z_1
x_2 y_2 z_2
x_3 y_3 z_3
...
x_n y_n z_n

where n is the number of points, *dim* is the dimension (`2` or `3`), and *type* is `open` or `closed`. For example, a closed 3-dimensional contour with 12 control points could be defined as:

```
 12 3 closed
 0.16 -1.12 2.0
 0.41 -1.04 1.0
 0.58 -0.33 0.5
 1.08 -0.04 0.2
 1.08  0.49 0.0
 0.49  0.54 0.0
 0.33  0.91 0.1
-0.37  1.04 0.3
-0.70  0.62 0.2
-1.12  0.16 0.1
-0.87 -0.74 0.3
-0.41 -0.66 1.0
```

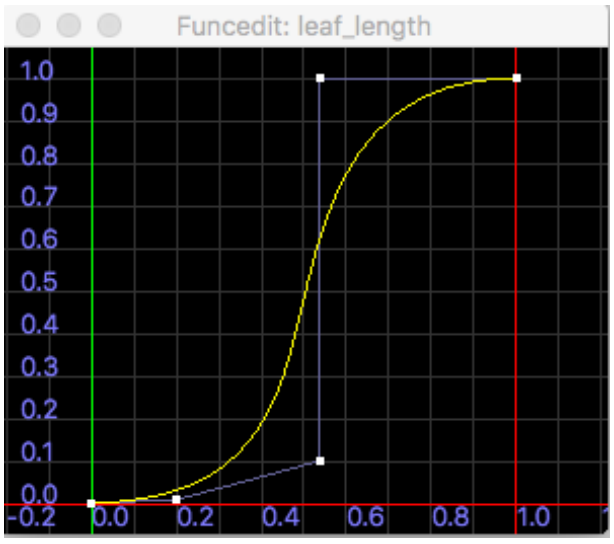


Figure 26: An example of the *funcedit* window.

8 Function editor (*funcedit*)

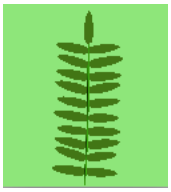
The function editor defines a function as a spline curve in 2D space where the first control point's x coordinate is equal to 0, and the last point's x coordinate is equal to 1 (Figure 26). In addition, for any two control points, p_i and p_{i+1}, $x_{p_i} \leq x_{p_{i+1}}$.

The command line for invoking the editor is:

```
funcedit [-rmode mode] [filename]
```

The `-rmode` option can be used to set the refresh mode (see Section 8.3).

Functions defined by *funcedit* can also be grouped using *gallery* (Section 9), similar to curves defined by *cuspy* (Section 7).



See object: LeafRandom

8.1 Manipulating the view

Use the menu (Section 8.3) to show/hide elements of the view (points, line segments, curve, limits), and the mouse and keyboard to:

- Zoom in and out (Alt key). It is also possible to zoom with a scrolling wheel on the mouse, and using two fingers on a mouse pad.
- Pan (Shift key)

8.2 Manipulating the function

The shape of the function is manipulated by moving the control points. The actions related to control points all use the left mouse button. They are:

Action	Description
Move	Select and drag the control point. The first and last control points are constrained to the limits of the range [0,1].
Add	Hold down the Command key, and click on the location for a new control point.
Translate all	Hold down the Command key, and use the arrow keys to move the entire contour. For larger steps, hold the Shift key down as well.
Delete	Hold down the Shift and Command keys, and click on the point to be deleted.

8.3 The *funcedit* menus

Funcedit has both a pop-up menu, invoked by clicking on the window with the right mouse button, and a menu bar. Both contain the same actions. The following table lists the actions in the order given on the pop-up menu, indicating where they can be found on the menu bar.

Action	Description	Menu Bar
Save	Save the current function to the file. This is only needed when Refresh mode = Explicit (see below).	File
Save as...	Save the current function to a new file. A dialog box will be displayed to enter the new file name.	File
Revert to saved	Reload the function from the file, overwriting changes made since the function was last saved.	File
Load background image	Load an image to be displayed in the background. This makes it possible to define the function to match the image. By default the image is displayed with the lower left corner at the origin. It can be moved using the arrow keys.	File
Flip view	Flip the x and y axes.	View
View points	Display/hide the control points.	View
View segments	Display/hide the line segments connecting the control points.	View
View curve	Display/hide the function curve.	View
View limits	Display/hide the lines representing the range constraints of the function.	View
Edit name...	Update the name of the function within the file.	File
Edit number of samples...	Change the number of samples that will be precomputed.	File
Refresh mode	Set the mode used to refresh the file: Explicit = only with the Save command (default). Triggered = when a change is made and the mouse is released. Continuous = as a change is being made (all values as the mouse is moved).	

8.4 Function specification file

The current version of the function file has the following format. For earlier versions of the file see Section 8.5.

Parameter	Description
`fver 1 1`	The current version of the specification file.
`name:` *name*	The name of the function.

Parameter	Description
`samples:` n	The number of samples, n, to be precomputed (rather than calculated each time the function is accessed).
`flip:` *flag*	Defines whether the independent variable, x, is displayed horizontally or vertically. When *flag* = `no`, x is on the horizontal axis; when *flag* = `yes`, x is on the vertical axis.
`background:` *filename* `backgroundXY:` bx by	Optional parameters added when a background image is loaded (see the Load background image menu item), where *filename* specifies the image file, and bx and by are world coordinates of a translation vector displacing the bottom left corner of the image from the origin.
`points:` n	The number of control points, n, where $n \geq 4$.
x_1 y_1 x_2 y_2 x_3 y_3 ... x_n y_n	The x and y coordinates of each control point.

8.5 Obsolete Function Editor formats

The following file format may exist in old objects within *vlab*. Files with this format can still be read by the function editor, but will be saved using the latest format.

Version 1.0 does not include the `name, samples,` or `flip` parameters, and begins with a `range` parameter. The complete format is:

`range:` `0.0 1.0`
`points:` n
x_1 y_1
x_2 y_2
x_3 y_3
...
x_n y_n

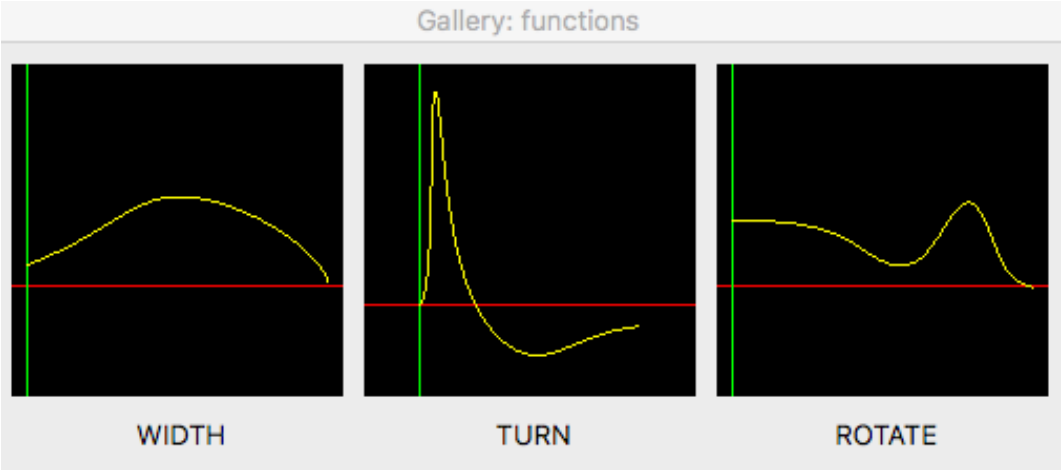


Figure 27: An example of a *gallery* window displaying three functions. Double-click on one of the icons to open the function in *funcedit*.

9 The *gallery* utility

The *gallery* utility can be used to organize contours created with *cuspy* (Section 7), or functions created with *funcedit* (Section 8) into a single file. This is convenient when developing models with multiple contours and/or functions as they can each be named and accessed from the same tool (see Figure 27).

The command line for invoking *gallery* is:

`gallery [-rmode` *mode*`] [`*filename*`]`

where *filename* has one of the following extensions:

`.cset` for a set of contours
`.fset` for a set of functions


See object:
LilyLeaf

The `-rmode` option can be used to set the refresh mode (see Section 9.1). This refresh mode propagates to each *cuspy* or *funcedit* specification called from the *gallery*.

To run *cuspy* or *funcedit*, simply double-click on the icon representing the contour or function.

9.1 The *gallery* menu

Right-click in the *gallery* window to display the pop-up menu. The items on the menu are:

Menu item	Description
Save gallery	Save changes made to the gallery.
Save gallery as...	Save a copy of the gallery to another file. A dialog box will be displayed to enter the new file name.
Update all views	Update the icons to display the current view of each contour/function.
Create new item...	Add a new contour/function to the gallery.
Duplicate item...	Create a duplicate of the contour/function that was right-clicked. A dialog box will be displayed to enter a name for the new item.
Load existing item...	Add an existing contour/function to the gallery from a `.con` or `.func` file.
Remove item	Remove the contour/function that was right-clicked.

Refresh mode	Set the mode for saving changes to the gallery file, and to contours/functions invoked from the gallery: Explicit = with the Save or Save gallery menu items (default). Triggered = when a change is made and the mouse is released. Continuous = as a change is being made (all values as the mouse is moved).
Exit	Quit *gallery*. If there are unsaved changed, a dialog box will be displayed.

9.2 Gallery specification file

The filename extension and first line of a gallery specification file defines whether the file contains contours or functions:

Set of	Filename extension	First line
Contours	`.cset`	`contourgalleryver 1 1`
Functions	`.fset`	`funcgalleryver 1 1`

The format of the remainder of the file is:

`items:` *n*
item1
item2
...
itemn

where each *item* is a complete definition of a *cuspy* contour (Section 7.4) or a *funcedit* function (Section 8.4).

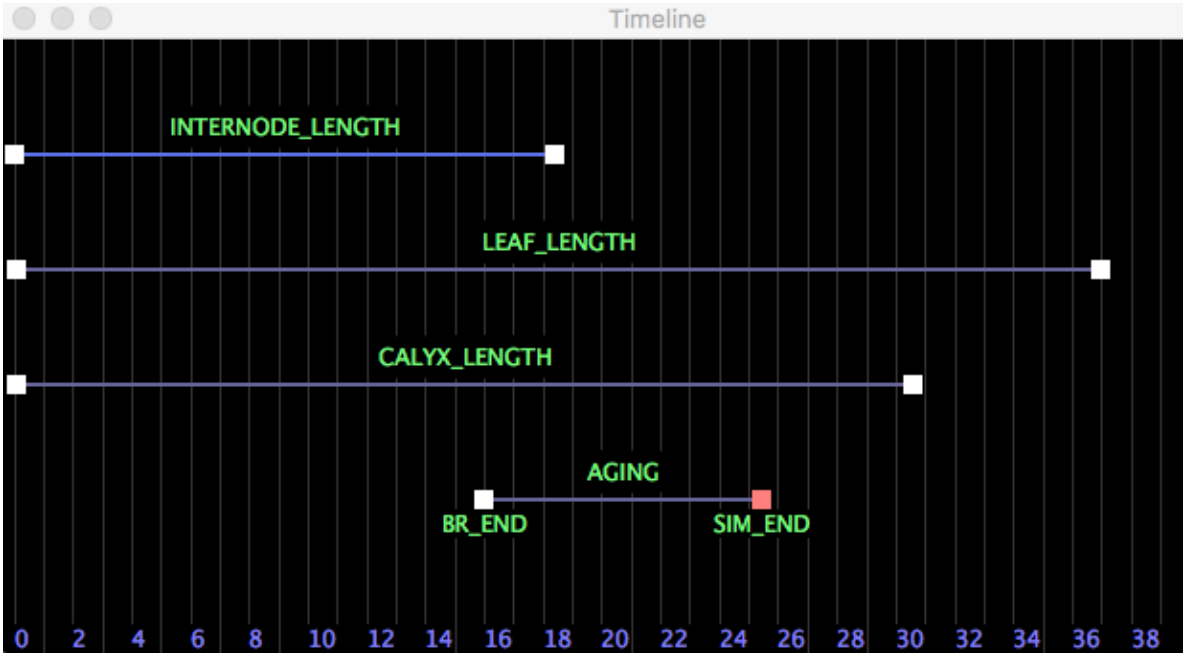


Figure 28: An example of a *timeline* editor window displaying four functions. Update a timeline by clicking and dragging on one of its endpoints.

10 Timeline editor (*timeline*)

The *timeline* editor provides another method of defining a set of functions. Each function is created using the *funcedit* tool over the range [0,1], but is evaluated using the range specified by its associated timeline (using the `tfunc()` function within *lpfg*). Timelines with labelled endpoints can also be used to update parameters, similar to using a panel (Section 2).

The command line for invoking the editor is:

`timeline [-rmode` *mode*`]` *filename*`.tset`

See object:
Lychnis

where *filename*`.tset` contains a set of functions each with a defined time period (see Section 10.3). The `-rmode` option can be used to specify the refresh mode (see Section 10.1.3). When invoked, a window such as the one in Figure 28 is displayed.

10.1 Using timelines

10.1.1 Manipulating the view

The mouse can be used to:

- Pan left/right - left-mouse click on the background, and drag
- Scroll up/down - use the scroll wheel, or two fingers on a mouse pad
- Zoom in/out - holding the Command key, left-mouse click and drag

10.1.2 Manipulating a timeline

The timeline endpoints can be adjusted by clicking and dragging on them. To move multiple endpoints in unison, hold the Shift key down and select each of them, then click and drag on any one of the selected endpoints to move them together. Click on the background, or use Deselect all on the pop-up menu (Section 10.1.3) to deselect them.

To edit the function associated with a timeline, double-click on its name. This will open *funcedit* (see Section 8).

10.1.3 General menu items

The main menu is available by right-clicking anywhere in the *timeline* window. Some of the options are also available on the menu bar, under the menu indicated.

Action	Description	Menu bar
Save	Save all changes to the current `.tset` file.	File
Save as	Save all changes to a different `.tset` file. A dialog box will be displayed to select the new file. All subsequent changes will also be saved to this new `.tset` file.	File
Deselect all	Deselect any endpoints that have been selected. Clicking anywhere except on an endpoint will also deselect all endpoints.	
Edit	Enter edit mode to add/change/delete timelines and their associated functions. See Section 10.2.	
Refresh mode	Set the refresh mode to Explicit, Triggered or Continuous (Section 10.1.4). This will override the mode set using the `-rmode` argument on the command line.	File
Quit	Exit the program. If changes have been made but not saved, a dialog box will be displayed.	Timeline

10.1.4 Timeline editor output

Changes to a timeline produce the following:

- An updated `.tset` file (Section 10.3).
- Messages to *stdout* if changes are made to a labelled endpoint.

Timeline changes Changes made to a timeline will be output to the `.tset` file as specified by the Refresh mode:

- Explicit - when the Save menu item is selected.
- Triggered - when the mouse is released after moving an endpoint.
- Continuous - as an endpoint is moved.

Messages This mechanism can be used to graphically update parameters in a data file by piping the messages to the parameter editor, *awkped* (Section 11.2). The messages are sent to *stdout* in the format:

`d` *endpoint-name value* `1`

which is the standard format used by *awkped* to update file parameters of the type:

`#define` *fieldname value*

For example, changes to the endpoints of the AGING timeline above could update parameters in a file containing the `#define` statements:

```
#define BR_END x
#define SIM_END y
```

See Section 11.2.2 for more information.

10.2 Timeline edit mode

To add, change, or delete a timeline and/or its associated function, select Edit from the pop-up menu to enter edit mode. The background colour will change to indicate the new mode.

Select a specific timeline by clicking on its name. Move it up or down in relation to the other timelines using the arrow keys on the keyboard, the Move selected timeline up/down menu items.

Double click on the timeline name to open a dialog box for editing its characteristics (see Section 10.2.2).

10.2.1 Timeline Edit Menu

Right-click anywhere in the window to display the pop-up menu. It contains the following items:

Menu item	Description
Add timeline	Add a new timeline at the bottom of the window. A dialog box will be displayed to enter the characteristics of the timeline (Section 10.2.2), followed by *funcedit* (Section 8) to define the associated function.
Move selected timeline up	Switch the selected timeline with the one above it. This can also be done with the up arrow key.
Move selected timeline down	Switch the selected timeline with the one below it. This can also be done with the down arrow key.
Delete selected timeline	Display a dialog box to confirm that the selected timeline should be removed. The timelines below will be moved upwards.
Open function	Open the *funcedit* tool to edit the associated function. This is similar to double-clicking on the timeline name when in Execute mode.
Execute	Return to Execute mode to manipulate the timelines.
Save	Save the updated timelines to the current `.tset` file.
Save as	Save the updated timelines to a different `.tset` file. A dialog box will be displayed to select the new file. All subsequent changes will also be saved to this new `.tset` file.

10.2.2 Timeline Characteristics

The characteristics of a timeline can be edited by double-clicking on the timeline name to display the dialog box (Figure 29). This dialog box is also displayed when adding a new timeline with the Add timeline menu item.

The fields in the dialog box are:

Field	Description
Timeline name	The name of the timeline, displayed above it.
Start time	The bottom of the range over which the function will be evaluated.
End time	The top of the range over which the function will be evaluated.
Start label	The name of the left endpoint of the timeline, displayed below the point.
End label	The name of the right endpoint of the timeline, displayed below the point.
Color	The color of the line. Click on the colored box to open a color wheel dialog.

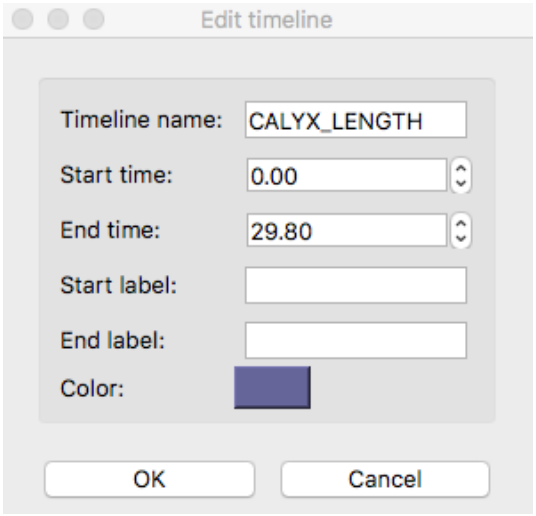


Figure 29: An example of the dialog box that is displayed to edit the characteristics of a timeline.

The Timeline name, as well as the Start label and End label values, should be a single word (no spaces) for use with the `tfunc` function within *lpfg*, and messages to *stdout* (Section 10.1.4).

The Start time and End time values are floating point numbers with two decimal places. The arrows at the side of the fields increase/decrease the value by 1.00.

10.3 Timeline specification file

The timeline editor reads and saves from/to a text file, *filename*`.tset`, which has a short header containing:

Parameter	Description
`timeEdit 1 2`	The current version of the specification file.
`items:` *n*	The number of timelines in the file.

The header is followed by a description of each timeline:

Parameter	Description
`start:` *startpt*	The left endpoint of the timeline defined as a number with two decimal places.
`end:` *endpt*	The right endpoint of the timeline defined as a number with two decimal places.
`name:` *linename*	The name of the timeline. This should be a single word (no spaces) for use with the `tfunc` function within *lpfg*.
`color:` *R G B*	The RGB components of the timeline color.
`startlabel:` *slabel*	The label name associated with the left endpoint of the timeline. This is optional.
`endlabel:` *elabel*	The label name associated with the right endpoint of the timeline. This is optional.
`timelineFunceditFileStart:`	The start of a *funcedit* description of the timeline's function, using the standard *funcedit* format (Section 8.4) which spans several lines.
`timelineFunceditFileEnd:`	The end of the function, and the timeline, description.

11 File Editors

There are two file editing tools available in *vlab*: a simple text editor, and a context editor. They are both available for general use, but also have specific applications within the *vlab* environment.

11.1 The text editor (*vlabTextEdit*)

The *vlab* text editor is a basic tool for editing text files. It includes standard features for opening and saving files (on the File menu), cutting and pasting (on the Edit menu), as well as providing standard keyboard shortcuts. In addition, the View menu allows the user to increase/decrease the font size of the entire window, and to enter/exit full screen mode.

The editor also includes two features specifically designed for the *vlab* environment:

- It uses syntax highlighting tuned for L-system files.
- It performs file monitoring: any changes made by other tools to the file while editing will automatically update the content of the editor.

The command line for invoking the editor is:

`vlabTextEdit` *filename*

Note that file monitoring is not available when *vlabTextEdit* is opened without specifying a file name on the command line.

The editor can be defined in the object manager preferences as `EDIT`, and used in specification files whenever a text file, especially an L-system, is to be edited.[2] See the **VLAB Framework** manual for more information.

11.2 The parameter editor (*awkped*)

The parameter editor is an *awk* program used to edit data files based on specific message formats. The editor, *awkped*, accepts messages from *stdin*. Therefore, any tool that outputs messages to *stdout* in one of the specified formats can utilize *awkped* to edit a data file. For example, both the Panel Manager (Section 2) and the Timeline Editor (Section 10) are able to output messages to *stdout* that can be piped into *awkped* (see Section 11.2.2).

Awkped can edit data files based on:

- `#define` statements; or
- specific line/word numbers.

The editor can also scale the incoming data before editing the data file. This is useful when the output from a tool is restricted to integers, such as the value of sliders in the Panel Manager, but the data in the file contains decimal places.

11.2.1 Message formats

Define statements The command to edit `#define` statements begins with the letter `d`, and has the format:

`d` *fieldname value scale*

[2] Alternatively, a different text editor can be associated with `EDIT`, and *vlabTextEdit* used only when file monitoring is needed.

The editor will search for a `#define` statement with the specified *fieldname*, and will replace the current value with *value* divided by *scale*, where *scale* is optional. For example, if the data file contains the line:

```
#define SIZE 4
```

the size can be changed to 5 with the command:

```
d SIZE 5
```

Or, the size can be changed to 4.6 using an integer value divided by 10:

```
d SIZE 46 10
```

Line/word numbers The command to edit a word on a specified line begins with the letter `n`, and has the format:

`n` *nline nword scaleexp value*

The editor replaces the $nword^{th}$ value on the $nline^{th}$ line with $value \times 10^{scaleexp}$. For example, if the first two lines of the data file are:

```
initial line width: 7 pixels
size: 4.2
```

the initial line width can be changed to 5 pixels with the command:

```
n 1 4 0 5
```

This will replace the current value of 7 with $5 \times 10^0 = 5$. The `size` can be changed to 4.8 using an integer and exponent ($48 \times 10^{-1} = 4.8$) with the command:

```
n 2 2 -1 48
```

11.2.2 Using the parameter editor

The parameter editor accepts input from *stdin* and, therefore, any tool that outputs to *stdout* can pipe messages to *awkped*. For example, the command lines for piping messages from the Panel Manager or Timeline Editor to *awkped* are:

`panel` *panelfile* `|` `awkped` *datafile*
`timeline` *functions*`.tset |` `awkped` *datafile*

This mechanism can be used to graphically update parameters embedded in a *cpfg* or *lpfg* L-system file. Or, in the case of *lpfg*, the parameters may be in a separate parameter file that is specified on the *lpfg* command line with a `.vset` extension. For example:

```
lpfg viewfile.v animatefile.a parameters.vset lsystem.l
```

The parameters can be read within the L-system using the `val()` function. For example, if the `parameters.vset` file contains:

```
#define SIZE 50
#define LENGTH 14
```

the values can be read using the following statements within *lpfg*:

```
leaf_size = val(SIZE);
branch_length = val(LENGTH);
```

See the **LPFG Reference Manual** for more details on using the `val()` function.

12 Credits

The *panel* editor was originally developed by Lynn Mercer and included in the first release of *vlab* [1]. The latest version, with graphical editing of the panel components, was developed by Alejandro Garcia and Pascal Ferraro.

The *palette* program was developed by Przemyslaw Prusinkiewicz, and enhanced by Joanne Penner.

The material editor, *medit*, was developed by Joanne Penner.

The original version of *funcedit* was developed by Radosław Karwowski in Motif. The current Qt implementation of *funcedit*, as well as the *bezieredit*, *cuspy*, and *gallery* tools were developed by Colin Smith and enhanced by Pascal Ferraro.

The *stedit* program was developed by Mark Koleszar. The file format used by both *stedit* and *bezieredit* is based on the surface editor, *ise*, developed by Jim Hanan [2].

The original version of the *timeline* editor was developed by John Hall. The current version was implemented by Pascal Ferraro.

The *vlab* text editor was developed by Pascal Ferraro. The *awkped* editor was developed by Przemyslaw Prusinkiewicz.

All tools have been enhanced and maintained by Pascal Ferraro.

13 Document History

This is the first manual to combine all the *vlab* tools into a single document. However, each tool was originally documented by the developer(s).

Date	Description	By
2022	First version combining all tools in a single manual	Lynn Mercer Przemyslaw Prusinkiewicz Pascal Ferraro

References

[1] Lynn Mercer. The virtual laboratory. Master's thesis, University of Regina, 1991.

[2] James S. Hanan. *Plantworks: A software system for realistic plant modeling*. PhD thesis, University of Regina, 1988.