

Fractals

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CS 106B
Lecture 7
Jan 22, 2016

CLaIR Hours

A photograph of a man with a beard and a straw hat holding two young children. One child has blonde hair and is looking down, while the other child has dark hair and is looking at the camera. The background is a green, leafy environment.

My sister, Claire

Me

CLaIR:

Get help on concepts

Sunday , Tuesday, Thursday

8-10PM

Old Union 2nd Floor



Review

Recursion

Define an operation in terms of **itself**.

Three Musts of Recursion

1. Your code must have a case for all valid inputs.
2. You must have a base case (makes no recursive calls).
3. When you make a recursive call it should be to a simpler instance (forward progress towards base case)

Recursive Factorial

$$N! = N * (N - 1)!$$

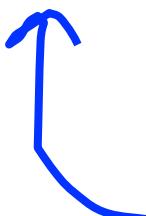
Fact(N) is equal to N times Fact(N – 1)

$$5! = 5 * 4 * 3 * 2 * 1$$

$$5! = 5 * 4!$$

Recursive Factorial

```
int fact(int n) {  
    [REDACTED]  
} else {  
    [REDACTED]  
}  
}
```



$$N! = N * (N-1)!$$

Recursive Factorial

```
int fact(int n) {  
    [REDACTED]  
} else {  
    // recursive case  
    return n * fact(n - 1);  
}  
}
```



$$N! = N * (N-1)!$$

Recursive Factorial

```
int fact(int n) {  
  
    if(n == 0) {  
        // base case  
        return 1;  
    } else {  
        // recursive case  
        return n * fact(n - 1);  
    }  
}
```

$$N! = N * (N-1)!$$

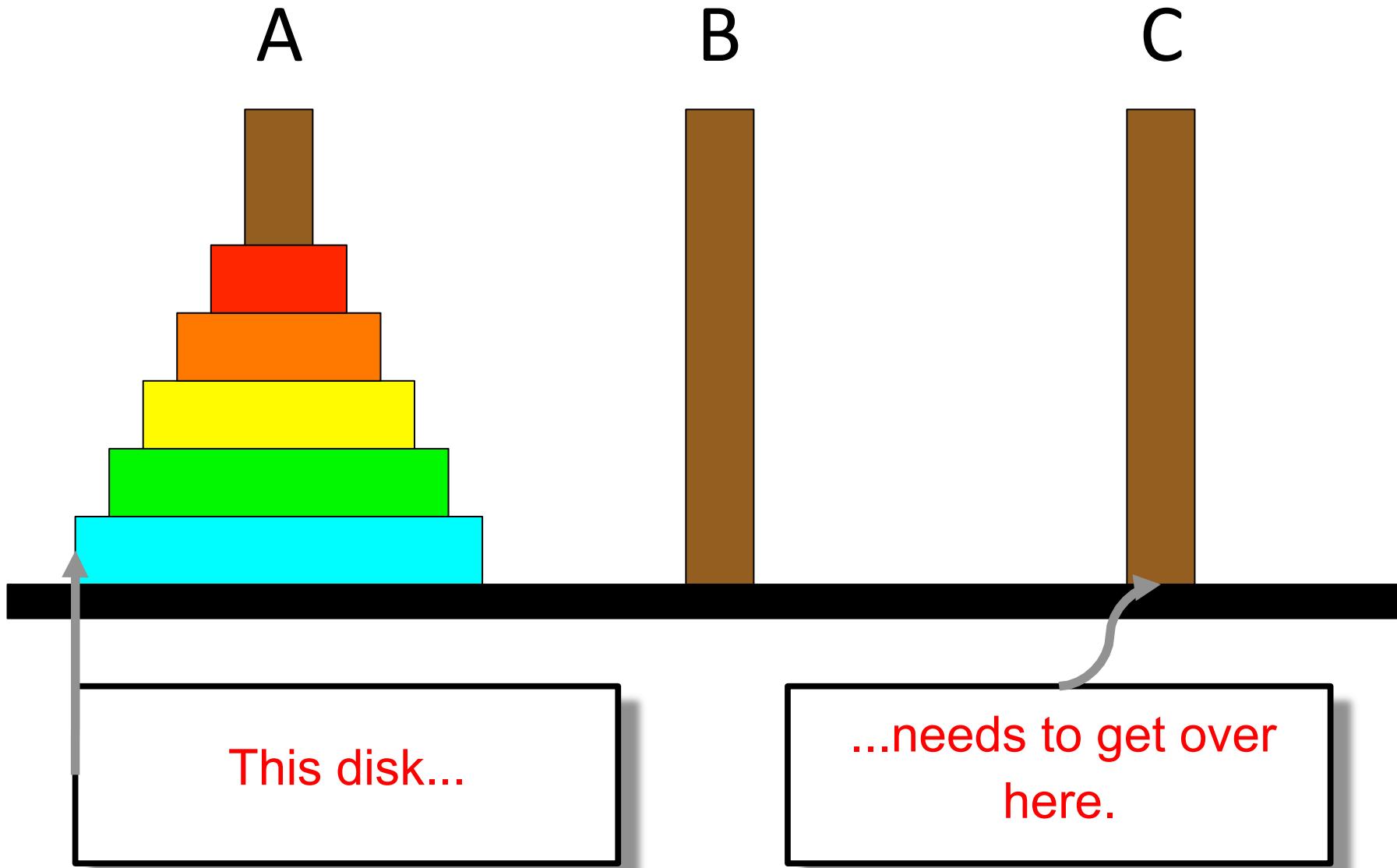
Common Bug

```
int fact(int n) {  
  
    if(n == 0) {  
        // base case  
        return 1;  
    } else {  
        // recursive case  
        n * fact(n - 1);  
    }  
}
```

$$N! = N * (N-1)!!$$

snazzy

Tower of Hanoi Insight



End Review

Today's Goal

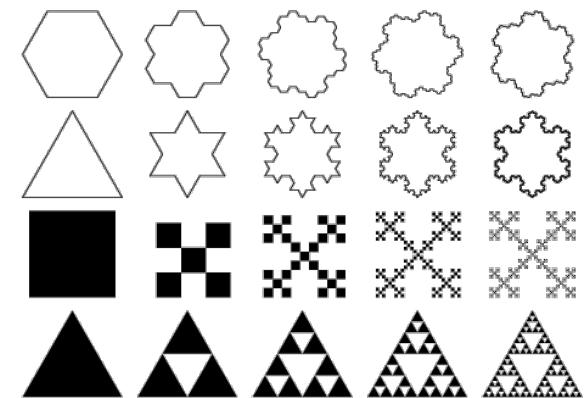
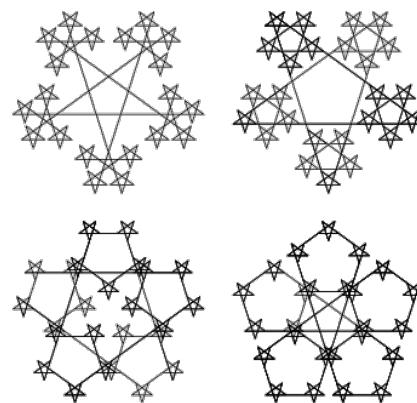
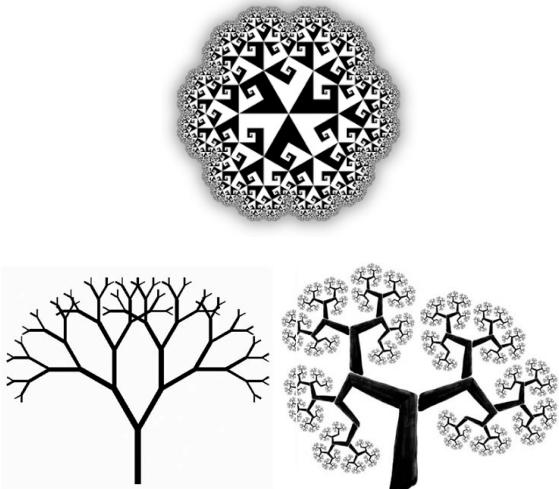
1. Be able to write graphical recursive functions



Recursion you can *see*

Fractals

fractal: A recurring graphical pattern. Smaller instances of the same shape or pattern occur within the pattern itself.



Fractals in Nature

Many natural phenomena generate fractal patterns:

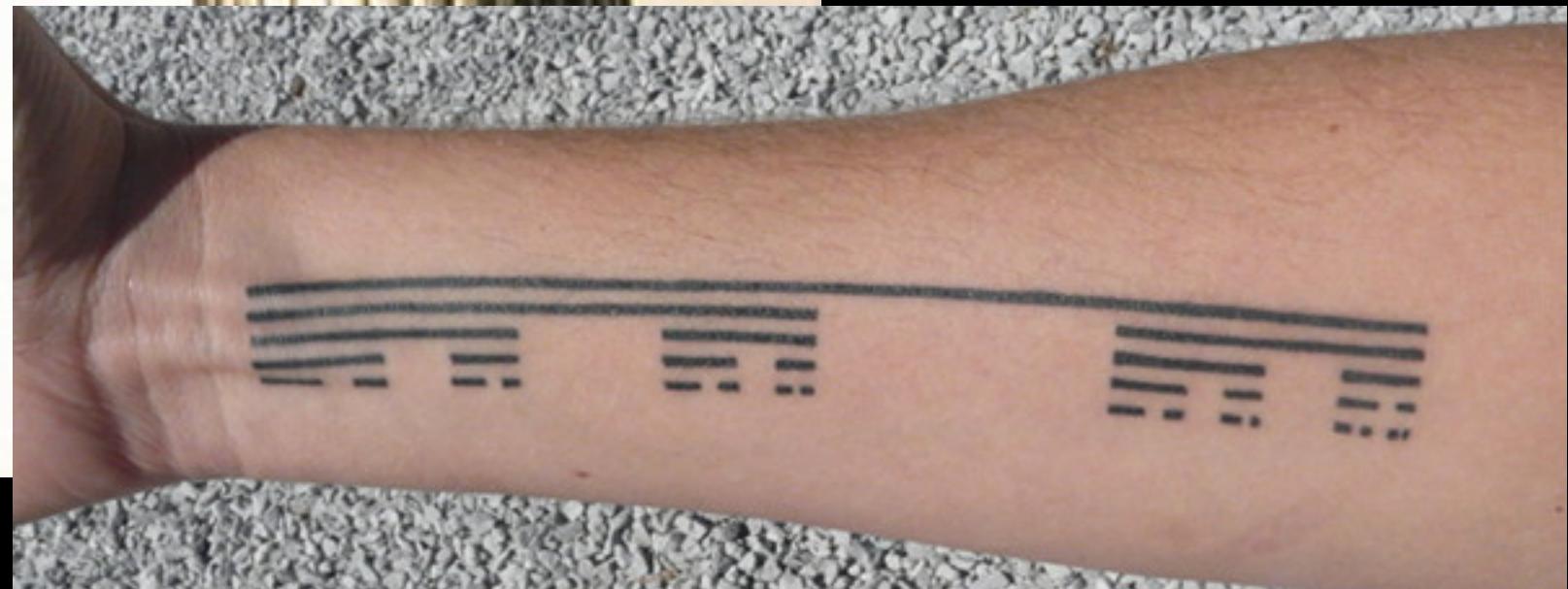
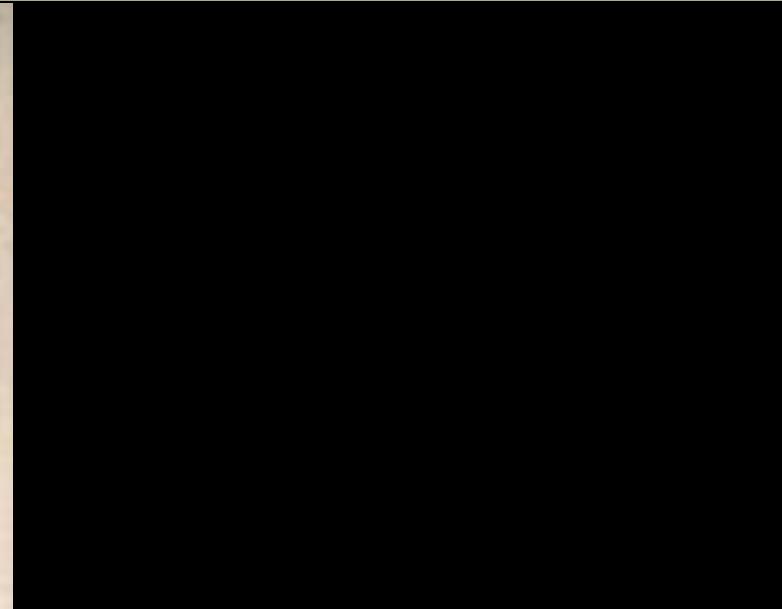
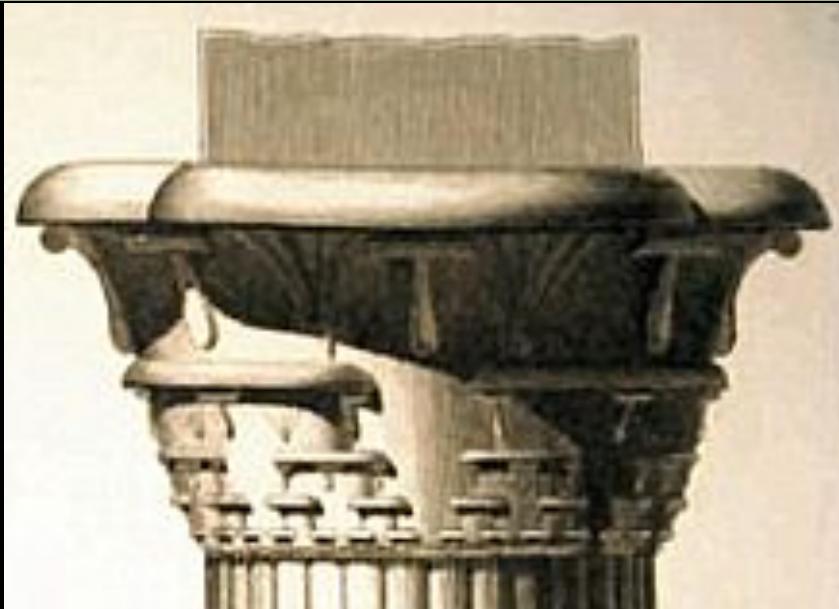
1. earthquake fault lines
2. animal color patterns
3. Clouds
4. mountain ranges
5. Snowflakes
6. Crystals
7. DNA
8. ...



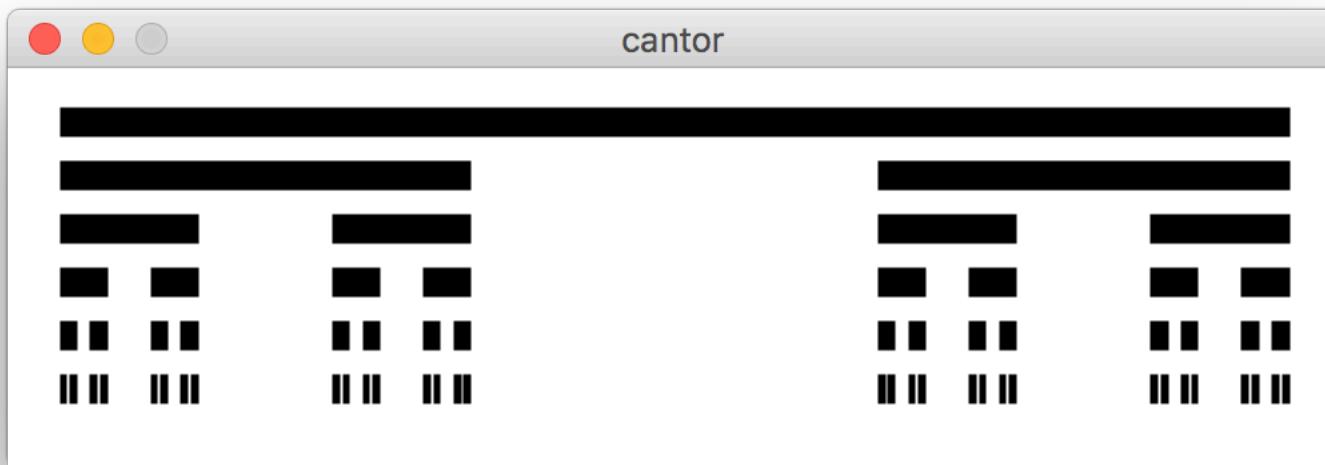
Ready?

Let's go!

Cantor Fractal

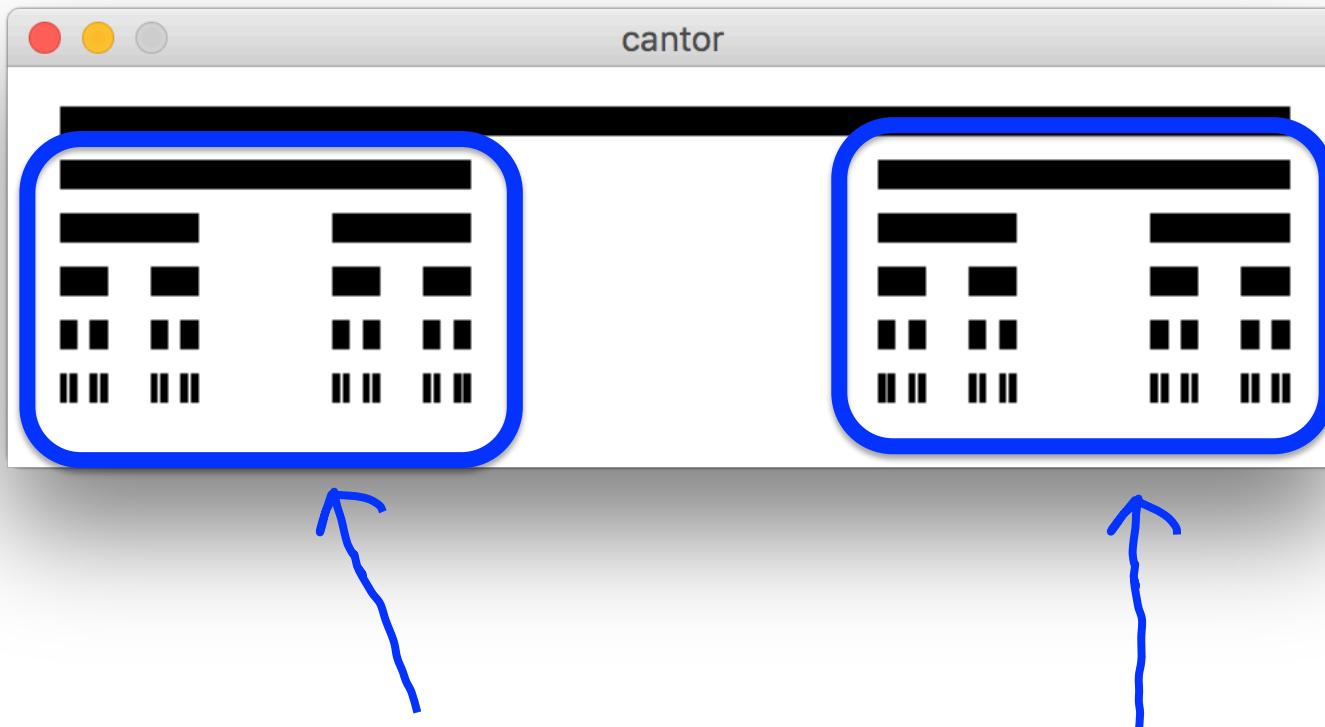


Cantor Fractal



Parts of a Cantor set image...
are Cantor set images

Cantor Fractal



Another cantor set

Also a cantor set

GPoint

x = 0

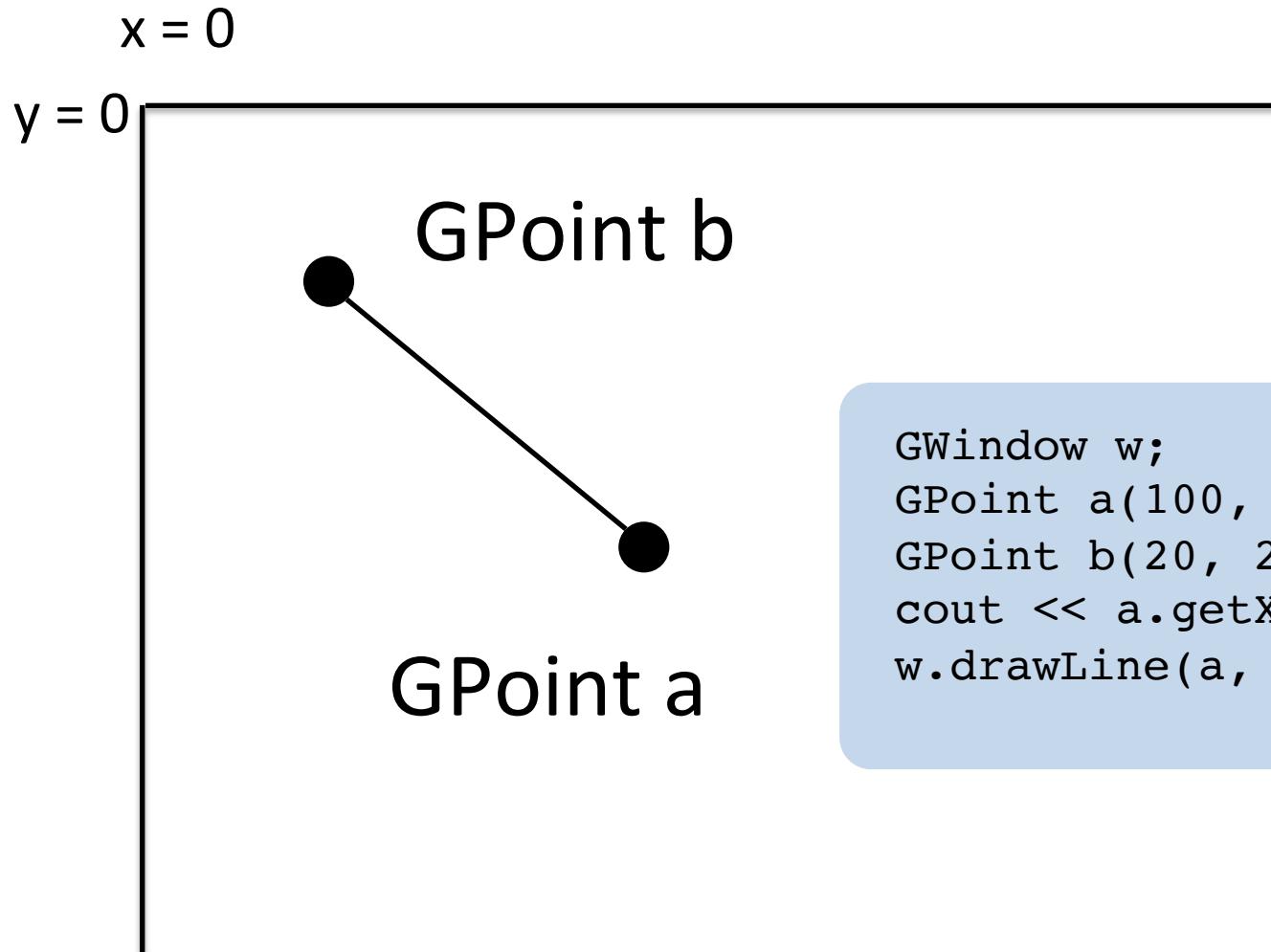
y = 0



GPoint a

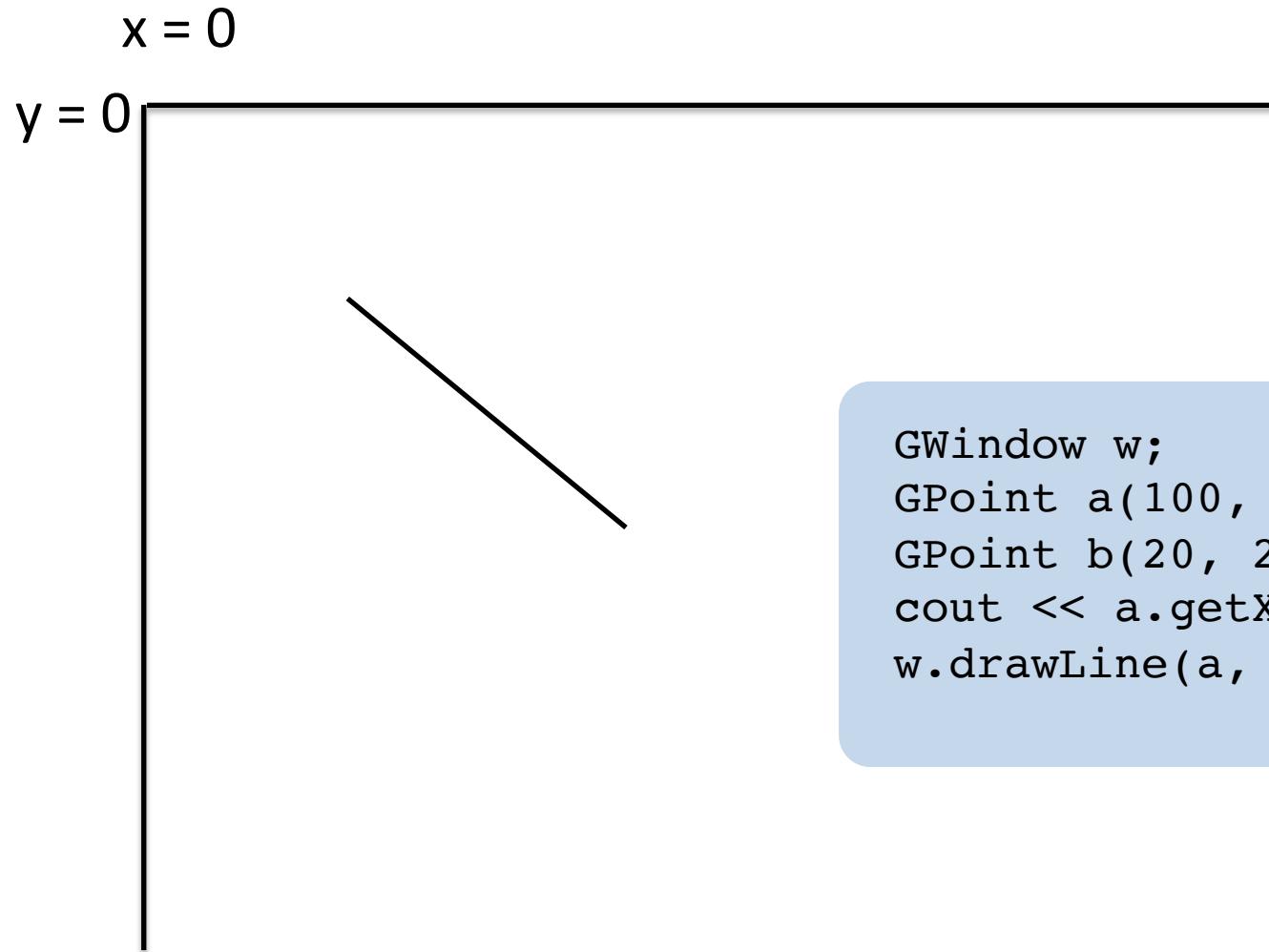
```
GWindow w;  
GPoint a(100, 100);  
cout << a.getX() << endl;
```

GPoint



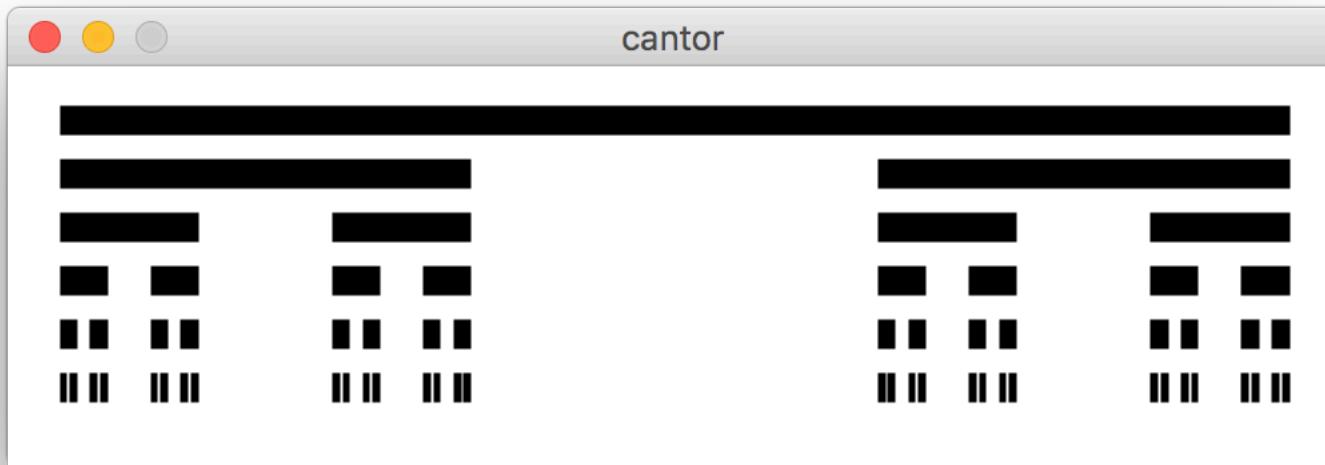
```
GWindow w;  
GPoint a(100, 100);  
GPoint b(20, 20);  
cout << a.getX() << endl;  
w.drawLine(a, b);
```

GPoint

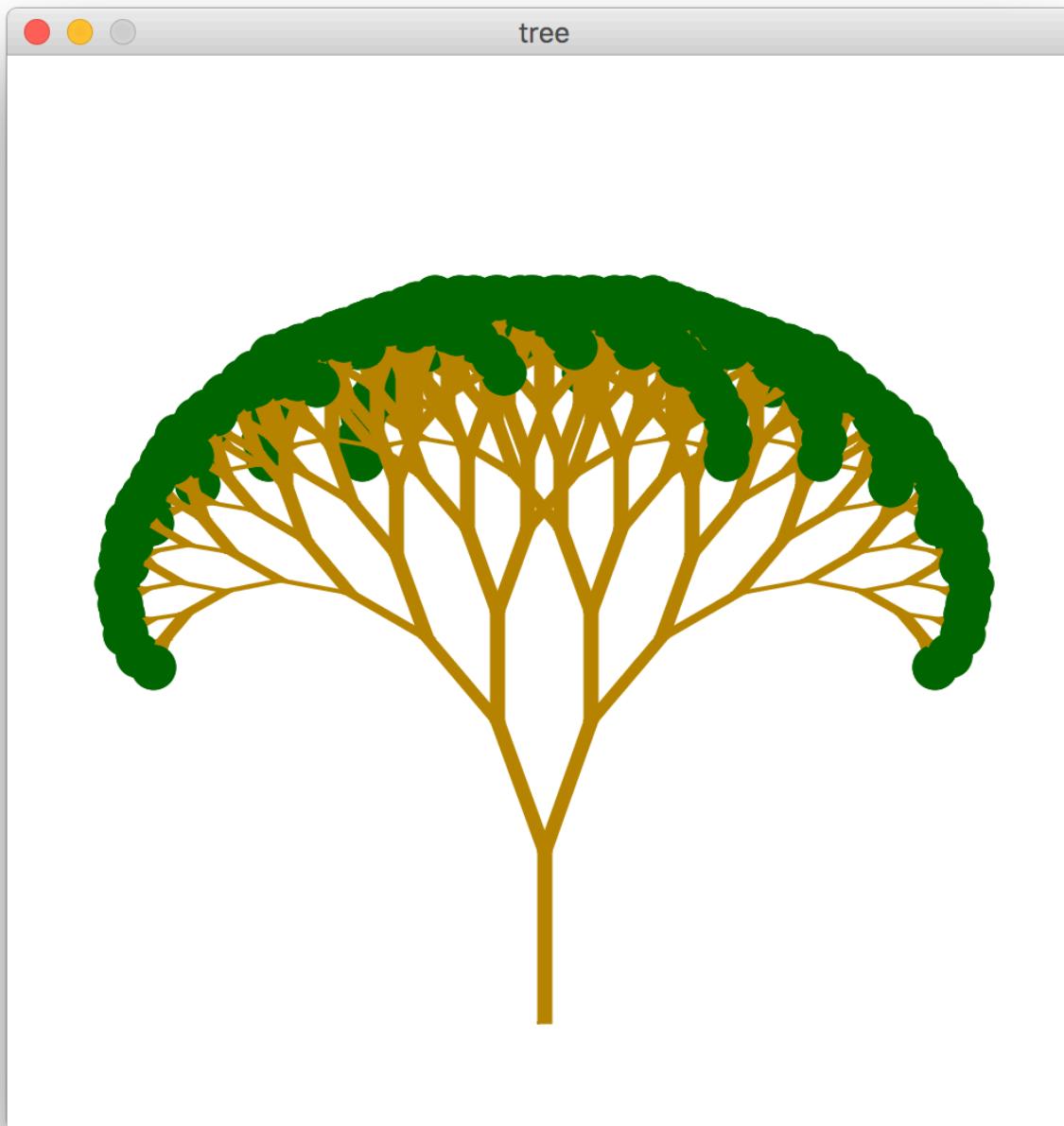


```
GWindow w;  
GPoint a(100, 100);  
GPoint b(20, 20);  
cout << a.getX() << endl;  
w.drawLine(a, b);
```

Cantor Fractal

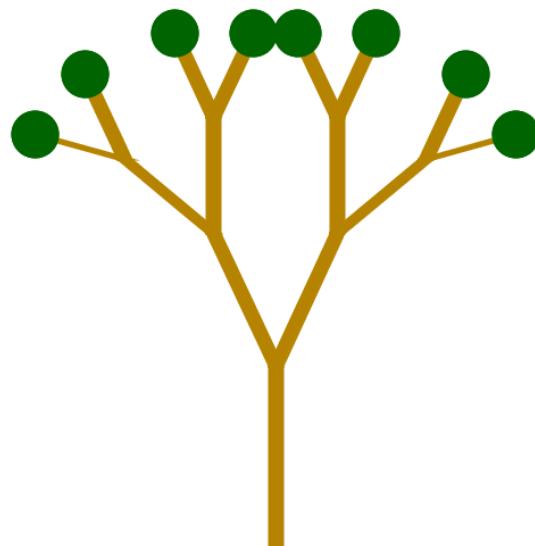


Pythagoreas Tree

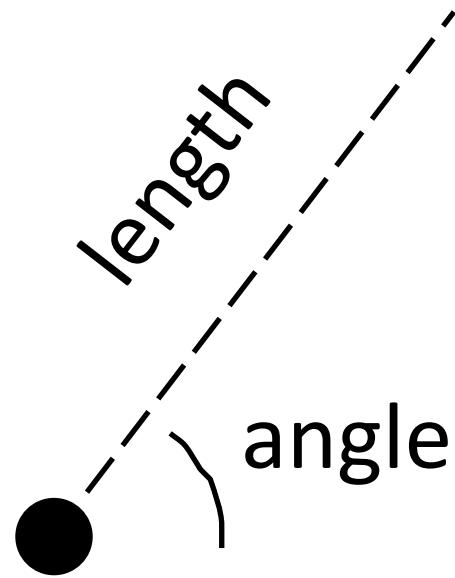


Pythagoreas Tree

Depth = 4

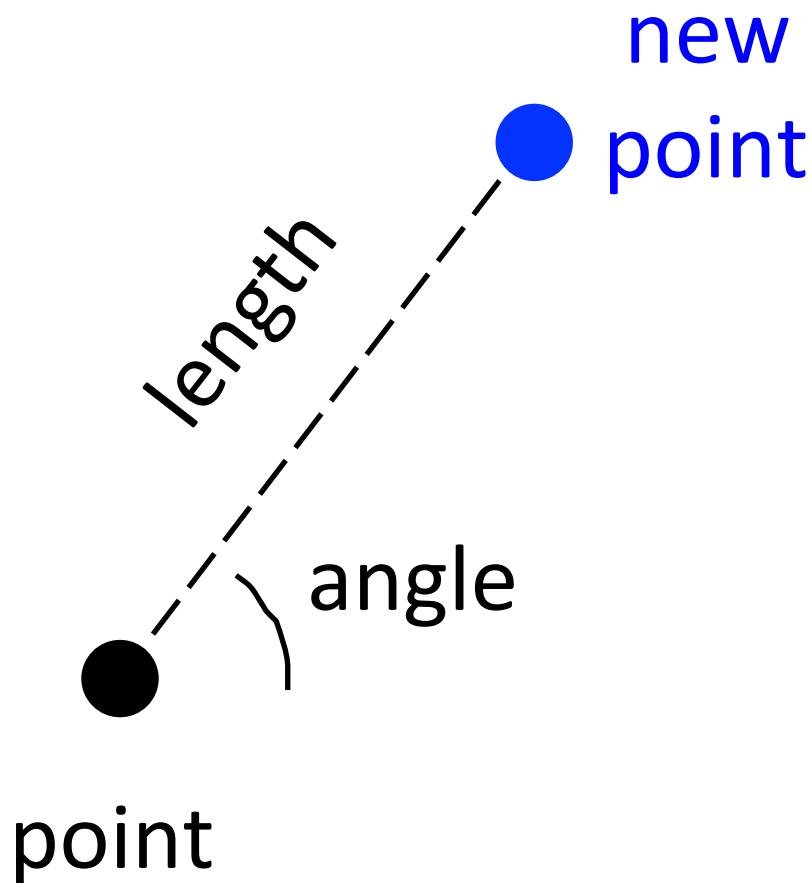


Polar Move

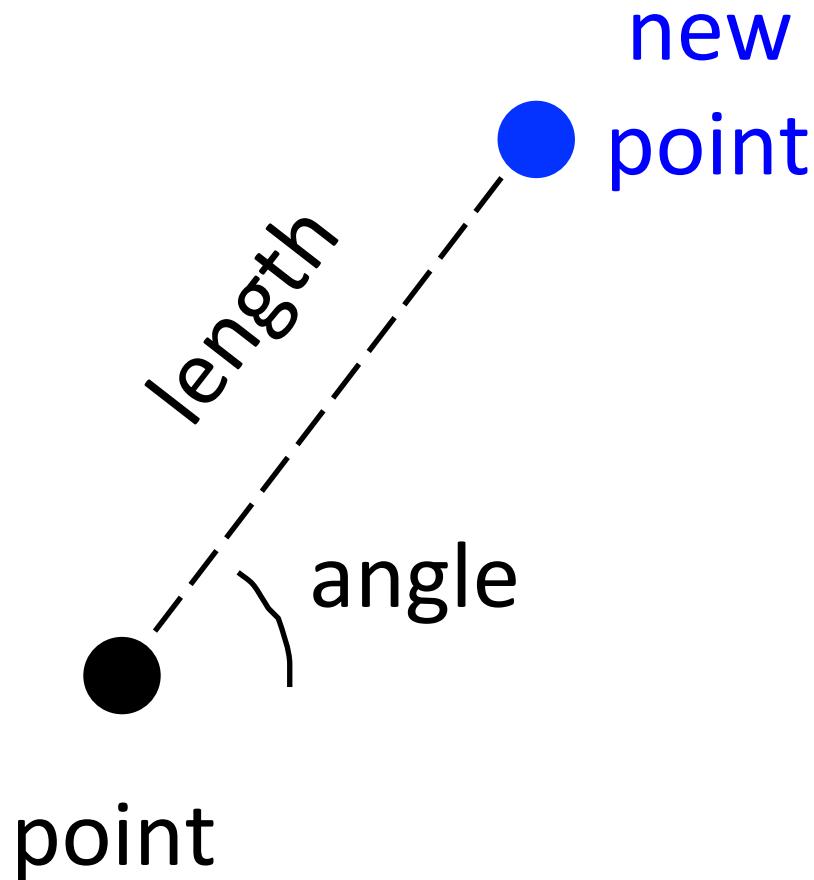


point

Polar Move

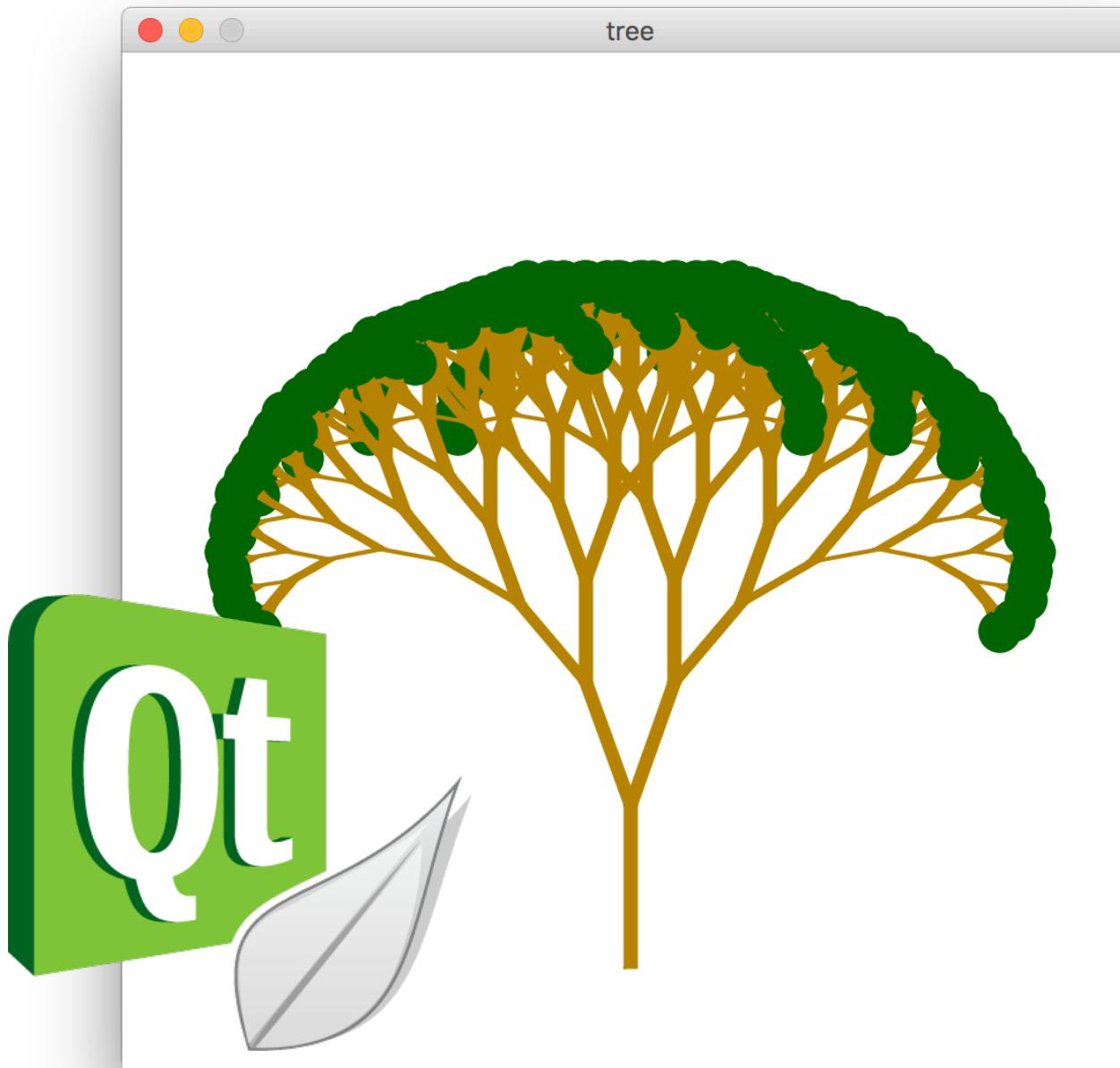


Polar Move



```
movePolar(GPoint start, double length, double angle);
```

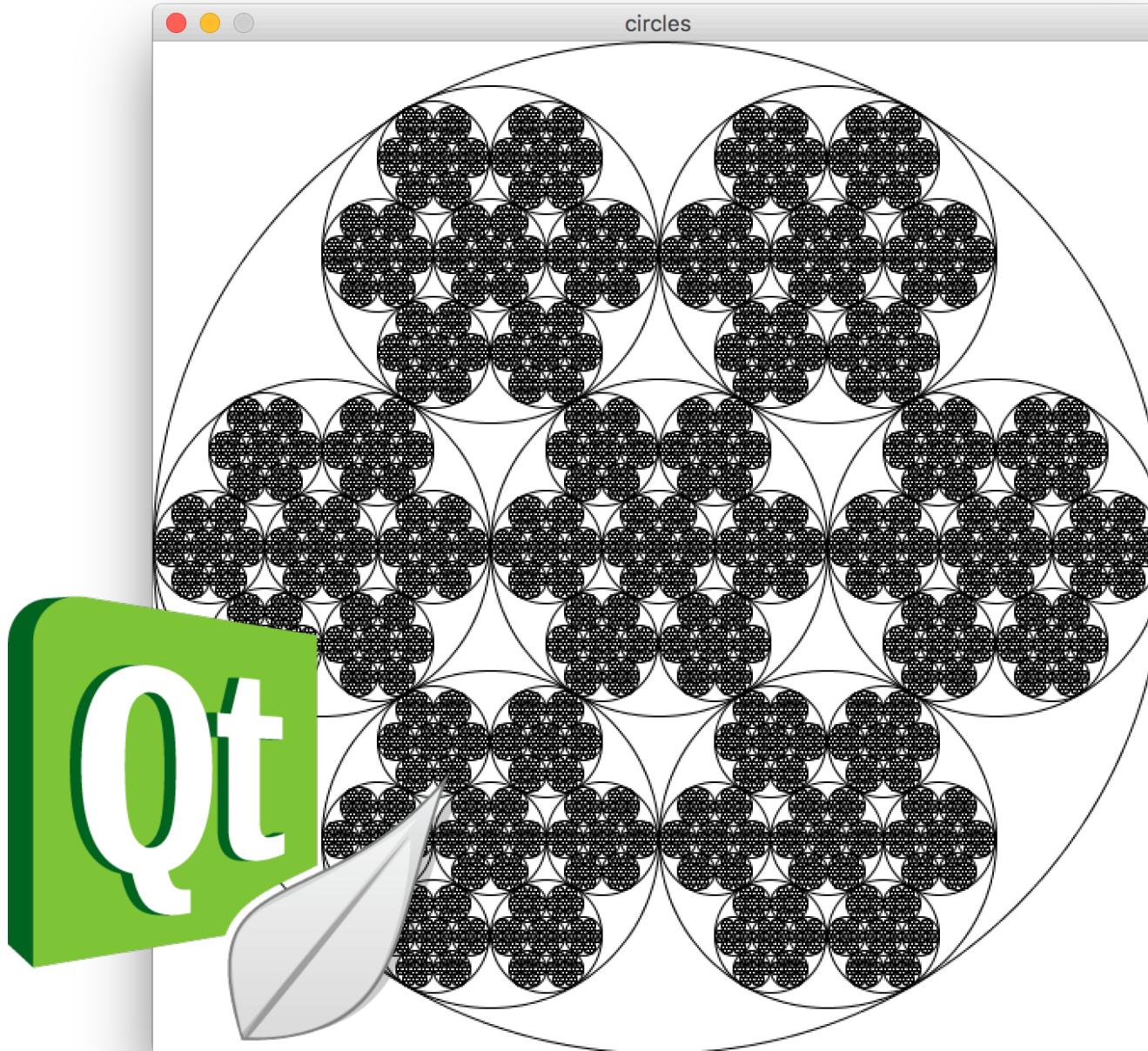
Pythagoreas Tree



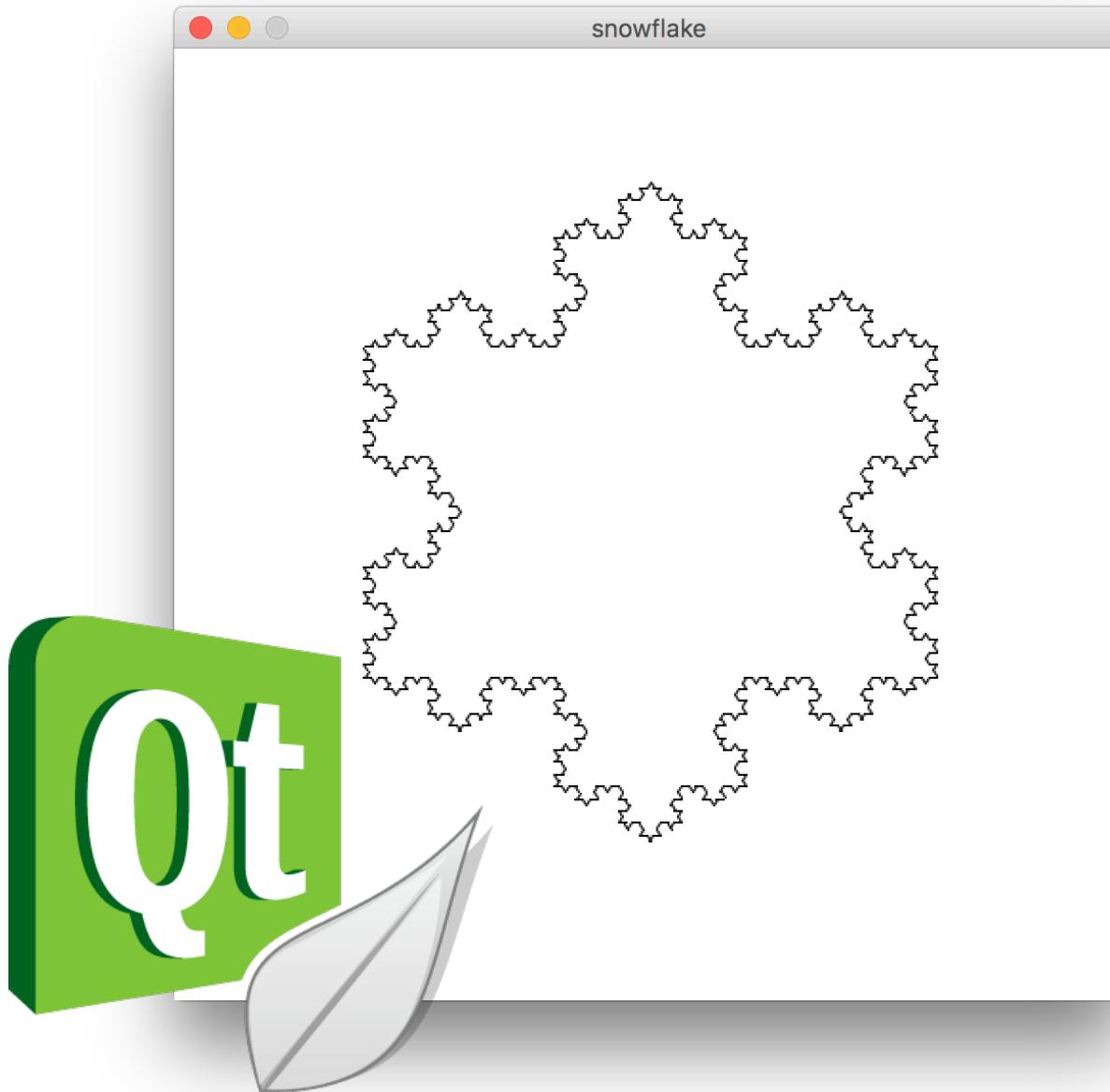


Soeren Perk, Guibas Lab, Stanford

Fractal Circles



Koch Snowflake



I don't
plan to
have time
to solve
this

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https://www.youtube.com/watch?v=mWmSGH_uIGw#t=187



A photograph of a still life arrangement on a reflective surface. In the foreground, two blue six-sided dice are visible. Behind them is a green glass bottle. To the left, there is a tall, slender glass filled with a light-colored liquid, and a shorter glass partially filled with a yellow liquid. On the right, a large, ornate glass mug is partially visible. The background is blurred, showing a window with a grid pattern and some foliage outside.

Recursive Ray Tracing

A Little Bit of Slope



John Ousterhout