

Programming Assignment 3

Due: 11/5/2022

The objective of this assignment is to explore an interesting algorithm known as k^{th} smallest element in an array.

Problem Definition:

The k^{th} order statistics of an array a of n elements is the k^{th} least element in the array, $k = 0, \dots, n - 1$. Moreover, finding the k^{th} order statistics of a can be accomplished by the following solutions

- 1- Sorting a and returning the k^{th} element in the sorted array. Using any sorting in $O(n \log n)$ would do the task!
- 2- Using Quicksort and reduce the running time for finding the k^{th} statistics down to $O(n)$.

Assignment

- 1- Implement two algorithms:
 - a. A min heap, that finds the k^{th} smallest element of a given input array and the value k .
 - b. Use quicksort (with some modification) to find the k^{th} smallest element of a given input array and the value k .
- 2- For both algorithms inputs and outputs are similar. Here are some examples:
 - a. Example1:
Input: [8, 4, 1, 2, 10] and $k = 3$
Output: 4
 - b. Example2:
Input: [7, 10, 4, 3, 20, 15] and $k = 4$
Output: 10
- 3- The algorithm for MinHeap can be found from class lecture notes.
- 4- The following pseudocode can be used for 1-a algorithm. This algorithm uses Quicksort concept to find the k^{th} element in an arbitrary array.

```
function kthSmallest(arr, l, r, k)
{
    if ( $k > 0$  and  $k \leq r - l$ )
         $q = \text{partition}(\text{arr}, l, r)$     // make a partition using the last element
    if ( $q == k$ )                        // if position is same as k
        return arr[pos]
    if ( $q > k$ )                        //if position is more, # recur for left subarray
        return kthSmallest(arr, l,  $q - 1$ , k)
    return kthSmallest(arr,  $q + 1$ , r,  $k - q + l$ )
}
```

Note: You may need to correct the array boundaries for python (e.g. starting from zero)

- 5- Your program should work for any array, as usual.

What to submit?

- 1- Write 2 programs for each algorithm. Please name your programs as follows:
 - a. minheapfind_yourname.py
 - b. quickfind_yourname.py
- 2- Your programs should be run as follows:
 - minheapfind_yourname.py [10,2,3,5] 2 or quickfind_yourname.py [10,2,3,5] 2
The first input is an array and the second input is the value of k
 - Both programs return an integer indicating the value of kth smallest element in the list.
Note: make sure test your program for boundary inputs!
- 3- Please have your name top of your all programs.
- 4- You should follow general software development rules such as proper and sufficient commenting if it is necessary and proper functions and variables naming.
- 5- Do not copy any code from online resources!