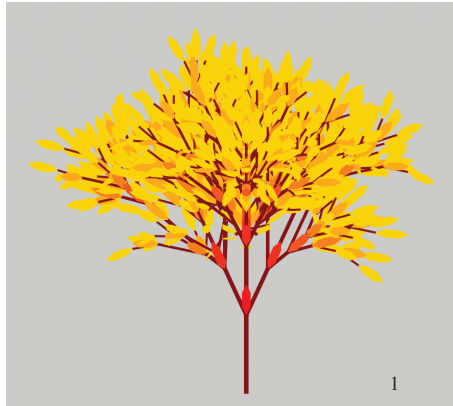


Experimenting with Grammars to Generate L-Systems – in JFLAP

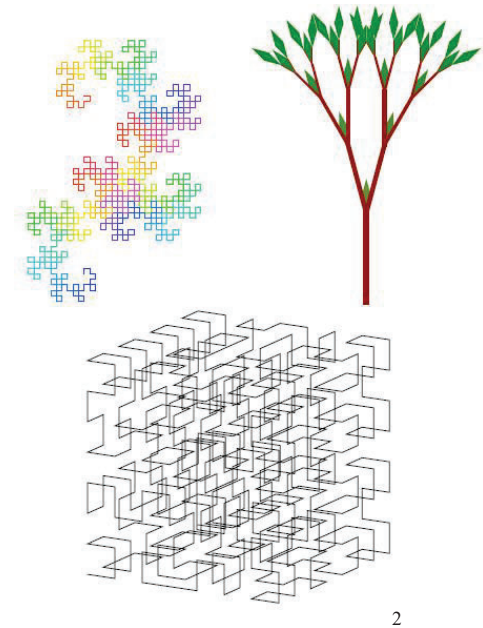
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L-Systems

- 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

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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, $h: \Sigma \rightarrow \Sigma^*$.

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$h(w)$

$h(w)$ 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

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

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

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

$$a \rightarrow bb$$

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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?

$L =$

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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.

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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

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Example: example1

axiom X

$X \rightarrow g f g X$

distance 15

lineWidth 5

color black

L =

What does this draw?

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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

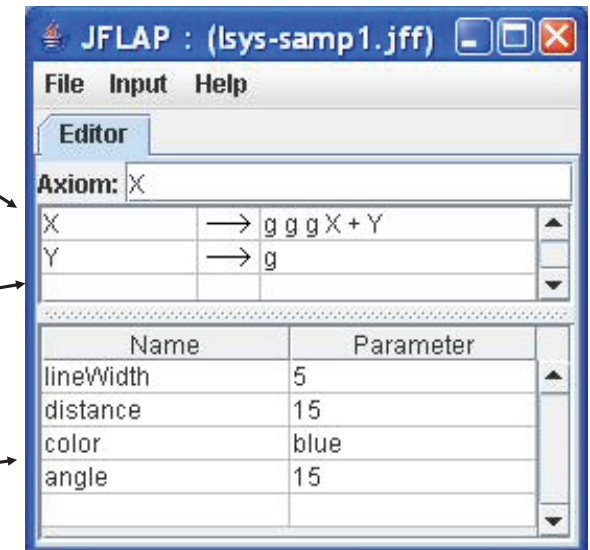
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Example – lsys-samp1

• Axiom

• Replacement
Rules

• Geometric
Rules

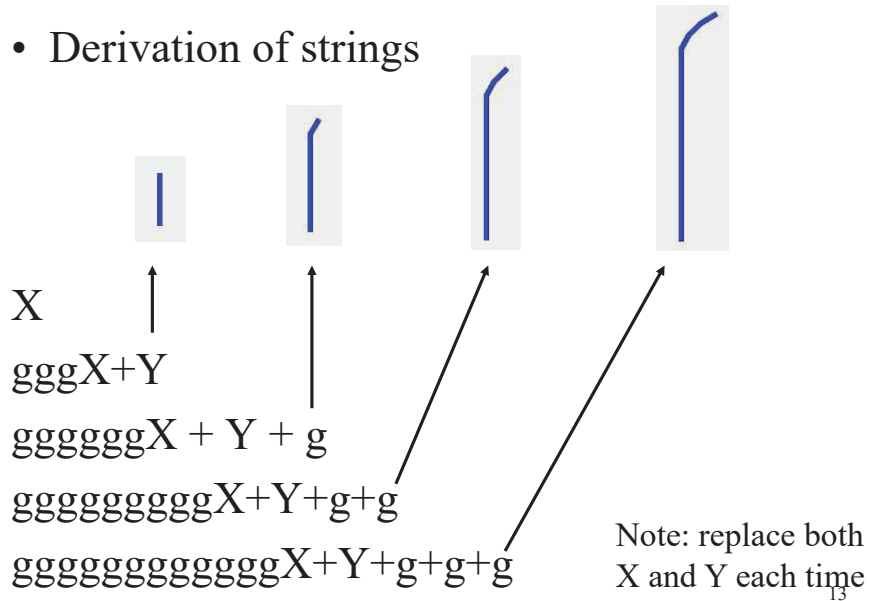


NOTE: Must use spaces as separator between symbols

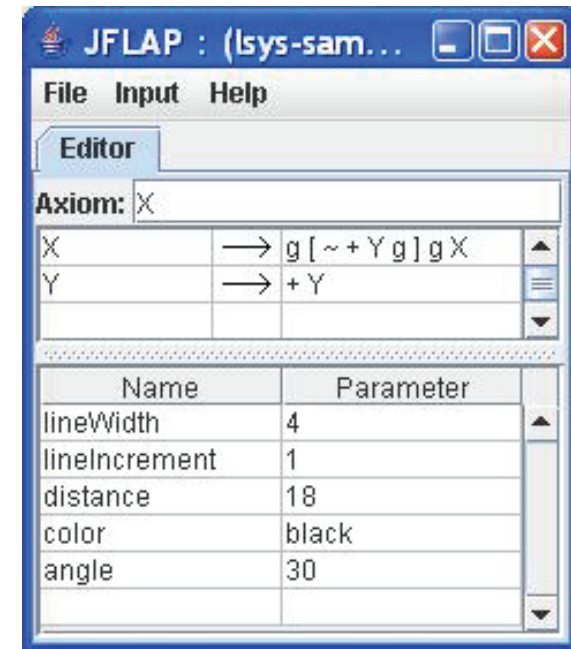
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Example – lsys-samp1(cont)

- Derivation of strings

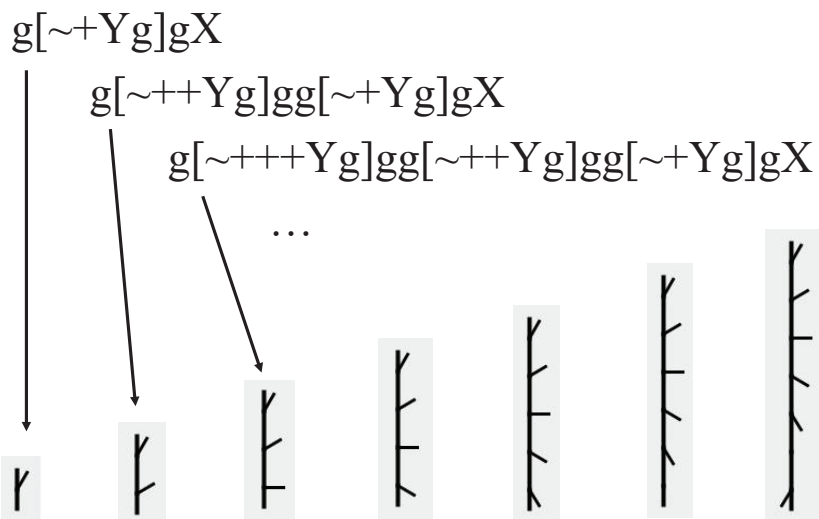


Example – lsys-samp2



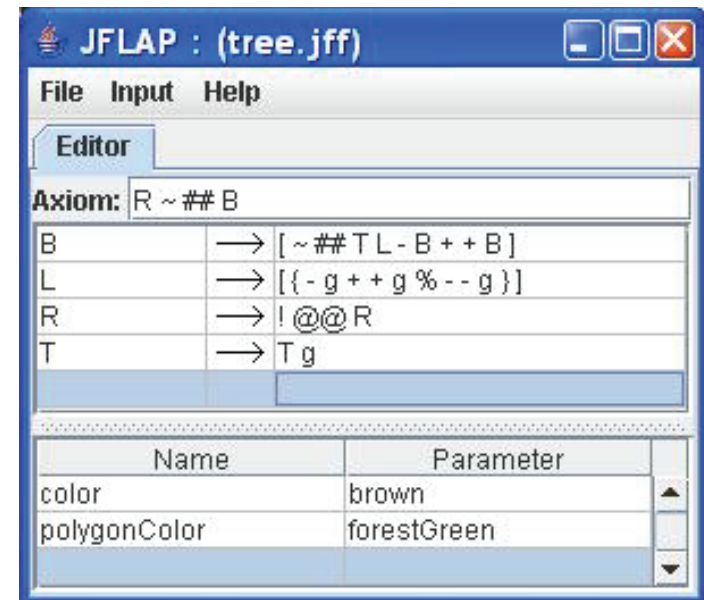
14

Example – lsys-samp2 (cont)



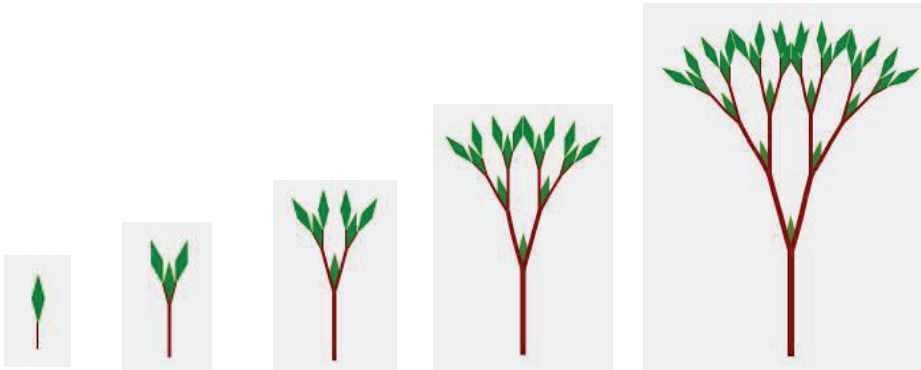
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Example - tree



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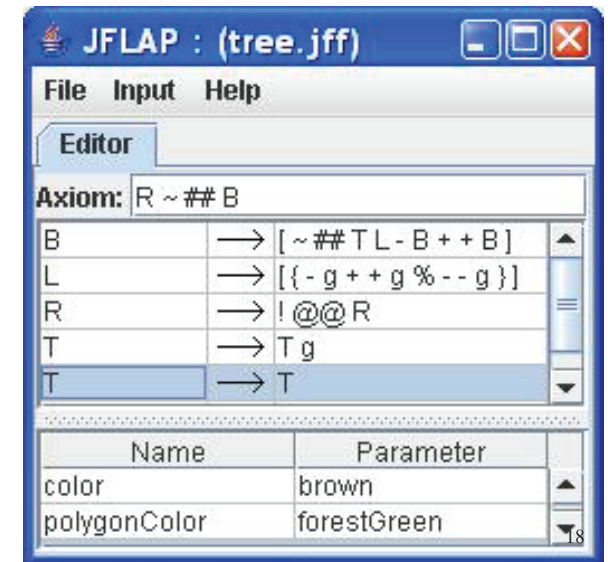
Example – tree rendered



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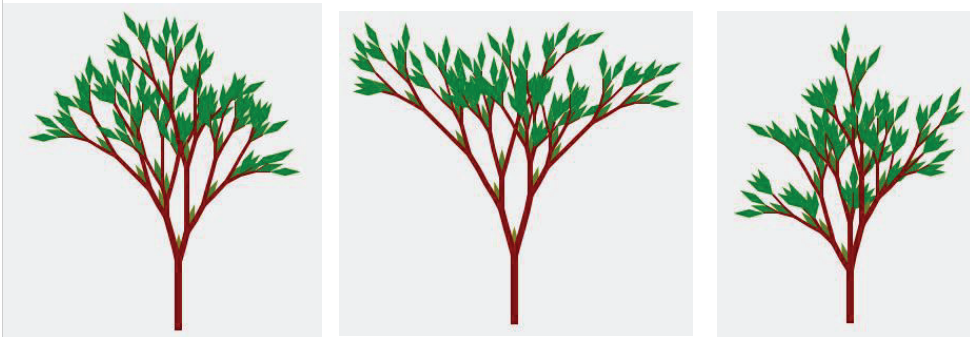
Stochastic Tree

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

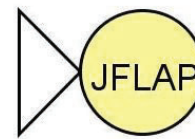


Same Stochastic L-System

- Rendered 3 times, each at 8th derivation



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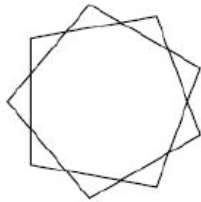
JFLAP

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

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Classwork - Exercise 1

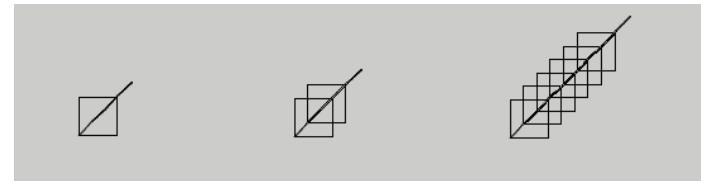
- Write an L-system for the picture below.
- Symbols needed are: g, + and one variable
- Distance of the line is 100, rendering at 1 draws the first line, each additional render draws another line.



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Exercise 2

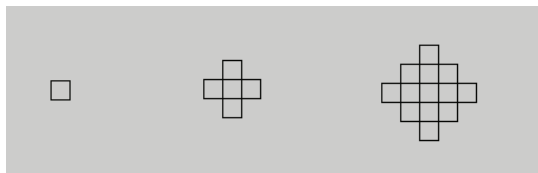
- Write an L-system for the picture below.
- Symbols may need: g, %, +
- Distance set to 15, angle set to 45, side of square is length 30, first diagonal line is 60
- 1st, 2nd and 6th renderings shown



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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



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