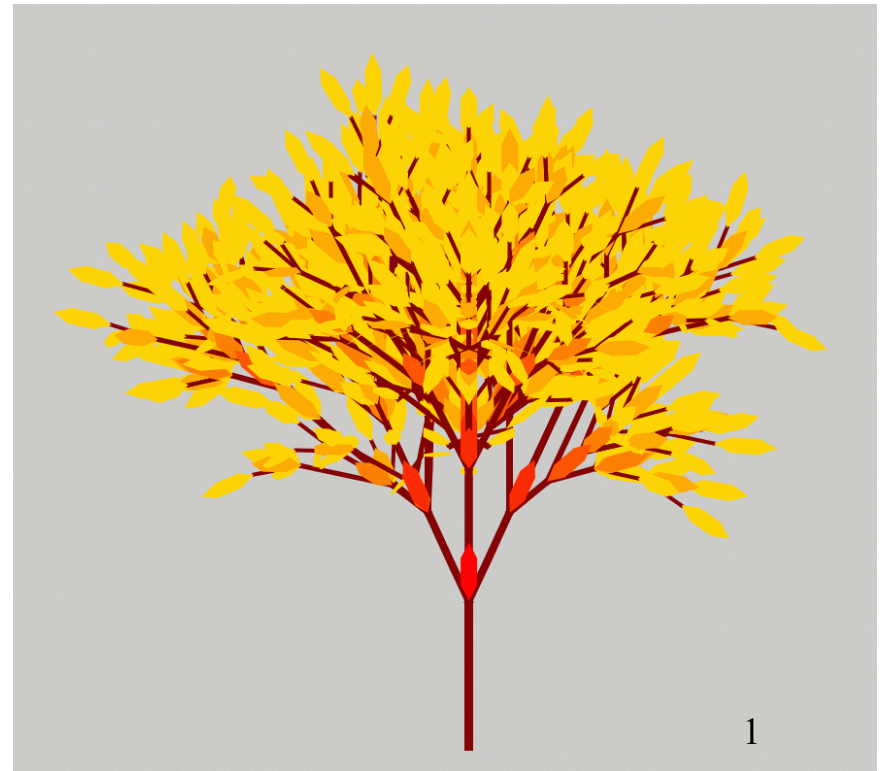


# Experimenting with Grammars to Generate L-Systems – in JFLAP

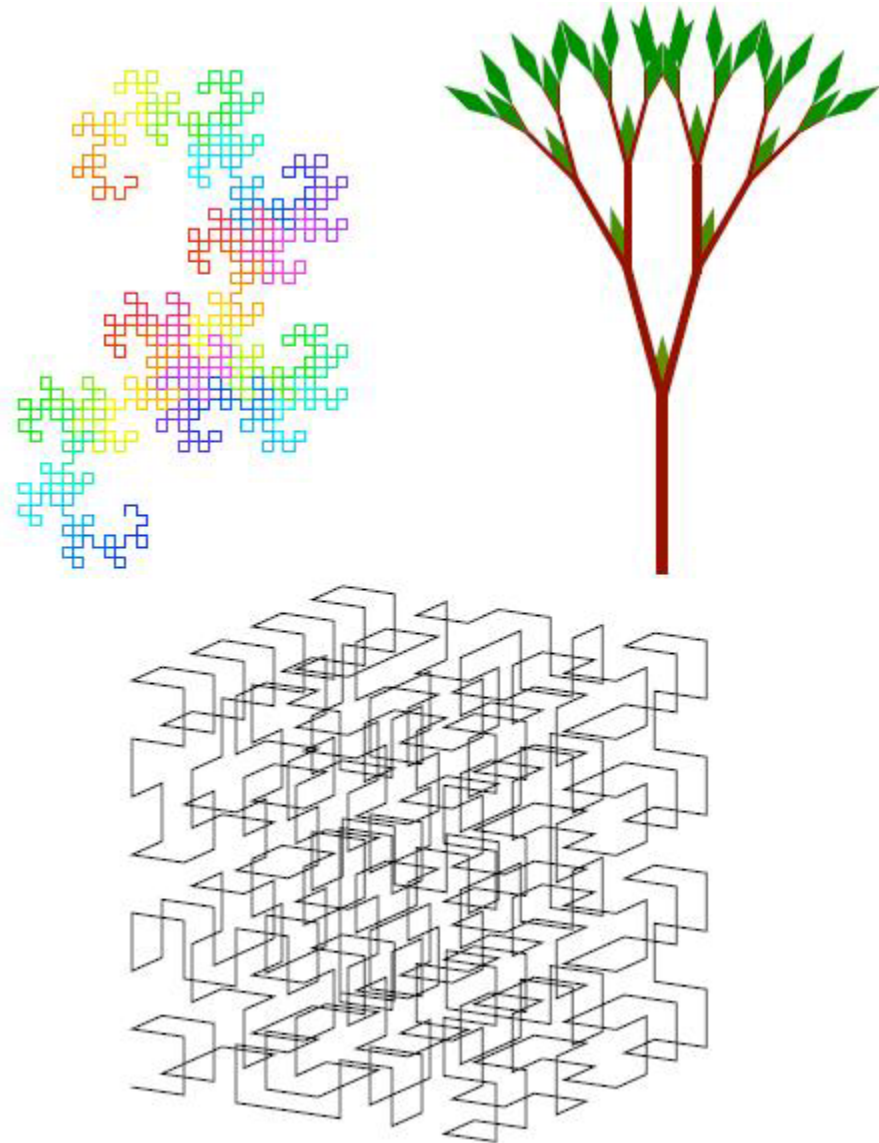
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# L-Systems

- Grammatical systems introduced by Lindenmayer
- 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  $(\Sigma, h, w)$

$\Sigma$	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  $\mathbf{L}$  of an L-system is the word sequence generated by

- $h^0(w) = w$
- $h^1(w) = h(w)$
- $h^2(w) = h(h(w))$
- ...

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

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

$$a \rightarrow bb$$

## Example:

$\Sigma$  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

$X \rightarrow g f g X$

distance 15

lineWidth 5

color black

L =

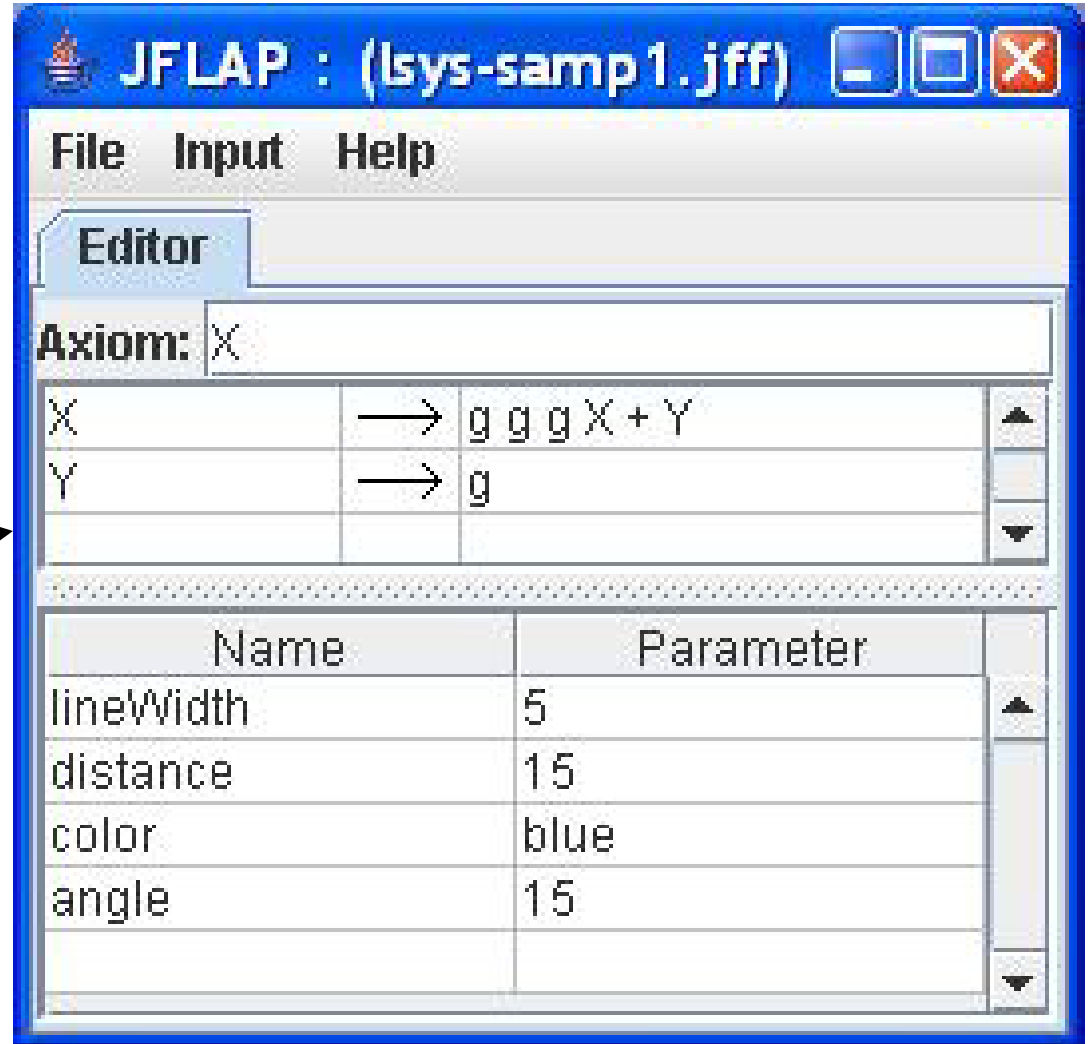
What does this draw?

# 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

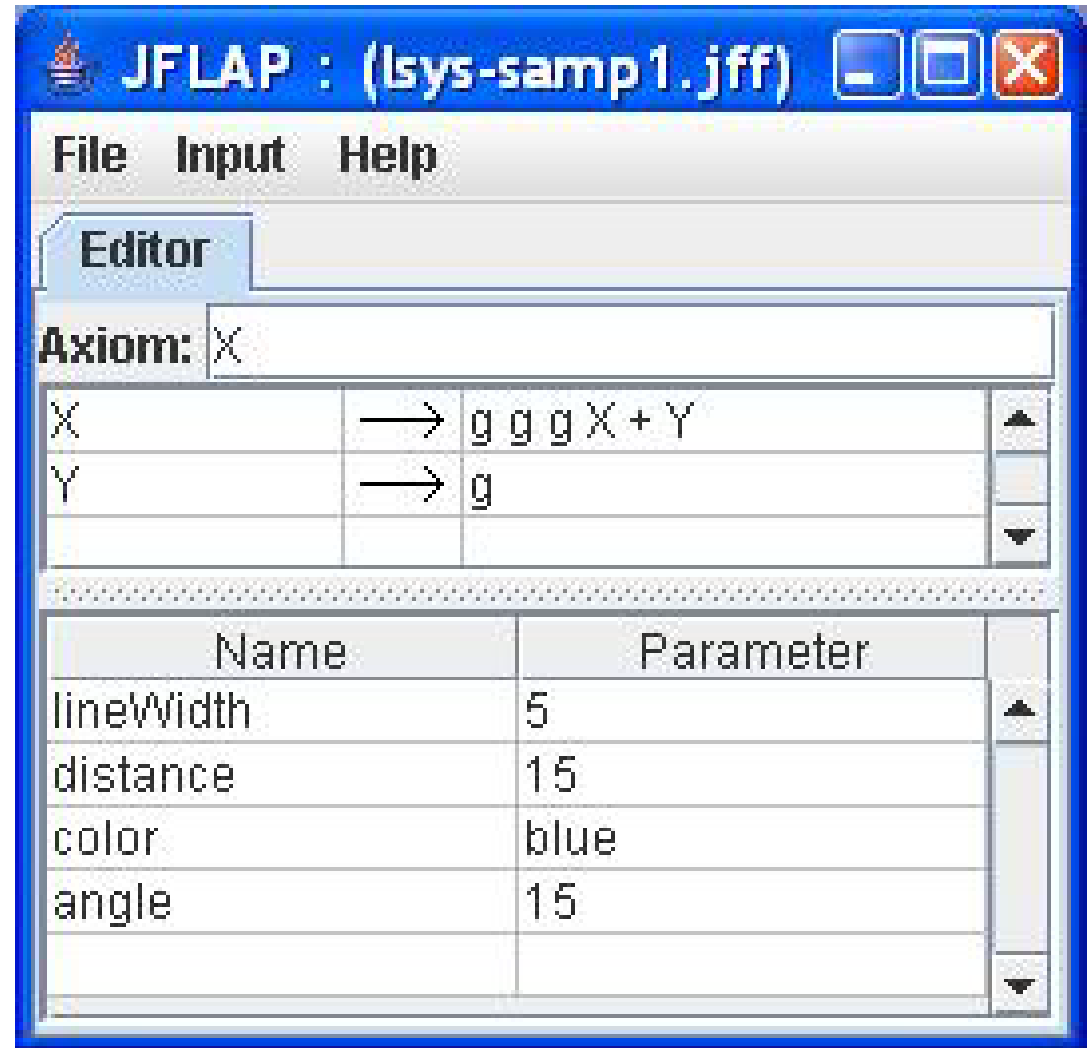


NOTE: Must use spaces as separator between symbols

# Example – lsys-samp1

- What are the strings?

$$L = \{X,$$

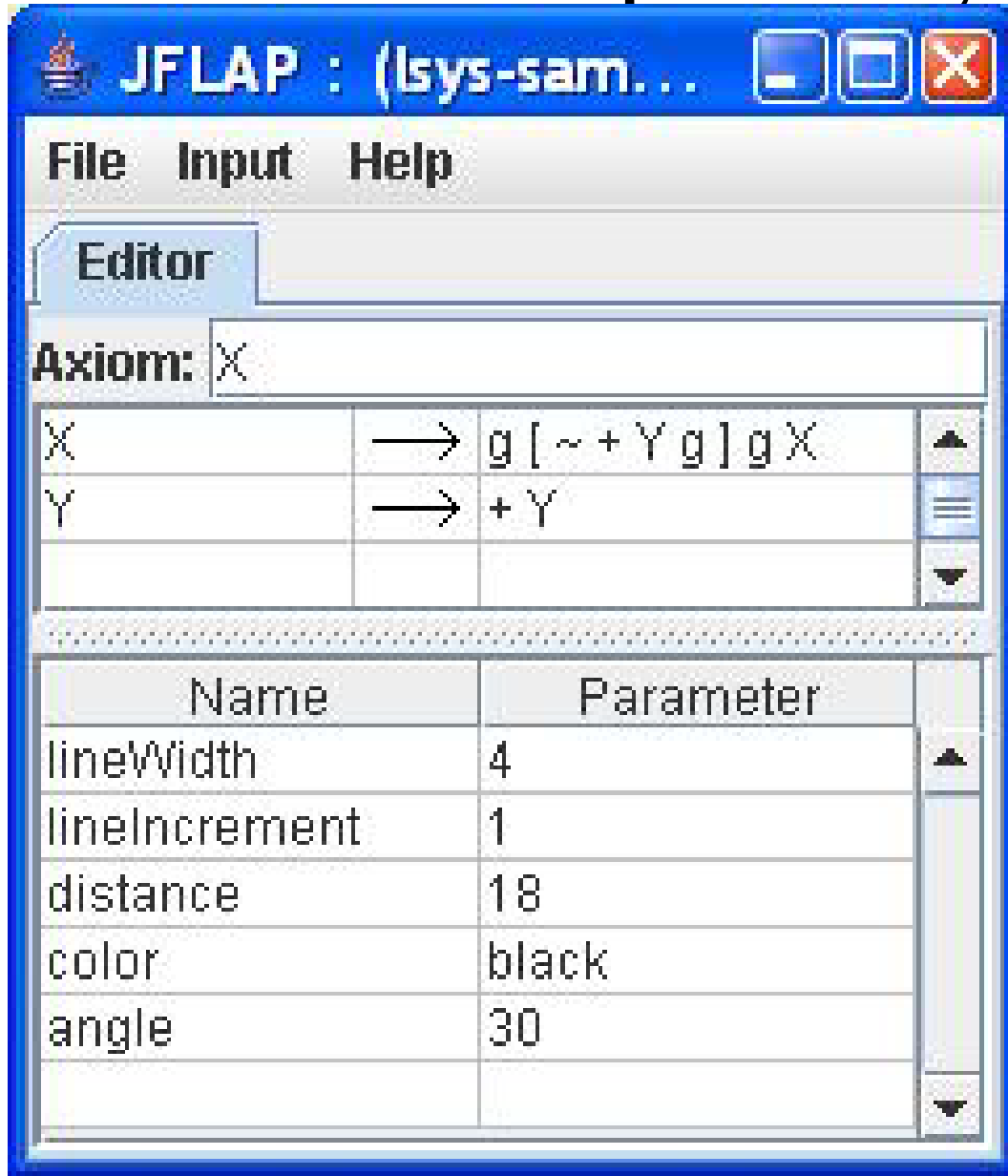


The screenshot shows the JFLAP software interface for the file 'lsys-samp1.jff'. The main editor area displays the following grammar rules:

Name	Parameter
lineWidth	5
distance	15
color	blue
angle	15

NOTE: Must use spaces as separator between symbols

# Example – lsys-samp2



The screenshot shows the JFLAP software interface. The title bar reads "JFLAP : (lsys-sam...". The menu bar includes "File", "Input", and "Help". The "Editor" tab is active, showing the "Axiom: X" field. Below this, a table defines the grammar rules:

X	→	g[~+Yg]gX
Y	→	+Y

Below the grammar rules is a table of parameters:

Name	Parameter
lineWidth	4
lineIncrement	1
distance	18
color	black
angle	30

- What are the strings?

$$L = \{X,$$

# Example - tree

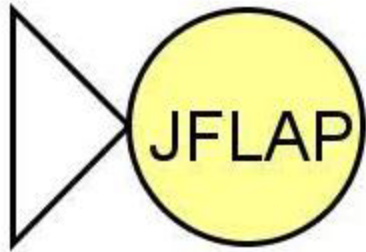
The screenshot shows the JFLAP software window titled "JFLAP : (tree.jff)". The window has a menu bar with "File", "Input", and "Help". Below the menu bar is a tab labeled "Editor". The main editing area contains the following text:

Axiom:  $R \sim \#\# B$

B	→	$[\sim \#\# T L - B + + B]$
L	→	$\{ - g + + g \% - - g \}$
R	→	$! @ @ R$
T	→	$T g$

Below the editing area is a table with two columns: "Name" and "Parameter".

Name	Parameter
color	brown
polygonColor	forestGreen



# JFLAP

- JFLAP is available for free:  
[www.jflap.org](http://www.jflap.org)
- Duke School of Environment uses L-systems to model pine needles in Duke Forest