Burning Ship

Burning Ship is a program that graphs the burning ship fractal, first described and created by Michael Michelitsch and Otto E. Rössler in 1992. Its name will be explained later. This fractal is generated in much the same way that the Mandelbrot set is generated, except that rather than generating the sequence $z_{n+1} = z_n^2 + c$ with $z_0 = 0$, we generate the sequence $z_{n+1} = (|\mathrm{Re}(z_n)| + i|\mathrm{Im}(z_n)|)^2 + c$ with $z_0 = 0$, and where $\mathrm{Re}(z_n)$ represents the real part of z_n and $\mathrm{Im}(z_n)$ represents the imaginary part of z_n. For each value of *c*, if the sequence generated is bounded, then *c* is a point in the fractal. Upon execution, **Burning Ship** will appear as in Figure 1.

Figure 1

The image in the middle always remains the same, where the real part ranges from -2.1 to 1.35 and the imaginary part ranges from -1.35 to 2.1. The initially blank window is where images with alternate real and/or imaginary ranges are graphed. One way to get an alternate image is to specify the ranges in the text boxes at the top of the status window. For instance if we set the real range to $[-1, 0]$ and the imaginary range to $[0,2]$, and then we press the "ReDraw" button, **Burning Ship** will look like Figure 2.

Note first, that the viewing rectangle was "squared" by lengthening the shorted side to be the same length as the longer side. This action preserves the original aspect ratio. Also, if the new viewing square is wholly contained within the original, a white square is drawn in the original image showing where the new viewing square is located. Finally, a new zoom level is created so that we can return to this viewing rectangle at a later time.

When we press the Zoom button, a cursor appears. The cursor can be relocated with the mouse and when the "OK" button is pressed one corner of the new viewing window is defined. Move the cursor to a new location and click the mouse to define the diagonally opposite corner. We will have the opportunity to either cancel or accept the zoomed window. As before the zoomed window is "squared" before the new image is drawn and a new zoom level is created.

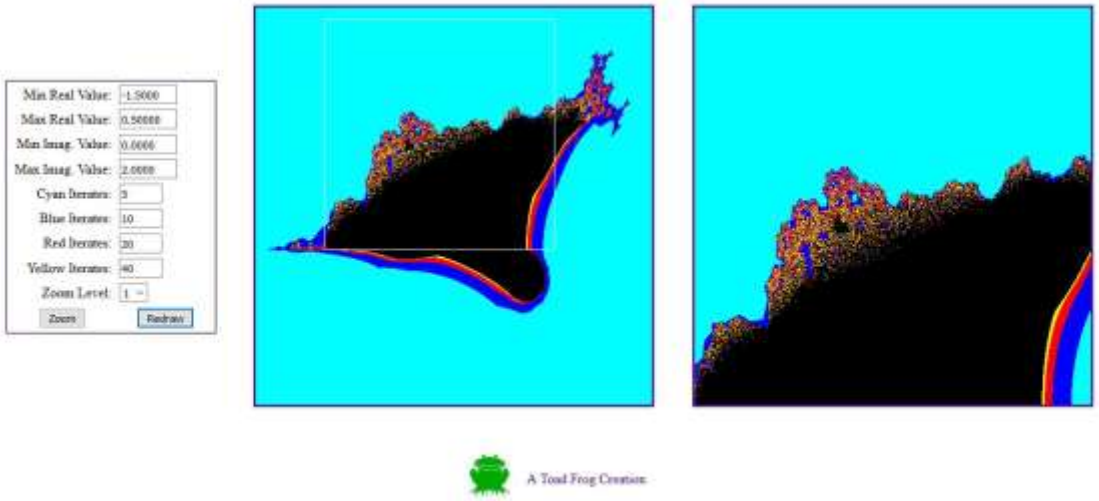


Figure 2

How did this fractal get its name? If we zoom in on the left side of the fractal, the image of Figure 3 appears, which some people are reminded of a burning ship.

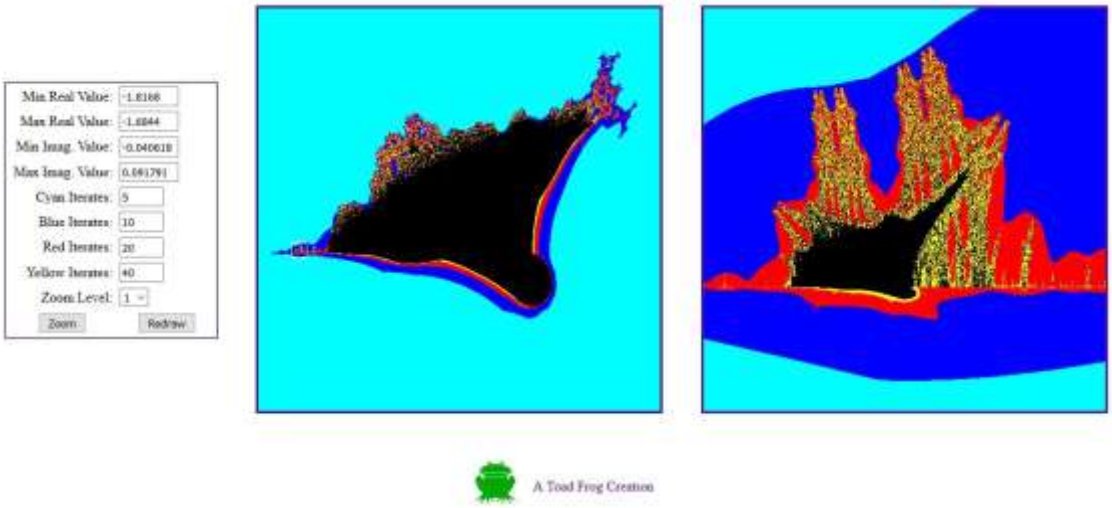
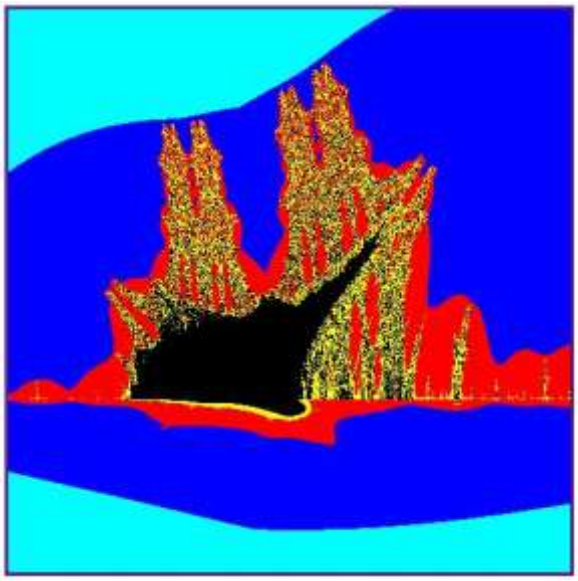


Figure 3

How are the colors generated? As stated before, for each complex value *c*, the sequence $(|\mathrm{Re}(z_n)| + i|\mathrm{Im}(z_n)|)^2 + c$ with $z_0 = 0$ is generated. If the sequence is bounded then *c* is a point in the burning ship fractal. If $|z_n| > 2$ for any value of *n*, then it can be shown that the sequence is unbounded and *c* is not a point in the fractal. If $|z_n| > 2$ for $n \leq 5$, then the point *c* is colored cyan . Otherwise if $|z_n| > 2$ for $n \leq 10$, then the point *c* is colored blue; if $|z_n| > 2$ for $n \leq 20$, then the point *c* is colored red; and if $|z_n| > 2$ for $n \leq 40$, then the point *c* is colored yellow. If all the above conditions fail, the point is colored black. The thresholds which determine the colors can be changed by editing the color textboxes in the status window. Figure 4 depicts the burning ship using the default thresholds vs. doubling all thresholds.

Default Color Thresholds



Double Color Thresholds

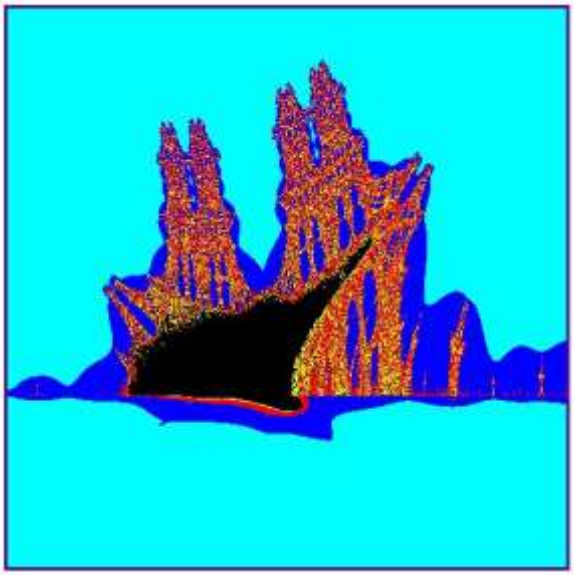


Figure 4

Finally, Figure 5 shows a zoomed area in the upper right hand portion of the fractal.

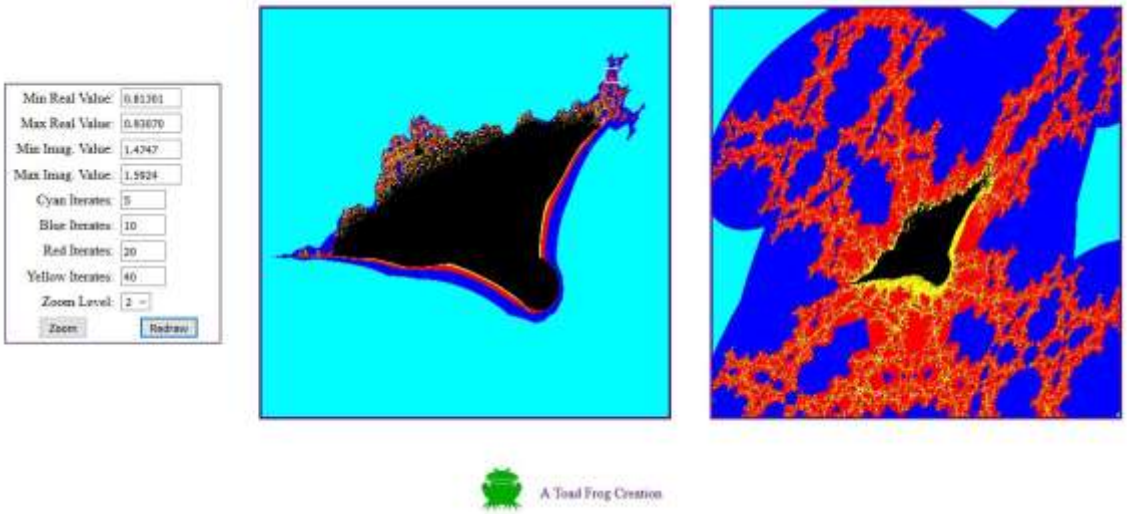


Figure 5