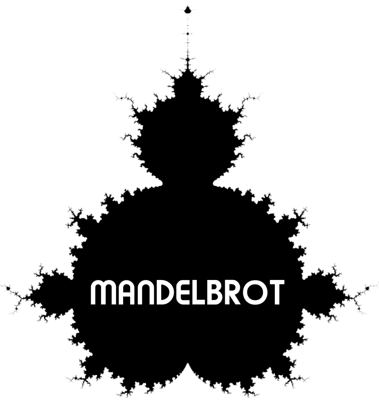
DRAW YOUR OWN



FRACTAL

Let's Mandel that Brot!

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Although it really isn't

Anyway you can make notes here or doodle or whatever?

FYI: the image on the cover was rotated -π/2 for aesthetic symmetry reasons, if your fractal points up something is wrong and you should gently help it get its bearing

Choose your environment wisely

Floating point support

Complex number support (optional)

Arrays, maybe; 2 dimensions is nice

Iteration / recursion

Fast-ish

Some way to visualise your stuff
(or it's all useless??!?)

On-screen

Needs pixel access
-> Canvas
-> Texture
-> BufferedImage
-> idk can we
still do VPOKE??

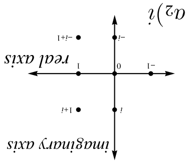
Or draw
1x1
rectangles

Write image

maybe PNG library
(don't use jpeg plz)

$c = a + bi; a, b \in \mathbb{R}; i^2 = -1$

$$c_1 + c_2 = (a_1 + b_1 i) + (a_2 + b_2 i)$$
$$= (a_1 + a_2) + (b_1 + b_2)i$$
$$c_1 c_2 = (a_1 + b_1 i)(a_2 + b_2 i)$$
$$= (a_1 a_2 - b_1 b_2) + (a_1 b_2 + b_1 a_2)i$$



$|c| = \sqrt{a^2 + b^2}$ the "absolute value"

$c \in \mathbb{C}$

for which the sequence

$$\begin{cases} z_0 = 0 \\ z_{n+1} = z_n^2 + c \end{cases}$$

remains bounded

unbounded = |z| becomes arbitrarily large

for this sequence, any |z| > 2 implies unbounded

(can you prove this?)

Examples!

c = 1+0i => 0, 1, 2, 5, 26, ... => unbounded

c = -1+0i => 0, -1, 0, -1, ... => bounded

c = 0+1i => 0, i, -1+i, -i, -1+i, -i, ... => bounded

c = 1/4+1/4i => 0, 1/4+1/4i, 1/4+3/8i, 11/64+7/16i, ...
=> bounded

HOW DO WE IMPLEMENT THIS?

```
For each pixel:
  map pixel to complex plane
    // define bounds of view on complex plane
    // same aspect ratios for viewport and bounds
    // some good initial (square) bounds:
    //    -2.1-1.3i to 0.5+1.3i
    // caution: drawing API might have
    //    positive y-axis going DOWN
  iterate that sequence
    // use complex primitives
    //  OR make your own Complex type
    //  OR just use separate real values
    // stop when |z| > 2 (unbounded)
    //   or after N iterations (bounded)
  if the sequence is bounded:
    color pixel black
```

You can do it!

Now let's make it SPARKLE

Whooo PRETTY COLORS

Select pixel color based on escape speed
= iteration count when we hit |z| > 2

Ex: `hsl(pow(it/max_it*360, 2) % 360, 30%, 60%)`

Whooo SMOOTH

A pixel is not a point but has an area
--> average multiple values per pixel,
distributed over pixel area
this is called "anti-aliasing" (not antipasti)

Whooo SPEED

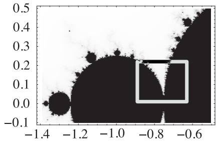
Can you make you algorithm FASTER?
Did you notice the parallelization potential?

Whooo DON'T MAKE ME THINK

Can you make an interactive zoom?
Controls to play with the color map?
Maybe you see other UI/UX improvements?

TIME FOR MATHEMATICAL FUN!

let's switch to a boring yet readable font for this



Professional mathematicians use the name "Seahorse Valley" for the region between the left bulb and the main cardioid. You can explore this area from these (square) bounds: -0.9-0.1i to -0.3+0.5i. Can you see why the region got this name? Let's dive into Seahorse Valley!

We're trying to reach the point P = -0.75+0i, where the cardioid and the bulb meet. We will approach from above. The points straight above P are outside the Mandelbrot set, so that means the series is unbounded. And that means the escape time (the amount of iterations until |z| > 2) for these points is defined.

What's the escape time for -0.75+0.1i? __________

What's the escape time for -0.75+0.01i? __________

What's the escape time for -0.75+0.001i? __________

What's the escape time for -0.75+0.0001i? __________

How much deeper can you go given your combination of algorithms, hardware and patience?

With the function N the escape time as above, what do you suspect is the value of $\lim_{\epsilon \to 0} N(-0.75 + \epsilon i)\epsilon$?

Happy birthday Benoit!

Benoit B. Mandelbrot (20 November 1924 – 14 October 2010) was a Polish-born French-American mathematician and polymath with broad interests in the practical sciences, especially regarding what he labeled as "the art of roughness" of physical phenomena and "the uncontrolled element in life". He referred to himself as a "fractalist" and is recognized for his contribution to the field of fractal geometry, which included coining the word "fractal", as well as developing a theory of "roughness and self-similarity" in nature.

(partially) made with Electric Zine Maker

↳ TRY IT