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Lab 2 Report

Introduction

This assignment has us finish some methods to the object type List. These methods are to create a list with size n, a copy linked list method, Finding an element at a certain part of the list, a sorting method, and a median method. In addition to this, 3 different types of sorting methods are to be created. These sorting methods are to be based on bubble sort, merge sort, and Quicksort. Another revised Quicksort method to be made is one where one recursive call is made. All these sorting methods are to sort the list and return the median.

Proposed solution design and implementation

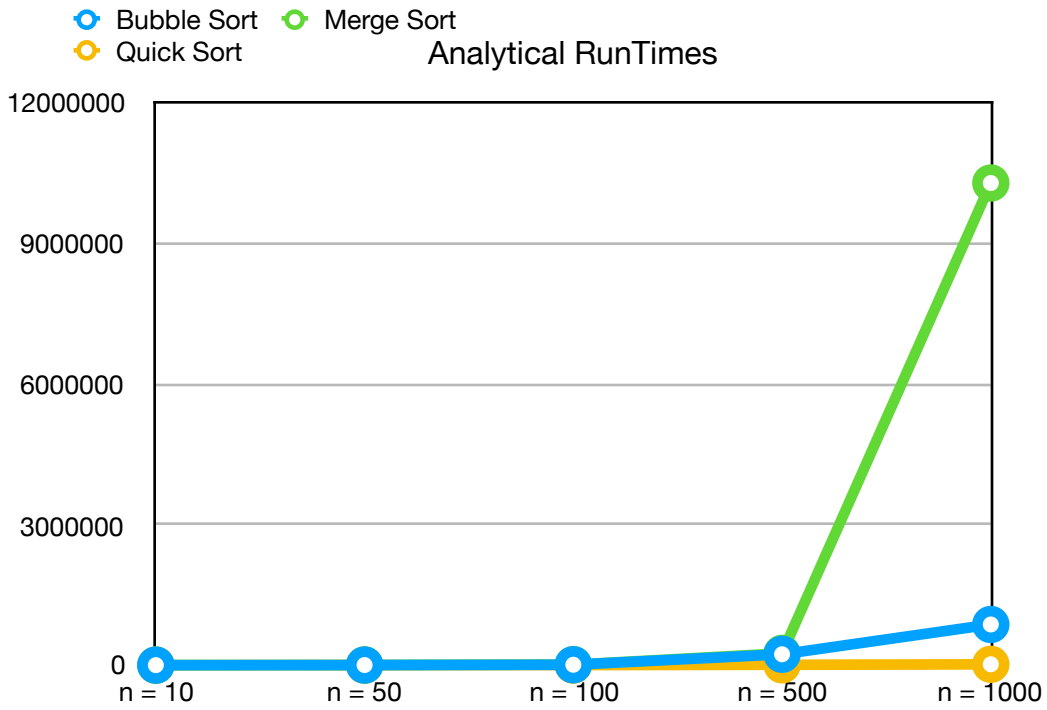
To return the median of the list, I duplicated the Median code provided to us in the lab. I decided to make three of those, one for each sorting algorithm. I did this so that the sorting works independently so its more universal and not always returning the median if its note needed. Essentially, I felt that making a method to return the median by calling a sorting algorithm that it is named made more sense. If someone simply just wanted a list sorted, they can call the method without getting the median. If someone wants the median of a bubble sorted list, they can call Bubble_Median which calls the bubble sort algorithm but also returns the median

For bubble sort, comparing a value with the one next to it and shifting all the large ones to the left side was coded. The linked list is determined as sorted if theres no more shifting of values. Mergesort was accomplished recursively by cutting the list in half until one node was left. Once values were in their individual nodes, it would compare and reconstruct a sorted list by iterating through the left side and placing the right values where they belong. Quicksort was also done recursively by picking the last node as the pivot and creating 2 lists, one where the smaller elements are placed and one where the larger elements are placed. These 2 lists are also sent recursively until there is a single node. The list is then reconstructed by appending the pivot and concatenating the left and right.

Experimental results

I created a list of length 10, 50, 100, 500, and 1000 using create_list. I programmed it to display the n amount, median, and comparison counts for each call. I displayed the results on a graph

```
n=10            n=50            n=100           n=500           n=1000
36              43              48              51              51
count:  63      count:  2058    count:  8316    count:  231536  count:  867132
36              43              48              51              51
count:  148     count:  2684    count:  11056   count:  251354  count:  1028214
36              43              48              51              51
count:  33      count:  426     count:  864     count:  6957    count:  17576
```



Quicksort was the most efficient of them all. All the running times were accurate with their complexities except for Mergesort. Mergesort towards the end had horrible runtime especially compared to the other sorting algorithms

Conclusions

I learned a more visual way to see how different sorting algorithms work. It also put into mind which sorting would be ideal for linked lists, arrays, or any other storage type of data structure. It also helped visualize recursion more and how to implement that into code. Overall the assignment helped understand different ways to sort and how efficient each sort is.

Appendix

```
#############################################################################
#######
#
# Course: CS2302 (MW - 1:30pm)
# Author: Ivan Perez
# Assignment: Lab 2
# Instructor: Olac Fuentes
# T.A.: Anindita Nath
# Last Modified: Feb 28, 2019
# Purpose: 2 object functions that consist of making a Node and a linked list
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```
# of nodes. They contain methods to Print, append, prepend, remove nodes, and
# create a random linked list among other things. It also consists of different
# sorting algorithms to sort different sizes of lists.
#
#################################################################################
#######
import random

# Node Functions
class Node(object):
    # Constructor
    def __init__(self, item, next=None):
        self.item = item
        self.next = next


def PrintNodes(N):
    if N != None:
        print(N.item, end=' ')
        PrintNodes(N.next)


def PrintNodesReverse(N):
    if N != None:
        PrintNodesReverse(N.next)
        print(N.item, end=' ')


# List Functions
class List(object):
    # Constructor
    def __init__(self):
        self.head = None
        self.tail = None


def IsEmpty(L):
    return L.head == None
```

```
def Append(L, x):
    # Inserts x at end of list L
    if IsEmpty(L):
        L.head = Node(x)
        L.tail = L.head
    else:
        L.tail.next = Node(x)
        L.tail = L.tail.next


def Print(L):
    # Prints list L's items in order using a loop
    temp = L.head
    while temp is not None:
        print(temp.item, end=' ')
        temp = temp.next
    print()  # New line


def PrintRec(L):
    # Prints list L's items in order using recursion
    PrintNodes(L.head)
    print()


def Remove(L, x):
    # Removes x from list L
    # It does nothing if x is not in L
    if L.head == None:
        return
    if L.head.item == x:
        if L.head == L.tail:  # x is the only element in list
            L.head = None
            L.tail = None
        else:
            L.head = L.head.next
    else:
        # Find x
        temp = L.head
        while temp.next != None and temp.next.item != x:
```

```
            temp = temp.next
        if temp.next != None:  # x was found
            if temp.next == L.tail:  # x is the last node
                L.tail = temp
                L.tail.next = None
            else:
                temp.next = temp.next.next


def PrintReverse(L):
    # Prints list L's items in reverse order
    PrintNodesReverse(L.head)
    print()

def Prepend(L, x):# Creates and places a node before a list
    if IsEmpty(L):
        L.head = Node(x)
        L.tail = L.head

    else:
        L.head = Node(x, L.head)


def Search(L, x): # Searches a list's node for item x
    temp = L.head
    while temp is not None:
        if temp.item == x:
            return temp
        temp = temp.next
    return None


def GetLength(L): # returns length of lsit
    temp = L.head
    count = 0
    while temp is not None:
        count += 1
        temp = temp.next
    return count
```

```
def insertAfter(L, w, x): # inserts a new node with item x after node w
    s = Search(L, w)
    if s is None:
        print("Location provided does not exist")
    else:
        s.next = Node(x, s.next)


def Concatenate(L1, L2): # appends a list to a list
    if IsEmpty(L1):
        L1.head = L2.head
        L1.tail = L2.tail

    else:
        L1.tail.next = L2.head
        L1.tail = L2.tail

    return L1

##############################################################################
#
# Below are the methods required for the assignment
#


def createList(n): # creates a random list of integers with size n
    L = List()
    for i in range(n):
        Append(L, random.randint(1, 100))
    return L


def Copy(L): # makes a new list and copies the elements into it
    C = List()
    temp = L.head
    while temp is not None:
        Append(C, temp.item)
        temp = temp.next
    return C
```

```
def ElementAt(L, p): # returns the address of the elemant desired
    temp = L.head
    for i in range(p):
        if temp is None:
            print("Undefined Location")
        temp = temp.next
    return temp

def Sort(L): # default sorting algorithm
    change = True
    while change:
        t = L.head
        change = False
        while t.next is not None:
            if t.item > t.next.item:
                temp = t.item
                t.item = t.next.item
                t.next.item = temp
                change = True
            t = t.next

def Findtail(L):
    temp = L.head
    if temp is None:
        L.tail = None
    else:
        while temp.next is not None:
            temp = temp.next
        L.tail = temp

def Bubble_Median(L): # Calls bubble sort and returns median of the list
    C = Copy(L)
    bubble_sort(C)
    return ElementAt(C,GetLength(C)//2)

def Merge_Median(L): # Calls merge sort and returns median of the list
    C = Copy(L)
    merge_sort(C)
    return ElementAt(C,GetLength(C)//2)
```

```
def Quick_Median(L): # Calls quick sort and returns median of the list
    C = Copy(L)
    quick_sort(C)
    return ElementAt(C,GetLength(C)//2)

########## Sorting Algorithms ############

# Bubble Sort
# Runtime: O(n^2)
def bubble_sort(L):
    global count
    change = True
    while change:
        t = L.head
        change = False # if if statement is run, sorting is not complete
        while t.next is not None:
            count += 1
            if t.item > t.next.item: # compares value of current node to the next node
                temp = t.item
                t.item = t.next.item
                t.next.item = temp
                change = True #if sorted, condition doesn't change
            t = t.next

# Merge Sort
# Runtime: O(nlogn)
def merge_sort(L):
    global count
    if GetLength(L) > 1: #if list is empty or has a length of one, it does nothing
        # Divides a list in half and creates 2 lists
        R = List()
        tail = L.tail
        mid = ElementAt(L, GetLength(L)//2-1)
        R.head = mid.next
        mid.next = None
        L.tail = mid
        R.tail = tail

        # Recursively divides the left and right list
```

```
if GetLength(L) > 0:
    merge_sort(L)
if GetLength(R) > 0:
    merge_sort(R)

# if the left is empty, the right head becomes the left head
if IsEmpty(L):
    Append(L, R.head.item)
    R.head = R.head.next

#if no R exists, nothing happens
if not IsEmpty(R):
    #iterating L elements
    Rtemp = R.head
    Ltemp = L.head
    place = None
    while Rtemp is not None:#Continues loop if R isnt sorted into L
        count += 2
        if Ltemp is None:#if it looped through L, R is bigger than all elements
            Rplace = Rtemp.next
            Append(L, Rtemp.item)
            Rtemp = Rplace
            Ltemp = L.head
            place = None# placeholder for previous node

        elif Rtemp.item < Ltemp.item:# places node before current node
            count += 1
            if place is None:#places R node as L's head
                Rplace = Rtemp.next
                place = Ltemp
                L.head = Rtemp
                Rtemp.next = place
                Ltemp = L.head
                place = None
                Rtemp = Rplace
            else:
                Rplace = Rtemp.next
                temp = place.next
                place.next = Rtemp
                Rtemp.next = temp
```

```
                Rtemp = Rplace
                Ltemp = L.head
                place = None

            else:#iterates through L
                place = Ltemp
                Ltemp = Ltemp.next

#Quick sort
#Runtime: O(nlogn)
def quick_sort(L):
    global count
    if GetLength(L) > 1:
        pivot = L.tail # grabs last element as the pivot
        newtail = ElementAt(L, GetLength(L)-2)
        newtail.next = None
        L.tail = newtail
        Ltemp = L.head
        R = List() # greater than pivot list
        place = None
        while Ltemp is not None: # iterates list and places largest in list R
            count += 1
            if Ltemp.item > pivot.item:
                Append(R, Ltemp.item)
                count += 1
                if place is None:
                    L.head = L.head.next
                    Ltemp = L.head
                    place = None
                else:
                    place.next = place.next.next
                    Ltemp = place.next
            else:
                place = Ltemp
                Ltemp = Ltemp.next

        # refinds the tails after moving elements into different lists
        Findtail(L)
        Findtail(R)
        # recursively calls smaller values list and larger value lists
```

```
        if GetLength(L) > 0:
            quick_sort(L)

        if GetLength(R) > 0:
            quick_sort(R)
        Findtail(L)
        Findtail(R)

        # Reconstructs list as L, pivot, R
        Append(L, pivot.item)
        Concatenate(L,R)


#------------------ Test code ----------------------#
l10 = createList(10)
l50 = createList(50)
l100 = createList(100)
l500 = createList(500)
l1000 = createList(1000)
global count
count = 0

# n = 10
print('n=10')
print(Bubble_Median(l10).item)
print('count: ', count)
count = 0
print(Merge_Median(l10).item)
print('count: ', count)
count = 0
print(Quick_Median(l10).item)
print('count: ', count)
count = 0

# n = 50
print('n=50')
print(Bubble_Median(l50).item)
print('count: ', count)
count = 0
print(Merge_Median(l50).item)
```

```
print('count: ', count)
count = 0
print(Quick_Median(l50).item)
print('count: ', count)
count = 0

# n = 100
print('n=100')
print(Bubble_Median(l100).item)
print('count: ', count)
count = 0
print(Merge_Median(l100).item)
print('count: ', count)
count = 0
print(Quick_Median(l100).item)
print('count: ', count)
count = 0

# n = 500
print('n=500')
print(Bubble_Median(l500).item)
print('count: ', count)
count = 0
print(Merge_Median(l500).item)
print('count: ', count)
count = 0
print(Quick_Median(l500).item)
print('count: ', count)
count = 0

# n = 1000
print('n=1000')
print(Bubble_Median(l1000).item)
print('count: ', count)
count = 0
print(Merge_Median(l1000).item)
print('count: ', count)
count = 0
print(Quick_Median(l1000).item)
print('count: ', count)
```

count = 0

I certify that this project is entirely my own work. I wrote, debugged, and tested the code being presented, performed the experiments, and wrote the report. I also certify that I did not share my code or report or provided inappropriate assistance to any student in the class.