CS 161 Intro. To Artificial Intelligence

Week 1, Discussion 1A

Xiao Zeng

General Information

- **Course info**:
  - Tue/Thur 10:00 am - 12:00 pm
  - Zoom Link: https://ucla.zoom.us/j/473325803 (can also access via CCLE)
  - 8 Projects - 4 LISP programming assignments + 4 written assignments (tentative)
  - More details about midterm/final will come later this quarter
- **TA** - Xiao (Steven) Zeng: stevennz@g.ucla.edu
- **Discussion 1A**:
  - Fridays 2:00 pm - 3:50 pm
  - Zoom Link: https://ucla.zoom.us/j/669226848
- **Office hours**:
  - Wednesdays 10:00 am - 12:00 pm
  - Zoom Link: https://ucla.zoom.us/j/807691266

Today’s Topics:

- Background of Lisp
- Running Environments of Lisp
- Lisp Syntax
- Example Functions

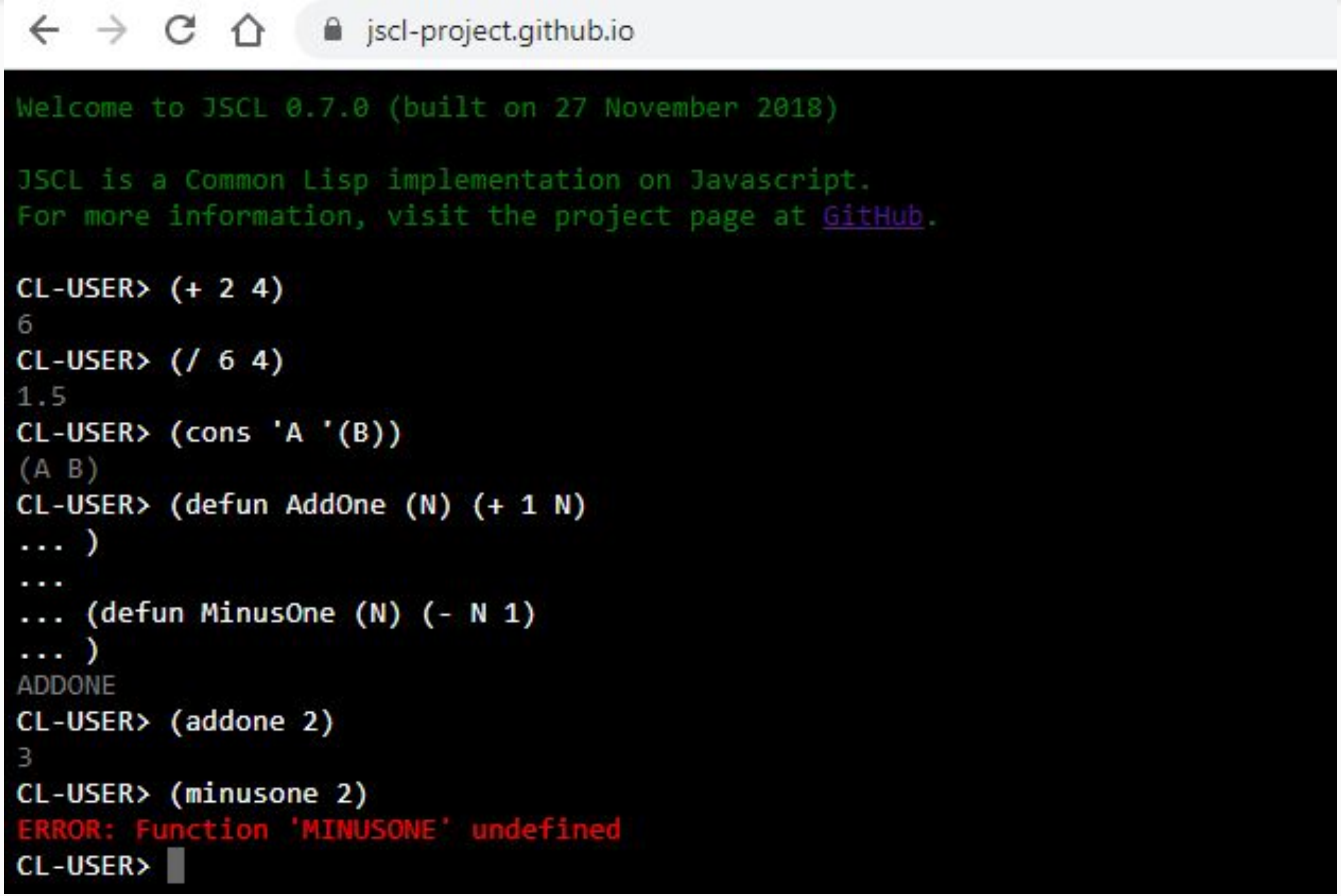
Background of Lisp

- **LISP** derived from “**LISt Processor**”
  - Use linked-list as one of major data structures
  - Source code are made of lists
  - Many dialects (Common Lisp, Scheme, etc.)
- Appeared in 1958 (2nd oldest high-level programming language)
- In this class, we mainly use **Common Lisp** -- a general-purpose, multi-paradigm programming language.
  - Object-oriented and fast prototyping capability

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



```
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> 
```

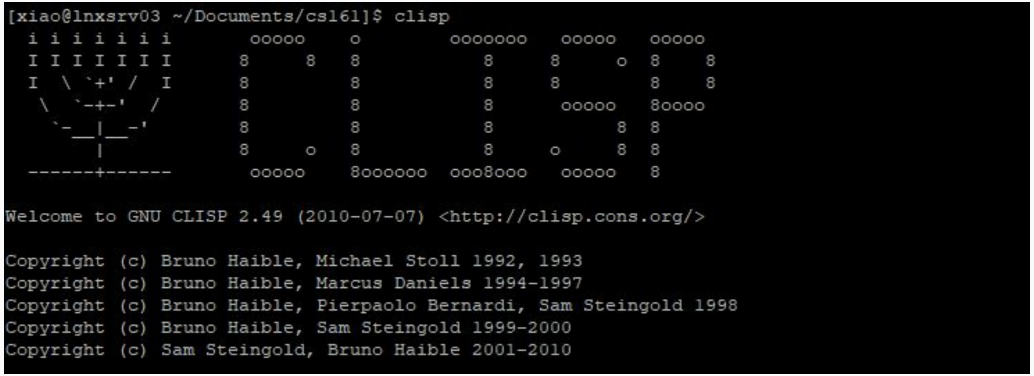
CLISP on SEASnet

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*



```
[xiao@lnxsrv03 ~/Documents/cs161]$ clisp
  i i i i i i i       ooooo    o        ooooooo   ooooo   ooooo
  I I I I I I I      8     8   8           8     8     o  8    8
  I  \ `+' /  I      8         8           8     8        8    8
   \  `-+-'  /       8         8           8      ooooo   8oooo
    `-__|__-'        8         8           8           8  8
        |            8     o   8           8     o     8  8
  ------+------       ooooo    8oooooo  ooo8ooo   ooooo   8

Welcome to GNU CLISP 2.49 (2010-07-07) <http://clisp.cons.org/>

Copyright (c) Bruno Haible, Michael Stoll 1992, 1993
Copyright (c) Bruno Haible, Marcus Daniels 1994-1997
Copyright (c) Bruno Haible, Pierpaolo Bernardi, Sam Steingold 1998
Copyright (c) Bruno Haible, Sam Steingold 1999-2000
Copyright (c) Sam Steingold, Bruno Haible 2001-2010
```

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

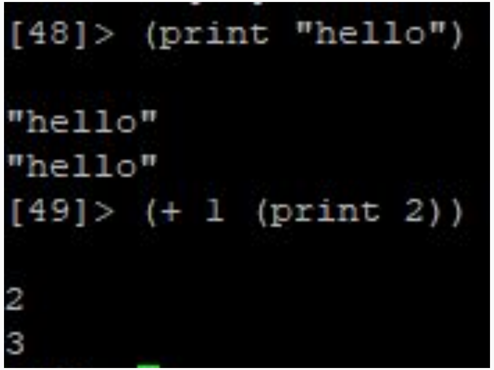
- Compare numbers using “=”
  - (**=** 2 2.0) ; => t
- Compare object identity using “eql”
  - (**eql** 2 2) ; => t
  - (eql 2 2.0) ; => nil
  - (eql ‘A ‘A) ; => t
  - (eql (list 3) (list 3)) ; => nil

  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** “I love CS161”)   ; 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



```
[48]> (print "hello")

"hello"
"hello"
[49]> (+ 1 (print 2))

2
3
```

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 **only use let/let***.

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)
```

Q: How do we delete k-th element in deep-level?

Questions?

- My slides take the following materials as references:
  - Shirley Chen’s slides
  - Yewen Wang’s (last quarter's TA) slides

Thank you!