Experimenting with Grammars to Generate L-Systems – in JFLAP
April 1, 2021

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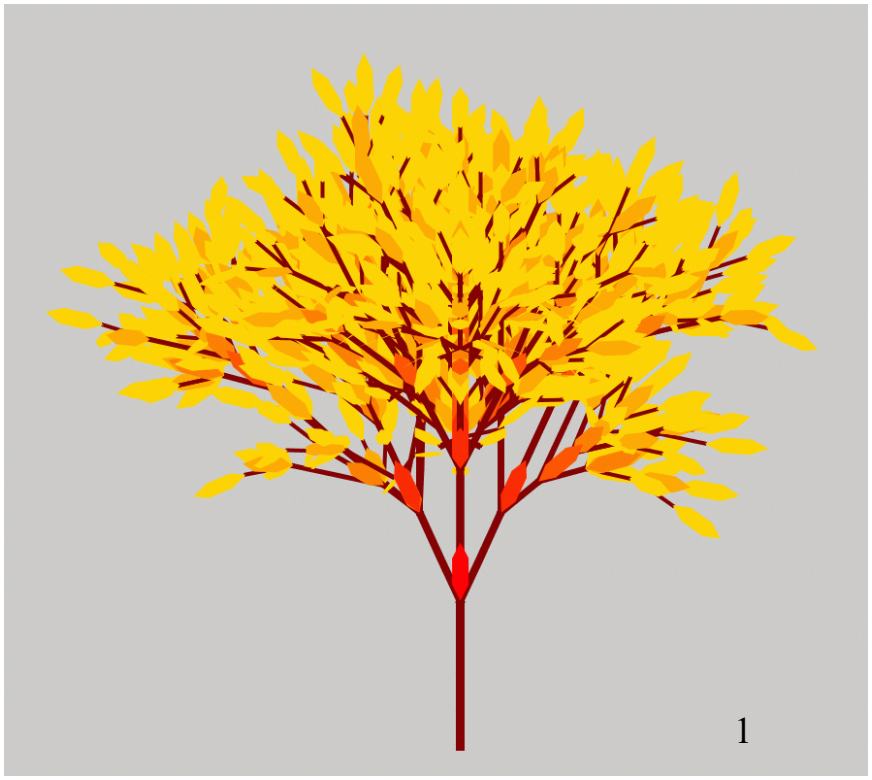
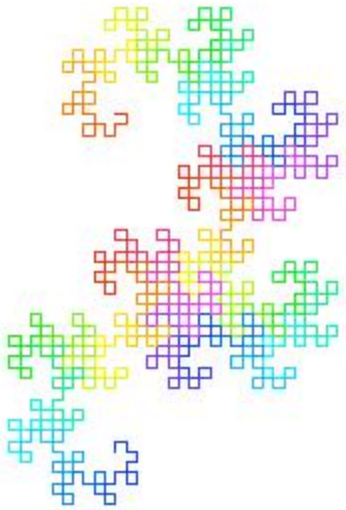
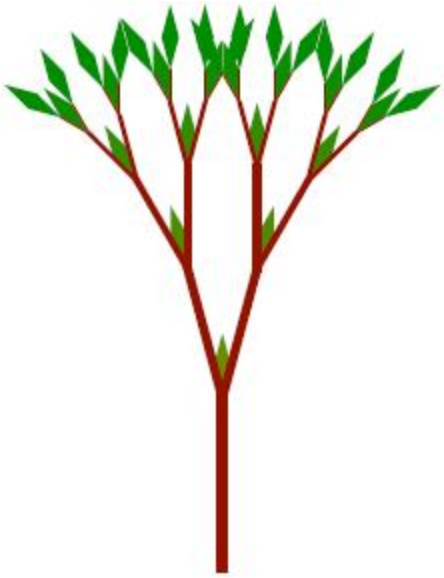
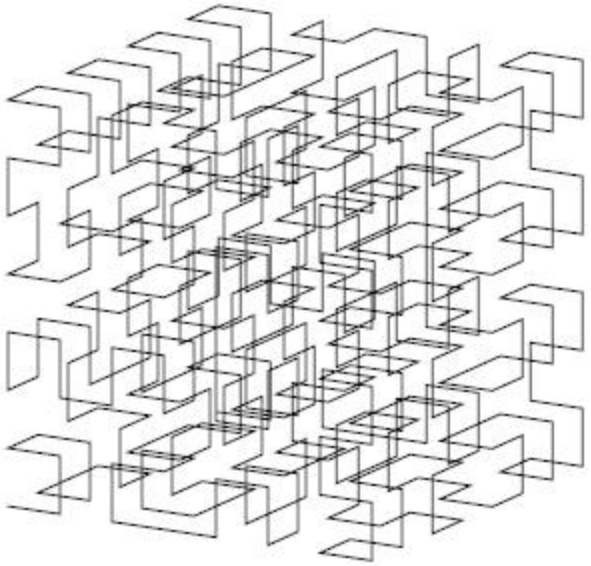


L-Systems

- Grammatical systems introduced by Lyndenmayer
- Model biological systems and create fractals
- Similar to Chomsky grammars, except all variables are replaced in each step, not just one!
- Successive strings are interpreted as strings of render commands and displayed graphically







Parts of an L-System (a type of grammar)

- Defined over an alphabet
- Three parts
  - Axiom (starting place)
  - Replacement rules (replaces all variables at once)
  - Geometric rules (for drawing)
    - g means move forward one unit with pen down
    - f means move forward one unit with pen up
    - + means turn right by the default angle
    - - means turn left by the default angle

L-System

An L-system is composed of three parts (Σ, h, w)

Σ	**finite alphabet**	**set of symbols**
h	**rewriting rules**	**each symbol is replaced by string of symbols**
w	**axiom**	**starting point**

h is finite substitutions, h:$\Sigma \rightarrow \Sigma^*$.

h(w)

h(w) is computed by replacing every symbol in w that has a rewrite rule by that rule.

A language L of an L-system is the word sequence generated by

- $h^0(w) = w$
- $h^1(w) = h(w)$
- $h^2(w) = h(h(w))$
- $\ldots$

$$\mathrm{L} = \{h^i(w) \mid i \geq 0\}$$

NOTE: If h(a)=bb we will write this as a rule

$$\mathbf{a \rightarrow bb}$$

Example:

Σ	**alphabet:**	$\{a, b\}$
h	**rules:**	**a** $\rightarrow$ **aa**
		b $\rightarrow$ **ab**
w	**axiom:**	**ab**

What is the language L of strings represented by this L-system?

L =

Drawing a picture of an L-system

Defining an L-system: (3 parts in this order)

- Axiom definition: This must be the first line of the file
- Production rules: Defines the replacement rules.
- Geometric rules: Defines colors, widths, etc.

Graphically represent

Symbols for drawing and moving:

- **g: draw a line one step in the current direction**
- **f: move forward one step in the current direction**

Example: example1

axiom X

X -> g f g X

distance 15

lineWidth 5

color black

L =

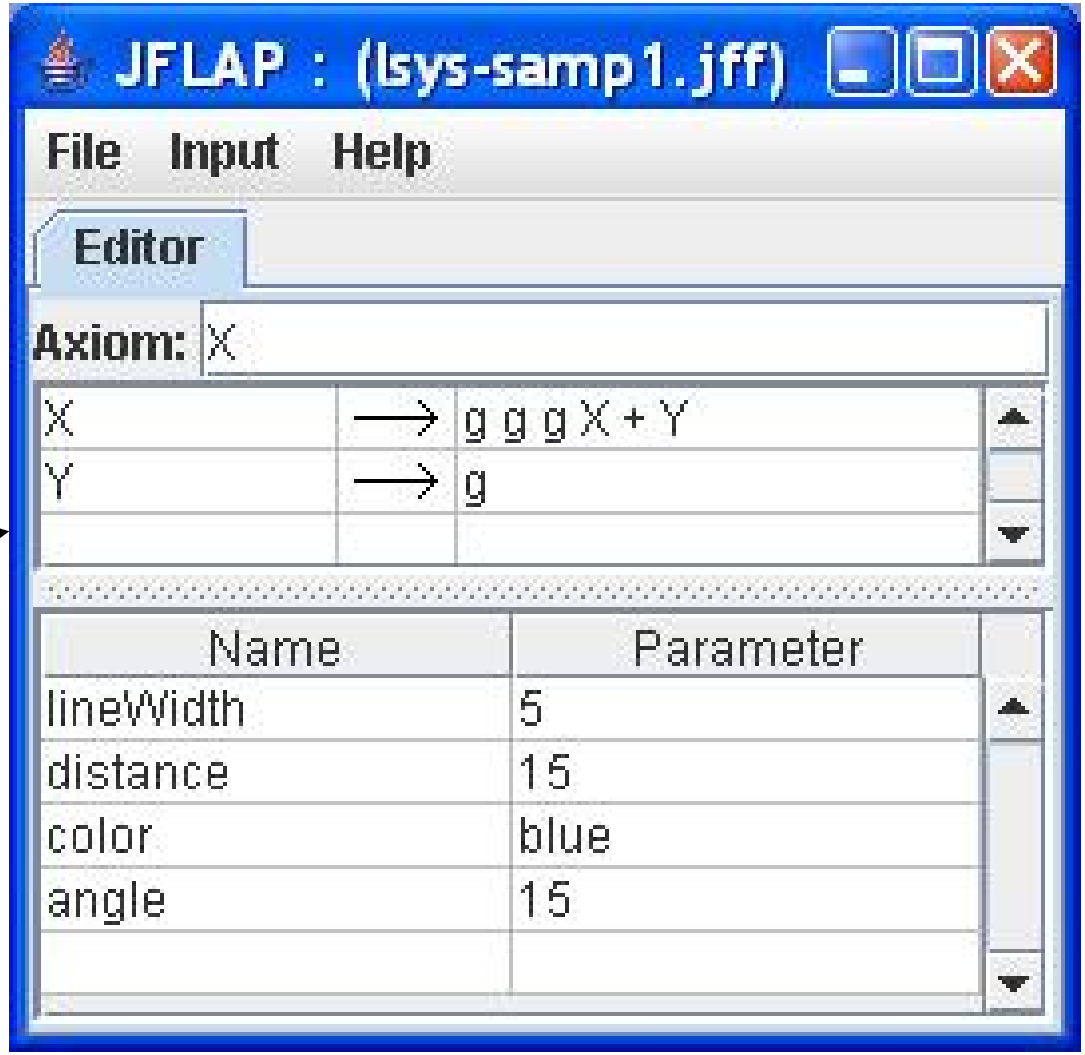
What does this draw?

Geometric rules

- + change direction to the right
- – change direction to the left
- % change direction 180 degrees
- ~ decrement the width of the next lines
- [save in stack current state info
-] recover from stack state info
- { start filled in polygon
- } end filled in polygon

Example – lsys-samp1

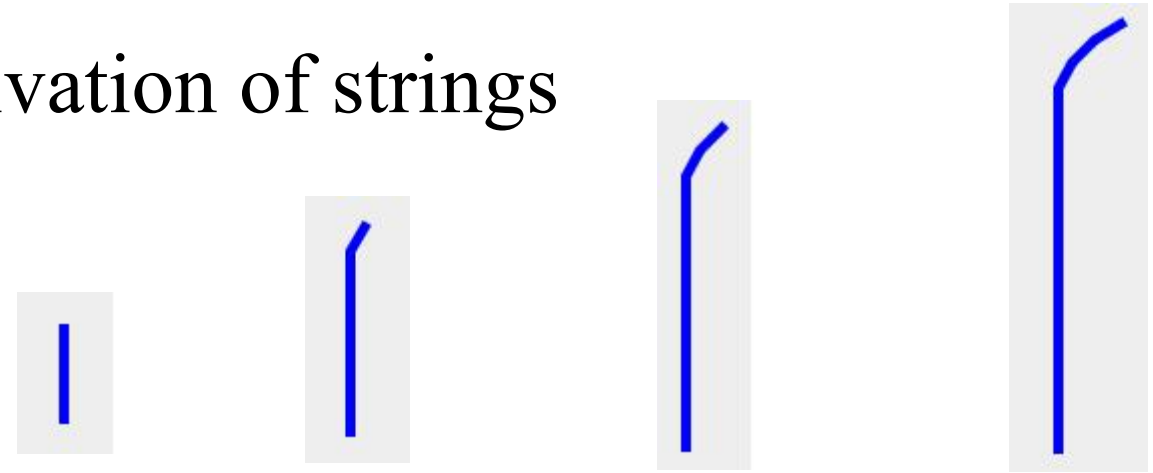
- Axiom
- Replacement Rules
- Geometric Rules



NOTE: Must use spaces as separator between symbols

Example – lsys-samp1(cont)

- Derivation of strings



X

gggX+Y

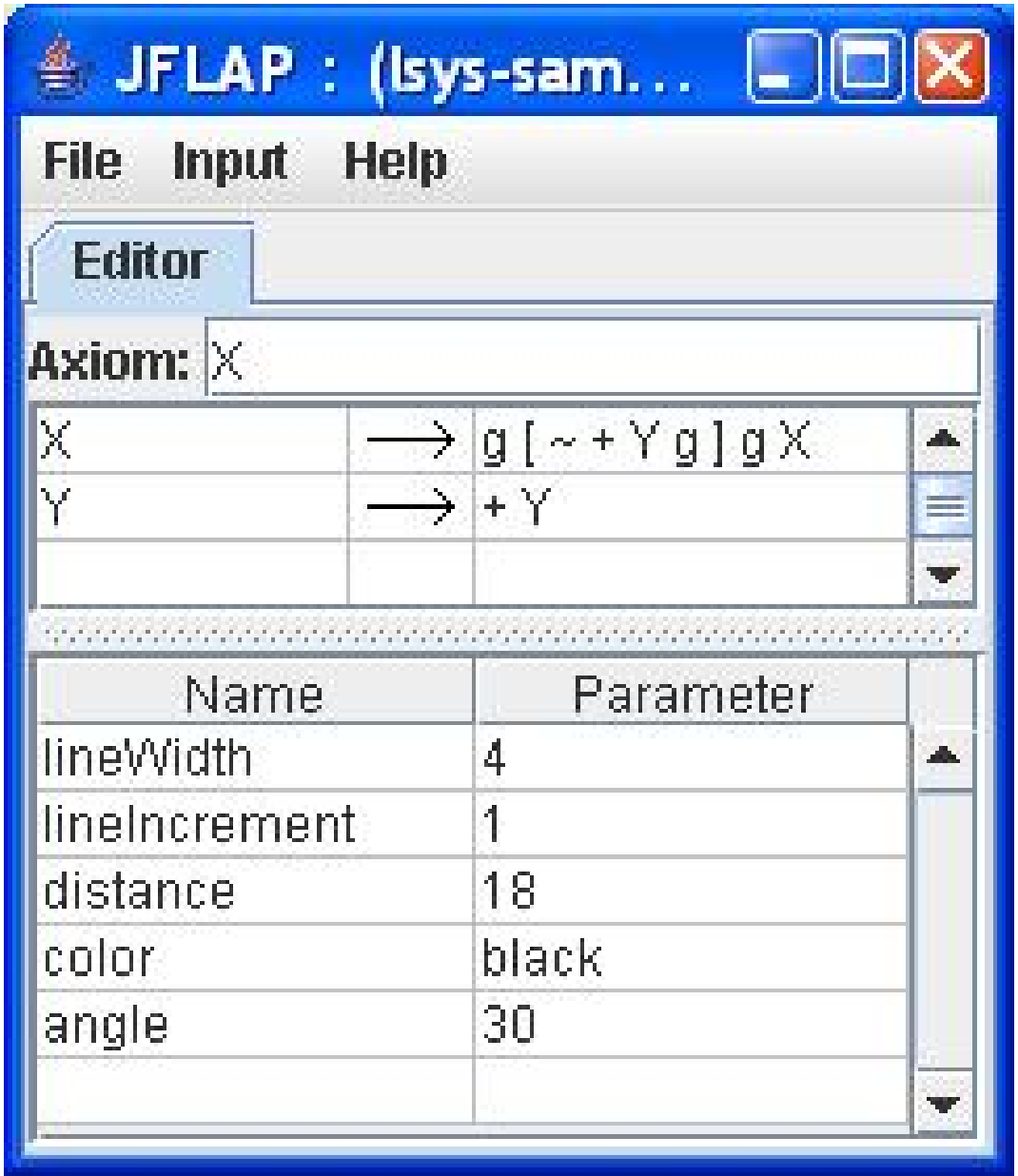
ggggggX + Y + g

gggggggggX+Y+g+g

ggggggggggggX+Y+g+g+g

Note: replace both X and Y each time

Example – lsys-samp2



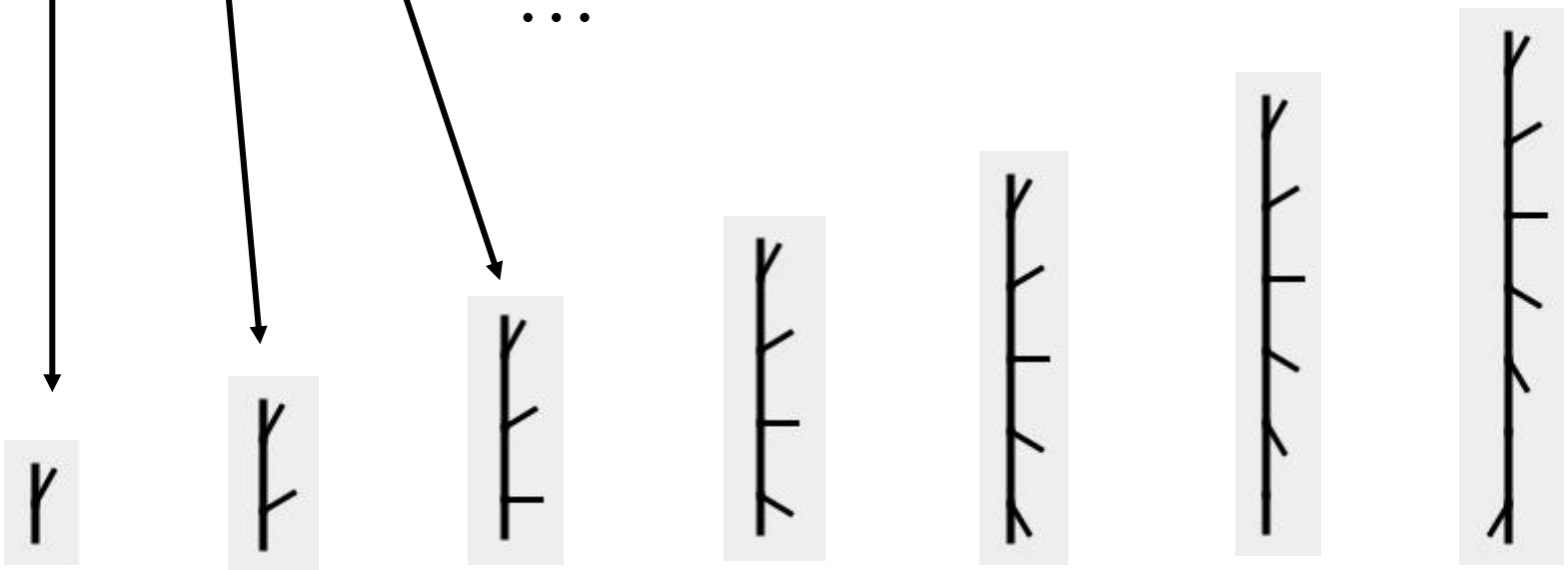
Example – lsys-samp2 (cont)

g[~+Yg]gX

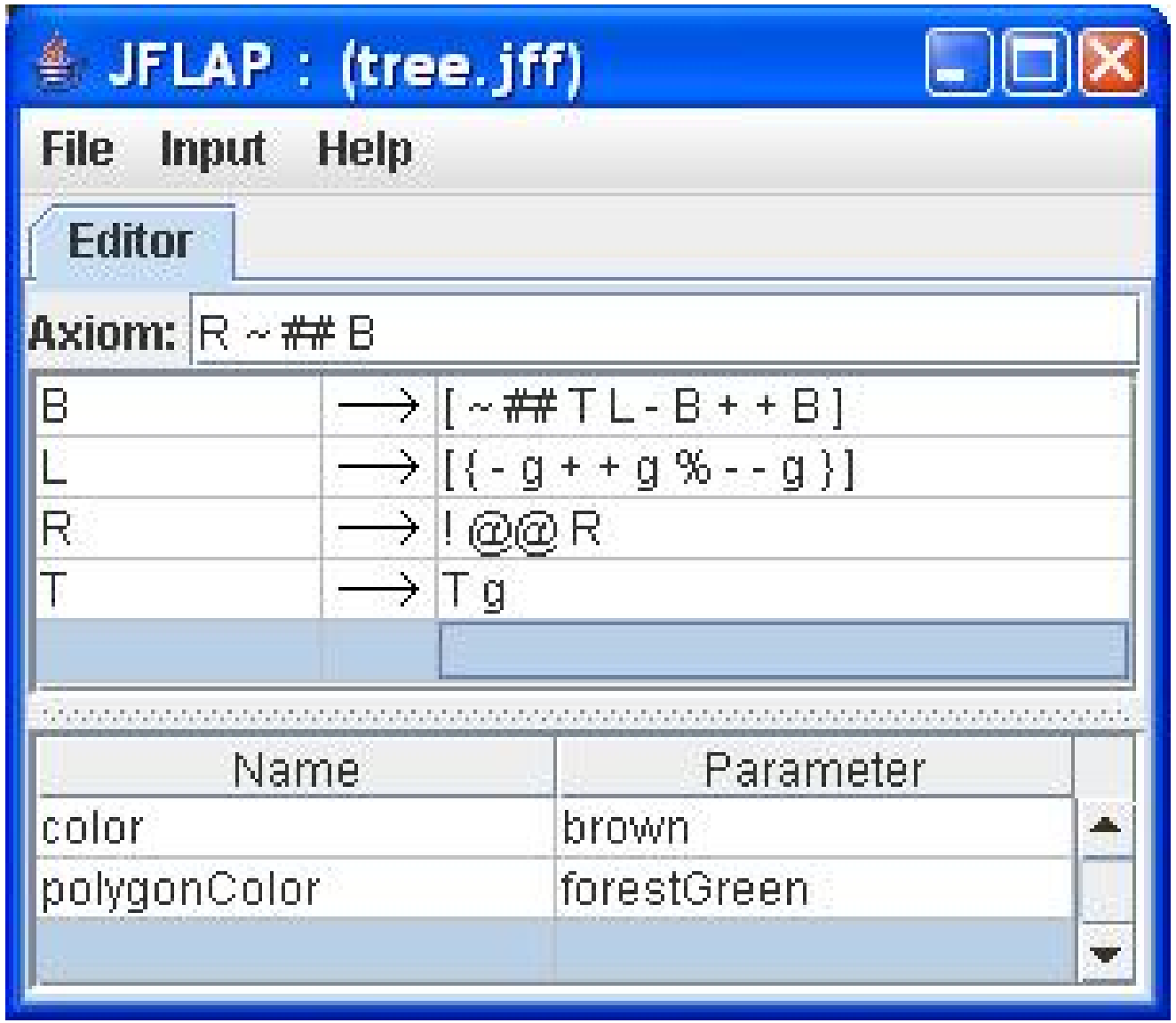
g[~++Yg]gg[~+Yg]gX

g[~+++Yg]gg[~++Yg]gg[~+Yg]gX

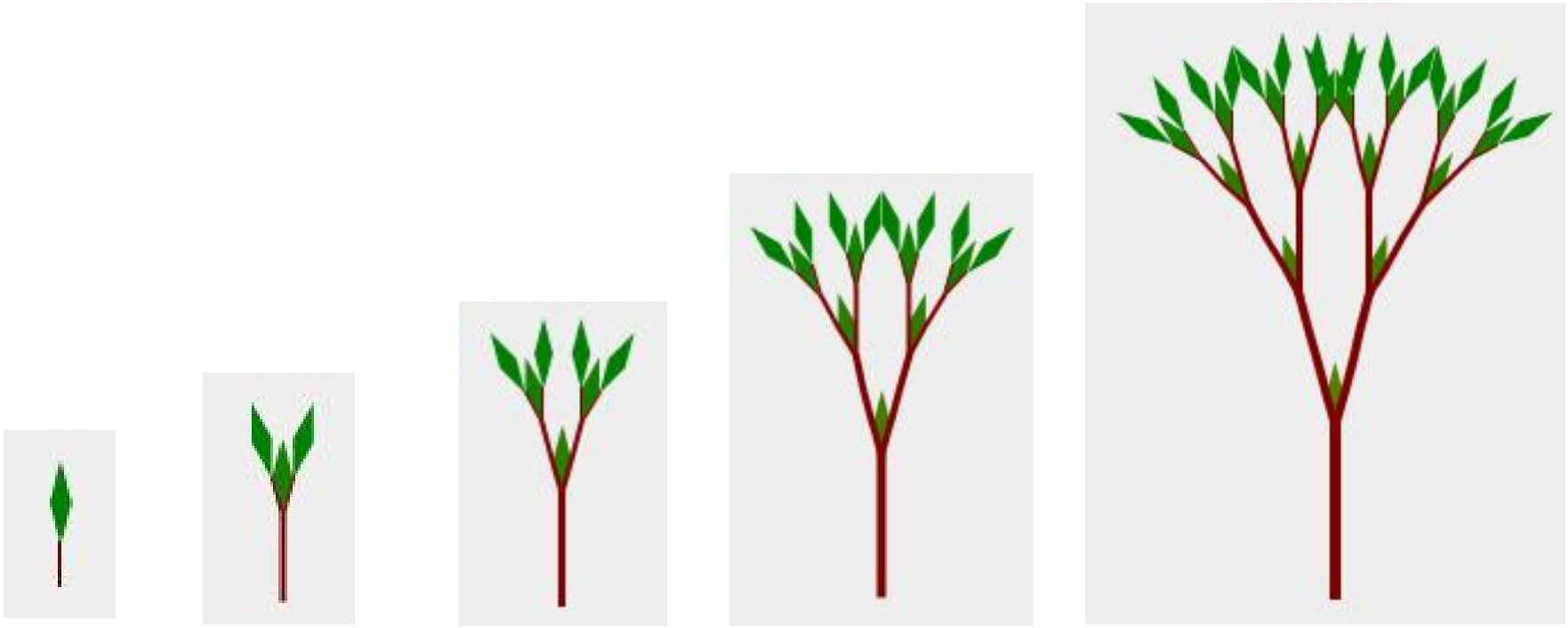
…



Example - tree

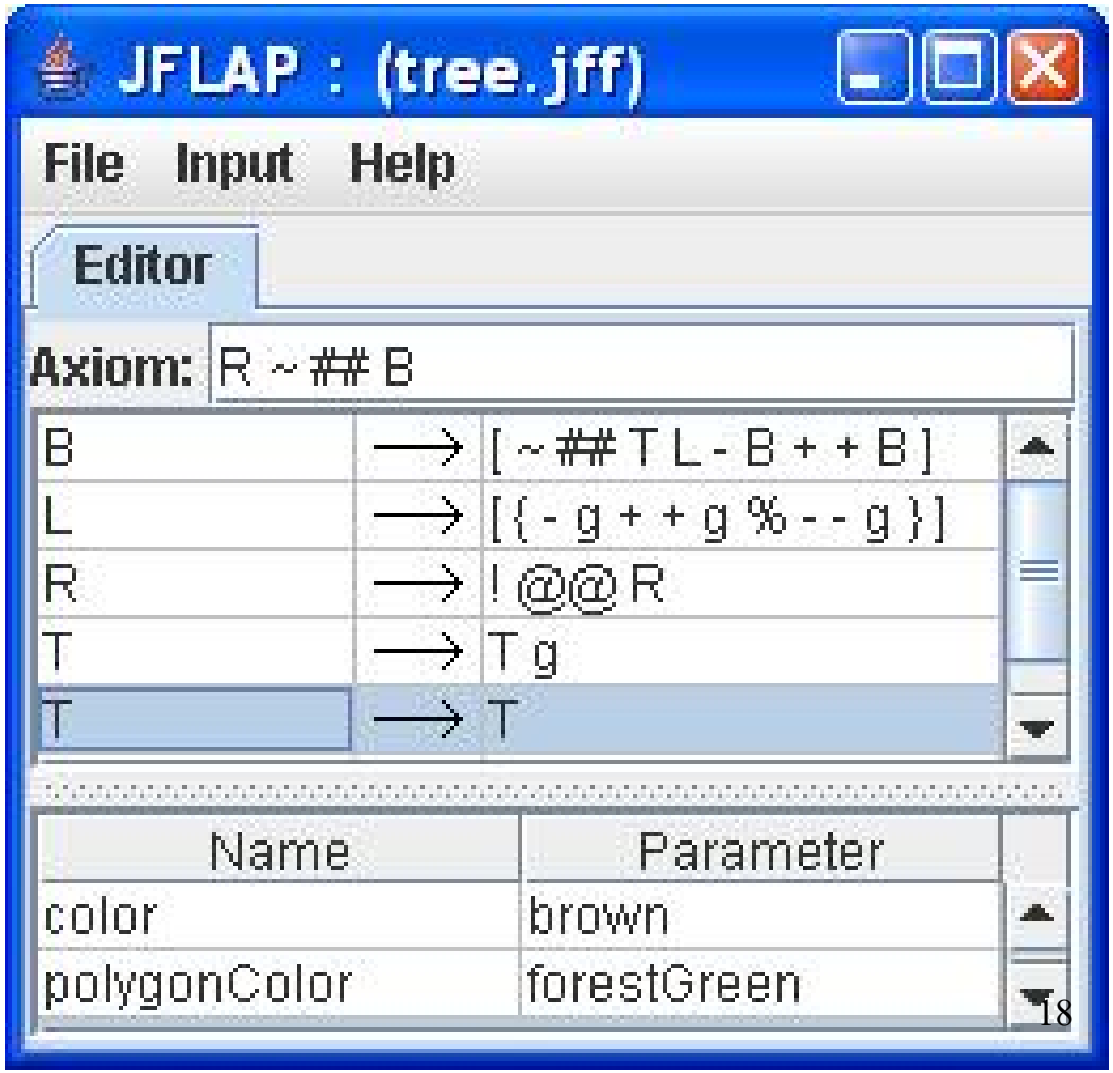


Example – tree rendered



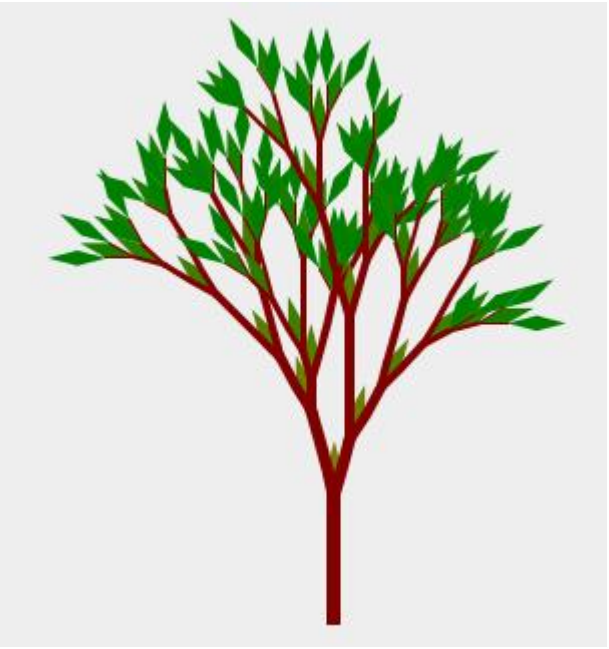
Stochastic Tree

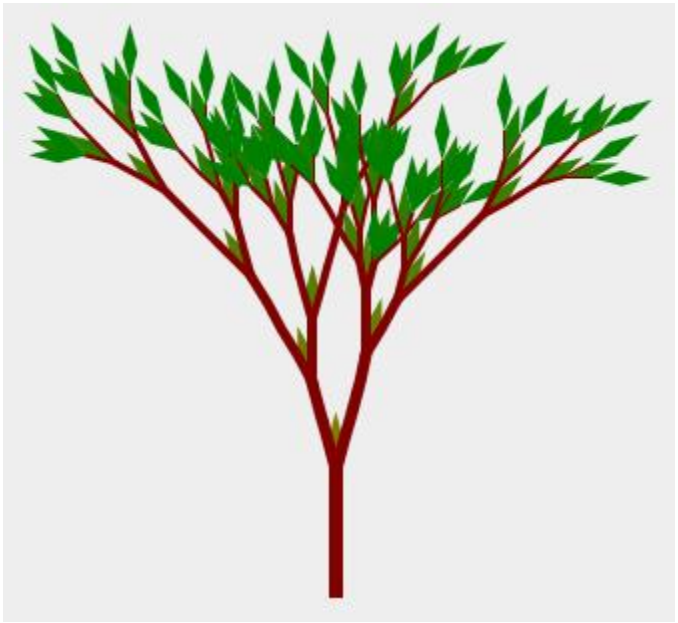
- Add a rule T -> T
- Now there is a choice for T, draw a line or don't

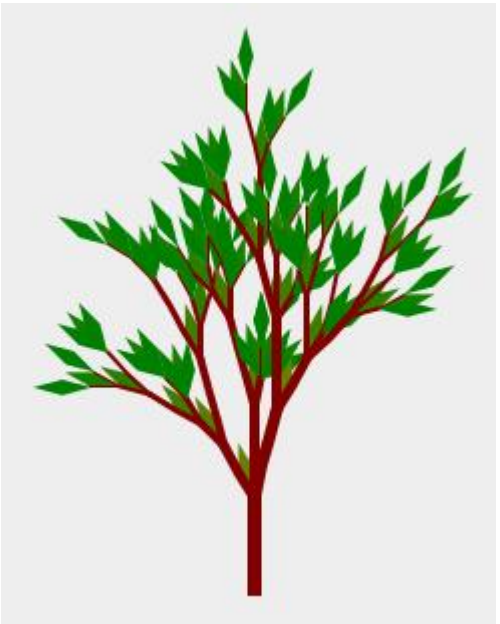


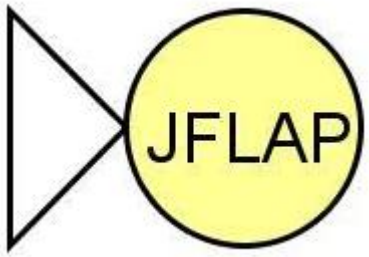
Same Stochastic L-System

- Rendered 3 times, each at 8^{th} derivation









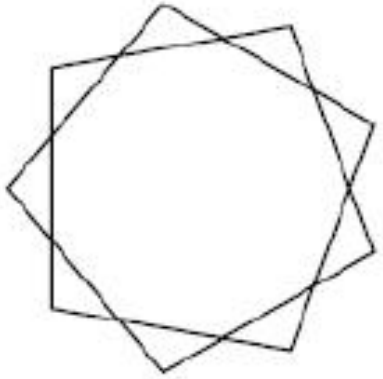
JFLAP

- JFLAP is available for free:

  www.jflap.org
- Duke School of Environment uses L-systems to model pine needles in Duke Forest

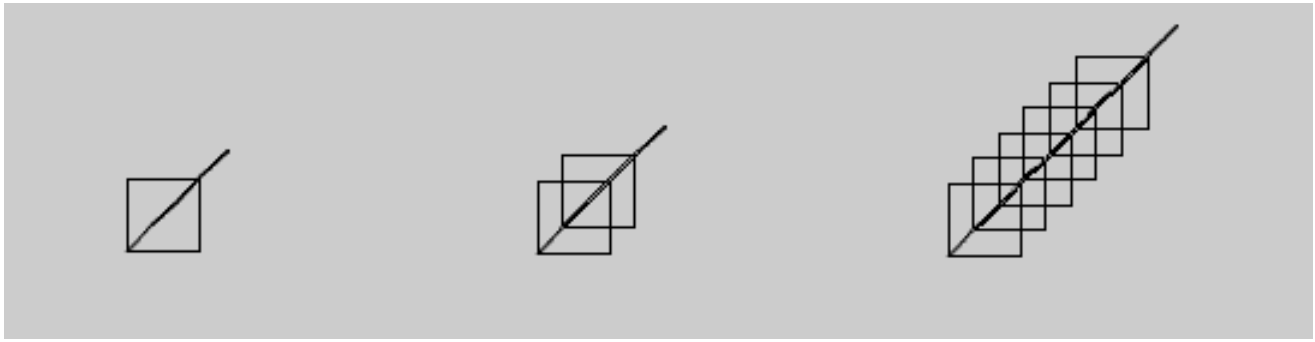
Classwork - Exercise 1

- Write an L-system for the picture below.
- Symbols needed are: g, + and one variable
- Distance of the line is 100, rendering at 1 draws the first line, each additional render draws another line.



Exercise 2

- Write an L-system for the picture below.
- Symbols may need: g, %, +
- Distance set to 15, angle set to 45, side of square is length 30, first diagonal line is 60
- 1st, 2nd and 6th renderings shown



Exercise 3

- Write an L-system for the picture below.
- Symbols may need: g, +, -, [ ]
- Angle set to 90, distance set to 15
- Shows 1st, 2nd and 3rd renderings