Musical Labyrinths & Puzzling Pegboards

"JUMP ALL BUT ONE GAMES"
JUMP EACH TEE AND REMOVE IT
LEAVE ONLY ONE—YOU'RE GENIUS
LEAVE TWO AND YOU'RE PURTY SMART
LEAVE THREE AND YOU'RE JUST PLAIN DUMB
LEAVE FOUR OR MOR'N YOU'RE JUST PLAIN
"EG-NO-RA-MOOSE"
CRACKER BARREL OLD COUNTRY STORE

One-Slide Summary

- **Recursive transition networks** and Backus-Naur Form **context-free grammars** are equivalent formalisms for specifying formal languages.
- Musical **harmony** contains an explicit notion of a stack. Music starts on the tonic, adds elements in a structured way, and returns to the tonic.
- **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 use our CS knowledge up to this point to defeat the evil scourge of Cracker Barrel **pegboard puzzles**! (More next time.)

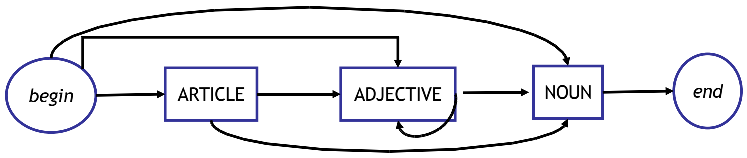
Outline

- Recursive Transition Networks
  - vs. Backus-Naur Form Grammars
- Stacks and Musical Harmony
- Playing Poker
  - Revenge of find-closest
- That Cursed Pegboard!
  - Problem Representation
  - Important Functions

With Special Guests: The CS 150 Chorus!

Recursive Transition Networks

ORNATE NOUN



Can we describe this using Backus Naur Form?

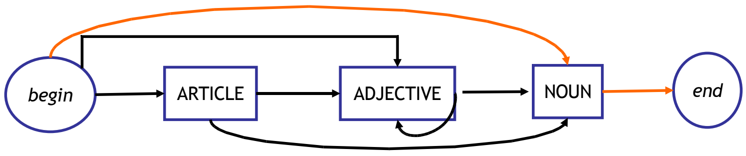
Turn Off Yahoo! Toolbar Smart Tools?

☐ Don't ask me again

OK | Yes | No | Cancel

Recursive Transition Networks

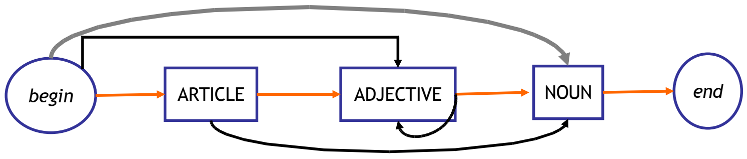
ORNATE NOUN



ORNATE NOUN ::= NOUN

Recursive Transition Networks

ORNATE NOUN

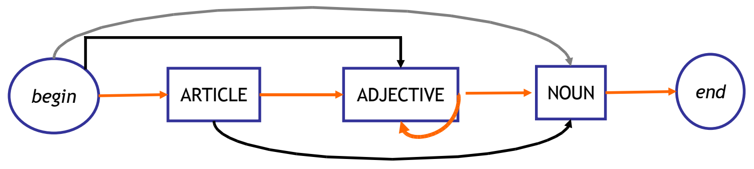


ORNATE NOUN ::= NOUN

ORNATE NOUN ::= ARTICLE ADJECTIVE NOUN

Recursive Transition Networks

ORNATE NOUN



ORNATE NOUN ::= ARTICLE ADJECTIVE NOUN

ORNATE NOUN ::= ARTICLE ADJECTIVE ADJECTIVE NOUN

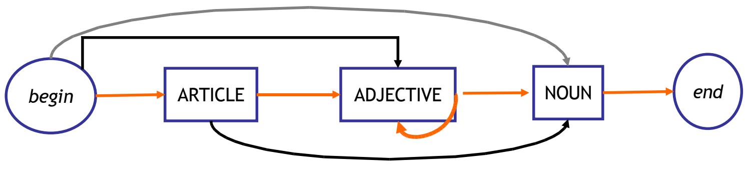
ORNATE NOUN ::= ARTICLE ADJECTIVE ADJECTIVE ADJECTIVE NOUN

ORNATE NOUN ::= ARTICLE ADJECTIVE ADJECTIVE ADJECTIVE ADJECTIVE NOUN

ORNATE NOUN ::= ARTICLE ADJECTIVE ADJECTIVE ADJECTIVE ADJECTIVE ADJECTIVE NOUN

Recursive Transition Networks

ORNATE NOUN



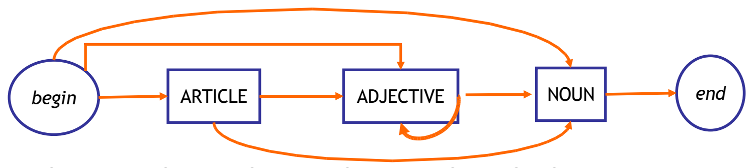
ORNATE NOUN ::= ARTICLE ADJECTIVES NOUN

ADJECTIVES ::= ADJECTIVE ADJECTIVES

ADJECTIVES ::=

Recursive Transition Networks

ORNATE NOUN



ORNATE NOUN ::= OPTARTICLE ADJECTIVES NOUN

ADJECTIVES ::= ADJECTIVE ADJECTIVES

ADJECTIVES ::= ε

OPTARTICLE ::= ARTICLE

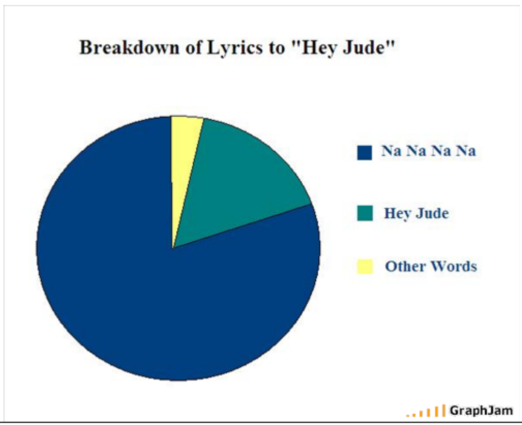
OPTARTICLE ::= ε

Which notation is *better*?

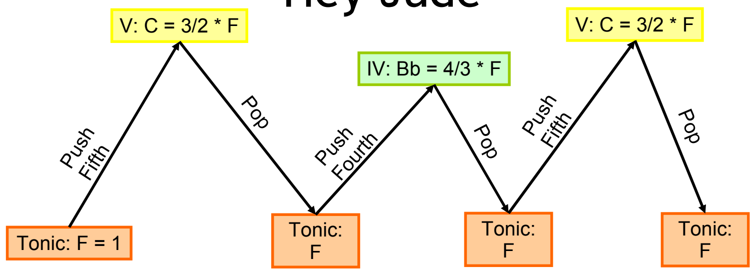
Music Harmony
Kleines Harmonisches Labyrinth
(Little Harmonic Labyrinth)

Hey Jude

- John Lennon and Paul McCartney, 1968



Hey Jude



Tonic: ***Hey Jude, don't make it***

V: ***bad. take a sad song and make it***

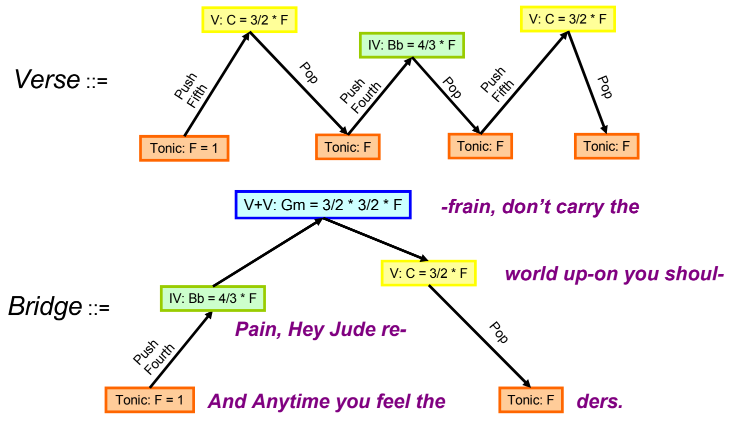
Tonic: ***better Re-***

IV: ***member to let her into your***

Tonic: ***heart, then you can***

V: ***start to make it bet-***

Tonic: ***-ter.***



HeyJude ::= *Verse VBBN VBBN Verse Verse Better Coda*
VBBN ::= *Verse Bridge Bridge Nanana (ends on C)*
Coda ::= F Eb Bb F *Coda*

Music

- **Almost All Music Is Like This**
  - Pushes and Pops the listener's stack, but doesn't get too far away from it
  - Repeats similar patterns in a structured way
  - Keeps coming back to the Tonic, and ends on the Tonic
- Any famous Beatles song that doesn't end on the tonic?

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.

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

PS2: Question 4

Why is

```
(define (higher-card? card1 card2)
   (> (card-rank card1) (card-rank card2)
```

better than

```
(define (higher-card? card1 card2)
   (> (car card1) (car card2))
```

?

PS2: Question 9, 10

- Predict how long it will take
- Identify ways to make it faster

Most of next week and much of many later classes will be focused on how computer scientists **predict** how long programs will take, and on how to **make them faster**.

Can we do better?

This is what we used in PS2 for our Poker-Bot:

```
(define (find-best-hand hole-cards community-cards)
  (car (sort (possible-hands hole-cards
                             community-cards))
             higher-hand?))
```

Hmmm....

```
(define (find-closest goal lst closeness)
  (if (= 1 (length lst))
      (car lst)
      (pick-closest closeness goal (car lst)
                    (find-closest goal (cdr lst) closeness))))

(define (pick-closest closeness goal num1 num2)
  (if (< (closeness goal num1)
         (closeness goal num2))
      num1
      num2))
```

We could use these to find the best hand!

find-bestest

```
(define (find-bestiest lst bestiness)
  (if (= 1 (length lst))
      (car lst)
      (pick-bestier bestiness
                    (car lst)
                    (find-bestiest (cdr lst) bestiness))))

(define (pick-bestier bestiness num1 num2)
  (if (bestiness num1 num2)
      num1
      num2))
```

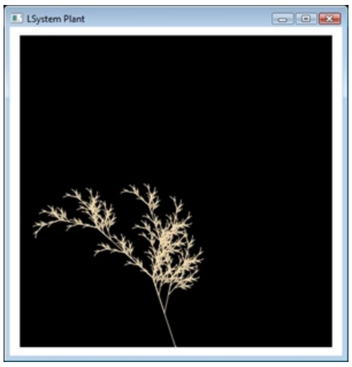
This used to be
(< (dist num1 goal)
(dist num2 goal))

find-best-hand

```
(define (find-bestiest lst bestiness)
  (if (= 1 (length lst)) (car lst)
      (pick-bestier bestiness
                    (car lst)
                    (find-bestiest (cdr lst) bestiness))))
(define (pick-bestier bestiness num1 num2)
  (if (bestiness num1 num2) num1 num2))

(define (find-best-hand lst)
   (find-bestest lst higher-hand?))
```

Next week: how much better is this?

PS3: Lindenmayer System Fractals



L-Systems

CommandSequence ::= **(** *CommandList* **)**
CommandList ::= *Command CommandList*
CommandList ::=
Command ::= **F**
Command ::= **R***Angle*
Command ::= **O***CommandSequence*

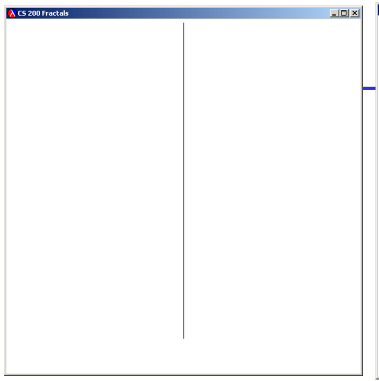
L-System Rewriting

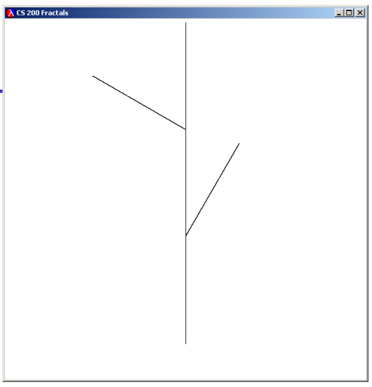
CommandSequence ::= **(** *CommandList* **)**
CommandList ::= *Command CommandList*
CommandList ::=
Command ::= **F**
Command ::= **R***Angle*
Command ::= **O***CommandSequence*

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?

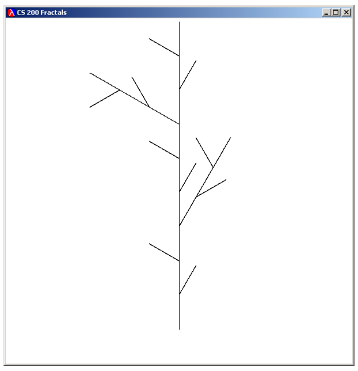


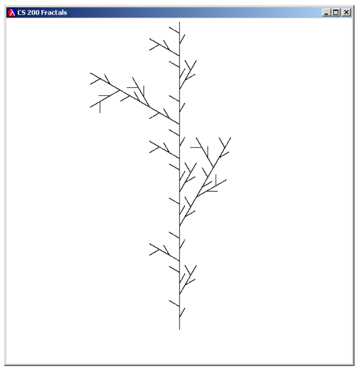


Level 0
Start: (F)
(F)

Level 1
F → (F O(R30 F) F O(R-60 F) F)

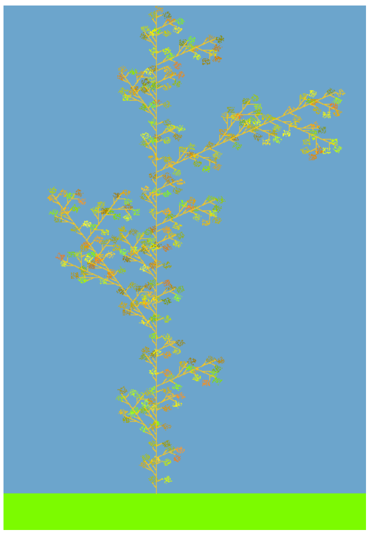
(F O(R30 F) F O(R-60 F) F)





Level 2

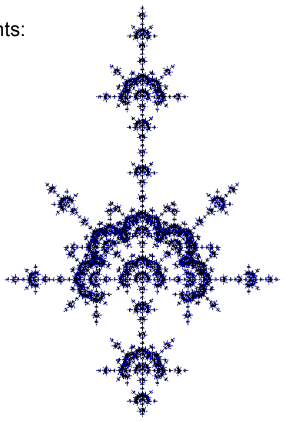
Level 3



The Great Lambda Tree of Ultimate Knowledge and Infinite Power

(Level 5 with color)

Previous CS 150 Students:



Tie Dye by Bill Ingram

Rose Bush by Jacintha Henry and Rachel Kay

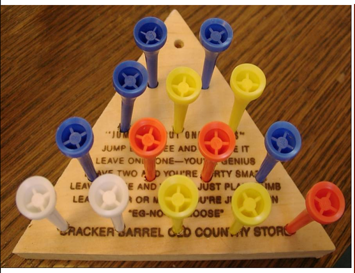
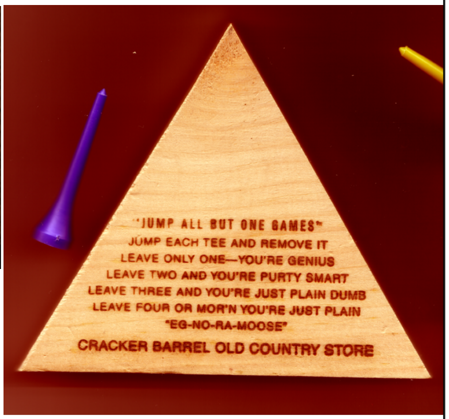
Liberal Arts Trivia: Medicine

- 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.

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 an collaborator of Leonardo da Vinci, is called the "father of accounting" because he published a usable, detailed description of this system.

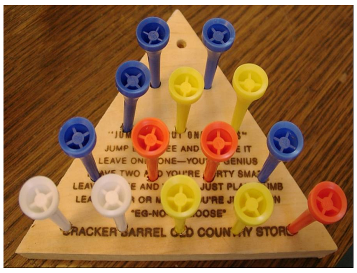
Pegboard Puzzle



"JUMP ALL BUT ONE GAMES"
JUMP EACH TEE AND REMOVE IT
LEAVE ONLY ONE—YOU'RE GENIUS
LEAVE TWO AND YOU'RE PURTY SMART
LEAVE THREE AND YOU'RE JUST PLAIN DUMB
LEAVE FOUR OR MOR'N YOU'RE JUST PLAIN
"EG-NO-RA-MOOSE"
CRACKER BARREL OLD COUNTRY STORE

Solving the Pegboard Puzzle

- How to represent the state of the board?
  - Which holes have pegs in them
- How can we simulate a jump?
  - board state, jump positions → board state
- How can we generate a list of all possible jumps on a given board?
- How can we find a winning sequence of jumps?

Pegboard Puzzle



- We'll use an (x,y) notation to represent positions on the pegboard.

```
            1,1
         2,1   2,2
      3,1   3,2   3,3
   4,1   4,2   4,3   4,4
5,1   5,2   5,3   5,4   5,5
```

Data Abstractions

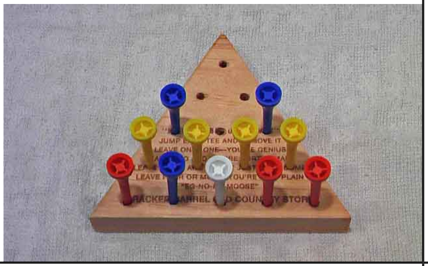
```
(define (make-board rows holes)
  (cons rows holes))

(define (board-holes board) (cdr board))
(define (board-rows board) (car board))

(define (make-position row col) (cons row col)) ;; (x.y)
(define (get-row posn) (car posn))
(define (get-col posn) (cdr posn))

(define (same-position pos1 pos2)
  (and  (= (get-row pos1) (get-row pos2))
        (= (get-col pos1) (get-col pos2))))
```

We are defining our data structures!

Example Board: "Grey"

```
(define grey-rows 5)
(define grey-holes (list (make-position 1 1) (make-
   position 2 1) (make-position 2 2) (make-position 3 2))
(define grey-board (make-board grey-rows grey-holes))
```

```
          1,1
       2,1   2,2
     3,1   3,2   3,3
  4,1   4,2   4,3   4,4
5,1   5,2   5,3   5,4   5,5
```



Removing a Peg

```
;;; remove-peg evaluates to the board you
;;; get by removing a peg at posn from the
;;; passed board (removing a peg adds a
;;; hole)

(define (remove-peg board posn)
  (make-board (board-rows board)
              (cons posn (board-holes board))))
```

Adding a Peg

```
;;; add-peg evaluates to the board you get
;;; by adding a peg at posn to board
;;; (adding a peg removes a hole)

(define (add-peg board posn)
  (make-board (board-rows board)
    (remove-hole
         (board-holes board) posn)))
```

Remove Hole

```
(define (remove-hole lst posn)
  (if (same-position (car lst) posn)
      (cdr lst)
      (cons (car lst) (remove-hole (cdr lst) posn))))
```

Could we instead define remove-hole using **map**?

Remove Hole

```
(define (remove-hole lst posn)
  (if (same-position (car lst) posn)
      (cdr lst)
      (cons (car lst) (remove-hole (cdr lst) posn))))
```

Could we instead define remove-hole using **map**?

No. (length (map f lst)) is always the same as (length lst), but remove-hole needs to remove elements from the list.

What if we had a procedure (filter proc lst) that removes from lst all elements for which proc (applied to that element) is false? Oh, wait! We do!

Filter

```
(define (filter pred lst)
  (if (null? lst)
      null
      (if (pred (car lst)) ;; pred is true, keep it
          (cons (car lst) (filter proc (cdr lst)))
          (filter pred (cdr lst))))) ;; pred is false, drop it
```

```
> (filter (lambda (x) (> x 0)) (list 1 4 -3 2 -8))
(1 4 2)
```

Filter Remove

```
(define (filter pred lst)
  (if (null? lst)
      null
      (if (pred (car lst)) ; pred is true, keep it
          (cons (car lst) (filter proc (cdr lst)))
          (filter pred (cdr lst))))) ; pred is false, drop it
```

```
(define (remove-hole lst posn)
  (filter (lambda (pos)
            (not (same-position pos posn)))
          lst))
```

Solving the Peg Board Game

- Try all possible moves on the board
- Try all possible moves from the positions you get after each possible first move
- Try all possible moves from the positions you get after trying each possible move from the positions you get after each possible first move
- …

Jumps

```
;;; move creates a list of three positions: a start (the posn
;;; that the jumping peg starts from), a jump (the posn
;;; that is being jumped over), and end (the posn that
;;; the peg will end up in)

(define (make-move start jump end) (list start jump end))
(define (get-start move) (first move))
(define (get-jump move) (second move))
(define (get-end move) (third move))

;;; execute-move evaluates to the board after making move
;;; move on board.
(define (execute-move board move)
  (add-peg (remove-peg (remove-peg board (get-start move))
                       (get-jump move))
           (get-end move)))
```

Homework

- Read Course Book Chapter 6 before Monday
- Start on reading Chapter 7
  - As soon as it's available ...