Day 4: Lisp II

Sunday, February 14, 2021 5:18 PM

I didn't actually watch this lecture, I just read the slides and worked through the examples.

FAI Day 4

Lisp 201: Recursion and Iteration

Recursion

- A native style to lisp
- Very useful
- a good way to think of programming

Writing in a Recursive Style

- Solve Easy (Base) Case
- Make Predicate for Base Case
- [Magic] Assume it works for some arbitrary size (call this N-1)
- Show how to solve size N problem, given function works on size N-1 or smaller
  - Lisp compiler is good at converting recursion to iteration

Factorial

- (defun fact (n)
-    (if (< n 2) 1 (* n (fact (- n 1))))

Recursive Fibonacci

- (defun fib (n) (if (< n 2) 1 (+ (fib (- n 1))(fib (- n 2)))))

Length

```
(defun leng (lst)
  (if (null lst)
      0
      (+ 1 (leng (cdr lst)))))
```

- O(n) time
- Remember a list is a right-branching tree ending in NIL, not a vector or 1d array!

beyond cadddr: Accessing Nth item in a list

- if n=0, nth should return the car
- if n=1, return the cadr
- if n=2, return the caddr, etc

```
(defun enth (n lst)
  (if (= n 0)  (car lst)
               (enth (- n 1)(cdr lst)))
```

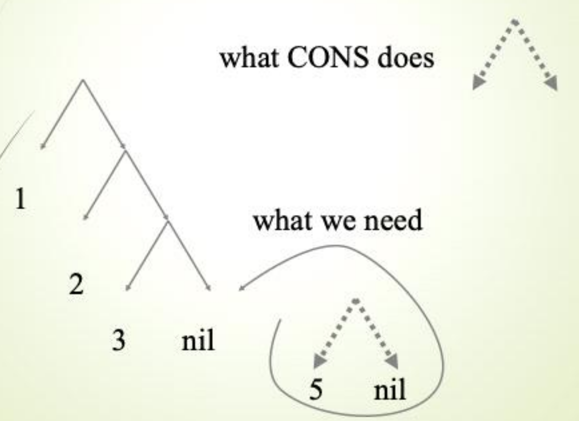
extending a list?

- x -> (1 2 3 4)
- how do we make (0 1 2 3 4)?
- How do we make (1 2 3 4 5)?
- How about (1 2 3 4 1 2 3 4)?

extending a list?

- (setf x '(1 2 3 4))
- how do we make (0 1 2 3 4)?
  - very easily: (cons 0 x)
    - –CONS and CAR work as PUSH and POP!
- How do we make (1 2 3 4 5)?
  - (cons x 5)? (1 2 3 4 . 5)
  - (cons x (list 5))? ((1 2 3 4) 5)
- How about (1 2 3 4 1 2 3 4)
  - (cons x x)? (1 2 3 4 (1 2 3 4))
  - (list x x)? ((1 2 3 4)(1 2 3 4))

Append to the end



Recursive definition for append

- base case:
  If list1 is the empty list, then result is just list2
- recursive step:
  - cons the first element of list1 onto the front of (append (cdr list1) with list2)

Append

```
(defun apend (list1 list2)
  (if (null list1) list2
      (cons (car list1)
            (apend (cdr list1) list2))))
```

reverse a list

- (last x) -> (4)
- (butlast x) (1 2 3)

- (defun revrse (lst)
- (if (null lst) nil (cons (car (last lst))(revrse (butlast lst)))))

square root, recursively

- start with a guess of 1
- if |n-g^2| < epsilon, halt
- else average g and n/g

- (defun sqrt1 (n &optional (guess 1))
- (if (< (abs (- n (* guess guess))) .0001)
- guess
- (sqrt1 n (/ (+ guess (/ n guess)) 2.0))))

Factoring

- Iteration in a recursive style, with bug
- (defun factor (n &optional (i 2))
-     (cond ((> i (sqrt n)) nil)
-           ((zerop (rem n i))
-           (cons (/ n i)
-                 (cons i (factor n (+ 1 i)))))
-           (t (factor n (+ i 1)))))

Writing in an Iterative Style

- map Forms: Map, Mapc, Mapcar, Mapl, Maplist, mapcan,mapcon, reduce
- uses function as argument, and applies it to each element (or each tail) of a list, collecting (or not) the results

Mapcar and #' (bangquote)

- mapcar maps a function "across" a list or multiple lists
- #' or (function quote) is a special form which gets the f-value of the symbol

- (mapcar #'square '(1 2 3)) -> (1 4 9)
- (mapcar #'+ '(1 2 3) '(4 5 6))-> (5 7 9)

Example Arrays as nested Lists

- Representing arrays as lists of lists
  - (setf A '((1 2 3)(4 5 6)(7 8 9)))
- Rotating and transposing...
- So how do you get
-   ((3 2 1)(6 5 4)(9 8 7))
  - (MAPCAR #'REVERSE A)
- ((1 4 7)(2 5 8)(3 6 9)) ;transpose the array

Thinking Transpose, Recursively

- MAPCAR #'CAR A will get the (1 4 7)
- MAPCAR #'CDR A will get ((2 3)(5 6)(8 9))
  - MAPCAR #'CAR will get (2 5 8)
  - MAPCAR #'CDR THAT gets ((3)(6)(9))
    - MAPCAR #CAR THAT gets (3 6 9)
    - MAPCAR #CDR THAT gets (? ? ?)
- What is the base case? How to test for it?

(NIL NIL NIL)

Transpose, Recursively

```
(defun transpose (x)
  (if (null (car x)) nil
    (cons (mapcar #'car x)
          (transpose (mapcar #'cdr x)))))
```

Loop Macros to the rescue!

- The LOOP macro Package (powerful and elegant)
  - Added in CLTL2
  - Loops with lists, integers, arrays
  - Powerful collection facilities
  - powerful stop logic
  - use of auxiliary variables

Compare to Mapcar

- (mapcar #'square '(1 2 3))
- (loop for i from 1 to 3 collect (square i))
- or
- (loop for i in '(1 2 3) collect (square i)))

works like C forloop

- (loop for i from 1 to 5 by 2 collect i)
- (loop for j from 20 downto 10 sum j)

In and On (tails) lists

- (loop for x in '(a b c) do (print x))
- (loop for x on '(a b c) do (print x))

Conditional Logic for do

- When, if, unless, while, until
  - (loop for x in '(a b c d e 1 2 3 4)
    - until (numberp x)
    - collect (list x 'foo))

Collection Facilities

- Do, Collect, Append, Nconc, Count, Sum, Minimize, Maximize
- (loop for x in (factor 36) maximize x)
- (loop for x in '(a b c) as y from 1
  - collect (list x y))
- (loop for x in '(a b c) as y from 1
  - append (list x y))
- (loop for i from 1 to 10 when (evenp i) sum i)
- (loop for x on '(5 4 3 2 1) collect
  - (reduce #'+ x)))

Termination Logic

- (loop for x in (factor 36) thereis (evenp x))
- T

- VERY IMPORTANT FEATURE:
  - Thereis, Always, Never, while, until
  - Thereis stops at first non-NIL
  - Always stops at first NIL
  - Never means ALL NILS
  - Always means ALL non-NILS
  - While and Until are like other languages

WITH Auxiliary Variables

- (loop for x from 1 to n with y = 10 and z = 20
  ....

Redo Fibonacci

- (defun fib (n)
- (loop for i from 1 to n with f1 = 0 and f2 = 1 and f3 do
- (setf f3 f1)
- (setf f1 f2)
- (setf f2 (+ f3 f2))
- finally (return f2))

You can also iterate using recursion, often prettier!

- (defun fib (n &optional (f1 1)(f2 1))
- (if (= n 1)
- f1
- (fib (- n 1) f2 (+ f1 f2)))))

Lets Redo Factoring

```
(defun factor (n)
  (loop for i from 2 to (floor (sqrt n)) append
     (if (zerop (rem n i))
         (list i (/ n i))
         nil)))
```

- Instead of collect, append NILS and (numbers). Append “throws away” Parens.

simplified factoring no bug

```
(defun factor (n)
 (loop for i from 1 to n
     when (zerop (rem n i))
     collect i))
```