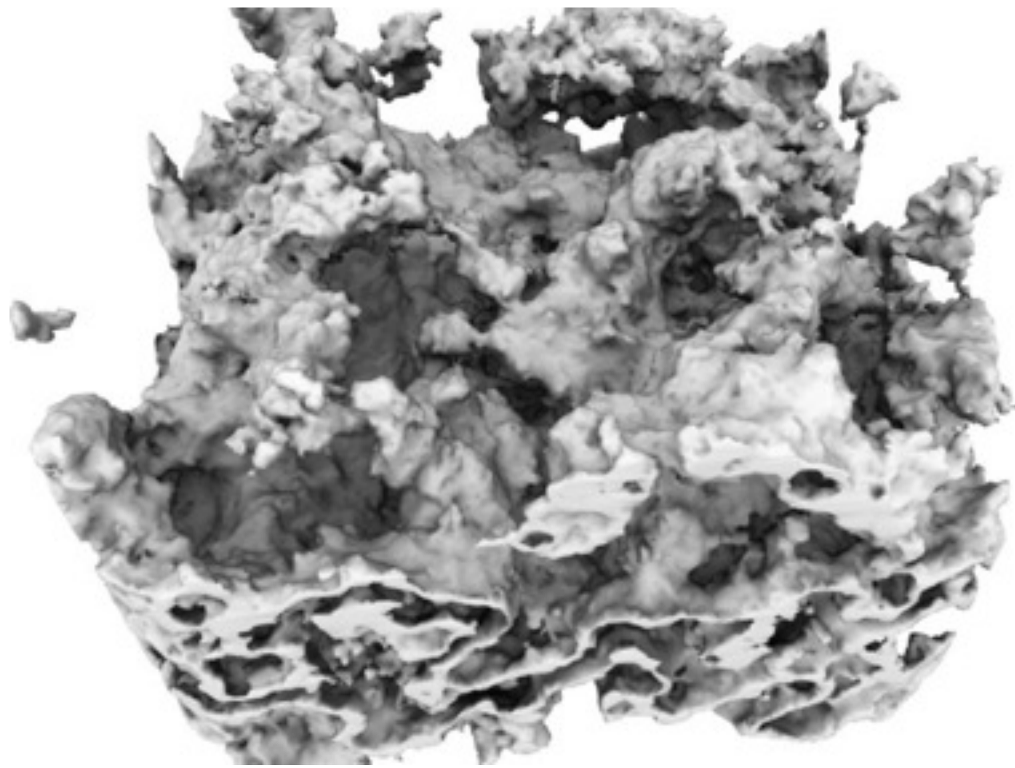
L-Systems

Procedural Modeling

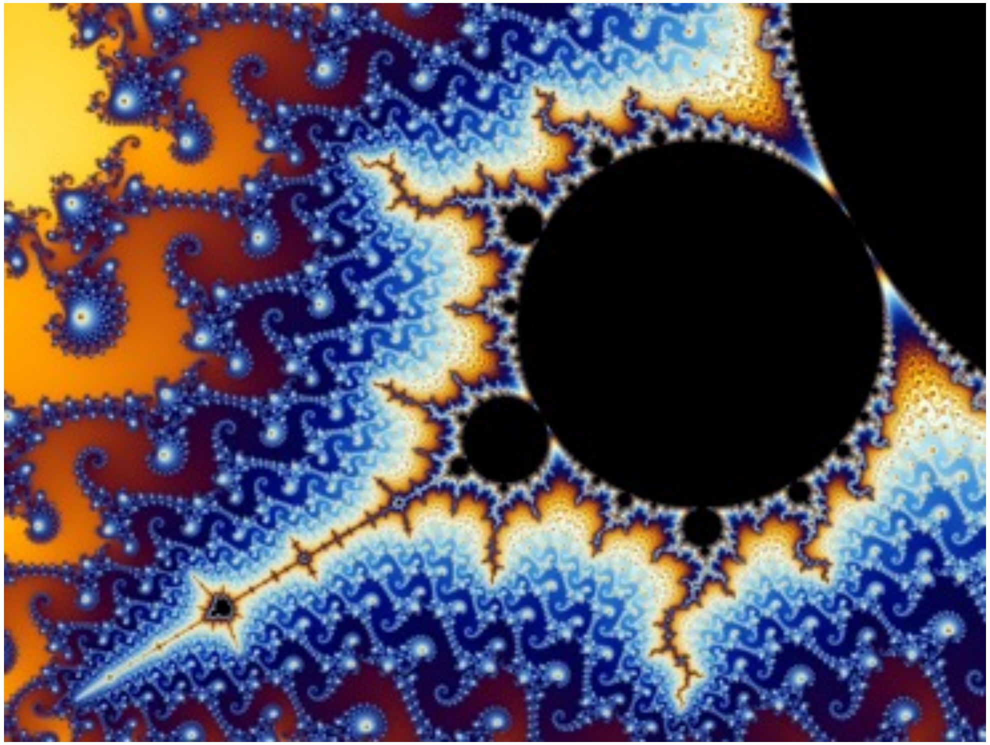
Idea: Detailed meshes are hard to build by hand, so let's create a function that builds out meshes for us

Same idea as Perlin noise but in 3D!



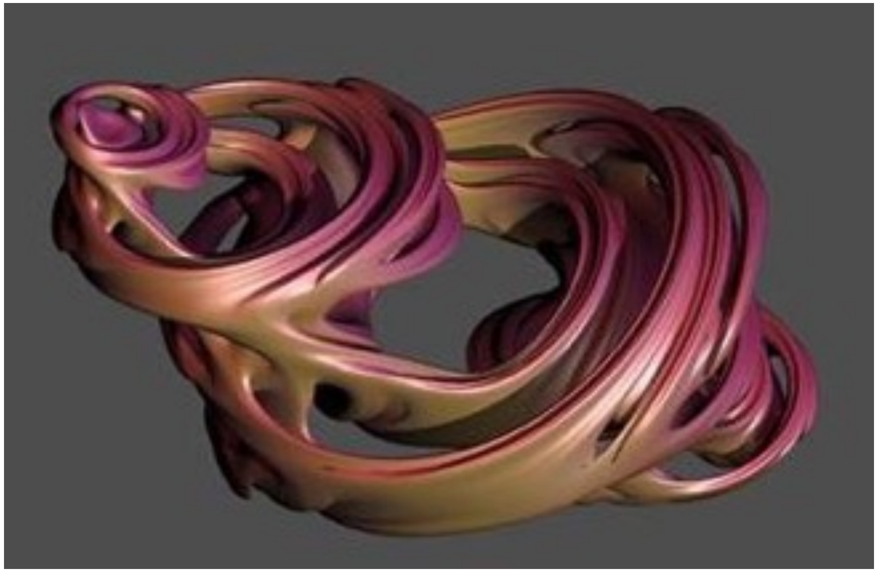
Another Example: Fractals

Iterated function system leads to infinite detail



4D Fractals

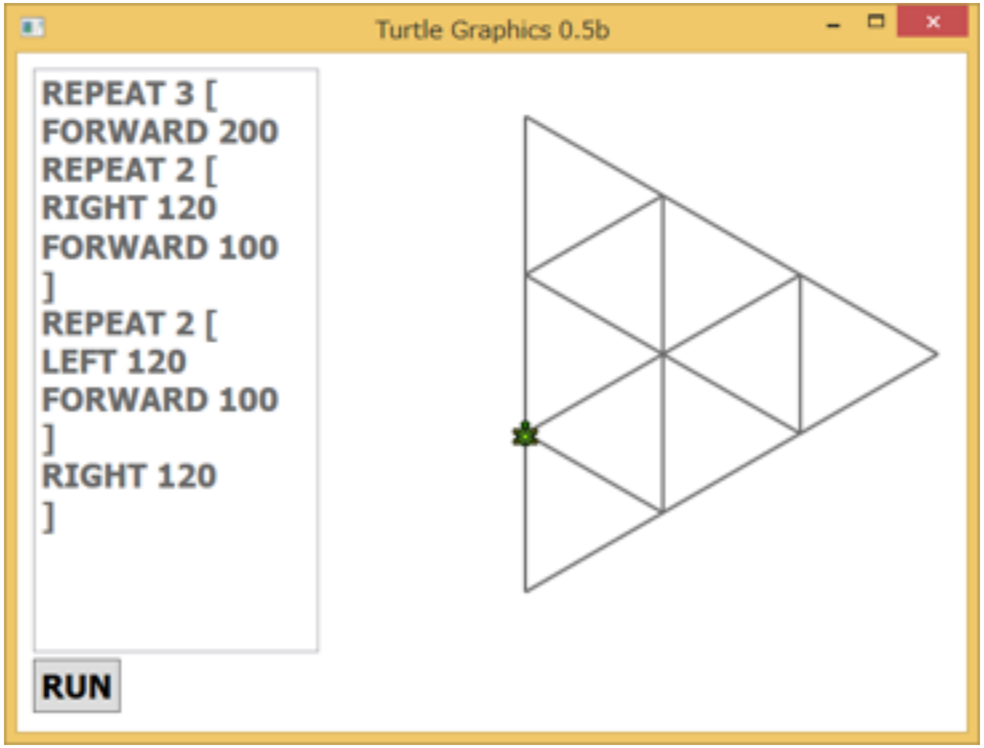
Can be created using quaternions



https://www.youtube.com/watch?v=eS7qCfttmBk

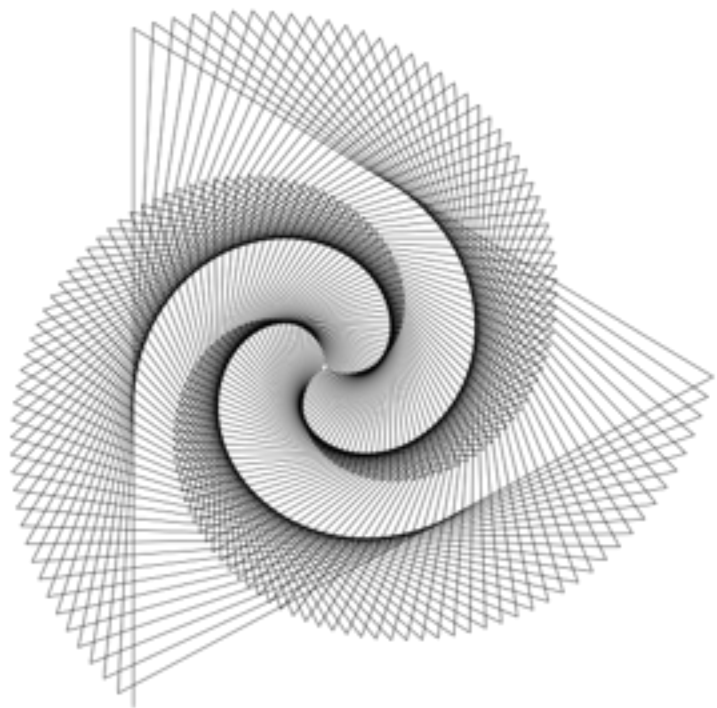
Turtle Graphics

- Graphics system implemented in LOGO (1967)
- Cursor is “turtle” with position and orientation
- Code moves turtle, creating a line trail



Turtle Graphics

Simple code generates very complex results



L-Systems

- Recursive definition of an object using a string rewriting system and formal grammar
- Invented by botanist, Aristid Lindenmayer
- Designed to model plants
- Przemyslaw Prusinkiewicz brought concepts to graphics

L-System Definition

Axiom: Starting string

Variables: Set of symbols to be rewritten according to rules

Terminals: Set of symbols that have no rewriting rules

Rules: Set of substitutions possible for variables

Using L-Systems in Graphics

1. Associate actions (e.g. draw line, rotate, etc) with each variable and terminal
2. Recursively expand the axiom *n* times
    1. Execute actions of resulting string
    2. Generate image from string

Example: Koch Curve

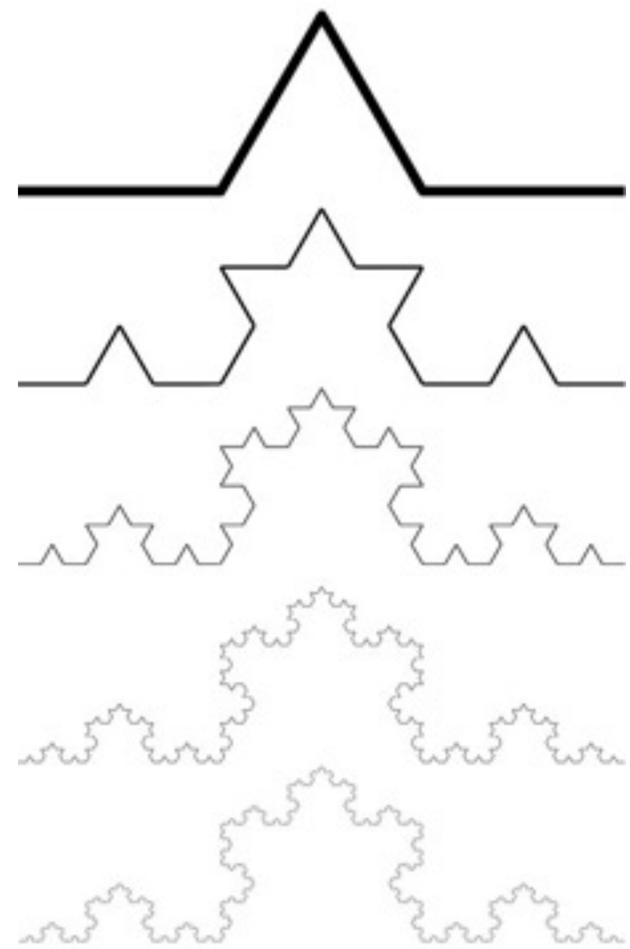
Rule:

F = F-F++F-F

F: Draw line segment
scaled by 1/3

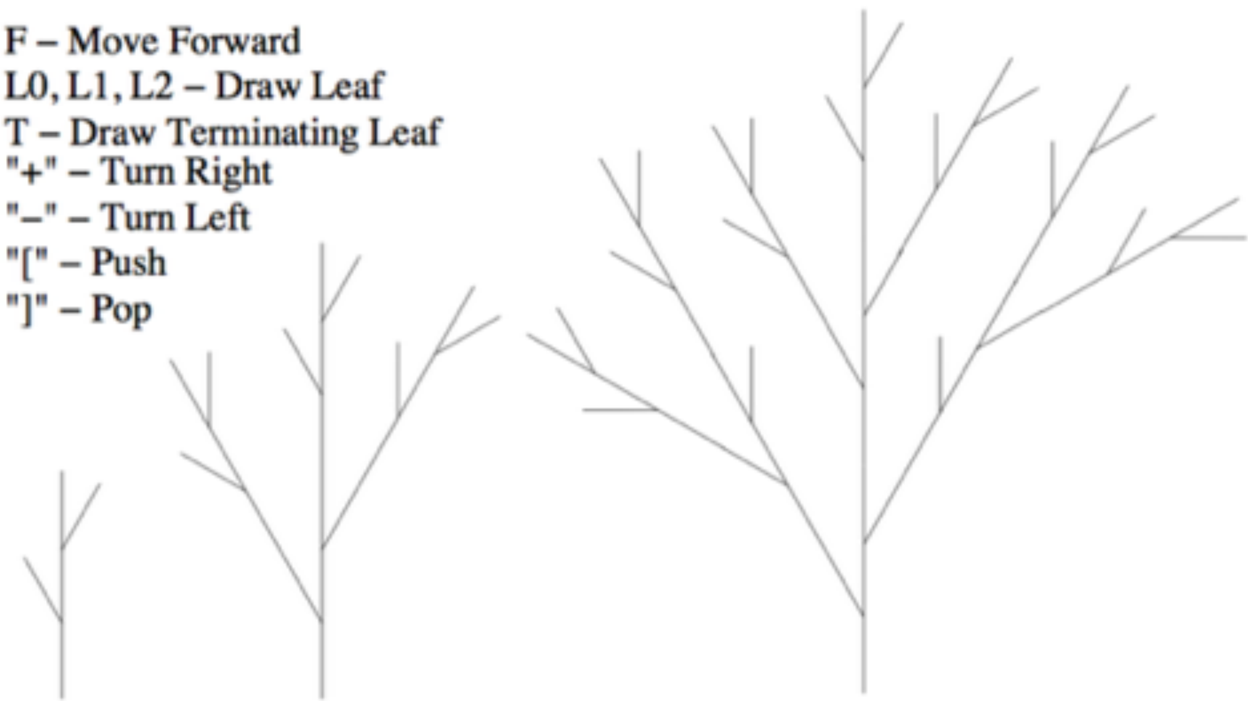
-: Turn 60° left

+: Turn 60° right



Example: 2D Tree

F – Move Forward
L0, L1, L2 – Draw Leaf
T – Draw Terminating Leaf
"+" – Turn Right
"–" – Turn Left
"[" – Push
"]" – Pop



Depth 1 Depth 2 Depth 3

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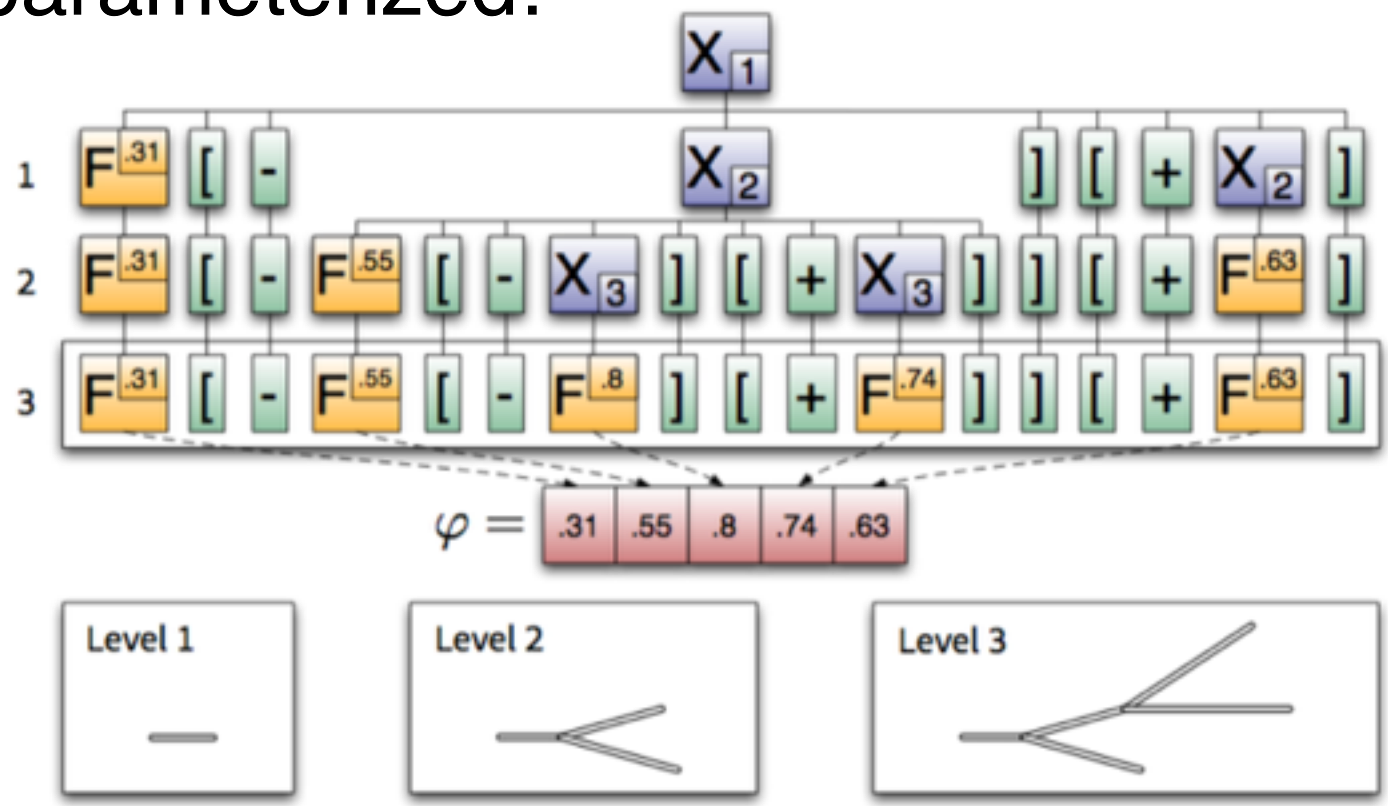
Axiom: L0
1. L0 -> F [ - F L1 ] F [ + F L2 ] F L0
2. L1 -> F [ - F L1 ] F [ + F T  ] F L1
3. L2 -> F [ - F T  ] F [ + F L2 ] F L2
```

1. (center branch)
2. (left half of tree)
3. (right half of tree)

Parameterized L-Systems

Action specified by symbol can be parameterized:



Parameterized L-Systems

Not just parameterized symbols!

- Randomized rule-selection
- Parameterization based on depth
- Changes in parameters over time

L-System Examples

SpeedTree

Leading vegetation generator:

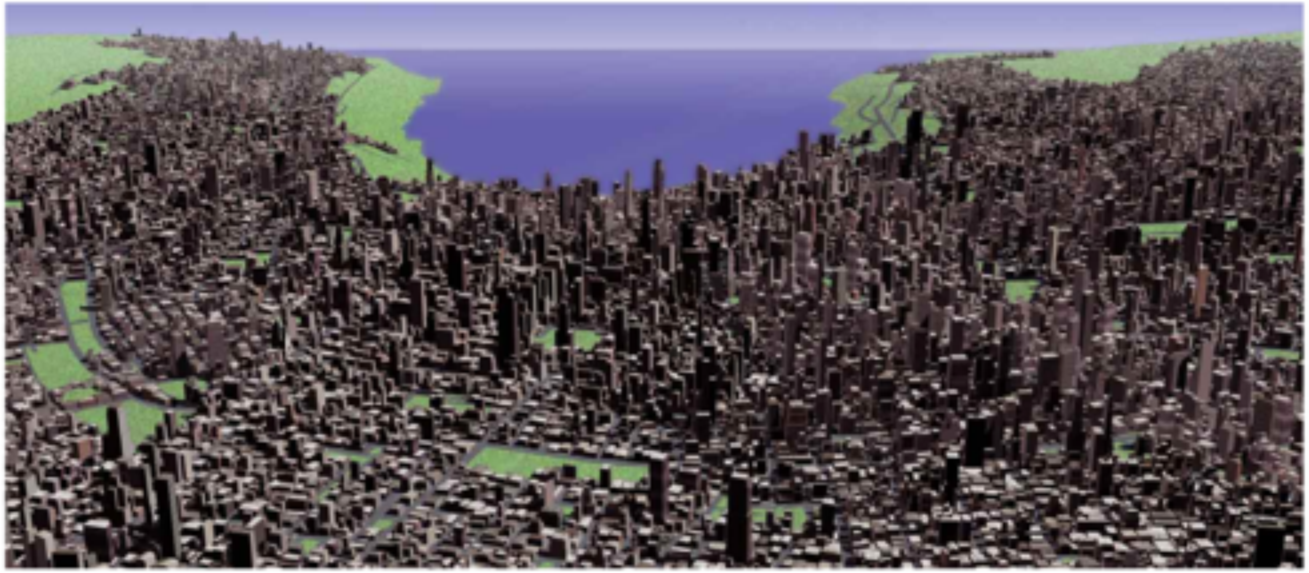
http://www.speedtree.com/

https://www.youtube.com/watch?v=N2wmmdKzp8E

Generating Cities

Same idea with different symbols and rules

- Good idea to having working understanding of the modeled system



https://graphics.ethz.ch/Downloads/Publications/Papers/2001/p_Par01.pdf

Additional Reading

http://algorithmicbotany.org/papers/graphical.gi86.pdf

http://algorithmicbotany.org/papers/