CSCI: 4500/6500 Programming Languages

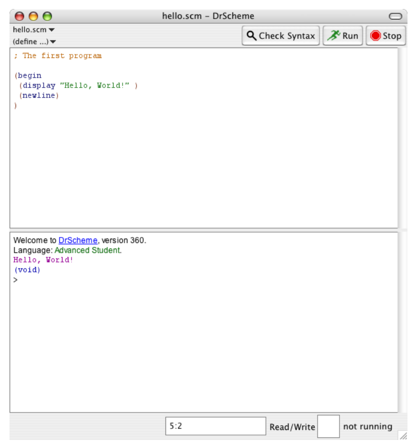
Functional Programming Languages

Part 2: Tutorial

Tutorial: Scheme

- **Download:**
  - » http://download.plt-scheme.org/drscheme/
- **Select Platform and Download links**
- **IDE: Select Appropriate Language:**
  - » "Advance Student" or is a good start
  - » "Essentials of Programming Languages 2nd)
  - » Create a file using an external editor
- **Top: Definitions of Functions**
- **Bottom: Scheme listener, which read input, evaluates and prints out results**

Simple Introduction



List Examples

```
> null
empty
> (cons 1 null)
(1)
(list 1)
> (list? null)
#t
true
> (list? (cons 1 2))
#f
> (list? (cons 1 null))
#t
> (list? (cons 1 (cons 2 null)))
#t
> (car (cons 1 (cons 2 null)))
1
> (cdr (cons 1 (cons 2 null)))
(2)
```


Predicates

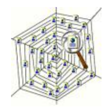
- `null?` **tests whether it is the empty list e.g.**
  - » (null? '(A B)) => #f
  - » (null? '()) => #t
- `list?` **takes a single argument and returns #t if its single argument is a list. e.g.,**
  - » (list? '(x y)) => #t
  - » (list? 'x) => #f
  - » (list? (1 . 2) => #f
- `pair?` **takes a single argument and returns #t if its single argument is a pair. e.g.,**
  - » (pair? '(1 . 2)) => #t
  - » (pair? '(1 2)) => #t
  - » (pair? '()) => #f

map, apply : Built-in Higher-Order Functions

- ***map*** applies a function to ***sequence of lists.***
  - » (map + ‘(2 3 4) ‘(5 4 3)) => (7 7 7)
  - » must be as many lists as number of arguments of the function
  - » all lists must be of the same length
- **apply** applies its first argument to its second argument -- a list.
  - » `(apply max '(3 7 2 9)) => 9`

Searching for members

- **memq**, **memv** and **member**
- List procedures:
  - » Check help pages
- (memq ‘a ‘(a b c))
- (memq ‘b ‘(a b c))
- (memq ‘a (b c d))



Consequences: Conditionals Expressions

- ```
  ( if condition
    then-consequent
    else-alternative )
  ```
- Example:
  - » `( if ( < 2 3 ) 4 5 )   => 4`

then-consequence

- ```
  ( cond  (condition1 then-consequent1)
          (condition2 then-consequent2) . . .
          (else alternative ) )
  ```
  - » Example:
  - » ```
    (cond
        ((< 3 2) 1)
        ((< 4 3) 2)
        (else 3)) ⇒ 3
    ```



# List and functions: f(g(x))

- Take the car of the rest

```
(define ccompose
   ( lambda( f g )
        ( lambda ( x ) ( f ( g x ) ) ) ) )
```

```
( ( ccompose car cdr ) ‘(1 2 3 ) )
->2
```

- High order function! Takes a function as an argument (or return one)

Math: Factorials!

- `10! = 10 * 9 * 8 * 7 * 6 * 5 * 4 * 3 * 2 * 1 * 1`

f(0) = 0! = 1 ; n = 0
*f(n) = n * f(n-1) ; n > 0*

`f(3) = 3 * f(3-1) = 3 * f(2) = 3 * 2 * f(2-1) = 3 * 2 * f(1)`

- Base case in scheme: `( if ( = n 0 ) 1 ? )`
- The rest:

```
(define ( factorial n )
  ( lambda (n)
      (
        if ( = n 0 )
        1
        ( * n  ( factorial( - n  1 ) ) )
      )) )
```

➢ `(factorial 4)`
24

Math: Factorials!

- The rest:

```
(define (factorial n)
  ( if ( = n 0 )
       1
       ( * n  ( factorial( - n  1 ) ) )
  ))
```

➢ `(factorial 4)`
24

- Equivalent (back to lambda):

```
(define factorial
(lambda (n)
  ( if ( = n 0 )
       1
       ( * n  ( factorial( - n  1 ) ) )
  )))
```

➢ `(factorial 4)`
24
```

Practice: Fibonacci Numbers

- 1 2 3 4 5 6 7
- 1, 1, 2, 3, 5, 8, 13, ...
- Each term after the second is the sum of the preceding two
- Define the recursion:
  - » fib(n) = 1 ; if n =0 or n = 1
  - » fib(n) = fib(n-1) + fib(n-2) ; otherwise * do this first
- (+ (fib (- n 1)) (fib (- n 2)))
- (define fib
  - » (lambda (n)
    - – (if (= n 0)
      - 0
      - (if (= n 1)
        - » 1
        - » (+ (fib (- n 1)) (fib (- n 2))))))

Bindings: Local Variables

- `let, let* letrec` creates local variables


```
(let ((var1 exp1)
     (var2 exp2) . . .
     (varn expn))
     body )
```

- Scope of variable within body (only) of let:
  - » Example:

```
>(let ( (x 2)
        (y 10))
    (+ x y))
12
```

- – Let*: allows you do use previously bounded variables when defining a new variable (so the scope is not in the body only)
- – letrec: allows recursion

Sequencing

```
(define display3
  (lambda (arg1 arg2 arg3)
    (begin
      (display arg1)
      (display " ")
      (display arg2)
      (display " ")
      (display arg3)
      (newline))))

(display3 "this" "is" "great!" )
```


Run Schreme from OS prompt

- OS prompt driven:
  - » `mzscheme [-r] [hello.scm]`
- (load "hello.scm") ; Language Choice
- File of loads

Characteristics of "Pure" Functional Languages

- No side effects (e.g. no access to global variables)
- No assignment statements
- Often no variables
- Small concise framework
- Simple uniform syntax
- Recursive (that is how we get things done)
- Interpreted

Learning Scheme

- Practice

Summary

- Downloading Scheme
- Installation & Running
- Examples
  - » Simple Expressions
  - » Lambda Expressions
  - » Binding Variables and Expressions
  - » Recursion
- Language Levels
- Debugging