



Recursive Graphics

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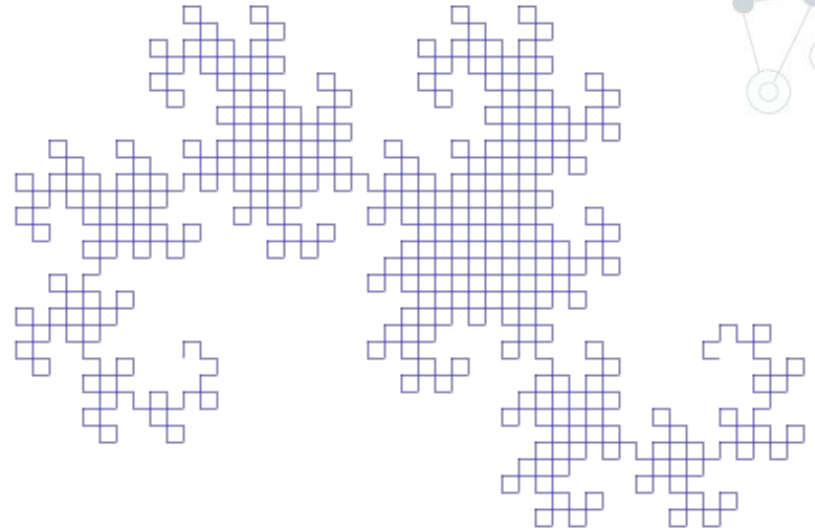


• What are Recursive Graphics?



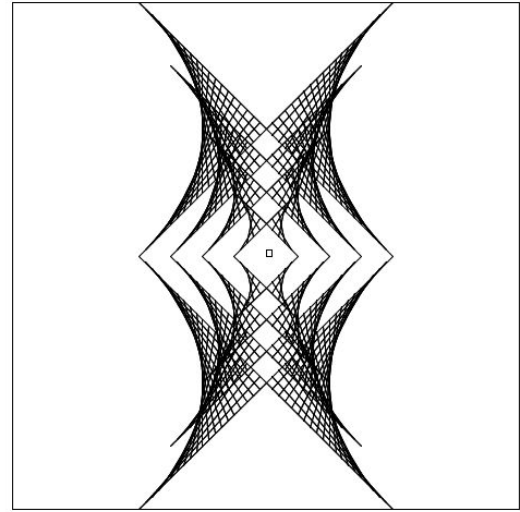
What they are

- Recursive graphics are sect of computer graphics using recursion to generate images
- Famous examples include Koch Snowflake and Sierpinski Triangle



How they work

- Apply a set of rules to a shape ie. square, triangle, circle, L-shape
- Repeat them, upscale or downscale the shapes
- Through repeated transformations create complex patterns like fractals



Applications

- Comp graphics and animation
 - Complex shapes and patterns
- Data visualization
 - Appealing and intuitive visual of data
- Video games
 - Generate terrain/landscapes
- Art
 - Fractal patterns/L-systems

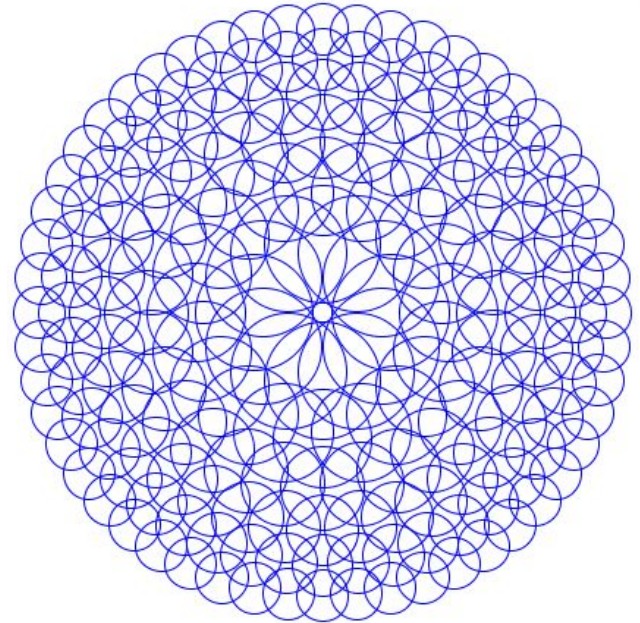


Image from [Recursive Graphics Gallery](#)

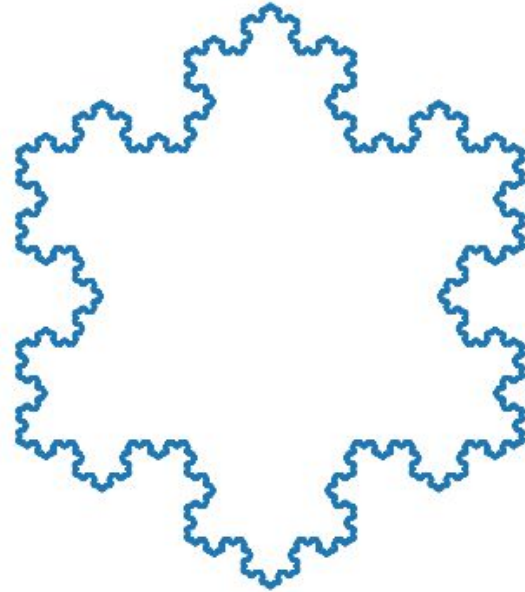
A decorative network graphic in the top-left corner, featuring a cluster of interconnected nodes. Some nodes are solid blue circles, while others are white circles with blue outlines. They are connected by thin, light gray lines.

Our Graphics

A decorative network graphic in the bottom-right corner, similar to the one in the top-left. It shows a cluster of interconnected nodes, with some being solid blue circles and others being white circles with blue outlines, all connected by thin, light gray lines.

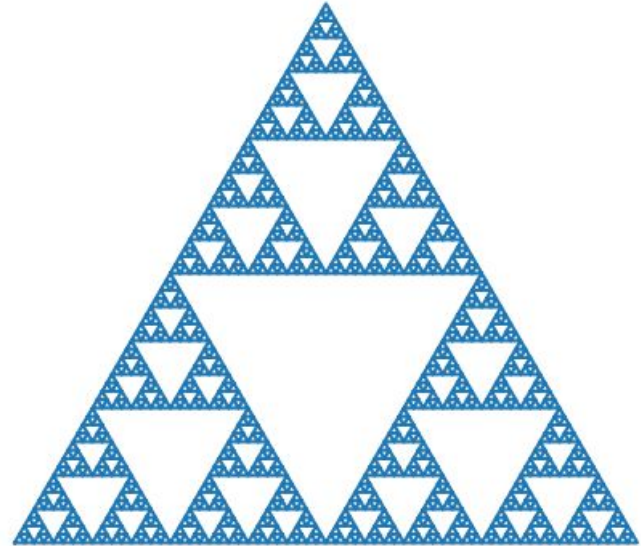
Koch Snowflake

- The Koch Snowflake is named after Swedish Mathematician Helge von Koch
- Fractal involving nested triangles
- Start with a straight line, break it into three parts, and replace the center line with an arch



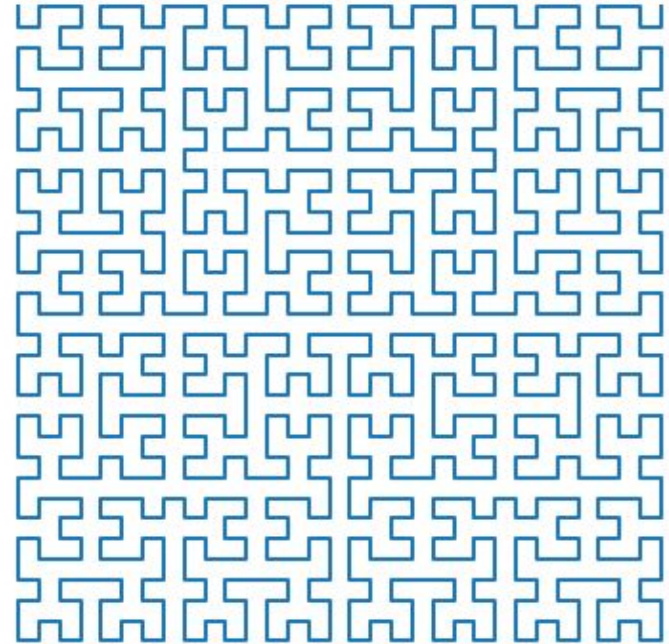
Sierpinski Triangle

- Named after Polish mathematician Wacław Sierpiński
- Start with an equilateral then divide it into 4 smaller triangles by connecting the midpoints of each side



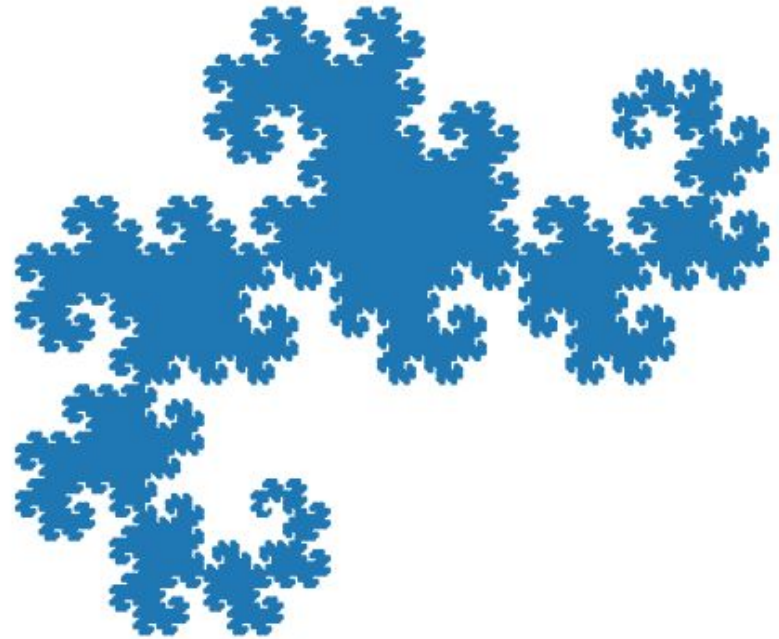
Hilbert Curve

- Continuous fractal space filling curve
- Begins with 3 sides of a square
- Bridges to further empty squares to make the shape displayed



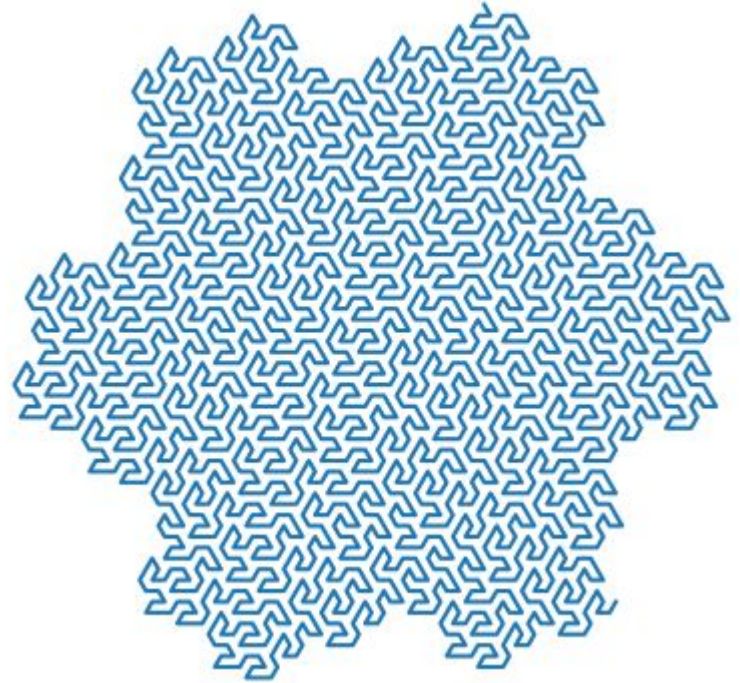
Dragon Curve

- Member of a family of fractal curves
- Self-replicating, can be scaled to create larger and smaller copies



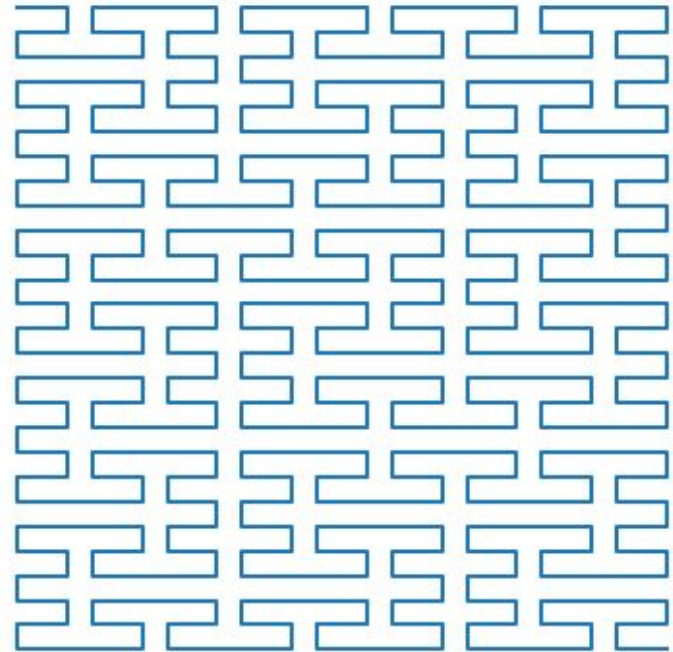
Peano Gosper

- Another member of the fractal curve family
- From mathematicians Bill Gosper and Giuseppe Peano



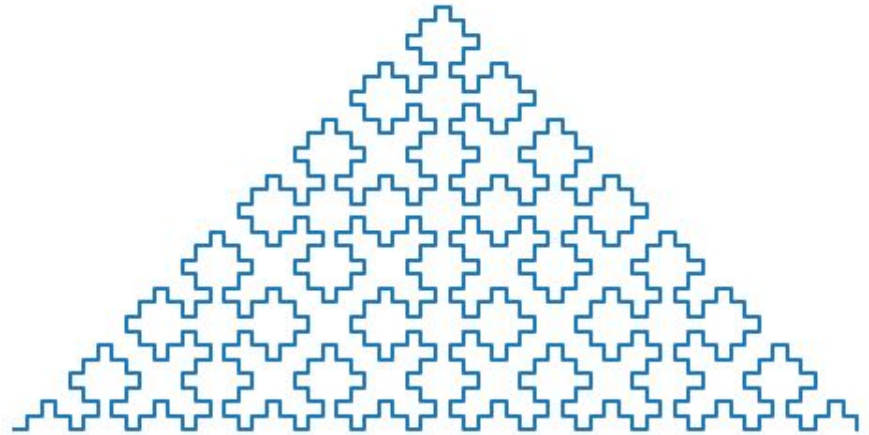
Hilbert Curve II

- Variant of the original Hilbert Curve
- Begins with an S instead of a U shape
- Emphasizes the butterfly effect found in fractal geometry



Square Curve

- Bottom left corner of pyramid displays the base case
- Builds off of initial structure with step shape fractals to form a larger overall pyramid shape



A decorative network diagram in the top-left corner, featuring a complex web of interconnected nodes and lines. Some nodes are highlighted with blue circles, and others with blue dots. The lines are thin and grey, creating a mesh-like structure.

Algorithms

A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It shows a network of nodes and lines, with some nodes highlighted by blue circles and others by blue dots.

L-Systems

Formula used to describe the fractal shape using text.

- Move forward - “F”
- Turn right by specified degree - “+”
- Turn left by specified degree - “-”

Once formula is determined, use recursive function to replace patterns with scaled up versions.

Ex. $F \rightarrow F+F-F$ turns into $F+F-F+F+F-F-F+F-F$ by substituting the pattern into each appearance of F.

Our Program

The first few functions defined in our program were created the more difficult way, by reverse engineering the pattern from a manually created correct L-System text file for various orders of magnitude.

For the extra graphics, we found pre-existing L-system formula that we easily substituted into recursive functions, such as the Dragon Curve formula describing the two patterns used:

$X \rightarrow X+YF+$, $Y \rightarrow -FX-Y$

Python Plotter

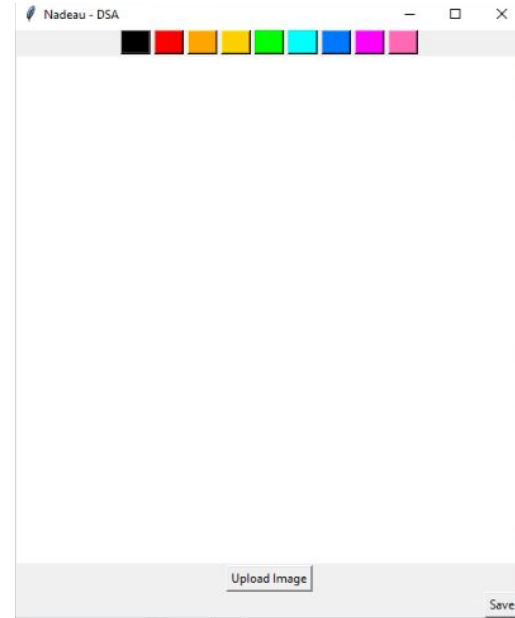
The python plotting script was created for Lab 6. It takes the L-System text file, and creates a plot via matplotlib by following the instructions embedded within.

A commonly used analogy is the Turtle. He follows the set of rules, dictated by forward motions (F), and turns (+/-) of a specific angle, fed in as a CLA.

Sample CLA's: `file.txt image.png <degrees>`

Python Coloring Book

As a fun twist we added created a small python program functioning off of the *Pillow* and *tkinter* libraries. By simply running the program it allows you to color in your png after uploading it, an even has the functionality to save.



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Our Source Code

A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It shows a network of nodes connected by lines, with some nodes highlighted in blue. The overall style is clean and modern, with a focus on connectivity and data flow.

A decorative network diagram in the top-left corner, featuring a complex web of interconnected nodes and lines. Some nodes are highlighted with blue circles, and others with blue dots. The lines are thin and grey, creating a mesh-like structure.

Questions

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