

Visualizing Complex Functions User Manual

Team Members: Paul Giacchetto, Bradley Watson, Branden Dundey

Faculty Advisor: Dr. Ryan Stansifer

Project URL: <http://srprojcomplex.webs.com/the-project>

Table of Contents

- Introduction to complex numbers
- Available functions
- Formatting functions
- Optional parameter 'a'
- Modes
 - Point
 - Grid
 - Color Square
 - Color Wheel
 - User Image
 - 4Quads
 - Color Grids
- GUI diagram and instructions

Introduction to Complex Numbers

A complex number is a number that can be expressed in the form $a + bi$, where a and b are real numbers and i is the imaginary unit, where $i^2 = -1$. In this expression, a is the real part and b is the imaginary part of the complex number. Complex numbers are represented with the symbol 'z' in this program, which represent an arbitrary value. Similar to the $y = mx + b$ format, the format for this program is $w = az + i$.

Available Functions

These are all of the available commands and symbols that can be used by the Applet.

Functions	Definition
sin	Sine
sinh	Hyperbolic Sine
cos	Consine
cosh	Hyperbolic Cosine
tan	Tangent
tanh	Hyperbolic Tangent
sec	Secant (1/cos)
sech	Hyperbolic Secant
csc	Cosecant (1/sin)
csch	Hyperbolic Cosecant
cot	Cotangent (1/tan)
coth	Hyperbolic Cotangent
log	Logarithm
abs	Absolute Value
sqrt	Square Root
asin	Inverse Sine
asinh	Inverse Hyp. Sine
acos	Inverse Cosine
acosh	Inverse Hyp. Cosine
atan	Inverse Tangent
atanh	Inverse Hyp. Tangent
asec	Inverse Secant
asech	Inverse Hyp. Secant
acsc	Inverse Cosecant
acsch	Inverse Hyp. Cosecant
acot	Inverse Cotangent
acoth	Inverse Hyp. Cotangent
ln	Natural Logarithm
mod	Modulus
exp	Complex Exponential

Symbols	Definition
z	Complex Variable (Real, Imag)
i	Imaginary Unit
pi	~3.14159...
e	~2.71828...
+	Plus
-	Minus / Negative
*	Times
/	Divide
^	To the power of...

Formatting Functions

The input needs to be formatted correctly in order to allow the program to parse the function.

Most symbols need to be separated by operands.

Optional Parameter 'a':

An optional parameter will be available where two text fields allow the user to set a real and imaginary value to a point and use that point in a calculation.

You want:	Equation entered:
2z	2*z
1/z	1/z
z^2	z^2
az	a*z
(z+3)(z-1)	(z+3)*(z-1)
i(1-z)/(1+z)	i*(1-z)/(1+z)
-i(z^2+2iz+1)/(z^2-2iz+1)	-i*(z^2+2*i*z+1)/(z^2-2*i*z+1)
sin^2(z)	sin(z)^2
sin^2(z^2)	sin(z^2)^2

Note:

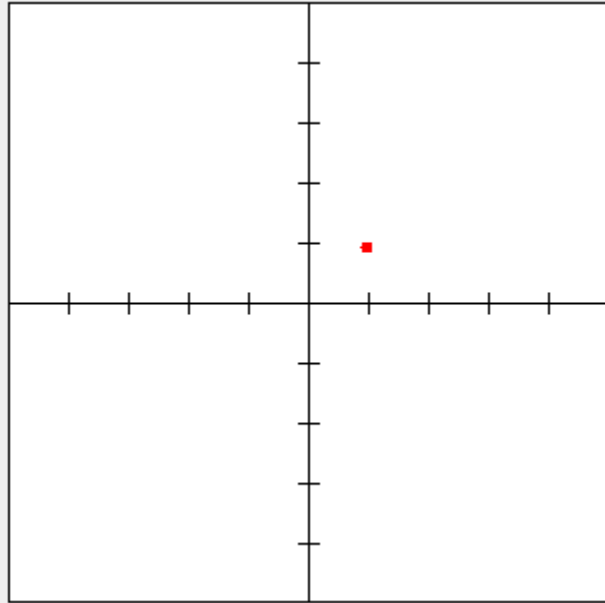
Some trigonometric functions, such as $\text{asin}(z)$, have the symbol 'a' but should not be confused with the optional parameter. If you want $a*\sin(z)$, but accidentally write $\text{asin}(z)$, it will treat the function as the inverse sine and won't report any errors.

Modes

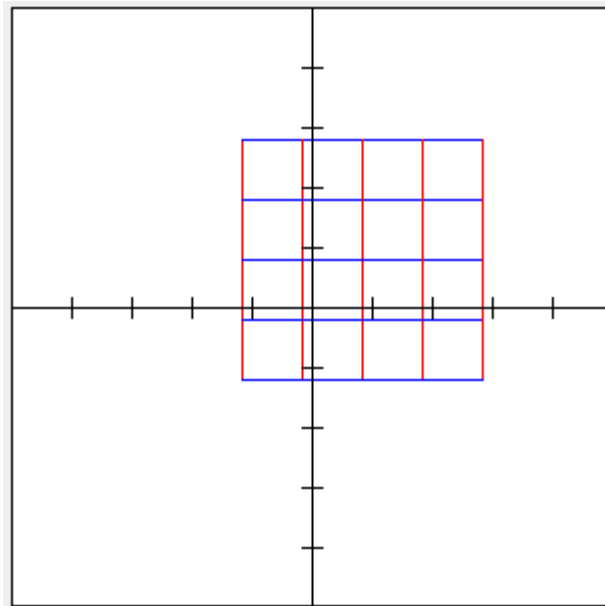
Depending on what mode is selected, a different domain picture will appear. All modes refer to the current equation inputted, and will map pixels according to that function. Most patterns refer to a central point that is displayed, in which the center of the image is equal to that point.

Point:

This is the basic, default pattern. The mapping process will only map a single point to display.

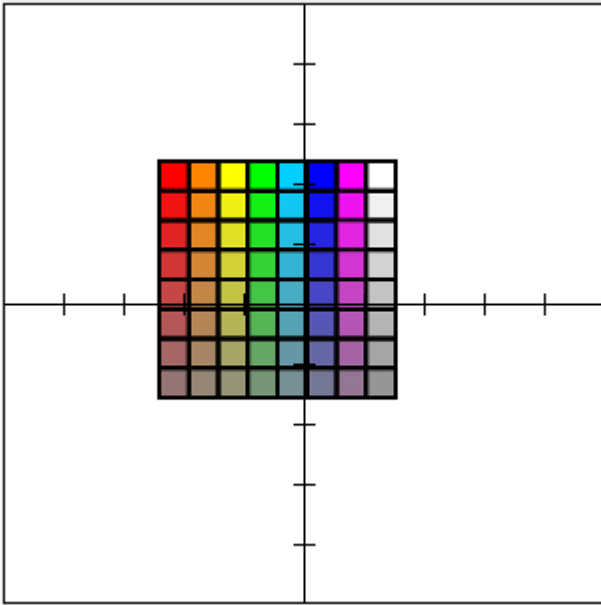
**Grid:**

A grid outline will appear, where the vertical lines are colored in red, and the horizontal lines are colored in blue. The grid size and number of lines can be changed by using the GUI.



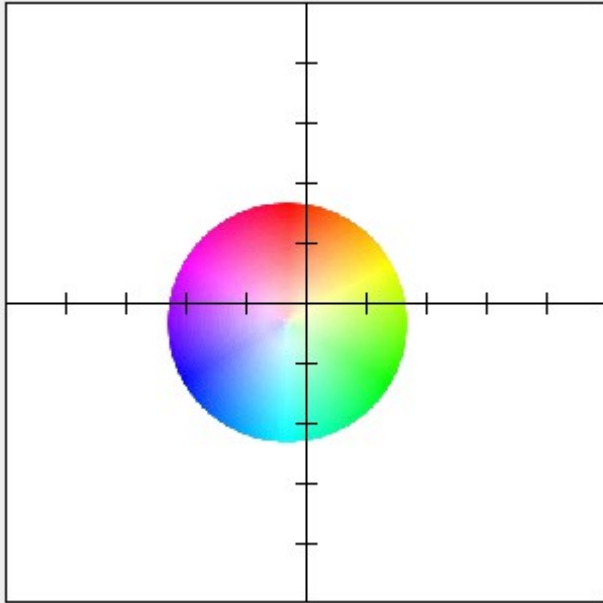
Color Square:

A solid grid will appear, in which the grid is filled with multiple colors. The number of lines stays the same, and the colors cannot be changed. The overall size of the grid can be altered.



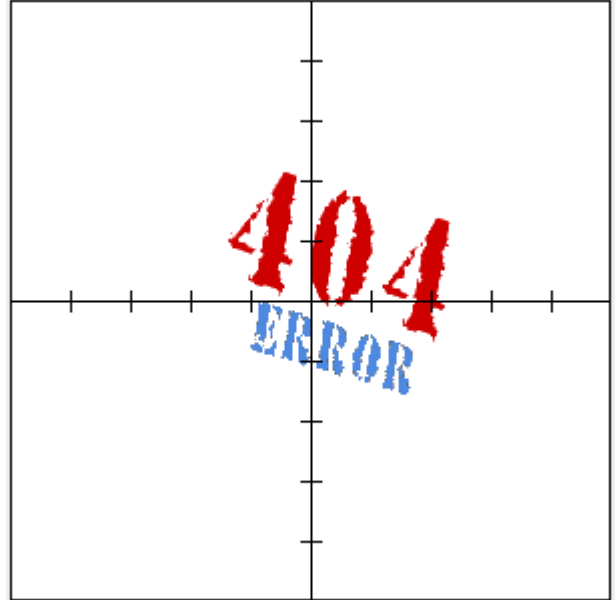
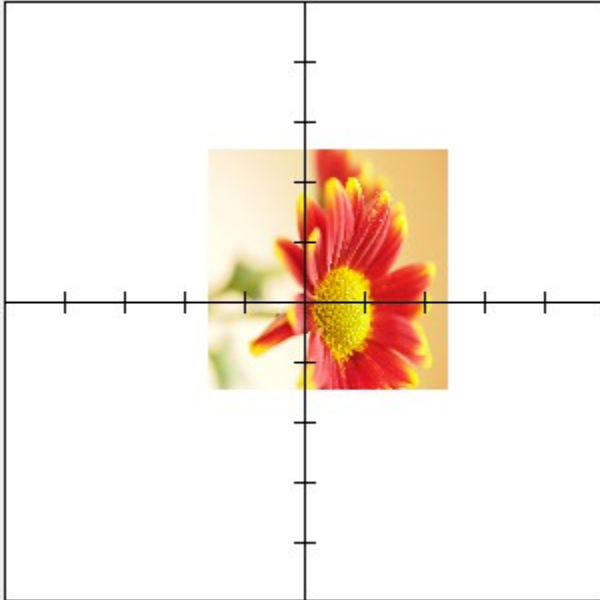
Color Wheel:

A solid circle with blended colors appears. The size and shape can be altered.



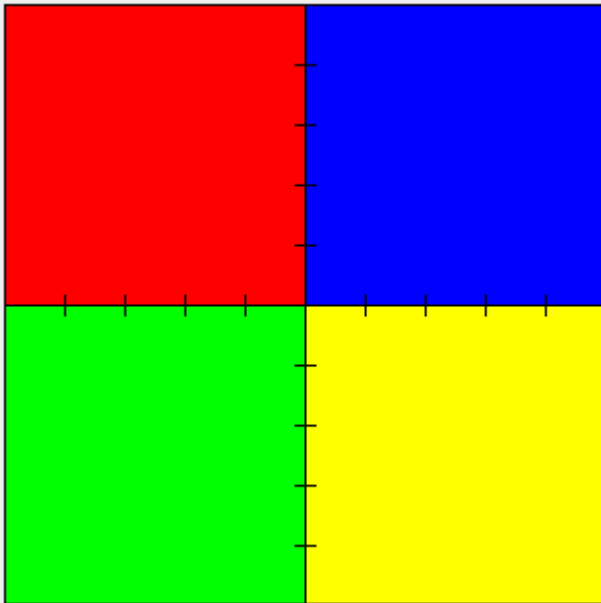
User Image:

When the user has uploaded their own image, this pattern will display their image. If no previous image has been uploaded, a 404 image will be present. The program will remember the last image uploaded, allowing the user to switch between patterns and always be able to refer back to their uploaded image. Uploading a second image will erase the first image from memory.



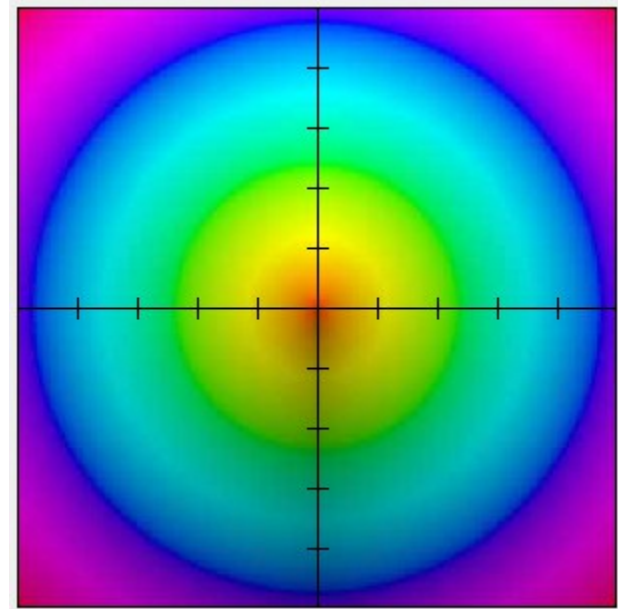
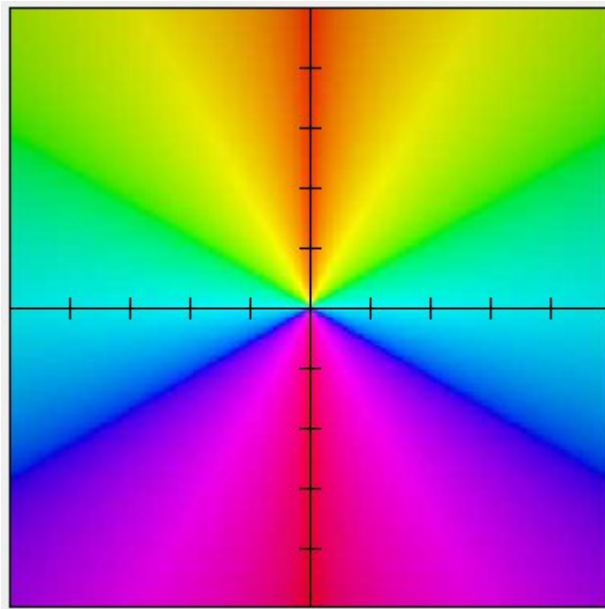
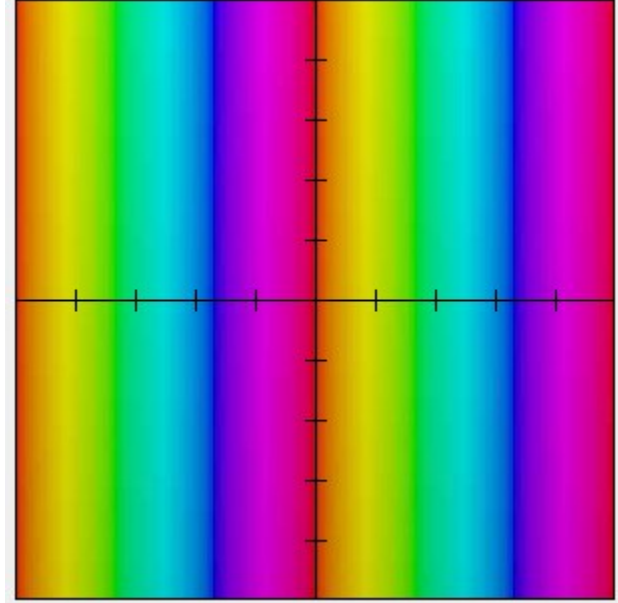
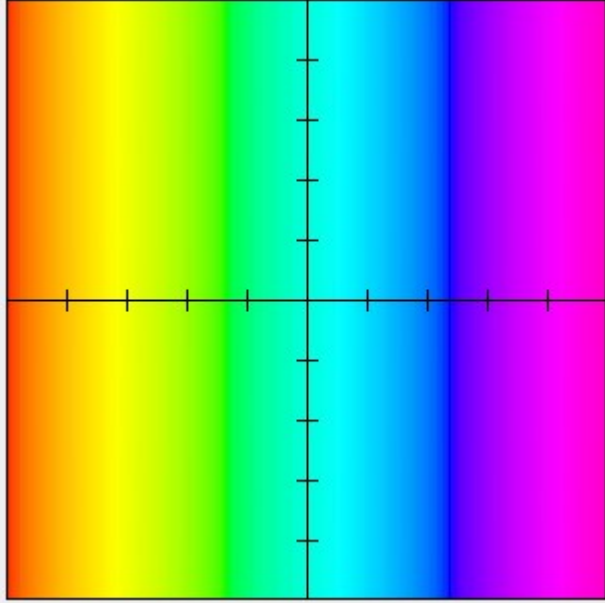
4Quads:

This is the first pattern that fills the entire domain grid. Each quadrant gets their own respective color. Altering the size of the domain field will also change the size of this pattern. Setting the domain field to 5, for example, is the same as making an image stretch to fill a 5x5 space with this pattern.



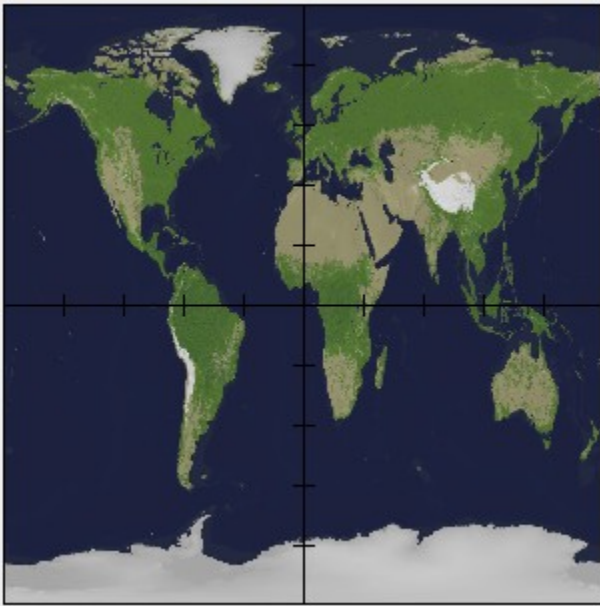
Color Grids:

There are 4 patterns that represent the color grids, all which work in a similar way as the 4Quads. The first pattern represents 3 dominant colored bars spread across the domain grid, and the second represents the 4 quadrants all having the same image, making the overall graph resemble 6 colored bars. The third pattern features a triangular spread, where the right side of the graph is a mirror of the left. The fourth pattern represents a circular spread, and also has the right side mirroring the left.



Earth:

Somewhat a "for fun" pattern, this pattern is also similar to the color grids and 4Quads, but has the entire earth as the pattern.



GUI

Everything you can change to alter the view of function.

The image shows a software interface for plotting a complex function. At the top, it displays the current function as z^2 and provides a text input for a new function. Below this, there are input fields for an optional parameter $a = 0.0 + 0.0i$ and a center point $0.56 + 0.5i$. The interface includes a 'Mode' dropdown set to 'Color Wheel' and an 'Upload Image' button. Two main plot windows are shown: the left one displays a full color wheel, and the right one shows a zoomed-in view of the function's image centered at the origin. To the right of the plots are controls for 'Redraw', 'Apply Blur?' (unchecked), 'Center At Origin' (checked), and a 'Blur Radius' of 2. Below these are settings for 'Set Image Width' (4.0) and 'Set Image Height' (4.0). A 'Set Resolution Scale' slider is set to 4. At the bottom, there are two sliders for 'Set Domain Graph Scale' (current value 5) and 'Set Range Graph Scale' (current value 25). Below these are input fields for 'Set Domain Intervals' (1.0) and 'Set Range Intervals' (1.0). On the far right, the current domain is $4.73 + 0.76i$ and the range is $21.81 + 7.25i$, with a 'Lock Scales Together' checkbox.

Labels (a) through (s) point to various GUI elements:

- (a) Enter New Function input field
- (b) Redraw button
- (c) Center At Origin button
- (d) Center At Origin button
- (e) Blur Radius input field
- (f) Set Image Width input field
- (g) Set Image Height input field
- (h) Set Resolution Scale slider
- (i) Set Resolution Scale slider
- (j) Center At Origin button
- (k) Domain and Range display
- (l) Lock Scales Together checkbox
- (m) Plot window
- (n) Set Domain Graph Scale slider
- (o) Set Range Graph Scale slider
- (p) Set Domain Intervals input field
- (q) Plot window
- (r) Mode dropdown
- (s) Current Function display

Current Function: $\sin(z)$
 Enter New Function:
 Optional Parameter: $a = 0.0 + 0.0i$ Center Point: i
 Mode: Apply Blur? Blur Radius = (g)
 Set Grid Size: (h)
 Set # of Lines:
 Set Resolution Scale: Current Value: 10
 Domain: $4.0 + -9.8i$
 Range: $-6823.99 + 5893.82i$ Lock Scales Together
 Set Domain Graph Scale: Current Value: 10
 Set Range Graph Scale: Current Value: 10
 Set Domain Intervals: Set Range Intervals:

(a)Center point:

The equivalent of the point clicked on the Domain grid. The text fields between the Upload image and Redraw buttons allow you to set the center point.

The left text field sets the real number and the right text field sets the imaginary number.

(b)Redraw:

Updates any changes performed since last drawing and executes the changes.

(c)Center at origin:

The same as Redraw, except the center point is changed to $(0,0i)$.

(d)Apply Blur:

This attempts to eliminate some white space in the output when the resolution is turned low. The algorithm searches around a white pixel in order to find the best color fit. Increasing the radius determines how far outwards the algorithm searches. Setting a large radius will cause the output to become blurrier. This is mainly used to get a general idea of what the output should look like without increasing resolution.

(e)Set Image Width:

Sets the width a picture will show.

Editable in the following modes: Color Wheel, Color Square, and User Image.

(f)Set Image Height:

Sets the height a picture will show.

Editable in the following modes: Color Wheel, Color Square, and User Image.

(g)Set Grid Size:

This option only appears when the Grid pattern is selected. This sets the size of the grid from the center-point. The grid is drawn from center-point to the number of units in the text field in four directions. Enter a number into the text field, then click the Redraw or Center At Origin button.

(h)Set Number of Lines:

This option only appears when the Grid pattern is selected. This draws the number of lines vertically and horizontally within the grid. Enter a number into the text field, then click the Redraw or Center At Origin button.

(i)Resolution Scale:

Since our mapping process uses forward mapping and isn't perfect, the output will naturally have white spaces in the output. In order to remove these, the user can increase the resolution to improve the quality of the picture. The downside to this is that with higher resolution, the loading times will become longer. Big pictures with high resolution will take the longest to map, so the user should be wary of how high they set the resolution.

(j)Smoothing:

Enabling this checkbox will try to implement a Gaussian blur algorithm on the output image. This is to try to improve upon loading times and keeping the resolution low. You may also increase the radius that the algorithm uses when mapping to the output. This radius determines how far out the algorithm tries to search for missing colors. A bigger radius will cause a blurrier picture.

(k)Current Mouse value:

In the lower right corner of the GUI, two values will adjust every time you move your mouse over the domain grid. This is similar to the point pattern; the program will "map" the current point your mouse is on and display what the destination point should be. The domain is the point your mouse is currently on, and the range is what that point maps to.

(l)Locking Scales Together:

Checking this checkbox will cause the domain and range scales that appear underneath the grids to become locked together. This means that when you move one scale, the other scale will also move accordingly. Both current values will be the same, as well as the position of the marker. The checkbox takes effect the next time you try to adjust either scale.

(m)Grid

This section explains the 2 graphs that appear in the center of the GUI. The left grid is referred to as the domain grid, where input is accepted. The right grid is referred to as the range grid, where output is displayed.

(n)Domain Scale:

Sliding the bar left zooms into the Domain grid while sliding the bar to the right zooms out of the Domain Grid. Due to the way some patterns work, this may also change the input and give a different output. Click the Redraw or Center At Origin button to execute changes.

(o)Range Scale:

Sliding the bar left zooms into the Range grid while sliding the bar to the right zooms out of the Range Grid. Click the Redraw or Center At Origin button to execute changes.

(p)Intervals:

The the number spacing of the tick-marks on the graph. The markings automatically scale with the domain/range scaling, but can have adjusted values. Example: the Domain Scale is set to 10 and the Domain Interval is set to 1. There would be 10 tick-marks, each with 1 unit spacing between them.

(q)Grid:

Clicking on the Domain grid will set the program to draw the current pattern. The point clicked is the center-point of the grid. Clicking on the Range grid will do nothing. Hovering over the domain grid will bring up a small tooltip showing what points your mouse is currently over.

Alternate ways of drawing the grid:

- 1) Set the initial draw point (will be the center-point of the grid), then click the Redraw button.
- 2) Click the Center At Origin button.

(r)Mode:

Drop-down box with a set of modes for drawing on the domain, like point, grid, and color wheel.

(s)Function field:

This is where you type in the function. Always press enter after you have typed your function so the function goes to the label above. Refer to the previous sections for syntax and formatting.