CS 2740 Knowledge Representation
Lecture 5

Introduction to LISP II.

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LISP language

LISP: LISt Processing language

- **An AI language developed in 1958 (J. McCarthy at MIT)**
- **Special focus on symbolic processing and symbol manipulation**
  - Linked list structures
  - Also programs, functions are represented as lists

LISP tutorial: data types

Basic data types:

- **Symbols**
  - **a**
  - **john**
  - **34**

- **Lists**
  - **( )**
  - **(a)**
  - **(a john 34)**
  - **(lambda (arg) (* arg arg))**

LISP tutorial

Lists represent function calls as well as basic data structures

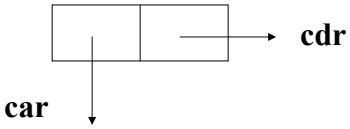
> (factorial 3)
6
> (+ 2 4)
6

> (setq a '(john peter 34))
(john peter 34)
> (setq a '((john 1) (peter 2)))
((john 1) (peter 2))

LISP tutorial: lists

List representation:

- **A singly linked list**




```
> (setq a '(john peter))
  (john peter)
> (car a)
  john
> (cdr a)
  (peter)
```


LISP tutorial

Useful list functions:

```
> (reverse '(1 2 3)) ;reverse the elements of a list
(3 2 1)
> (member 'a '(b d a c)) ;set membership -- returns the first tail
(A C)              ;whose car is the desired element
> (find 'a '(b d a c)) ;another way to do set membership
A
 > (find '(a b) '((a d) (a d e) (a b d e) ()) :test #'subsetp)
(A B D E)                  ;find is more flexible though
> (subsetp '(a b) '(a d e))      ;set containment
NIL
```

LISP tutorial: equality

4 equality predicates: =, equal, eq, eql

```
> (= 2 4/2)     ;; used for numerical values only
  T
> (setf a '(1 2 3 4))
    (1 2 3 4)
>(setf b '(1 2 3 4))
    (1 2 3 4)
>(setf c b)
  (1 2 3 4)
> (equal a b)  ;; equal is true if the two objects are isomorphic
   T
> (equal c b)
   T
```


LISP tutorial: equalities

```
>(eq a b)     ;; eq is true if the two arguments point to the
    same object
 NIL
>(eq b c)
 T
```

LISP tutorial: nil

Nil represents False and an empty list

> (null nil)
  T
> (null ( ))
  T
> (null ‘(a b))
  NIL
> (not ‘(a b))
  NIL

LISP tutorial: functions

Logical operators: and, or

> (and NIL T)
  NIL
> (and T 2 3)
  3
> (or nil (= 5 4))
  NIL
> (or nil 5)
  5

LISP tutorial: recursion

Recursive function definitions are typical for LISP

```
> (defun factorial (num)
    (cond ((<=  num 0) 1)
    (t (* (factorial (- num 1)) num))
        ))
   FACTORIAL
> (factorial 4)
  24
```


LISP tutorial: local and global variables

```
> (setq a 12)
   12
> (defun foo (n)
    (setq a 14)
     (+ n 2))
  FOO
> a
  12
> (foo 3)
  5
> a
 14
```

LISP tutorial: local variables

Defining local variables with let

```
> (setq a 7)      ;store a number as the value of a symbol
 7
> a               ;take the value of a symbol
 7
> (let ((a 1)) a)   ;bind the value of a symbol temporarily to 6
 1
> a               ;the value is 7 again once the let is finished
7
> b               ;try to take the value of a symbol which has no value
Error: Attempt to take the value of the unbound symbol B
```


LISP tutorial: local variables

Defining local variables with let and let*

```
> (let ((a 5)           ;; binds vars to values locally (in parallel)
        (b 4))
    (+ a b))
   9
> (let* ((a 5)          ;; binds vars sequentially
         (b (+ a 2))
    (+ a b))
   12
```

LISP tutorial: functions revisited

Standard function – all parameters defined

```
(defun fact (x)
   (if (> x 0)
       (* x (fact (- x 1)))
       1))
```

But it is possible to define functions:

- with variable number of parameters,
- optional parameters and
- keyword-based parameters

LISP tutorial: functions revisited

Functions with optional parameters

```
> (defun bar (x &optional y) (if y x 0))
BAR
> (defun baaz (&optional (x 3) (z 10)) (+ x z))
BAAZ
> (bar 5)
0
> (bar 5 t)
5
> (baaz)
13
> (baaz 5 6)
11
> (baaz 5)
15
```

LISP tutorial: functions revisited

Functions with variable number of parameters

```
> (defun foo (x &rest y) y)  ;; all but the first parameters are put
                               ;; into a list
FOO
> (foo 3)
NIL
> (foo 1 2 3)
(2 3)
> (foo 1 2 3 4 5)
(2 3 4 5)
```


LISP tutorial: functions revisited

Functions with 'keyword' parameters

```
> (defun foo (&key x y) (cons x y))
 FOO
> (foo :x 5 :y '(3))
(5  3)
 > (foo :y '(3) :x 5)
 (5  3)
> (foo :y 3)
(NIL 3)
> (foo)
(NIL)
```

LISP tutorial: arrays

List is a basic structure; but arrays and structures are supported

```
> (setf a (make-array '(3 2)) ;; make a 3 by 2 array
#2a((NIL NIL) (NIL NIL) (NIL NIL))
> (aref a 1 1)
NIL
> (setf (aref a 1 1) 2)
2
> (aref a 1 1)
2
```


LISP tutorial: structures

```
>(defstruct weather
        temperature
        rain
        pressure)
WEATHER
> (setf a (make-weather))   ;; make a structure
#s(WEATHER :TEMPERATURE NIL :RAIN NIL :PRESSURE  NIL)
 > (setf a (make-weather :temperature 35))
#s(WEATHER :TEMPERATURE 35 :RAIN NIL :PRESSURE  NIL)
> (weather-temperature a)   ;; access a field
35
 > (weather-rain a)
NIL
> (setf (weather-rain a) T)   ;; set the value of a field
T
> (weather-rain a)
T
```

LISP tutorial: iterations

Many ways to define iterations

Commands:

- **loop**
- **dolist**
- **dotimes**
- **do, do***

Also we can write compactly the code for repeated application of function to elements of the list:

- **mapc, mapcar**

LISP tutorial: iterations

Iterations: loop

```
> (setq a 4)
4
> (loop (setq a (+ a 1))
     (when (> a 7) (return a)))  ;; return exists the loop
 8
> (loop (setq a (- a 1))
      (when (< a 3) (return)))
NIL
```

LISP tutorial: iterations

Iterations: dolist

```
> (dolist (x '(1 2 3 4)) (print x))
1
2
3
4
NIL  ;; NIL is returned by dolist
>
```


LISP tutorial: iterations

Iterations: dotimes

```
> (dotimes (i 4) (print i)) ;; starts from 0 and continues till
                                limit 4
 0
 1
 2
 3
 4
NIL   ;; returns NIL
```

LISP tutorial: iterations

Iterations: do

```
> (do ((x 1 (+ x 1))    ;; variable, initial value, next cycle update
       (y 1 (* y 2)))   ;; the same
      ((> x 5) y)       ;; end condition, value do returns
     (print (list x y)) ;; body of do – a sequence of operations
    (print 'next))
(1 1)
NEXT
(2 2)
NEXT
(3 4)
NEXT
(4 8)
NEXT
(5 16)
NEXT
32
```


LISP tutorial: iterations

Iterations: do *

```
> (do* ((x 1 (+ x 1))    ;; variable, initial value, next cycle update
        (y 1 (* x 2)))   ;; <<< --- update based on x
      ((> x 5) y)        ;; end condition, value do returns
     (print (list x y))  ;; body of do – a sequence of operations
    (print 'next))
(1 1)
NEXT
(2 4)
NEXT
(3 6)
NEXT
(4 8)
NEXT
(5 10)
NEXT
12
```

LISP tutorial: mapcar

Repeated application of a function to elements of the list

```
> (mapcar #'oddp '(1 2 3 4 5))  ;; named function
(T NIL T NIL T)
> (mapcar #'(lambda(x) (* x x)) '(1 2 3 4 5))  ;;temp function
(1 4  9 16 25)
```


LISP tutorial

Evals and function calls

- **A piece of code can be built, manipulated as data**
- **What if we want to execute it?**

```
> (setq b '(+ a 4))
  (+ a 4)
> (eval b)          ;; explicit evaluation call
  16
> (funcall  #'+ 2 4)   ;; calls a function with args
  6
> (apply #'+ 2 '(5 6))  ;; calls a function with args
                              (last args as a list)
13
```

LISP tutorial: input/output

You can input/output data to:

- standard input/output,
- string or
- file

A number of functions supported by the Lisp:

- (read) ;; reads the input from the standard input
- (print ‘a) ;; prints to the standard output
- (scanf …) (printf …) (format …) for formatted input and output
- (open ..) (close ..) for opening and closing the files

LISP tutorial: program calls

Assume you have your lisp code ready in the .lisp file

… and this is how you load it

(load "~/private/lsp/file-to-load.lisp")

… and you can call another load from it as well

LISP on CS machines

Common Lisp for linux is available in

- **/usr/local/contrib/cmucl-19d/ directory**

The bin directory with the lisp executable is:

- **/usr/local/contrib/cmucl-19d/bin/**
- **Other subdirectories include manual, docs and libraries**
- **Please add them to your active path**
- **Type lisp to start the program**

Other option to run lisp is to do it from emacs editor. There is a lisp interpreter window you get once you start the editor