CS 161 Intro. To Artificial Intelligence

Week 1, Discussion 1B

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General Information

- **TA** – Qian Long: longqian@ucla.edu
- **Discussion 1B** :
  - Fridays 12:00 pm – 1:50 pm
- Office Hour:
  - Thursdays 12:30 pm – 2:30 pm

Today's Topics:

- Running Environments of Lisp
- Lisp Syntax
- Example Functions

Running Environments

- CLISP: implements the language described in the ANSI Common Lisp standard with many extensions.
  - https://clisp.sourceforge.io/
  - You can also access it from SEASnet (**recommended**)
- Lisp online: https://jscl-project.github.io/
  - Good for testing syntax and single functions
- Tutorials:
  - https://www.tutorialspoint.com/lisp/
  - Practical Common Lisp (Book) -- free online!
    http://www.gigamonkeys.com/book/

LISP Online

jscl-project.github.io

```
Welcome to JSCL 0.7.0 (built on 27 November 2018)

JSCL is a Common Lisp implementation on Javascript.
For more information, visit the project page at GitHub.

CL-USER> (+ 2 4)
6
CL-USER> (/ 6 4)
1.5
CL-USER> (cons 'A '(B))
(A B)
CL-USER> (defun AddOne (N) (+ 1 N)
... )
...
... (defun MinusOne (N) (- N 1)
... )
ADDONE
CL-USER> (addone 2)
3
CL-USER> (minusone 2)
ERROR: Function 'MINUSONE' undefined
CL-USER>
```

CLISP on SEASnet

Requirements:

- SEASnet account
    - https://www.seasnet.ucla.edu/seasnet-accounts/
- Connection to SEASnet server (**important**)
    - Use Cisco VPN connect to campus network!
    - https://www.it.ucla.edu/it-support-center/services/virtual-private-network-vpn-clients
- Some familiarity to Linux commands

CLISP on SEASnet

- Log into your SEASnet account:
  - macOS -> terminal: ***ssh -X*** ***lnxsrv.seas.ucla.edu*** ***-l*** ***yourseasaccountname***
  - Windows -> putty: SSH to ***yourseasaccountname@lnxsrv.seas.ucla.edu***
    - Download putty: https://www.chiark.greenend.org.uk/~sgtatham/putty/
- Copy Lisp file to SEASnet:
  - scp -r LocalPath/file yourSEASaccount@lnxsrv.seas.ucla.edu:./SEASpath
- **Interactive mode**:
  - ***clisp***
  - ***(quit)*** or ***(exit)*** to leave
- **Load from file**:
  - ***clisp ./SEASpath/file***

Lisp Syntax

- Two fundamental pieces:
  - Atom
  - Symbolic expression (S-expression)
- Not case sensitive
- Use “;” to comment

Lisp Syntax

Atom: all objects except cons cells (lists), can’t be further divided

- 3 ; => 3
- ‘/’ ; single character symbol
- “Hello, world!” ; all of the quoted text is a single atom
- t ; boolean True. In Lisp **any non-nil value is True!**
- nil ; boolean False **OR** an empty list ()
- A ; Error! Not defined.

Lisp Syntax

S-expression (symbolic expression): simple, no operator priority, no ambiguity

- (function arg1 arg2 … argN)
    - Eg. (+ 3 5) ; => 8
- (+ 2(/ (* 2 10) 5)) ; represents 2 + 2 * 10 / 5
- Use ***quote*** or ***‘*** to prevent it from being evaluated:
    - ‘(+ 3 5) ; => (+ 3 5)
    - (quote (* 2 4)) ; => (* 2 4)
    - ‘(1 2 3) ; list (1 2 3)

Lisp Syntax

Basic data types:

- Numeric:
    - Integers (e.g. 2), floating point (e.g. 2.0), ratios (e.g. ½)
    - Binary (e.g. #b111, output is 7), hexadecimal (#x111, which is 273)
    - Complex numbers (e.g. #C(1 2))
- Symbolic:
    - It’s a name that represents data objects and it’s also a data object.
    - It contains a property list, or plist.
    - LISP allows you to assign properties to symbols (e.g. ‘A)
- Boolean:
    - False (nil) and True (t or any non-nil value, e.g. 0)

Lisp Syntax

Basic arithmetic operations:

- (+ 2 3) ; => 5
- (- 5 1) ; => 4
- (* 10 2) ; => 20
- (expt 2 3) ; => 8
- (mod 7 2) ; => 1
- (/ 20 4) ; => 5
- (/ 2 3) ; => 2/3 or 0.6666...

Lisp Syntax

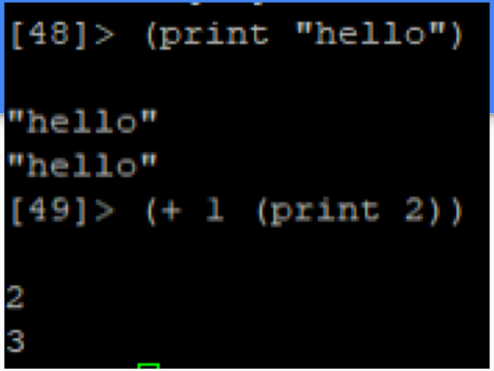
Booleans and Equity:

- (**not** nil) ; => t
- (**and** 0 t) ; => t
- (and 0 1 2) ; => 2
- (**or** 0 nil) ; => 0
- (or 0 1 2) ; => 0
- (and 1 ()) ; => nil
- (and 3) ; => 3

- Compare numbers using “=”
  - (**=** 2 2.0) ; => t
- Compare object identity using “eql”
  - (**eql** 2 2) ; => t
  - (eql 2 2.0) ; => nil
  - (eql ‘A ‘A) ; => t
  - (eql (list 3) (list 3)) ; => nil

    Note: eql compares based on memory chunk
- Compare lists, strings using “equal”
  - (**equal** (list ‘A) (list ‘A)) ; => t
  - (equal (list ‘A ‘B) (list ‘B ‘A)) ; => nil

Lisp Syntax



Strings:

- Concatenation of two strings using “concatenate”:
    - (**concatenate** ‘string “Hello, ” “world!”)   ; => “Hello, world!”
- Print a string using “print”:
    - (**print** “hello”)   ; prints “hello” and returns “hello”
    - (+ 1 (print 2))   ; prints 2, returns 3.
- Return/print a string using “format”:
    - (**format** nil “hello ~a” “alice”)   ; return “hello alice”
    - (format t “hello ~a” “alice”)   ; prints “hello alice”, return nil
    - “~a” for string, “~d” for integer, “~2f” for float

Lisp Syntax

Variables:

- Global variables:
  - Variable name can contain any character except ()",'`;#|\
  - (**defparameter** age 24) ; define a variable age with value 24
  - (defparameter *age* 30) ; define a variable *age* (not age) with value 30
  - (defparameter age 30) ; age => 30, value of variable changed!
  - (**defvar** *city* “LA”) ; *city* => “LA”
  - (defvar *city* “NYC”) ; *city* => “LA”, defvar doesn’t change value!
  - (**setq** *city* “NYC”) ; *city* => “NYC”, can replace setq with setf too

    Note: Use setq on a variable before define it will work, but returns a warning

Lisp Syntax

Variables:

- Local variables:
  - Use "let" or "let*"statement
  - "let" does parallel assignment, "let*" does sequential assignment
  - (**let** ((var1 value1) (var2 value2) … (varN valueN)) (s-expression))

Binding

Body

E.g.
```
(let ( (a 10) (b 20) )
          (+ a b)
              )                                   ; returns 30
```

- For homeworks, you are **NOT** allowed to use global variables. You can **<u>only use let/let*</u>**.

Lisp Syntax

Lists: uses linked-list data structure, made of atoms and/or CONS paris

- Construct lists using “cons” (take **only two** arguments):
  - (**cons** 2 ‘B) ; => ‘(2 . B)
  - (cons 2 ‘(B)) ; => ‘(2 B)
  - (cons 2 ‘B ‘(C)) ; => Error! Too many arguments.
  - (cons 1 (cons 2 (cons 3 nil))) ; => '(1 2 3)
  - (cons ‘(A C) ‘(9 4)) ; => ‘((A C) 9 4)
- Construct lists using”list” (take **multiple** arguments):
  - (**list** 1 2 ‘3) ; => ‘(1 2 3)
  - (list ‘(A (C)) ‘(9)) ; => ‘((A (C)) (9))
  - (list 1 2 nil) ; => (1 2 nil)

Lisp Syntax

Lists:

- Construct lists using “append” (**only take lists** as args, can have **multiple args**):
  - (**append** 2 ‘B) ; Error! 2 and ‘B are not lists
  - (append ‘(2) ‘(B) ‘(C)) ; => (2 B C)
  - (append '(A) '(F (2)) nil '(H)) ; => (A F (2) H)

- Parse lists using “car”/“first”, “cdr”/“rest”, “cadr”, “caddr”, etc. (only works for list):
  - (**car** ‘(1 2 3 4)) or (**first** ‘(1 2 3 4)) ; => 1
  - (**cdr** ‘(1 2 3 4)) or (**rest** ‘(1 2 3 4)) ; => (2 3 4), cdr always return a list
  - (**caddr** ‘(1 2 3 4)) ; => 3, caddr operates from right to left
  - “cons” is the reverse of “car” + “cdr”

Lisp Syntax

Functions:

- Define a function using “defun”:
  - (**defun** functionName (arg1 … argN) (s-expression))
  - E.g. (defun sayHello (name) (format nil "Hello, ~A" name))

- Call a function by its name:
  - (sayHello “Sam”) ; => “Hello, Sam”

Lisp Syntax

Control Flow:

- If-statement:
    - (**if** (test expression) (then expression) (else expression))
    - E.g. (if (equal name "Fred") ; test expression

      "Found Fred!" ; then expression

      "Not found.") ; else expression
- Chain of tests using "cond":
    - (**cond** (cond1 value1) (cond2 value2) … (t valueT))
    - E.g. (cond ((> *age* 20) "Older than 20")

      ((< *age* 20) "Younger than 20")

      (t "Exactly 20")) ; without default case, it returns nil if *age*==20

Default case

You are encouraged to use cond (instead of if) in homeworks

Lisp Syntax

Control Flow:

- Recursion: “cond” becomes very useful
    - E.g. Check if a list x contains an element e

```
(defun contains (e x)
    (cond ((not x) nil)                     ; base case when x is empty
        ((atom x) (equal e x))              ; base case when x has only one item
        (t (or (contains e (car x)) (contains e (cdr x))))        ; recursive step
    )
)

(contains ‘c ‘(a (2 d) c e))                ; => t
```

Lisp Syntax

Control Flow:

- Iteration:
  - E.g. Print out numbers from 1 to 5

```
(loop for x in '(1 2 3 4 5)
        do (print x) )
```

prints: 1
2
3
4
5

return: nil

- For homeworks, you are **NOT** allowed to use iteration, you can **only use recursion**.

Example Functions - Using Recursion

- Factorial
- Compute list length
  - Top-level
  - Deep-level
- Check if a list contain a specific element
- Check if a list contain any number
- Find k-th element (top-level)
- Delete k-th element (top-level)

Example Functions

Factorial:

```
(defun factorial (n)
    (if (< n 2)
            1                               ; when n<2 return 1
            (* n (factorial (- n 1)))       ; when n>=2 do recursive steps
        )
)

(factorial 5)                                       ; => 120
```

Example Functions

Compute list length (top-level):

E.g. Top-level length of ‘((a b) c ((1 2) d)) is 3.

```
(defun listlength (x)
    (if (not x)
            0                                   ; when x is empty return 0
            (+ (listlength (cdr x)) 1)   ; otherwise do recursive steps
        )
)
```

Example Functions

Compute list length (deep-level):

E.g. Deep-level length of ‘((a b) c ((1 2) d)) is 6.

```
(defun deeplength (x)
    (cond ((not x) 0)                                       ; empty list, returns 0
        ((atom x) 1)                                        ; atom: check if x is an atom. If yes returns 1
        (t (+ (deeplength (car x)) (deeplength (cdr x))))   ; else, do recursive steps
        )
    )
)
```

Example Functions

Check if a list contain a specific element:

```
(defun contains (e x)
    (cond ((not x) nil)                                   ; base case when x is empty
        ((atom x) (equal e x))                            ; base case when x has only one item
        (t (or (contains e (car x)) (contains e (cdr x))))    ; recursive step
    )
)

(contains ‘2 ‘(4 3 (1 2) 8))                              ; => t
```

Example Functions

Check if a list contain any number:

```
(defun contains_number (x)
    (if (atom x)                                                    ; nil if x is a list
        (numberp x)                                                 ; numberp: check if x is a number
        (or (contains_number (car x)) (contains_number (cdr x)))   ; recursively flatten
    )
)

(contains_number '(a b c))                                         ; => nil
(contains_number '(a (b 2) c))                                     ; => t
```

Example Functions

Find k-th element (top-level):

```
(defun find_kth (k x)
    (if  (= k 1)                                   ; nil if k is larger than 1
        (car x)                                ; if k is 1 return the 1st item
        (find_kth (- k 1) (cdr x))         ; else pass (k-1) and rest of list to find_kth
    recursively
    )
)

(find_kth 4 '(a (b c) d (e f) g))            ; => (e f)
```

Q: How do we find k-th element in deep-level? E.g. (find_kth 4 '(a (b c) d (e f) g)) => d

Example Functions

Delete k-th element (top-level):

```
(defun delete_kth (k x)
	(if  (= k 1)                                    ; nil if k is larger than 1
		(cdr x)                                 ; if k is one return the rest of list (discard the 1st
	item)
		(cons (car x) (delete_kth (- k 1) (cdr x)))   ; else, recursive steps
	)
)

(delete_kth 4 '(a (b c) d (e f) g))             ; => (a (b c) d g)
```

Questions?

- My slides take the following materials as references:
  - Xiao Zeng's slides

Thank you!