22AIE212 Design and Analysis of Algorithms

Lab Sheet 4

Sorting Techniques

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1. Merge sort

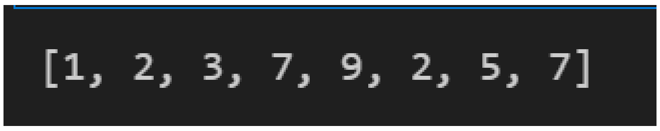
    a. What is the time complexity of a merge sort algorithm? Is there any difference between the best case and the worst case?

    b. Give examples for best-case and worst-case inputs.

Code :

```
#1

def ms(arr):
    if len(arr) > 1:
        left = arr[:len(arr)//2]
        right = arr[len(arr)//2:]

        ms(left)
        ms(right)
        merge(arr,left,right)

def merge(arr,left,right):
    i = j = k = 0

    while i < len(left) and j < len(right):
        if left[i] < right[j]:
            arr[k] = left[i]
            i+=1
        else:
            arr[k] = right[j]
            j+=1
        k+=1

        while i<len(left):
            arr[k] = left[i]
            i+=1
            k+=1
        while j<len(right):
            arr[k] = right[j]
            j+=1
            k+=1

arr = [3,7,2,9,1,2,5,7]
ms(arr)
print(arr)
```

Output :



```
[1, 2, 3, 7, 9, 2, 5, 7]
```

a. Time Complexity of Merge Sort:

- **Best Case:** O(nlogn)
- **Worst Case:** O(nlogn)

There is no difference between the best case and the worst case time complexity for merge sort. This is because the algorithm always divides the list into two halves and takes linear time to merge them, regardless of the initial order of the elements.

b. Examples of Best-Case and Worst-Case Inputs:

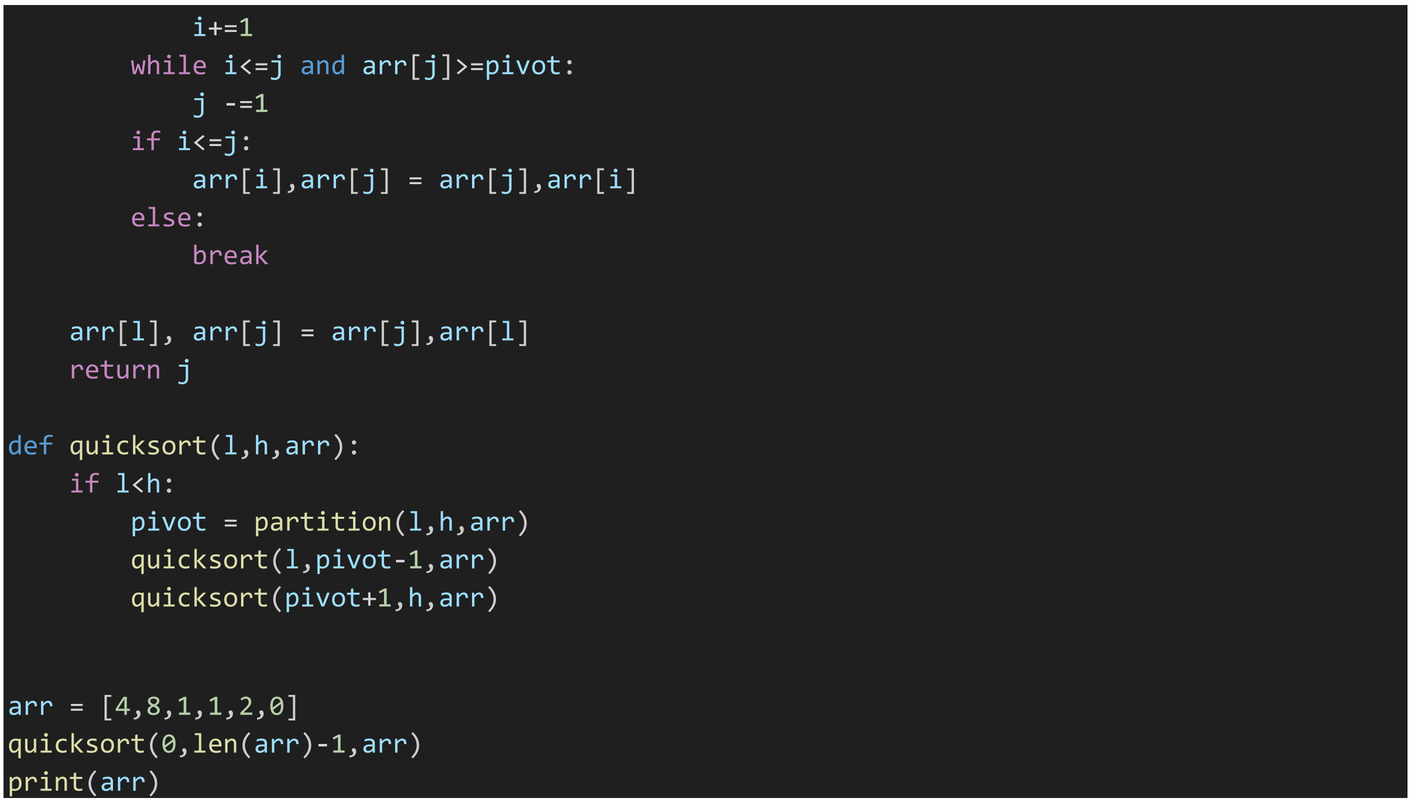
- **Best Case Input:** Any input is the best case since merge sort consistently performs O(nlogn) operations regardless of the input.
- **Worst Case Input:** Similar to the best case, the worst-case performance is also O(nlogn) for any input.

Example: [5,4,3,2,1]

2. Quick sort
    a. What is the time complexity of the Quick Sort algorithm? Is there any difference between the best case and the worst case?
    b. Give examples for best-case and worst-case inputs.

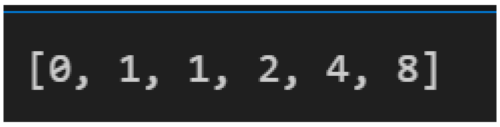
Code :

```
#2

def partition(l,h,arr):
    i,j = l,h
    pivot = arr[l]

    while True:
        while i<=j and arr[i]<=pivot:
```



```
            i+=1
        while i<=j and arr[j]>=pivot:
            j -=1
        if i<=j:
            arr[i],arr[j] = arr[j],arr[i]
        else:
            break

    arr[l], arr[j] = arr[j],arr[l]
    return j

def quicksort(l,h,arr):
    if l<h:
        pivot = partition(l,h,arr)
        quicksort(l,pivot-1,arr)
        quicksort(pivot+1,h,arr)


arr = [4,8,1,1,2,0]
quicksort(0,len(arr)-1,arr)
print(arr)
```

Output :



```
[0, 1, 1, 2, 4, 8]
```

a. Time Complexity of Quick Sort:

- **Best Case:** O(nlogn)
- **Average Case:** O(nlogn)
- **Worst Case:** O(n^2)

Best,worst and avg case varies due to the selection of pivot and unbalanced partitions.

b. Examples of Best-Case and Worst-Case Inputs:

- **Best Case Input:** [3,1,2,5,4] (divides list into nearly equal halves in each partition)
- **Worst Case Input:** The worst case occurs when the array is sorted or reverse sorted making the pivot the smallest or largest element in each iteration. It also leads to unbalanced partitioning.
    - Example: [1,2,3,4,5]

3. Sort a set of strings{a,p,p,l,e} using Radix sort

Code :

```
#3
def counting_sort(arr):
    count = [0] * 256
    output = [''] * len(arr)
    for char in arr:
        count[ord(char)] += 1
    for i in range(1, 256):
        count[i] += count[i - 1]
    for char in reversed(arr):
        output[count[ord(char)] - 1] = char
        count[ord(char)] -= 1
    return output

s = ["a", "p", "p", "l", "e"]
s = counting_sort(s)
print(s)
```

Output :

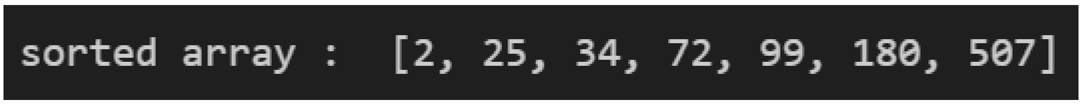
```
['a', 'e', 'l', 'p', 'p']
```

4. Perform Radix sort on the following elements: 180, 25, 72, 507, 34, 2, 99

Code :

```
#4
def countingSort(arr, exp1):
    n = len(arr)
    output = [0] * (n)
    count = [0] * (10)

    for i in range(0, n):
        index = arr[i] // exp1
        count[index % 10] += 1
    for i in range(1, 10):
        count[i] += count[i - 1]

    i = n - 1
    while i >= 0:
        index = arr[i] // exp1
        output[count[index % 10] - 1] = arr[i]
        count[index % 10] -= 1
        i -= 1
    for i in range(0, len(arr)):
        arr[i] = output[i]


def radixSort(arr):
    max1 = max(arr)
    exp = 1
    while max1 / exp >= 1:
        countingSort(arr, exp)
        exp *= 10


arr = [180, 25, 72, 507, 34, 2, 99]
radixSort(arr)
print("sorted array : ",arr)
```

Output :



```
sorted array :  [2, 25, 34, 72, 99, 180, 507]
```

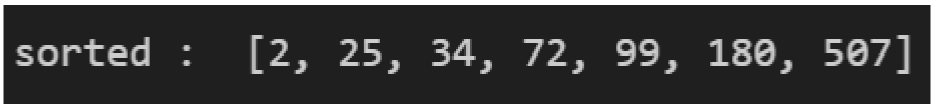
5. Perform Heapsort on the following elements: 180, 25, 72, 507, 34, 2, 99

Code :

```
def heapify(arr, n, i):
    largest = i
    left = 2 * i + 1
    right = 2 * i + 2

    if left < n and arr[i] < arr[left]:
        largest = left
    if right < n and arr[largest] < arr[right]:
        largest = right
    if largest != i:
        arr[i], arr[largest] = arr[largest], arr[i]
        heapify(arr, n, largest)


def heap_sort(arr):
    n = len(arr)
    for i in range(n // 2 - 1, -1, -1):
        heapify(arr, n, i)
    for i in range(n - 1, 0, -1):
        arr[i], arr[0] = arr[0], arr[i]
        heapify(arr, i, 0)


arr = [180, 25, 72, 507, 34, 2, 99]
heap_sort(arr)
```

```
print("sorted : ",arr)
```

Output :



```
sorted :  [2, 25, 34, 72, 99, 180, 507]
```