Programming in Lisp

Lecture #2
Kenneth W. Flynn
RPI CS

Outline

- Items from last time
- Recursion, briefly
- How to run Lisp
- I/O, Variables and other miscellany
- Lists
- Arrays
- Other data structures

TA

- Jin Li
- *lij3@rpi.edu*
- Office Hours:
  - M: 2-3:30 pm
  - W 10 am - 12 pm
- Office: ???

Items From Last Time I

- `(cdr nil)`
  - Returns nil
- Unlimited arguments?
  - `&rest`
  - We'll talk about this next week

Items From Last Time II -- (listp)

- > (listp 'a)
  NIL
- > (listp 1)
  NIL
- > (listp '(1 2 3))
  T
- > (listp '())
  T
- > (listp nil)
  T
- > (listp '(HELLO))
  T
- > (listp (5))
  ;; Error:

Items From Last Time III -- '

- The following characters cannot appear in symbols:
  - `();"'`,#`
- So, '*hi* is valid:

```
> (listp '*hi*)
NIL
>
```

Recursion, Briefly

- Frequently we'll write recursive Lisp functions
- Recursive functions should have
  - Basis case (at least one)
  - Recursive case
- Don't forget terminating condition

How To Run Lisp

- Under UNIX
  - kcl, gcl
  - Specify in homework which used
  - :q if you make an error
  - ^D to exit
- Under Win '95
  - Goto http://www.franz.com/dload/dload.html
  - Select Allegro CL Lite for Windows

How To Write Lisp

- Use a text editor with paren matching!
  - vi
    - :set sm
  - emacs
  - Others?
- Load code into Lisp and then try it...

load

- Allows you to not write programs at the top-level
- Reads a file and executes commands inside the file as if you typed them at the top-level
- > (load "hello.lsp")
  t

Output With *format*

- Output is done with the format command
- (format destination format-string args...)
- Destination is "t" for the console
- Format string is similar to C's printf function
- Usually returns nil, but we don't care!

format Examples I

```
>(format t "~%Hello World.~%")
Hello World.

NIL
> (format t "~%Two plus two is
~A.~%" (+ 2 2))
Two plus two is 4.

NIL
```

format Examples II

```
> (format t "~%Words fail,
  buildings ~A." "tumble")
  Words fail, buildings tumble.

> (format t "~%The ~A opens
  ~A~%" "ground" "wide.")
  The ground opens wide.
```

read and *read-line*

- *read*
  - "Incredibly powerful" says the text.
  - Reads input and parses into Lisp objects
- *read-line*
  - Reads up to a newline; puts input into string
  - Prefered for reading from console

read and *read-line* Examples

```
> (read)2
  2
> (read)Hello
  HELLO
> (read-line)Hello World
  "Hello World"
  T
```

progn

- Used to create a "block"
- Allows side-effects
- Value of last expression evaluated is returned
- Avoid if possible; frequently needed for debuging output, etc.

progn Example

```
(defun stupid-hello ()
  (progn
   (format t "~%Hello")
   (format t " World~%")
  )
 )
```

So Many Forms of Equality...

- For numbers, you have (= args...)
  - > (= 1 1 1)
    t
- For others you have: eq, eql, equal, equalp
  - eq: Implementationly identical (rarely used)
  - eql: Logically identical (what we were thinking)
  - equal: Object identical (lists)
- Stick with equal (more info on Steele 103-110)

Equality Examples

```
> (equal '(1 2 3) '(1 2 3))
 T
> (eq '(1 2 3) '(1 2 3))
 NIL
> (equal "Hello" "Hello")
 T
> (= 1 1.0)
 T
```

setf

- Assigns value to variable
  - Side-effect

```
> (setf x '(1 2 3))
 (1 2 3)
> x
 (1 2 3)
```

let

- Introduces new local variables
- Form (*let* Variable-Bindings-List Expressions*)
  - Variable-Bindings-List is a list of pairs of variables and expressions to set them equal to. These are your new local variables
  - Implicit *progn*

let Example

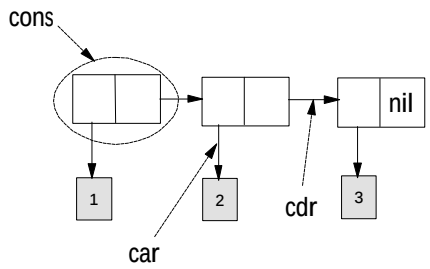
```
> (let ((x "Hello")
        (y " World")
       )
    (format t "~%~A~A~%" x y)
   )
 Hello World

 NIL
```

Lists

- Lisp lists
- List construction functions
- Access (review)
- Mapping functions
- Sets, Sequences
- Dotted lists

Lisp Lists I



Lisp Lists II

- A "cons" refers to a pair of pointers
  - The first pointer may point to data or another cons
  - The second may point to data, another cons, or nil
  - *cons* is used to construct such a pair
- *car* refers to the first pointer
- *cdr* refers to the second pointer

List Construction Functions

- *copy-list* literally copies a list
  - (copy-list list)
- *append* copies the list arguments onto the beginning of the last list argument
  - (append list1 list2 list3)
  - list1 -> list2 -> list3
- Don't forget *list* and *cons*

Access (Review)

- *car* and *cdr* (*first* and *rest*), *first, second, third...*
- *nth* returns nth car in the list
  - >(nth 2 '(1 2 3))
    3
- *nthcdr* returns the nth cdr in the list (confused?)
  - >(nthcdr 2 '(1 2 3 4))
    (3 4)
- *last* returns the last cons in the list

Mapping Functions

- All about *mapcar*
- *mapcar* is used to apply a function to each element in one or more lists
- *mapcar*'s first argument is a function
- One by one, the nth arguments of each list are passed to the function

Function Passing: #'

- #' Sharp Quote
- All functions can be passed as parameters
  - #'+
  - #'-
  - #'list
  - #'my-function
- Used in many standard functions
- Generics...

lambda Functions (A rose without a name...)

- Sometimes you create a function just to pass it to something like *mapcar*
- Instead of naming the function, you can create a function with no name -- a *lambda* function
- Simply use the special symbol *lambda* instead of the function name
- #'(lambda (x y) (+ x y)) is our old friend the adder

mapcar Examples

```
> (mapcar #'+ '(1 2) '(1 2))
 (2 4)
> (mapcar #'(lambda (x y)
             (+ x y)
           )
          '(1 2)
          '(1 2)
  )
 (2 4)
```

member

- (*member* object list) returns a cons begining with object if present
- *member* takes several *keyword arguments*
- Keyword arguments are of the form :keyword key-value
- :test equilvalance-function
- :key function-to-be-applied-first
- Order is irrelevant

member Examples I

```
> (member 2 '(1 2 3))
 (2 3)
> (member 3 '(1 2 3)
          :key #'(lambda (x)
                   (+ x 1)
                 )
  )
 (2 3)
```

member Examples II

```
> (member '(1 2)
          '((2 3) (1 2)))
 NIL
> (member '(1 2)
          '((2 3) (1 2))
          :test #'equal)
 ((1 2))
```

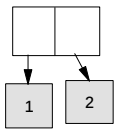
Sequences

- *length*
  - (length '(1 2 3)) returns 3
- *reverse*
  - (reverse '(1 2 3)) returns (3 2 1)
- (*sort* list sort-function)
  - (sort '(3 1 2) #'>) returns (3 2 1)

Dotted Lists

- Proper list refers to a list in which every cdr points to another cons (or nil)
- Dotted list refers to the case when this is not true

(1 . 2)



To Dot Or Not To Dot?

- Lisp displays a list with the dot only for the cons which is not proper
- So a cons can be used as a two field data structure.
- Better ways of doing this, though... Structures (next week) come to mind

Arrays

- Creation
  - *make-array*
    - 1 required argument -- list of dimensions or integer
    - :initial-element initializes array
- Retrieval
  - *aref*
    - Returns reference to element

Array Example

```
> (setf x (make-array 3
            :initial-element 0))
 #(0 0 0)
> (setf (aref x 1) 1)
 1
> (setf (aref x 2) 2)
 2
> x
 #(0 1 2
```

Vectors

- Just one dimensional arrays
- Create with *vector*
  - Simliar to *list*
- Can access quickly with *svref* instead of *aref*

```
> (setf x (vector 1 2 3))
 #(1 2 3)
> (svref x 2)
 3
```

Whew!

- We've covered a lot today!
- For next week
  - Read Chapters 3 and 4 in Graham
  - Start Homework #1 (Due 9/14. New due date!)
- On the next exciting episode
  - Structures
  - Control Flow
  - Gory function details