Lisp

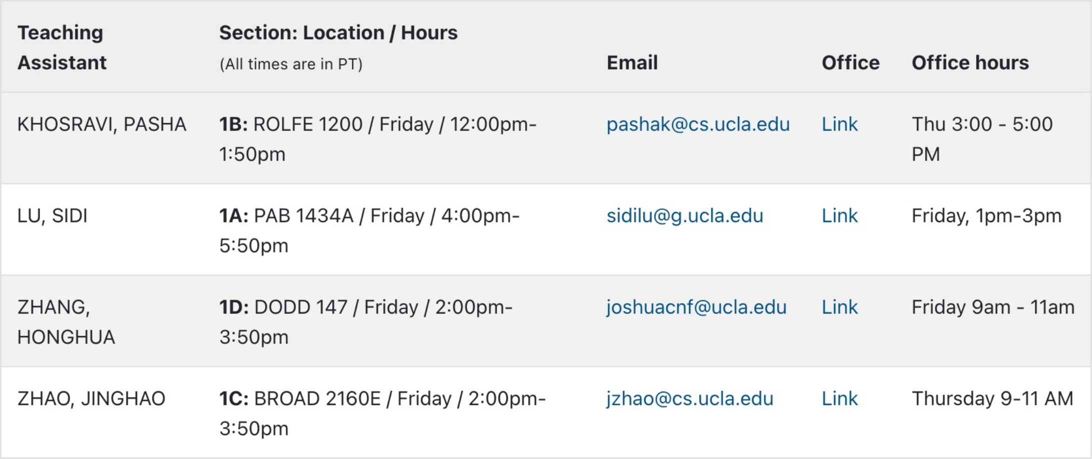
CS161 Discussion 1

Jinghao (Vincent) Zhao

10/01/2021

CS 161

- Syllabus: http://web.cs.ucla.edu/~guyvdb/teaching/cs161/2021f/
- Office hour



Teaching Assistant	Section: Location / Hours (All times are in PT)	Email	Office	Office hours
KHOSRAVI, PASHA	**1B:** ROLFE 1200 / Friday / 12:00pm-1:50pm	pashak@cs.ucla.edu	Link	Thu 3:00 - 5:00 PM
LU, SIDI	**1A:** PAB 1434A / Friday / 4:00pm-5:50pm	sidilu@g.ucla.edu	Link	Friday, 1pm-3pm
ZHANG, HONGHUA	**1D:** DODD 147 / Friday / 2:00pm-3:50pm	joshuacnf@ucla.edu	Link	Friday 9am - 11am
ZHAO, JINGHAO	**1C:** BROAD 2160E / Friday / 2:00pm-3:50pm	jzhao@cs.ucla.edu	Link	Thursday 9-11 AM

- Grading
  - Homework 20% (one-week deadline. The late policy subtracts 25% of the total points for each day you submit late.)
  - Midterm 35%: a mix of free-form and multiple choice
  - Final 45%: multiple choice

Background

- What is Lisp?
  - Originally specified in 1958 by John McCarthy, Lisp is the second-oldest high-level programming language
- Why do we use it in this class?
- Common Lisp
  - The modern, multi-paradigm, high-performance, compiled, ANSI-standardized, most prominent descendant of the long-running family of Lisp programming languages.
  - Object oriented programming and fast prototyping capabilities

CLISP on SEASnet

```
ssh -X lnxsrv.seas.ucla.edu -l yourseasaccountname
```

⇒Interactive mode

```
clisp
```

⇒Load from file

```
clisp "./hw1.lsp"
```

Windows OS: use putty for ssh

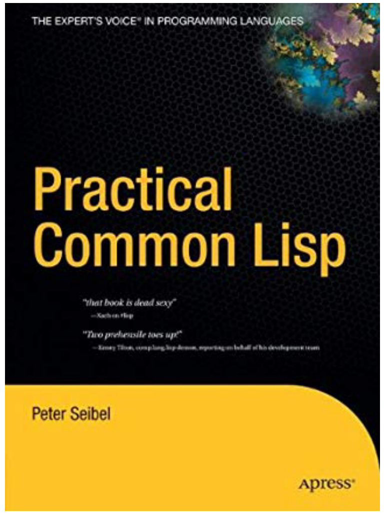
https://www.chiark.greenend.org.uk/~sgtatham/putty/

For MacOS: you can also use **brew install clisp** to install it locally.

```
(load “test.lsp”)
(exit)
```

Useful links

- CLISP
  - 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
- Try Lisp online:
  - https://jscl-project.github.io/
- ***Practical Common Lisp (Book)***
  - http://www.gigamonkeys.com/book/



Syntax

Two fundamental pieces

- ATOM
- S-EXPRESSION.

Atom

```
             comment
30            ; => 30
"Hello!"  ; string

t             ; denoting true    any non-NIL value is true!
nil      ; false; the empty list: ()

:A       ; symbol
A        ; Error. Not defined
```

Atom

```
9999999999999999999999 ; integer
#b111                  ; binary => 7
#x111                  ; hexadecimal => 273
3.14159s0             ; single
3.14159d0              ; double
1/2                    ; ratios
#C(1 2)                ; complex numbers
```

s-expression: super simple, super elegant

```
(f x y z ...)
```

function   arguments

```
(+ 1 2 3 4)    ; 1+2+3+4 => 10
```

(atom 1) ; T

```
Use quote or ' to prevent it from being evaluated
'(+ 1 2)                  ; => (+ 1 2)
(quote (+ 1 2))           ; => (+ 1 2)
```

'(1 2 3)   ; list (1 2 3)

Basic arithmetic operations

```
(+ 1 1)                ; => 2
(- 8 1)                ; => 7
(* 10 2)               ; => 20
(expt 2 3)             ; => 8
(mod 5 2)              ; => 1
(/ 35 5)               ; => 7
(/ 1 3)                ; => 1/3
(+ #C(1 2) #C(6 -4))   ; => #C(7 -2)
```

Booleans and Equality

```
(not nil)           ; => T
(and 0 t)            ; => T
(or 0 nil)          ; => 0
(and 1 ())           ; => 0
             empty list
```

Booleans and Equality

compare numbers

```
(= 3 3.0)             ; => T
(= 2 1)               ; => NIL
```

compare object identity

```
(eql 3 3)             ; => T
(eql 3 3.0)           ; => NIL
(eql (list 3) (list 3)) ; => NIL
```

compare lists, strings

```
(equal (list 'a 'b) (list 'a 'b)) ; => T
(equal (list 'a 'b) (list 'b 'a)) ; => NIL
```

Strings

type

```
(concatenate 'string "Hello," "world!") ; => "Hello,world!"
```

```
(format nil "Hello, ~a" "Alice") ; returns "Hello, Alice"
(format t "Hello, ~a" "Alice")              ; returns nil. formatted string
                                            goes to standard output
```

```
(print "hello")   ; value is returned and printed to std out
(+ 1 (print 2))   ; prints 2. returns 3.
```

Variables

- global (dynamically scoped) variable
- The variable name can use any character except: ()",'`;#|\

```
(defparameter age 35)
age                ; => 35
name                 ; error

(defparameter *city* "LA")
*city*               ; => "LA"
```

Variables

```
(defparameter age 35)  ; age => 35
(defparameter age 60)  ; age => 60

(defvar newage 20)     ; newage => 20
(defvar newage 60)     ; newage => 20

(setq newage 30)       ; newage => 30
```

defvar does not change the value of the variable!

Local variable

```
(let ( (a 1) (b 2) )   ; binding
    (+ a b)            ; body
)
```

You will NOT be allowed to set global variables in your homework!

let only

Lists

- Linked-list data structures
- Made of CONS pairs

```
(cons 1 2)                    ; => '(1 2)
(cons 3 nil)                  ; => '(3)
(cons 1 (cons 2 (cons 3 nil)))    ; => '(1 2 3)
(list 1 2 3)                  ; => '(1 2 3)
(cons 4 '(1 2 3))                ; => '(4 1 2 3)
(cons '(4 5) '(1 2 3))            ; =>  ?
```

Lists

```
(cons 1 (cons 2 (cons 3 nil)))     ; => '(1 2 3)
(list 1 2 3)                    ; => '(1 2 3)
(cons 4 '(1 2 3))                  ; => '(4 1 2 3)
(cons '(4 5) '(1 2 3))             ; => '((4 5) 1 2 3)

(append '(1 2) '(3 4))             ; => '(1 2 3 4)
(append 1 '(1 2))                  ; ERROR!
(append '(1) '(2 3))               ; => '(1 2 3)
(concatenate 'list '(1 2) '(3 4))  ; => '(1 2 3 4)

(car '(1 2 3 4))                   ; => 1
(cdr '(1 2 3 4))                   ; => '(2 3 4)
```

car and cdr should be used for list, you can also use first/rest

Functions

- Define a function

```
(defun hello (name) (format nil "Hello, ~A" name))
```

- Call the function

```
(hello "Bob")          ; => "Hello, Bob"
```

Control Flow

```
(if (equal *name* "bob")   ; test expression
    "ok"                   ; then expression
    "no")                  ; else expression
```

- Chains of tests: cond

```
(cond ((> *age* 20) "Older than 20")
      ((< *age* 20) "Younger than 20")
      (t "Exactly 20"))
```

```
(cond ((> *age* 20) "Older than 20")
      ((< *age* 20) "Younger than 20"))    ; returns NIL when *age*=20
```

Programming Practice!

- Factorial
- compute list length
- find kth element
- check if list contains a number
- delete kth element

Recursion - factorial

```
(defun factorial (n)
 (if (< n 2)
   1                           ; returns 1 when n<2
   (* n (factorial (- n 1)))     ; when n>=2
  )
)

(factorial 5)                  ; => 120
```

Recursion – compute list length (top-level)

'((a b) (c (d 1)) e) => 3

```
(defun listlength (x)
        (if (not x)          ; base case: empty list
                0
                (+ (listlength (cdr x)) 1)
        )                                  '(1 2 3 4) -> '(2 3 4)
)
```

Recursion – compute list length (deep)

```
'((a b) (c (d 1)) e)  => 6

(defun deeplength (x)
        (cond ((not x) 0)      ; empty list. returns 0
            ((atom x) 1)     ; atom. returns 1
            (t (+ (deeplength (car x))   ; else
                         (deeplength (cdr x))
                  )
                 )
        )
)
```

Recursion – check if list contains an element

```
(defun contains (e x)
        (cond ((not x) nil)
           ((atom x) (equal e x))
           (t (or (contains e (car x)) (contains e (cdr x))))
        )
)

(contains 'a '((b a) (1 e c)))
```

Recursion – check if list contains a number

Consider this case: '((a b) (c (d 1)) e)

```
(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
          )
        )
)
```

Recursion – find kth element (top-level)

```
(defun find_kth (k x)
        (if  (= k 1)
                (car x)
                (find_kth (- k 1) (cdr x))
        )
)
```

How do we find kth element in the flattened list?

3, '((a b) (c (d 1)) e)   => c

Flatten a nested list

```
(defun flatten (l)
  (if (eql l nil)
    nil
    (let ((elem (car l)) (restl (cdr l)))
      (if (listp elem)
        (append (flatten elem) (flatten restl))
        (append (cons elem nil) (flatten restl))))))
```

Recursion – delete kth element

```
(defun delete_kth (k x)
        (if  (= k 1)
                (cdr x)
                (cons (car x)
                      (delete_kth (- k 1) (cdr x))
                )
        )
)
```