Exam Prep Section 9 Sols. - CS61A Spring 2018

Worksheet 9: More Scheme, Interpreters, Streams & Macros

Scheme

Non-contiguous

Write a function `non-contiguous` that checks whether `subseq` is a non-contiguous subsequence of `lst`. A sequence is a non-contiguous subsequence if its elements appear in the list in order but not necessarily immediately next to each other.

```
scm> (non-contiguous '() lst)
True
scm> (non-contiguous '(1 3 6) '(1 2 3 4 5 6))
True
scm> (non-contiguous '(1 5 2) '(1 2 3 4 5 6))
False
```

```
(define (non-contiguous subseq lst)
  (cond ((null? subseq) #t)
        ((null? lst) #f)
        ((= (car subseq) (car lst)) (non-contiguous (cdr subseq) (cdr lst)))
        (else (non-contiguous subseq (cdr lst)))))
```

Is this procedure properly tail recursive? Yes

Write a function `assert-equals` that takes in the `expected` value of the given `expression` to check whether your implementation works!

```
scm> (assert-equals #t ‘(non-contiguous ‘(1 3 6) ‘(1 2 3 4 5 6)))
ok
scm> (assert-equals #f ‘(non-contiguous ‘(1 5 2) ‘(1 2 3 4 5 6))
ok
```

```
(define (assert-equals expected expression)
      (if (eq? expected (eval expression))
            'OK
            (list 'expected expected 'but 'got (eval expression))))
```

Lazy Sunday (Fa14 Final Q4c)

(4 pt) Implement the Scheme procedure **directions**, which takes a number **n** and a symbol **sym** that is bound to a nested list of numbers. It returns a Scheme expression that evaluates to **n** by repeatedly applying **car** and **cdr** to the nested list. Assume that **n** appears exactly once in the nested list bound to **sym**.

Hint: The implementation searches for the number **n** in the nested list **s** that is bound to **sym**. The returned expression is built during the search. See the tests at the bottom of the page for usage examples.

```
(define (directions n sym)

    (define (search s exp)

        ; Search an expression s for n and return an expression based on exp.

        (cond ((number? s) (if (= s n) exp nil))

              ((null? s) nil)

              (else (search-list s exp))))

    (define (search-list s exp)

        ; Search a nested list s for n and return an expression based on exp.

        (let ((first (search (car s) (list 'car exp)))

              (rest  (search (cdr s) (list 'cdr exp))))

             (if (null? first) rest first)))

    (search (eval sym) sym))

     (define a '(1 (2 3) ((4))))
     (directions 1 'a)
     ; expect (car a)
     (directions 2 'a)
     ; expect (car (car (cdr a)))
     (define b '((3 4) 5))
     (directions 4 'b)
     ; expect (car (cdr (car b)))
```

(d) **(2 pt)** What expression will `(directions 4 'a)` evaluate to?

(car (car (car (cdr (cdr a)))))

Interpreters: Implementing Special Forms (Su14 Final Q12)

In the Scheme project, you implemented several *special forms*, such as `if`, `and`, `begin`, and `or`. Now we're going to look at a new special form: `when`. A `when` expression takes in a `condition` and any number of other subexpressions, like this:

```
(when <condition>
      <exp>
      <exp>
      ...
      <exp>)
```

If `condition` is true, **all** of the following subexpressions are evaluated **in order** and the value of the `when` is the value of the last subexpression. If it is false, **none** of them are evaluated and the value of the `when` is `okay`. For example, `(when (= 1 1) (+ 2 3) (* 1 2))` would first evaluate `(+ 2 3)` and then `(* 1 2)`.

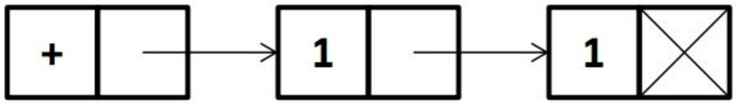
(a) (2 pt) Equivalent Scheme Expression Rewrite the `when` expression below into **another Scheme expression** which uses **only** the special forms you **already** implemented in your project. That is, create a Scheme expression which does the same thing as this `when` expression **without** using `when`. You should use `if` in your answer.

```
(when (= days-left 0)
      (print 'im-free)
      'jk-final)
```

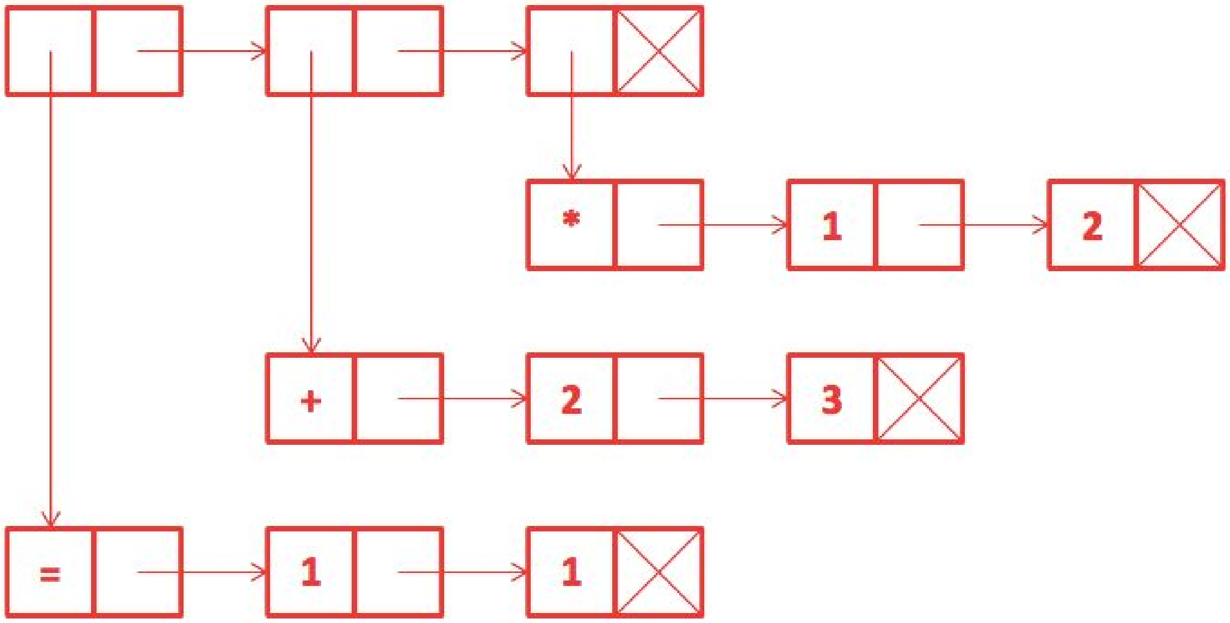
You may or may not need to use all of the lines provided.

```
(if (= days-left 0)
    (begin (print 'im-free) 'jk-final))
```

(b) **(2 pt) Box and Pointer** Remember that `do_when_form`, like the other do_something_form functions in the Scheme project, takes in `vals` and the `env` to evaluate in. We will be drawing the box-and-pointer diagram for `vals` above. As an example, the box-and-pointer diagram for `'(+ 1 1)` would be



In the example from the description, `vals` would be `'((= 1 1) (+ 2 3) (* 1 2))`. Draw the box-and-pointer diagram for this list in the space provided below.



(c) **(3 pt) Implementing When** Now implement `do_when_form`. Assume that the other parts of `scheme.py` have already been modified to accommodate this new special form. You may not need to use all of the lines provided. You do not need to worry about tail recursion. Remember that `do_when_form` must return *two* things - a Scheme expression or value and an environment or `None`.

```
def do_when_form(vals, env):
    return Pair("if", Pair(vals.first, Pair(Pair("begin", \
     vals.second), nil))), env
```

(d) **(2 pt) Implementing Another Special Form** Now let's implement another special form `until`, which takes in a `condition` and a series of expressions, and evaluates the expressions in order only if the `condition` is **NOT** true. Implement `do_until_form` using `do_when_form`. (Remember that Scheme has a built-in `not` function which your interpreter can evaluate!)

```
def do_until_form(vals, env):
    return do_when_form(Pair(Pair('not', vals.first), \
        vals.second), env)
```

Streams

Stream-to-List
Write a function that turns a list into a stream, with the feature of that the end of the stream points back to the beginning (therefore creating a cycle). You must copy the lst `n` times into the stream before creating the cycle.

```
scm> (define a (cycle '(1 2 3) 3))
a
scm> (stream-to-list a 20)
(1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2)
scm > (define (cycle lst n)
  (define s (cons-stream (car lst) (helper (cdr lst) n)))
  (define (helper buffer num)
    (cond ((= n 0) s)
          ((null? buffer) (helper lst (- n 1)))
          (else (cons-stream (car buffer) (helper (cdr buffer) n)))))
  s
)
```

Cyclic Stream
Write a function that creates a cyclic stream out of the first `n` elements of `lst`, or the entire `lst` if the length of `lst` is less than `n`.

```
scm> (stream-to-list (stream-first-n 3 '(1 2 3 4)) 10)
(1 2 3 1 2 3 1 2 3 1)
scm> (stream-to-list (stream-first-n 7 '(1 2 3 4)) 10)
(1 2 3 4 1 2 3 4 1 2)

(define (stream-first-n n lst)
  (define (stream-helper i curr-lst)
    (if (or (zero? i) (null? curr-lst))
        (stream-first-n n lst)
        (cons-stream (car curr-lst) (stream-helper (- i 1) (cdr curr-lst)))
    ))
  (stream-helper n lst))
```

Macros

Suppose we wish to implement an OOP system in Scheme using macros. We will observe the following restriction: There are only class attributes-- no instance attributes. Implement the define-class, construct, define-method, call-method, and get-attr macros below so that the Scheme OOP code has the same effect as the Python OOP code.

```
===== PYTHON OOP CODE =====
class Dog:
    def age_type():
        if Dog.a < 7:
            return "young"
        elif Dog.a > 7:
            return "old"
        else:
            return "middle aged"
Dog.n = "Fido"
Dog.a = 9
d = Dog()
print(d.age_type())

===== SCHEME OOP CODE =====
(define-class Dog)
(define-attr Dog n 'Fido)
(define-attr Dog a 9)
(define-method Dog (age-type)
    (cond
        ((< (get-attr Dog a) 7) 'young)
        ((> (get-attr Dog a) 7) 'old)
        (else 'middle-aged)
    )
)
(define d (construct Dog))
(print (call-method d (age-type)))
```

```
===== IMPLEMENTATION =====
(define-macro (define-class class-name)
    `(define ,class-name nil)
)
(define-macro (construct class-name)
    `(quote ,class-name)
)
(define-macro (define-attr class-name attr-name value)
    `(define
        ,class-name
        (cons
            '(,attr-name ,(eval value))
            ,class-name
        )
    )
)
(define-macro (get-attr class-name attr-name)
    `(begin
        (define (helper class)
            (if (eq? (quote ,attr-name) (car (car class)))
                (car (cdr (car class)))
                (helper (cdr class))
            )
        )
        (helper ,class-name)
    )
)
(define-macro (define-method class-name signature body)
    `(define-attr ,class-name ,(car signature) (lambda ,(cdr signature)
,body))
)
(define-macro (call-method instance call)
    (cons `(get-attr ,(eval instance) ,(car call)) (cdr call))
)
```