CS 135 Fall 2018

Tutorial 6: Types of Recursion and Trees
Goals of this tutorial

You should be able to...

• understand the difference between structural and accumulative recursion.

• write functions using accumulative recursion.

• recognize generative recursion.

• perform structural recursion on binary trees
Group Problem: Structural Recursion

Write a function called `sum-lon` that consumes a `(listof Num)` and produces the sum of the numbers in the list. This function should use pure structural recursion.
Group Problem: Accumulative Recursion

Write a function called `sum-lon2` that consumes a `(listof Number)` and produces the sum of the numbers in the list. This function should use `accumulative` recursion.
;; sum-pairs: (listof Num) → (listof Num)
;; requires: lon has an even number of elements
;; Examples:
(check-expect (sum-pairs empty) empty)
(check-expect (sum-pairs '(1 2 3 4)) '(3 7))

(define (sum-pairs lon)
  (cond
   [(empty? lon) empty]
   [else (cons (+ (first lon) (second lon))
                (sum-pairs (rest (rest lon))))])))

What kind of recursion is this?
A Pure structural
B Generative
C Accumulative
D I don’t know
;; average-lon: (listof Num) Num Nat → Num
;; requires: lon is non-empty or n > 0
;; Examples:
(check-expect (average-lon '(1) 0 0) 1)
(check-expect (average-lon '(1 2 3) 0 0) 2)

(define (average-lon lon sum n)
  (cond
   [(empty? lon) (/ sum n)]
   [else (average-lon (rest lon) (+ (first lon) sum) (add1 n))])))

What kind of recursion is this?
A  Pure structural
B  Generative
C  Accumulative
D  I don’t know
Group Problem - Encode-msg

Recall the Data Definition for a Decryptor from last assignment:

;; A Decryptor is a (list Nat Nat Nat)

Also recall the bonus question from last assignment: write a function encode-msg that consumes two strings and produces the Decryptor needed to hide the second string in the first one. You may assume that a valid Decryptor exists and the second string has length 3 and does not contain *. Use accumulative recursion. Of the built-in list functions, you may use only cons, first, second, third, rest, empty?, cons?, and list. You may use string->list and list->string but other string functions are banned. Here are some examples:

(encode-msg "abcdefg" "abc") ⇒ (list 0 0 0)
(encode-msg "abcdefg" "beg") ⇒ (list 1 2 1)
Review: CS 135 Data Progression

Here is a visual representation of the kind of data studied in CS 135.

- children: 0
  - value

- children: 1
  - list

- children: 2
  - binary tree

- children: x
  - unbounded tree

![Diagram showing different data structures]

We've studied these

Now we're studying these
Review: CS 135 Data Progression

- One can think of a **value** as a type of tree where each element has 0 **children**. For a simple manipulation of such a value, **no recursion** is necessary.

- A **list** can be thought of as a tree where each element has only 1 **child**, and so the template has 1 **recursive call** for a function that consumes a list.

- Following this pattern, for a **binary tree**, each element (or node) has 2 **children**, so the template contains 2 **recursive calls**.
Group Problem: exists-in?

Recall the definition of a Node and Binary Tree from Lecture:

```
(define-struct node (key left right))
;; A Node is a (make-node Num BT BT)
```

```
;; A binary tree (BT) is one of:
;; * empty
;; * Node
```

Write a function called `exists-in?` that consumes number and a binary tree, and determines whether or not the number exists in the binary tree as a key.
Group Problem: replace-val/bt

Recall:

(define-struct node (key val left right))

;; A Node is a (make-node Num Str BT BT)

;; A binary tree (BT) is one of:
;; * empty
;; * Node

Write a function called replace-val/bt that consumes a binary tree and 2 strings called old-str and new-str. It replaces every occurrence of old-str in the tree as a value, with new-str. In the next slide, the code for replace-val in a list is demonstrated to start this problem off:
Group Problem: replace-val/bt

;;; (replace-val/list lst old-str new-str) replaces every occurrence of old-str in lst with new-str
;;; replace-val/list: (listof Str) Str Str → (listof Str)
(define (replace-val/list lst old-str new-str)
  (cond
    [(empty? lst) empty]
    [(string=? (first lst) old-str)
      (cons new-str (replace-val/list (rest lst) old-str new-str))]
    [else (cons (first lst) (replace-val/list (rest lst) old-str new-str))])))
Group Problem: max-gap

Recall:

(define-struct node (key left right))
;; A Node is a (make-node Nat BST BST)
;; requires: key > every key in left BST
;; key < every key in right BST
;; A BST is one of:
;; * empty
;; * Node

Write a function called max-gap that consumes a non-empty binary search tree and produces the maximum difference between any 2 nodes in the BST.
Structural vs. Accumulative

In (pure) structural recursion, all arguments to the recursive call or calls are either unchanged, or one step closer to a base case.

In accumulative recursion, arguments are the same as above, plus one or more accumulators, or arguments containing partial answers. The accumulatively recursive function is a helper function, and a wrapper function sets the initial value of the accumulator(s).

If a parameter is used to produce the answer in the base case, then that parameter is probably an accumulator.
Structural vs. Generative

In (pure) structural recursion, all arguments to the recursive call or calls are either unchanged, or one step closer to a base case.

In generative recursion, arguments to the recursive call may be calculated without any restrictions.

If an argument to the recursive call is changing so that it is closer to a base case, always refer to its data definition to check that it is exactly one step closer to its base case.