Lecture 9: Mostly Not About Matter, Music, and Mayhem

Menu
- Finishing find-closest
- Mapping on Lists
- GEB Chapter V

Last class: find-closest-number

(define (find-closest-number goal p)
  (if (null? (cdr p))
    (car p)
    (if (< (abs (- goal (car p)))
     (abs (- goal (find-closest-number goal (cdr p)))))
      (car p)
      (find-closest-number goal (cdr p))))

Avoiding Duplicate Work

(define (pick-closest goal a b)
  (if (< (abs (- goal a)) (abs (- goal b))) a b))

(define (find-closest-number goal p)
  (if (null? (cdr p))
    (car p)
    (pick-closest goal
     (car p)
     (find-closest-number goal (cdr p)))))

Generalizing find-closest-number

- How would we implement find-closest-number-without-going-over?
- What about find-closest-word?
- ...

The “closeness” metric should be a procedure parameter

find-minimizer

(define (pick-minimizer f a b)
  (if (< (f a) (f b)) a b))

(define (find-minimizer f p)
  (if (null? (cdr p))
    (car p)
    (pick-minimizer f (car p)
     (find-minimizer f (cdr p))))

find-minimizer takes two inputs: a procedure and a list. Its output is the element of the input list for which applying the procedure produces the lowest value.
Examples

> (find-minimizer (lambda (n) (abs (- 1120 n)))
   (list 1130 1125 1203 1108))

1125

> (find-minimizer (lambda (n) (- n))
   (list 1 2 4 8 16))

16

> (find-minimizer
   (lambda (n) (if (<= n 1120) (-1120 n) 99999))
   (list 1130 1125 1203 1108))

1108

find-closest-number

(define (find-closest-number goal p)
  (find-minimizer
   (lambda (n) (abs (- goal n)))
   p))

Seen Anything Like This?

(define (find-best-match sample tiles color-comparator)
  (if (= (length tiles) 1)
      (car tiles)
      (pick-better-match
       sample
       (pick-better-match
        (find-best-match
         sample
         (cdr tiles)
         color-comparator)
        color-comparator) (car tiles)
        color-comparator))))

Better find-best-match

(define (find-best-match sample tiles color-comparator)
  (find-minimizer
   (lambda (tile)
    (color-differentecer tile sample))
   tiles))

(define (color-difference coloracolorb)
  (+ (square (- (get-red colora) (get-red colorb)))
      (square (- (get-green colora) (get-green colorb)))
      (square (- (get-blue colora) (get-blue colorb)))))

GEB Chapter V

You could spend the rest of your life just studying things in this chapter (25 pages)!

- Music Harmony
- Stacks and Recursion
- Theology
- Language Structure
- Number Sequences
- Chaos
- Fractals (PS3 out today)
- Quantum Electrodynamics (later lecture)
- DNA (later lecture)
- Sameness-in-differentness
- Game-playing algorithms (later lecture)

Fibonacci’s Problem

Filius Bonacci, 1202 in Pisa:

Suppose a newly-born pair of rabbits, one male, one female, are put in a field. Rabbits mate at the age of one month so that at the end of its second month a female can produce another pair of rabbits.

Suppose that our rabbits never die and that the female always produces one new pair (one male, one female) every month from the second month on.

How many pairs will there be in one year?
Fibonacci Numbers

GEB p. 136:
These numbers are best defined recursively by the pair of formulas
FIBO \( n \) = FIBO \( n - 1 \) + FIBO \( n - 2 \)
for \( n > 2 \)
FIBO \( 1 \) = FIBO \( 2 \) = 1
Can we turn this into a Scheme procedure?

Defining FIBO

1. Be optimistic - assume you can solve it, if you could, how would you solve a bigger problem.
2. Think of the simplest version of the problem, something you can already solve.
3. Combine them to solve the problem.

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Defining fibo

;;; (fibo n) evaluates to the nth Fibonacci
;;; number
(define (fibo n)
  (if (or (= n 1) (= n 2))
      1         ;;; base case
      (+ (fibo (- n 1))
          (fibo (- n 2)))))

FIBO \( 1 \) = FIBO \( 2 \) = 1
FIBO \( n \) =
FIBO \( n - 1 \)
+ FIBO \( n - 2 \)
for \( n > 2 \)

Fibo Results

> (fibo 2)
1
> (fibo 3)
2
> (fibo 4)
3
> (fibo 10)
55
> (fibo 60)
Still working after 4 hours...

Recursive Transition Networks

Why can’t our 4Mx Apollo Guidance Computer figure out how many rabbits there will be in 5 years?

To be continued...
(Chapter 7)
Can we describe this using a BNF Grammar?

```
ORNATE-NOUN ::= 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 ADJECTIVE NOUN
```

```
FANCY-NOUN ::= ORNATE-NOUN
FANCY-NOUN ::= ORNATE-NOUN PREPOSITION FANCY-NOUN
PREPOSITION ::= below | on | above | under | ...
```

```
ORNATE-NOUN ::= ARTICLE ADJECTIVES NOUN
ADJECTIVES ::= ADJECTIVE ADJECTIVES
ADJECTIVES ::=
```
Recursive Transition Networks

ORNATE NOUN

begin ARTICLE ADJECTIVE NOUN end

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

FANCY-NOUN ::= ORNATE-NOUN
FANCY-NOUN ::= ORNATE-NOUN PREPOSITION
FANCY-NOUN
PREPOSITION ::= below | on | above | under | ...
ARTICLE ::= the | a | an
NOUN ::= bagel | cow | cloud | ...

This demonstrates that one RTN can be converted to a BNF. For a proof that all RTNs can be converted to BNFs, we would need to formalize the transformation as a systematic and general algorithm.

Music Harmony

*Kleines Harmonisches Labyrinth*  
(Little Harmonic Labyrinth)

Not actually by Bach  
(by Johann David Heinichen)

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Hey Jude

John Lennon and Paul McCartney, 1968

Verse ::=  

Bridge ::=  

HeyJude ::= Verse VBBD VBBD Verse Verse Better Coda VBBD ::= Verse Bridge Bridge Dadada (ends on C)  
Coda ::= F Eb Bb F Coda

---

Hey Jude

Tonic: F = 1  
V: bad. take a sad song and make it  
Tonic: F  
IV: member to let her into your  
Tonic: heart, then you can  
V: start to make it better  
Tonic: F

Bridge

Pain, Hey Jude re-

And Anytime you feel the Pain, Hey Jude re-

world on you shoul-

—frain, don’t carry the world up-on you shoul-

ers.
Music

• Almost All Music Is Like This
  – Pushes and pops the listener’s stack, but doesn’t go too far away from it
  – Repeats similar patterns in structured way
  – Keeps coming back to Tonic, and Ends on the Tonic
• Any famous Beatles song that doesn’t end on Tonic?

  “A Day in the Life” (starts on G, ends on E)

Charge

• Challenge: Find a “pop” song with a 3-level deep (or higher) harmonic stack
• PS3: due 23 Sept.
  Be optimistic! You know everything you need to finish it now, and it is longer than ps2, so get started now!