Experimenting with Grammars to Generate L-Systems – in JFLAP
April 1, 2010

Prof. Susan Rodger
Computer Science Dept
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 \((\Sigma, h, w)\)

- \(\Sigma\): finite alphabet, set of symbols
- \(h\): rewriting rules, each symbol is replaced by a 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

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

$L = \{ h^i(w) | \ i \geq 0 \}$
NOTE: If $h(a) = bb$ we will write this as a rule

$$a \rightarrow bb$$
Example:

\[ \Sigma \text{ alphabet: } \{a, b\} \]

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

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

\[ X \]

\[ gggX+Y \]

\[ gggggggX + Y + g \]

\[ gggggggggX+Y+g+g+g \]

Note: replace both \( X \) and \( Y \) each time
Example – lsys-samp2
Example – lsys-samp2 (cont)

\[ g[\sim+Yg]gX \]

\[ g[\sim+++Yg]gg[\sim+Yg]gX \]

\[ g[\sim++++Yg]gg[\sim+++Yg]gg[\sim+Yg]gX \]

...
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\textsuperscript{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 5 - 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