## PPM Menu

The program `ppm_menu` can be used to edit and create images. The program keeps track of 3 `PPM` objects: input image 1, input image 2, and output image.

# Quitting

The `quit` command terminates the program.

# Reading and writing images

The commands `read1` and `read2` read a `PPM` file into the input images. The command `write` writes to a `PPM` file from the output image. `draw-ascii` is an additional output mode, displaying the output image to the terminal in a simple ASCII art format. The `copy` command allows us to copy from input image 1 into the output image.

# Image editing

We also provide some primitive image editing commands. These commands generally work on the input image 1. The `size` command sets the image dimensions, and the `max-color-value` command assigns the maximum allowable color value for any color channel.

The `channel` and `pixel` commands allow the user to change the color of individual pixels.

## Drawing to multiple pixels

The `clear` command sets all pixels to black. The `circle` and `box` commands allow the user to set a color for a group of pixels in a circular or rectangular shape.

# Image filters

Image filters are commands that work on a group of pixels at the same time, in the same way. Some filters use only input image 1, while others use both input images. Some filters modify input image 1, and other filters modify the output image.

## Filters that modify input image 1 using only input image 1

`*=` and `/=` modify the pixels of input image 1 using the pixels of input image 1 and a user specified number, with the mathematical operation specified in the command name on a channel by channel basis.

## Filters that modify input image 1 using both input images

`+=` and `-=` modify the pixels of input image 1 using the pixels of input image 1 and input image 2, with the mathematical operation specified in the command name on a channel by channel basis.

## Filters that modify the output image using only input image 1

`*` and `/` modify the pixels of the output image using the pixels of input image 1 and a user specified number, with the mathematical operation specified in the command name on a channel by channel basis.

`red-gray`, `green-gray`, `blue-gray`, and `linear-gray` modify the pixels of the output image using the pixels from input image 1. The output image only contains grayscale colors.

## Filters that modify output image using both input images

`+` and `-` modify the pixels of the output image using the pixels of input image 1 and input image 2, with the mathematical operation specified in the command name on a channel by channel basis.

# Image Creation via Paint by Numbers

In the paint by numbers mode, the user specifies the desired size of the image and a color pallet as a numbered table of colors. The user then chooses the color for each pixel in the image by putting the number of a color from the color table in a grid. Finally, the numbers in the grid are used to lookup colors in the

table, and those colors are used to assign to the output image.

The paint by numbers process:

- Select the desired pattern.
- Configure the number grid's size and maximum number.
- Store numbers in the number grid according to the desired geometric pattern.
- Configure the color table to contain the desired colors.
- Create the output image using the number grid and color table.
- Write the output image to a file.

## Selecting the pattern

`complex-fractal`, `julia`, and `mandelbrot` allow the user to select the form. Some versions of the program may have additional patterns based on student choices during assignments, personal interest, or exam work.

## Number Grid Configuration

The `grid` command allows the user to choose the size of the number grid, which is the ultimate size of the output image. It also sets the maximum numeric value that can be stored in a grid location.

## Number Grid Manual Editing

`grid-set` allows the user to manually configure the number in a grid location.

## Number Grid Computational Editing

Algorithms may be used to insert numbers into the number grid according to a mathematical pattern.

The process for computational editing is:

- Configure the pattern.
- Compute and store numbers in the grid.

### Configuring the pattern

Most patterns are mappings between computations using real numbers in the number plane and the discrete row and column numbers of a grid location. `fractal-plane-size` allows the user to configure the region of the number plane that is mapped to the number grid rows and columns.

Some pattern forms have additional configuration options. `julia-parameters` allows the user to configure numeric parameters that control the Julia set pattern, if it is the currently selected choice.

### Computing and storing numbers

`fractal-calculate` and `fractal-calculate-single-thread` are used to compute the grid numbers by the selected and configured pattern, and store the numbers in the grid.

## Defining a Color Table

There is a built-in color table that the user can choose to use. But, there are additional commands to allow for a user created color table.

`set-color-table-size` sets the number of colors in the color table. `set-color` allows the user to configure the red/green/blue values for one color in the color table. `set-random-color` assigns a random set of red/green/blue values to the user selected color in the color table.

`set-color-gradient` sets a range of colors in the color table. The user selects the first and last color in the range, and the program linearly extrapolates between these two colors to fill in the spaces in the color table between them.

## Translating Numbers and Colors to an Image

This is the last step in the paint by numbers image creation mode. It is assumed that the color table has been configured correctly, and the number grid has been configured correctly before this operation.

`grid-apply` uses the numbers in the grid and the colors in the built-in color table to assign pixel colors to the

output image. `grid-apply-color-table` uses the numbers in the grid and the colors in the color table to assign pixel colors to the output image.

# Command Files

The user can create command files that with a sequence of commands to executed, then feed these commands to the program. This is convenient for creating an image by iterative updates to the commands, without having to retype all of the commands every iteration.

For example, if the commands are stored in a file named `pretty_picture.txt`, the commands can be used like this:

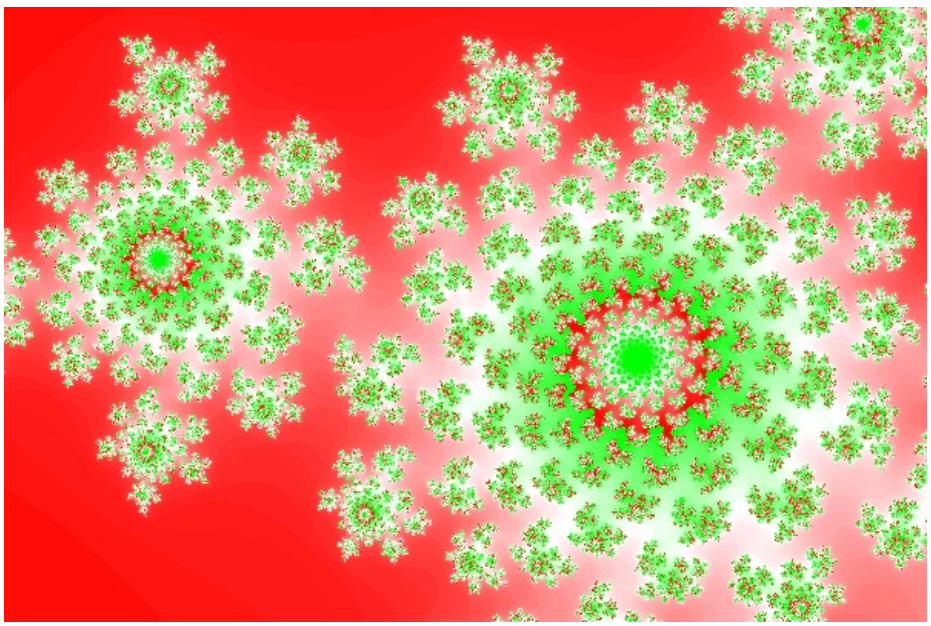
```
./ppm_menu < pretty_picture.txt
```

## Sample `pretty_picture.txt`

```
# select the desired pattern
julia
# configure the grid size and maximum number
grid 400 600 200
# configure the pattern
fractal-plane-size -1.2 0.0  0.0 0.8
julia-parameters -0.4 0.6
# compute and store the numbers
fractal-calculate
# <<<<<<<<< Start Color Table >>>>>>>>>>>>
set-color-table-size 101
set-color-gradient 0 255 0 0  50 255 255 255
set-color-gradient 50 255 255 255 100 0 255 0
# <<<<<<<<< End Color Table >>>>>>>>>>>>
# create output image
grid-apply-color-table
# save image to file
write pretty_picture.ppm
# done
quit
```

Notice the `#` command is used to add comments to the command file that don't affect the picture created, but give the human user information about the commands.

Download pretty_picture.txt



Download pretty_picture.ppm

# Table of Commands

| | Function Name | Description |
|---|---|---|

| Command Name | | |
|---|---|---|
| quit | `quit` | “Quit.” |
| `#` | `commentLine` | “Comment to end of line.” |
| Read/Write | | |
| read1 | `readUserImage1` | “Read file into input image 1.” |
| read2 | `readUserImage2` | “Read file into input image 2.” |
| write | `writeUserImage` | “Write output image to file.” |
| copy | `copyImage` | “Copy input image 1 to output image.” |
| draw-ascii | `drawAsciiImage` | “Write output image to terminal as ASCII art.” |
| Editing | | |
| size | `setSize` | “Set the size of input image 1.” |
| max-color-value | `setMaxColorValue` | “Set the max color value of input image 1.” |
| channel | `setChannel` | “Set a channel value in input image 1.” |
| pixel | `setPixel` | “Set a pixel’s 3 values in input image 1.” |
| clear | `clearAll` | “Set all pixels to 0,0,0 in input image 1.” |
| circle | drawCircle | Draw a circle shape in input image 1. |
| box | drawBox | Draw a box shape in input image 1. |
| Filters | | |
| ”+=” | `plusEquals` | “Set input image 1 by adding in input image 2.” |
| ”-=” | `minusEquals` | “Set input image 1 by subtracting input image 2.” |
| “*=” | `timesEquals` | “Set input image 1 by multiplying by a number.” |
| ”/=” | `divideEquals` | “Set input image 1 by dividing by a number.” |
| ”+” | `plus` | “Set output image from sum of input image 1 and input image 2.” |
| ”-” | `minus` | “Set output image from difference of input image 1 and input image 2.” |
| “*” | `times` | “Set output image from input image 1 multiplied by a number.” |
| ”/” | `divide` | “Set output image from input image 1 divided by a number.” |
| red-gray | grayFromRed | Set output image by grayscale from red on input image 1. |
| green-gray | grayFromGreen | Set output image by grayscale from green on input image 1. |
| blue-gray | grayFromBlue | Set output image by grayscale from blue on input image 1. |
| linear-gray | grayFromLinearColorimetric | Set output image by linear colorimetric grayscale on input image 1. |
| Paint by Numbers | | |
| grid | configureGrid | Configure the grid. |
| grid-set | setGrid | Set a single value in the grid. |
| grid-apply | applyGrid | Use the grid values to set colors in the output image. |
| grid-apply-color-table | applyGridColorTable | Use the grid values to set colors in the output image using the color table. |
| fractal-plane-size | setFractalPlaneSize | Set the dimensions of the grid in the complex plane. |
| julia-parameters | setJuliaParameters | Set the parameters of the Julia Set function. |
| complex-fractal | setComplexFractal | Choose to make a complex plane. |
| julia | setJuliaFractal | Choose to make a Julia set. |
| mandelbrot | setMandelbrotFractal | Choose to make a Mandelbrot set. |
| set-color-table-size | setColorTableSize | Change the number of slots in the color table. |
| set-color | setColor | Set the RGB values for one slot in the color table. |
| set-random-color | setRandomColor | Randomly set the RGB values for one slot in the color table. |
| set-color-gradient | setColorGradient | Smoothly set the RGB values for a range of slots in the color table. |

| | | |
|---|---|---|
| | | the color table. |
| fractal-calculate | calculateFractal | Calculate the escape values for the fractal. |
| fractal-calculate-single-thread | calculateFractalSingleThread | Calculate the escape values for the fractal, single-thread. |