Mandelbrot and Julia Set

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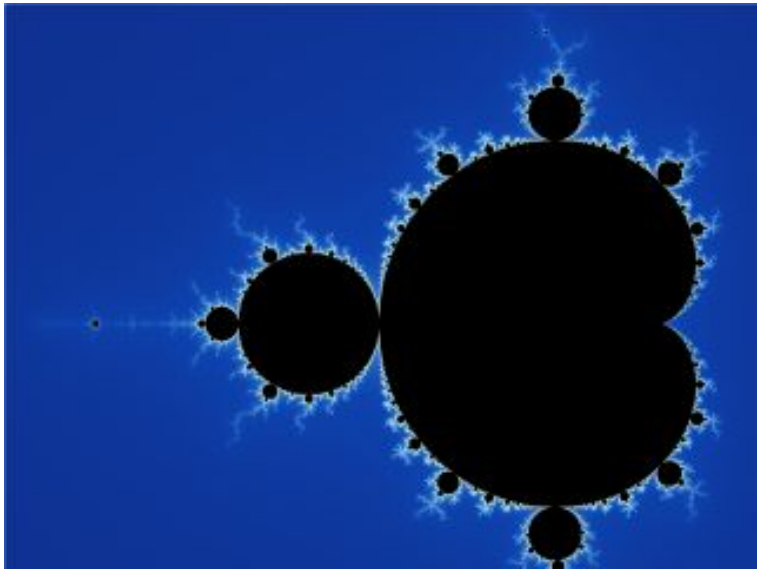
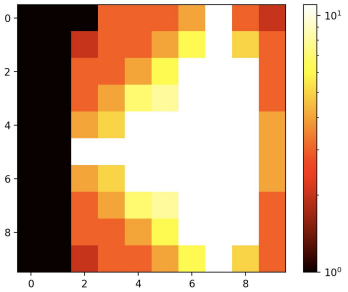
Mandelbrot Set

- Fractal
- Set of complex numbers for which the function f(z) = z^2 + c does not diverge when iterated from 0
- Named after Benoit Mandelbrot, pioneer for fractal geometry
- The area is bounded to |z| = 2
- The closer one zooms into the image, the more intricate details are revealed
- Zooming into a certain z value can provide a picture of the infinite unique geometric shapes

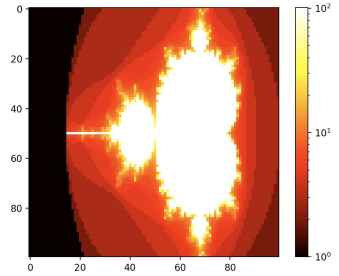


Mandelbrot Image

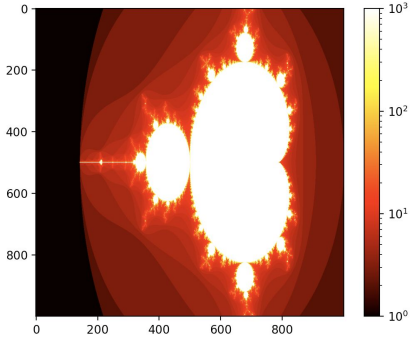
- Increasing the iterations and image resolution can create a more finely detailed mandelbrot image
- Huge iterations can create even finer detail images allowing us to “zoom in” and visualize the unique patterns however takes more time



10 Iterations
0.000185 secs

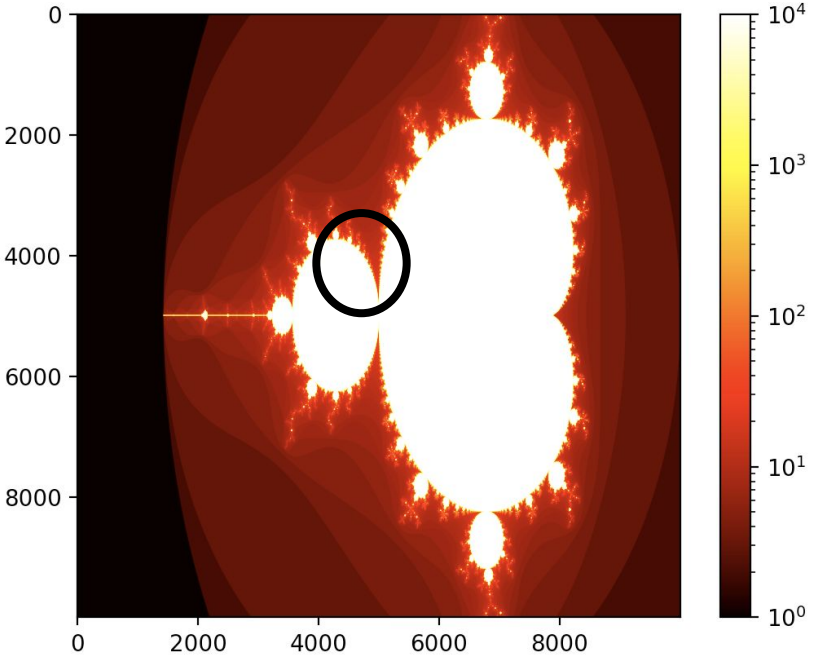


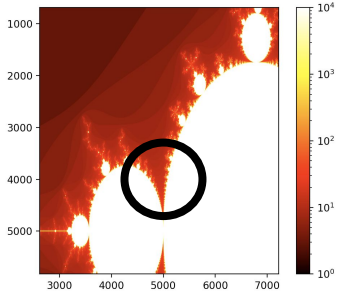
100 Iterations
0.000185 secs

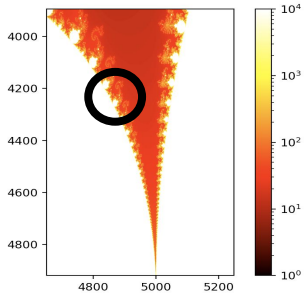


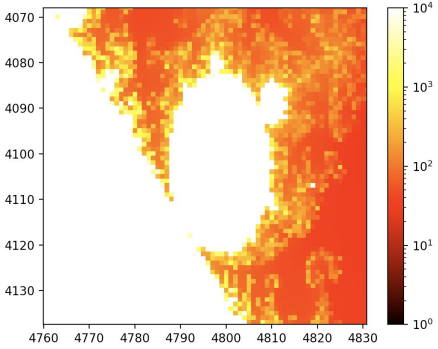
1000 Iterations
0.808790 secs

Enhanced Image : 10000 Iterations : 832.378 Seconds





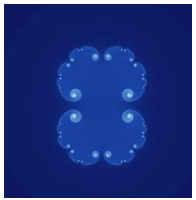




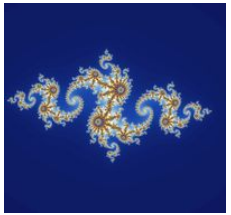
Massive iterations allows us to zoom into the image to recognize unique patterns

Julia Set

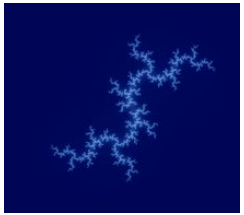
- Fractal
- Iterative properties of more general expressions within the mandelbrot set
- Unlike mandelbrot, Julia sets *c* value within the mandelbrot formula f(z) = z^2 + c stays the same
- The *c* value provides different patterns



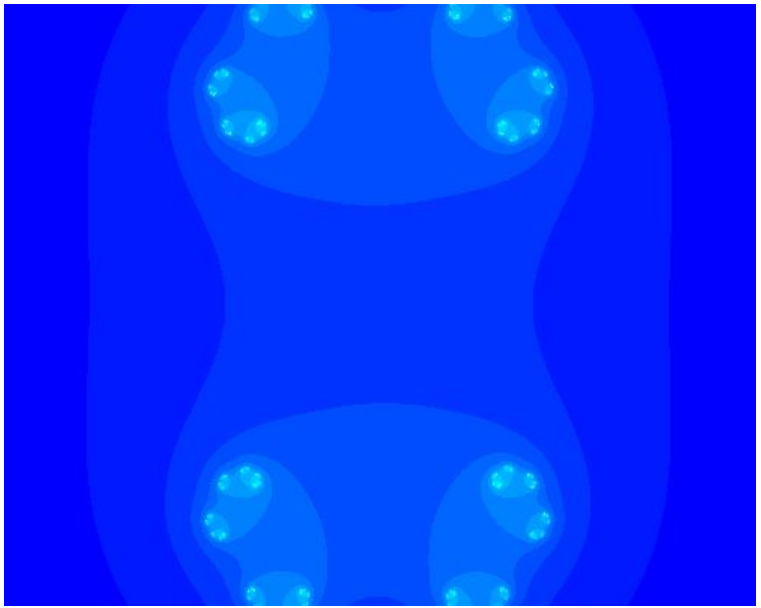
$c = 0.285 + 0i$



$c = -0.8 + 0.156i$

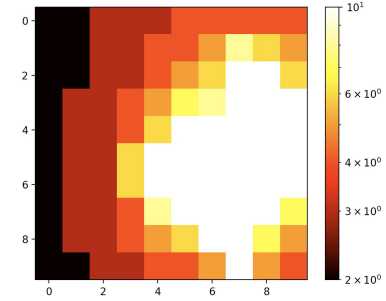


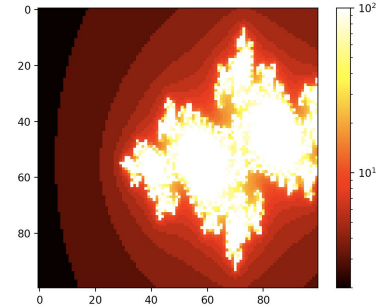
$c = -0.8i$

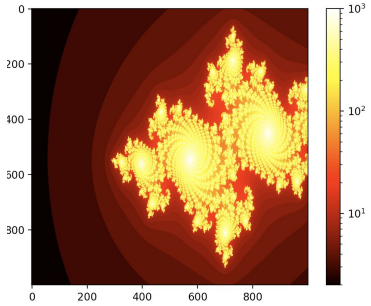


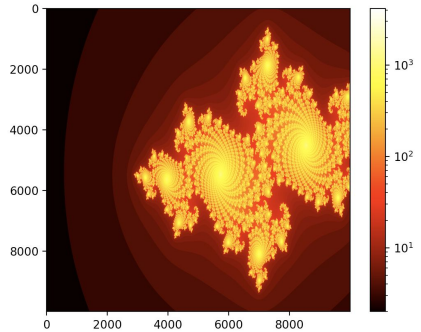
Julia Set Image

- Just like mandelbrot, increasing the iterations and image resolution can create a more finely detailed Julia image
- Just like mandelbrot, huge iterations can create even finer detail images allowing us to “zoom in” and visualize the unique patterns however takes more time



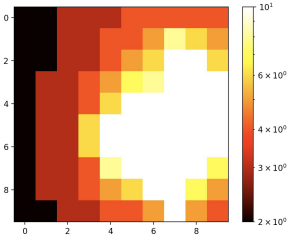


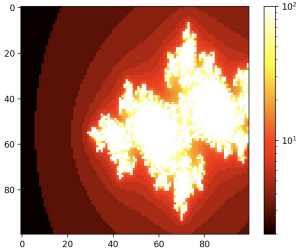


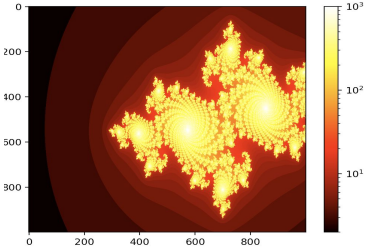


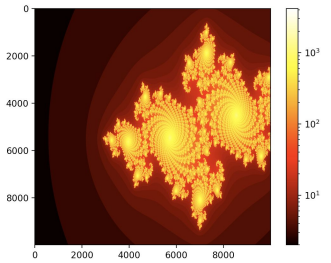
10000 Iterations 24.669331 secs

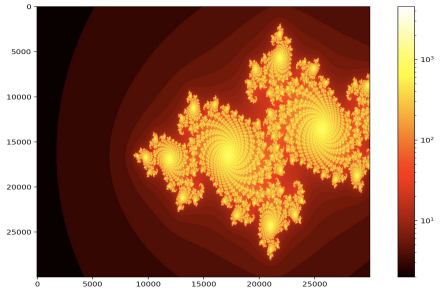
30000 Iterations : CUDA : 8.158948 Seconds



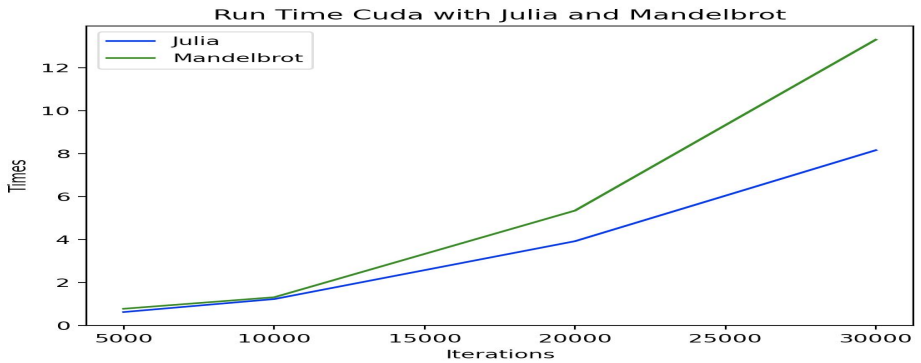


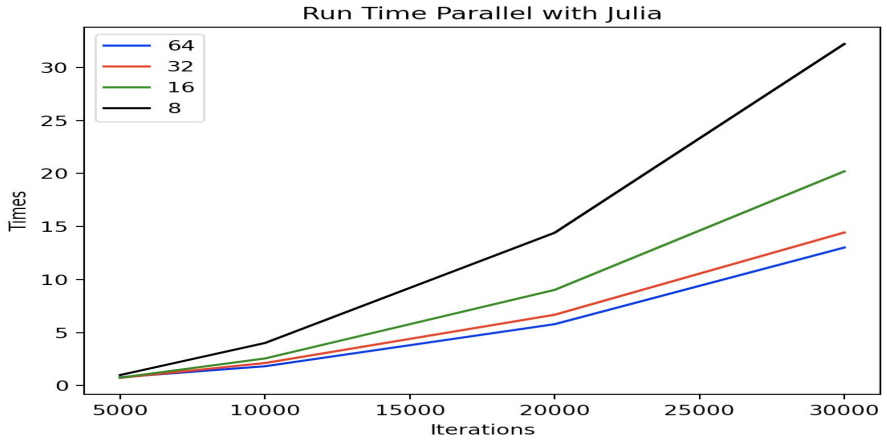


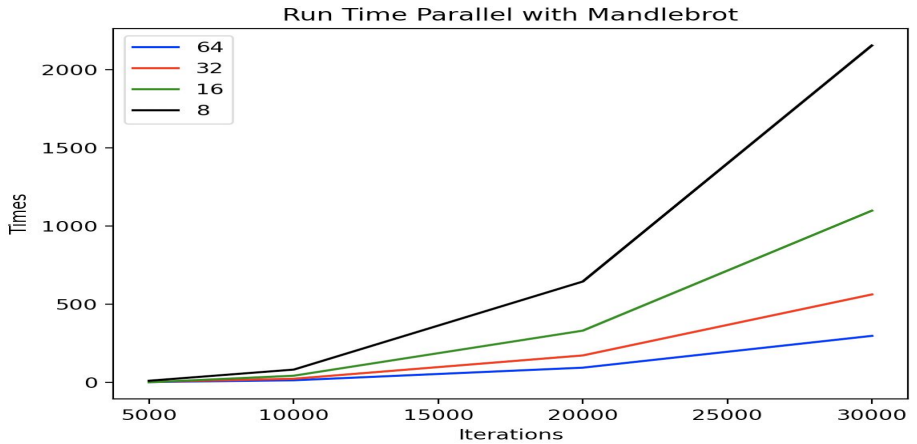




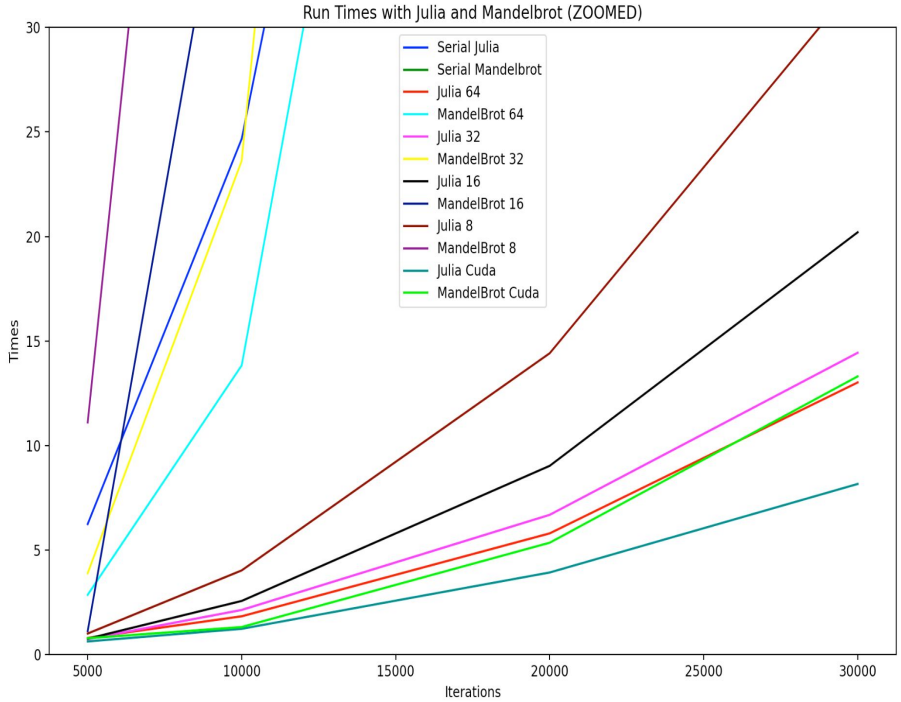
Speeds Comparison

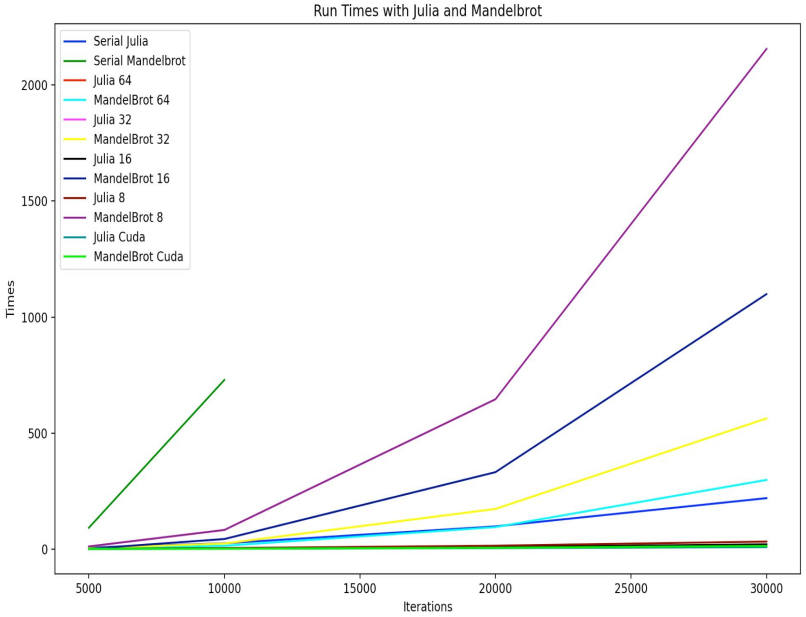






Speeds


Run Times with Julia and Mandelbrot (ZOOMED)
Serial Julia
Serial Mandelbrot
Julia 64
MandelBrot 64
Julia 32
MandelBrot 32
Julia 16
MandelBrot 16
Julia 8
MandelBrot 8
Julia Cuda
MandelBrot Cuda
Times
Iterations
0
5
10
15
20
25
30
5000
10000
15000
20000
25000
30000


Run Times with Julia and Mandelbrot
Serial Julia
Serial Mandelbrot
Julia 64
MandelBrot 64
Julia 32
MandelBrot 32
Julia 16
MandelBrot 16
Julia 8
MandelBrot 8
Julia Cuda
MandelBrot Cuda
Times
Iterations
0
500
1000
1500
2000
5000
10000
15000
20000
25000
30000

Speedup and Efficiency