CS 2740 Knowledge Representation
Lecture 4

Introduction to LISP

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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
- **At one point special LISP computers with basic LISP functions implemented directly on hardware were available (Symbolics Inc., 80s)**

LISP today:

- **Many AI programs now are written in C,C++, Java**
  - **List manipulation libraries are available**

LISP language

LISP Competitors:

- **Prolog, Python**
- **but LISP keeps its dominance among high level (AI) programming languages**

Current LISP:

- **Common Lisp**
- **Scheme**

are the most widely-known general-purpose Lisp dialects

Common LISP:

- **Interpreter and compiler**
- **CLOS: object oriented programming**

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Syntax:

- **Prefix notation**
  - **Operator first, arguments follow**
  - **E.g. (+ 3 2) adds 3 and 2**

A lots of parentheses

- **These define lists and also programs**
- **Examples:**
  - (a b c d) a list of 4 elements (atoms) a,b,c,d
  - (defun factorial (num)
    (cond ((<= num 0) 1)
    (t (* (factorial (- num 1)) num))
    ))

LISP tutorial: data types

Basic data types:

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

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

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For each symbol lisp attempts to find its value

```
> (setq a 10)     ;; sets a value of symbol a to 10
  10
 > a              ;; returns the value of a
  10
```

Special symbols:

```
> t      ;; true
  T
 > nil            ;; nil stands for false or
  NIL
 > ( )             ;; an empty list
  NIL
```


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Lists represent function calls as well as basic data structures

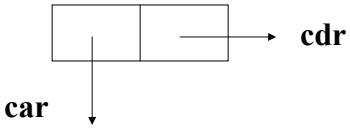
```
>  (factorial 3)
    6
> (+ 2 4)
    6


> (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: list

List building functions

> (cons 'b nil) ;; quote means: do not eval the argument
(b)
> (setq a (cons 'b (cons 'c nil)) ;; setq a is a shorthand for set 'a
(b c)
> (setq v (list 'john 34 25))
(john 34 25)
> (setq v (list a 34 25))
((b c) 34 25)
> (append '(1 2) '(2 3))
(1 2 2 3)

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List copying

> (setq foo (list 'a 'b 'c))

(a b c)

> (setq bar (cons 'x (cdr foo)))

(x b c)

> foo

(a b c) ;; (cdr foo) makes a copy of the remaining list before cons

> bar

(x b c)

- Car and cdr operations are nondestructive.

LISP tutorial: lists

> (setq bar '(a b c))

(a b c)

> (setq foo (cdr bar))

(b c)

> (rplaca foo 'u)

(u c)

> foo

(u c)

> bar

(a u c)

> (rplacd foo '(v))

(u v)

> bar

(a u v)

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The same effect as with rplaca and rplacd can be achieved with setf

```
> (setq bar '(a b c))
  (a b c)
> (setq foo (cdr bar))
  (b c)
> (setf (cadr bar) 'u)
  u
> bar
  (a u c)
> foo
  (u c)
```


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Evaluation rules:

- **A symbol value is sought and substituted**
- **A quoted value is kept untouched**

```
> (setf a 12)
  12
> (setf b (+ a 4))
  16
> (setf b '(+ a 4))
  (+ a 4)
> (eval b)          ;; explicit evaluation call
  16
```

LISP tutorial: functions and predicates

Some useful functions and predicates:

```
> (setq a '(1 2 3 4 5))
  (1 2 3 4 5)
> (length a)
  5
> (atom 'a)
  T
> (atom a)
  NIL
> (listp 'a)
  NIL
> (listp a)
  T
```


LISP tutorial: function definition

Definition of a function

(defun <f-name> <parameter-list> <body>)

```
>(defun square (x)
    (* x x))
  SQUARE
 >(square 2)
  4
>(square (square 2))
  16
```

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Definition of a function

(defun <f-name> <parameter-list> <body>)

<body> can be a sequence of function calls, the function returns the value of the last call in the sequence

```
> (defun foo (a)
    (setq b (+ a 1))
    (setq c (+ a 2))
    c)
  FOO
> (foo 2)
   4
```


LISP tutorial: conditionals

Cond statement: sequentially tests conditions, the call associated with the first true condition is executed

```
> (defun abs (a)
    (cond ((> a 0) a)
          (t   (- a))))
  ABS
> (abs 2)
  2
> (abs -3)
  3
```

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if statement:

(if <test> <then> <else>)

```
> (defun abs (a)
  (if (> a 0) a (- a)))
  ABS
> (abs 2)
   2
> (abs -3)
  3
```


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 very common in 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
```