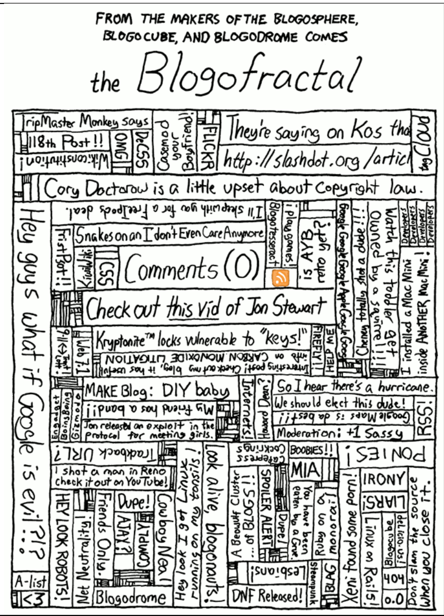
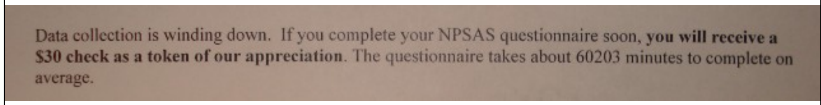
L-System Fractals & Procedure Practice


FROM THE MAKERS OF THE BLOGOSPHERE, BLOGOCUBE, AND BLOGODROME COMES
the Blogofractal

One-Slide Summary

- **Recursive transition networks** and Backus-Naur Form **context-free grammars** are equivalent formalisms for specifying formal languages.
- **find_closest** is quite powerful. Problem sets?
- **L-system fractals** are based on a **rewriting system** that is very similar to BNF grammars.
- We can practice our CS knowledge up to this point to solve problems by **writing recursive procedures**. (It won't take too long.)

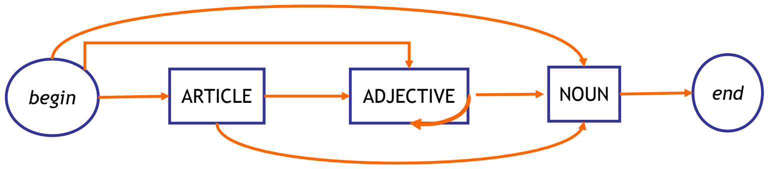

Data collection is winding down. If you complete your NPSAS questionnaire soon, **you will receive a $30 check as a token of our appreciation**. The questionnaire takes about 60203 minutes to complete on average.

Outline

- Briefly: Recursive Transition Networks
  - vs. Backus-Naur Form Grammars
- Problem Sets
  - Revenge of find_closest
- PS3 L-System Fractals
- Solving Problems
  - Problem Representation
  - Important Functions

Recursive Transition Networks

ORNATE NOUN



ORNATE NOUN	*::= OPTARTICLE ADJECTIVES NOUN*
ADJECTIVES	*::= ADJECTIVE ADJECTIVES*
ADJECTIVES	*::= ε*
OPTARTICLE	*::= ARTICLE*
OPTARTICLE	*::= ε*

Recall: the two notations are equivalent.

find_closest live demo

- Let's code it together now in PyCharm.

find_closest(goal, lst, dist)

- Hint: let's make test cases first.

Problem Sets

- **Not** just meant to review stuff you should already know
  - Get you to explore new ideas
  - Motivate what is coming up in the class
- The main point of the PSs is ***learning***, not ***evaluation***
  - Don't give up if you can't find the answer in the book (you won't solve many problems this way)
  - Do discuss with other students
  - (This is why they are difficult.)

PS2: Question 1

```
1.i.    len([1,2,3][0])
  =     len(1)
  =     error: 1 is not a list!

1.q.    map(len,[ [1,2,3], [4,5], [6] ])
  =     [len([1,2,3]), len([4,5]), len([6])]
  =     [3, 2, 1]
```

PS2: Question 4: Creativity

```
def seq_comp(lst):
 if not lst: return []
 return [nuc_comp(lst[0])] + seq_comp(lst[1:])

def seq_comp(lst):
 return map(nuc_comp, lst)

def seq_comp(lst):
 return [nuc_comp(nuc) for nuc in lst]
```

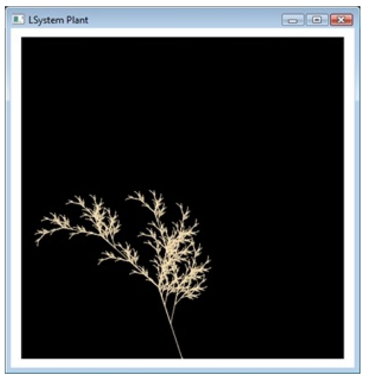
Liberal Arts Trivia: Latin American Studies

- This important leader of Spanish America's successful struggle for independence is credited with decisively contributing to the independence of the present-day countries of Venezuela, Colombia, Ecuador, Peru, Panama, and Bolivia. He defeated the Spanish Monarchy and was in turn defeated by tuberculosis.

Liberal Arts Trivia: Media Studies

- This 1988 book by Herman and Chomsky presented the seminal “propaganda model”, arguing that as news media outlets are run by corporations, they are under competitive pressure. Consider the dependency of mass media news outlets upon major sources of news, particularly the government. If a particular outlet is in disfavor with a government, it can be subtly 'shut out', and other outlets given preferential treatment. Since this results in a loss in news leadership, it can also result in a loss of viewership. That can itself result in a loss of advertising revenue, which is the primary income for most of the mass media (newspapers, magazines, television). To minimize the possibilities of lost revenue, therefore, outlets will tend to report news in a tone more favorable to government and business, and giving unfavorable news about government and business less emphasis.

PS3: Lindenmayer System Fractals



L-Systems

CommandSequence ::= [*CommandList*]
CommandList ::= *Command CommandList*
CommandList ::=
Command ::= **F**
Command ::= **R***Angle*
Command ::= **O***CommandSequence*

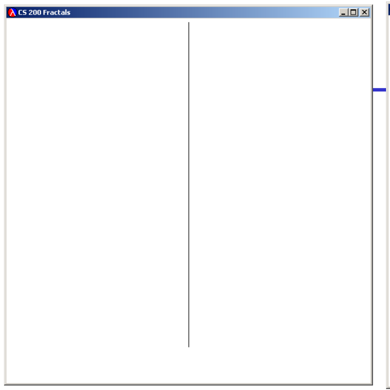
L-System Rewriting

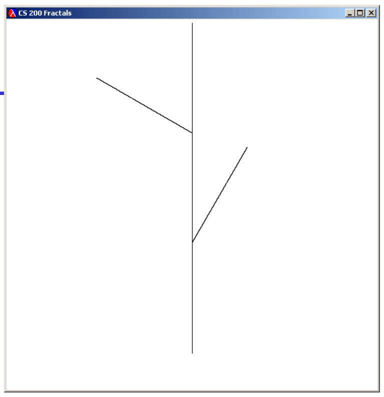
CommandSequence ::= [*CommandList*]
CommandList ::= *Command CommandList*
CommandList ::=
Command ::= **F**
Command ::= **R***Angle*
Command ::= **O***CommandSequence*

Start: [F]
Rewrite Rule:
F → [F O[R30 F] F O[R-60 F] F]

Work like BNF replacement rules, except replace all instances at once!

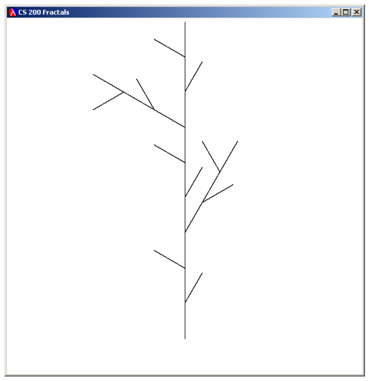
Why is this a better model for biological systems?

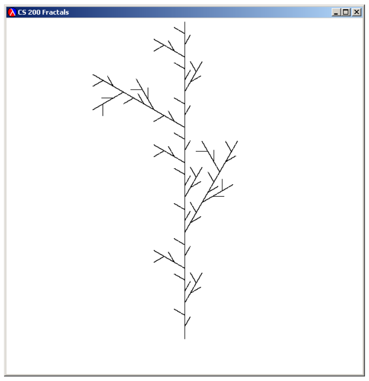




Level 0
Start: [F]
[F]

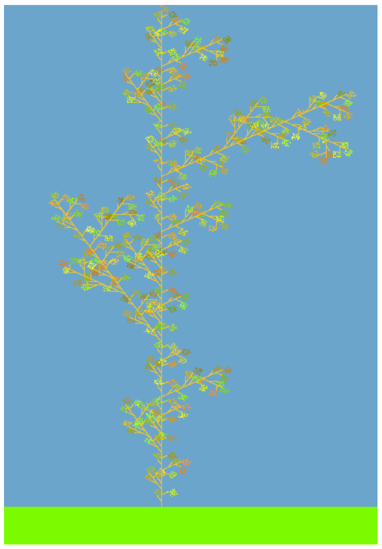
Level 1
F → [F O[R30 F] F O[R-60 F] F]
[F O[R30 F] F O[R-60 F] F]





Level 2

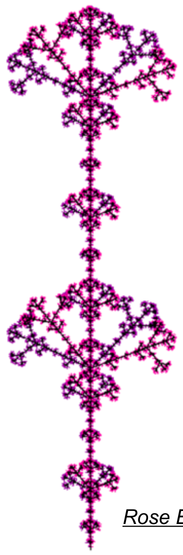
Level 3

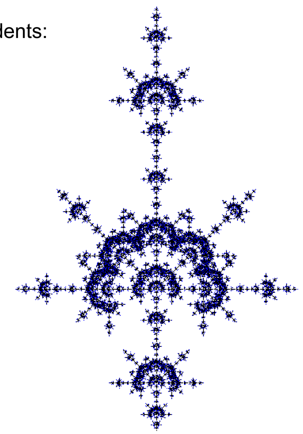


The Great Lambda Tree of Ultimate Knowledge and Infinite Power

(Level 5 with color)

Previous CS 1120 Students:

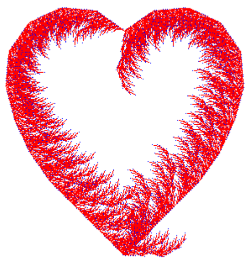


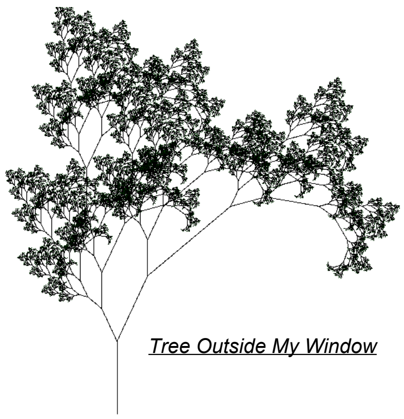


Tie Dye by Bill Ingram

Rose Bush by Jacintha Henry and Rachel Kay

Previous CS 1120 Students:





Tree Outside My Window

A Heart

PS3 - Fractals

- In addition to completing the problem set, each team will submit its prettiest fractal.
- The class will then vote for favorites, and the authors of the favorites will receive extra credit.
- No Photoshop, etc. All PS3.
  - You just change the rules:
    - F $\rightarrow$ [F O[R30 F] F O[R-60 F] F] *# one fractal*
    - F $\rightarrow$ [O[R60 F] F F O[R45 F]] *# a new one!*

#19

Procedure Practice

- For the rest of this class, we will be practicing writing recursive procedures together.
- Write a procedure **count-fives** that takes as input a list of numbers. It returns the number of fives contained in its input list.
  - count_fives([1, 2, 3, 4, 5,]) -> 1
  - count_fives([5, -5, 5, 7]) -> 2
  - count_fives([ ]) -> 0
  - count_fives([8, 6, 7, 5, 3, 0, 9]) -> 1

#20

Hints

- Remember our strategy!
- Be optimistic!
  - Assume that you can write "count_fives"
  - So the recursive case will work out
- Identify the smallest input you can solve
  - The base case
- How would you combine answers
  - From the current call (usually **lst[0]**)
  - And the result of the recursive call (on **lst[1:]**)
- Be creative! There are usually many solutions.

#21

Three versions of count_fives

```
def count_fives(lst):
  if not lst: return 0
  if lst[0] == 5: return 1 + count_fives(lst[1:])
  return count_fives(lst[1:])

def count_fives(lst):
  if not lst: return 0
  return (1 if lst[0] == 5 else 0) + count_fives(lst[1:])

def count_fives(lst):
  return len(filter(lambda x : x == 5, lst))
```

All work fine! How are they different?

#22

Liberal Arts Trivia: Medicine

- This vector-borne infectious disease is caused by protozoan parasites. It is widespread in tropical regions, such as sub-Saharan African. Each year there are about 515 million cases of it, killing between one and three million people. No formal vaccine is available. Classic symptoms include sudden coldness followed by rigor and then fever and sweating.

#23

Liberal Arts Trivia: Cognitive Psychology

- This American psychologist coined the term *Cognitive Psychology* in his late 1960's book of the same name. He was critical of linear programming models of psychology, felt that psychology should address everyday concerns, and respected the direct perception theories of J.J. And Eleanor Gibson. He headed the APA task force that reviewed *The Bell Curve*.

#24

Liberal Arts Trivia: Accounting

- In this bookkeeping system, each transaction is recorded in at least two accounts. Each transaction results in one account being debited and another account being credited, with the total debits equal to the total credits. Luca Pacioli, a monk and collaborator of Leonardo da Vinci, is called the "father of accounting" because he published a usable, detailed description of this system.

contains

- Write a procedure **contains** that takes two arguments: an element and a list. It returns True if the list contains the given element, False otherwise.

– contains(5, [1, 2, 3, 4])	-> False
– contains(5, [2, 3, 4, 5])	-> True
– contains([], [1, 2, 3])	-> False
– contains([], [1, 2, []])	-> True
– contains(1, [2, [], 1])	-> True
– contains(3, [ ])	-> False

contains explained

```
def contains(elt, lst):
  if not lst: return False
  elif lst[0] == elt: return True
  else: return contains(elt, lst[1:])
```

All work fine! How are they different?

```
def contains(elt, lst):
  if not lst: return False
  return (lst[0] == elt) or contains(elt, lst[1:])
```

```
def contains(elt, lst):
  return filter(lambda x : x == elt, lst) != []
```

common_elt

- Write a procedure **common_elt** that takes two lists as arguments. It returns True if there is a common element contained in both lists, False otherwise.

– common_elt([1, 2, 3], [3, 4, 5])	-> True
– common_elt([1, 2, 3], [4, 5, 6])	-> False
– common_elt([1, 2], [0, 0, 0, 1])	-> True
– common_elt([1], [])	-> False
– common_elt([], [1,2,3])	-> False
– common_elt([], [])	-> False

- Hint: You can use contains.

common_elt?

```
def common_elt(lst1, lst2)
  if not lst1: return False
  elif contains(lst1[0], lst2): return True
  else: return common_elt(lst1[1:], lst2)
```

All work! How are they different?

```
def common_elt(lst1, lst2)
  if (not lst1) or (not lst2): return False
  return (lst1[0] == lst2[0]) or common_elt(lst1,lst2[1:]) or \
    common_elt(lst1[1:], lst2) # this version is super slow!
```

```
def common_elt(lst1, lst2):
  return filter(lambda e1 : contains(e1, lst2), lst1) != []
```

zero2hero

- Write a procedure **zero2hero** that takes as input a list of strings. It returns the same list in the same order, but every element that used to be "zero" is now "hero".
  - zero2hero(["a", "zero", "b", "jercules"])
    -> ["a", "hero", "b", "jercules"]
  - zero2hero(["zorro"])
    -> ["zorro"]
  - zero2hero(["zero", "zero", "one", "zero"])
    -> ["hero", "hero", "one", "hero"]

zero2hero

```
def zero2hero(lst):
  if not lst: return [ ]
  if lst[0] == “zero”: return [“hero”] + zero2hero(lst[1:])
  return [lst[0]] + zero2hero(lst[1:])

def zero2hero(lst):
  if not lst: return [ ]
  return [“hero” if lst[0] == “zero” else lst[0]] + \
    zero2hero(lst[1:])

def zero2hero(lst):
  return [“hero” if x == “zero” else x  for x in lst]
```

All work! How are they different?

tiny_squares

- Write a procedure **tiny_squares** that takes as input a list of numbers. It returns a list of the squares of those numbers (in the same order), but any square above 100 is not included in the output.
  - tiny_squares([8, 9, 10, 11, 12])
    - [64, 81, 100]
  - tiny_squares([-2, 12, 4, 77, 5])
    - [4, 16, 25]
  - tiny_squares([3, 2, 1, 100])
    - [9, 4, 1]

tiny_squares

```
def tiny_squares(lst):
  if not lst: return [ ]
  if abs(lst[0]) <= 10:
    return [lst[0] * lst[0]] + tiny_squares(lst[1:])
  return tiny_squares(lst[1:])

def tiny_square(lst):
  return map(lamba x : x * x, \
    filter(lambda y : abs(y) <= 10, lst))

def tiny_squares(lst):
  return [x*x for x in lst if x*x <= 100] # so awesome!
```

All work! How are they different?

every

- Write a procedure **every** that takes two elements, a predicate and a list. (A predicate is a function that takes an element and returns True or False.) The procedure **every** returns True if the predicate returns True on each one of its elements. It returns False if even one element does not pass the test. On the empty list, every returns True.
  - every(lambda (x) :(x >3), [4,5,6])   -> True
  - every(lambda (x) :(x > 3), [9,1,1])   -> False
  - every(lambda (x) :(x == 3), [3,3])   -> True
  - every(lambda (x) :(x < y), [ ])   -> True

every heartbeat belongs to you!

```
def every(pred, lst):
  if not lst: return True
  if pred(lst[0]): return every(pred, lst[1:])
  return False

def every(pred, lst):
  if not lst: return True
  return pred(lst[0]) and every(pred,lst[1:])

def every(pred, lst):
  return len(filter(pred,lst)) == len(lst)
```

All work! How are they different?

count_false

- Write a function **count_false** that takes two arguments: a predicate and a list. It returns the number of elements in the list for which the predicate returns False.
  - count_false(lambda x: x > 3, [1,2,3,4,5,6,7,8,9,10])
    - 3
  - count_false(lambda x: x > 3, [-1, -2, -3, -4])
    - 4
  - count_false(lambda x: x == “a”, [“a”, “b”, “b”, “a”])
    - 2
  - count_false(lambda x: x == “a”, [ ])
    - 0

count_false

All work! How are they different?

```
def count_false(pred, lst):
  if not lst: return 0
  if pred(lst[0]): return count_false(pred, lst[1:])
  return 1 + count_false(pred, lst[1:])

def count_false(pred, lst):
  return len(filter(lambda x : not pred(x), lst))
  # return len([x for x in lst if not pred(x)])

def count_false(pred, lst):
  return len(lst) – len(filter(pred, lst))
```

Questions

- We're more or less **done** with procedure practice in class.
- Test questions may look a lot like this.
- If you're still having trouble with these, come see Wes or a TA. We'll make up problems for you to practice and go over writing recursive procedures with you.
- Time permitting, ask me anything now.

Homework

- Problem Set 3
  - Reading!