CS 201, Fall 2018

Homework 4

DUE: December 14, Friday @23:55

Description: In this assignment, you will write a C++ program that **finds the kth largest number** among a set of N numbers. However, this time, you will use **a variation of the quicksort** algorithm to implement the program. The details can be found below.

1) The Input and Expected Output

The input and the expected output of the program is the same as described in Homework 1 and 3. The program will take the **type of algorithm** to be applied, ***k*** (a number less than or equal to *N*). Then it will take ***N*** followed by a list of ***N*** **numbers**. As output, it will print out the ***kth*** **largest number** and the **total elapsed time** for the completion of the algorithm.

As the only difference from Homework 1 and 3, **the algorithm type** can be 1, 2, 3 or **4**. You can modify and reuse the test generator program to generate test inputs. You can also just modify the sample test inputs for Homework 1 to test the same set of numbers with algorithm type being 4.

Your code will only be tested with algorithm type 4.

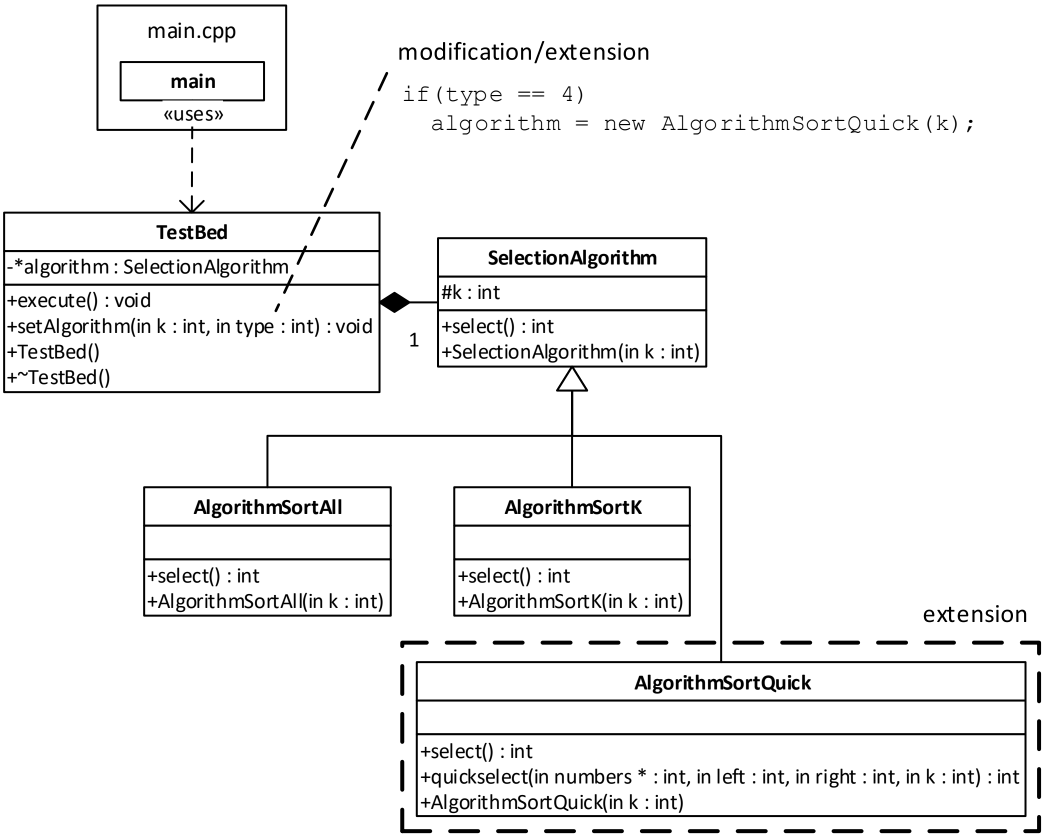
2) The Algorithm: quickselect

You will implement a variation of the **quicksort** algorithm to find the k^{th} largest number among a set of numbers S in $O(N)$ time on average, where N is the total amount of numbers, *i.e.,* $|S|$. The outline of the algorithm, **quickselect** is as follows.

- If $N <= 10$, sort all the numbers (using insertion sort) and return the k^{th} number.
- Else, pick a pivot number, $v \in S$.
    - Partition $S - \{v\}$ into S_1 and S_2, as done in quicksort.
    - If $k <= |S_1|$, then the k^{th} largest number must be in S_1. Return *quickselect*(S_1, k).
    - If $k = 1 + |S_1|$, then the pivot, v is the k^{th} largest number. Return v.
    - Otherwise, the k^{th} largest number lies in $|S_2|$, and it is the $(k - |S_1| - 1)st$ largest number in S_2. Return *quickselect*$(S_2, k - |S_1| - 1)$.

3) The (Extended) Design

You can reuse the design of Homework 1 and/or Homework 3. You just need to add one extra class, *AlgorithmSortQuick*, which extends from the *SelectionAlgorithm* class and overwrites the *select* method to implement the new algorithm. The *select* method within the *AlgorithmSortQuick* class should make a call to the recursive *quickselect* method. It takes an array of numbers, the left and the right index of the partition of interest, and *k*. The overall design is depicted below.


main.cpp
main
«uses»
modification/extension
if(type == 4)
  algorithm = new AlgorithmSortQuick(k);
TestBed
-*algorithm : SelectionAlgorithm
+execute() : void
+setAlgorithm(in k : int, in type : int) : void
+TestBed()
+~TestBed()
1
SelectionAlgorithm
#k : int
+select() : int
+SelectionAlgorithm(in k : int)
AlgorithmSortAll
+select() : int
+AlgorithmSortAll(in k : int)
AlgorithmSortK
+select() : int
+AlgorithmSortK(in k : int)
extension
AlgorithmSortQuick
+select() : int
+quickselect(in numbers * : int, in left : int, in right : int, in k : int) : int
+AlgorithmSortQuick(in k : int)

You might need to make further small modifications in function *main* and the *TestBed* class to accept 4 as the algorithm type. This is because, previously the algorithm type was assumed to be 1, 2 or 3. For instance, you should make a modification/extension within the *setAlgorithm* method of the *TestBed* class. If the *type* argument is 4, an object of type *AlgorithmSortQuick* should be assigned to the *algorithm* member variable. The rest of the design and implementation can be reused as is.

If you have not submitted Homework 1 or Homework 3, then you have to implement at least the *main* method, the *TestBed* class and the *SelectionAlgorithm* class as described in the assignment description of Homework 1.

4) Submission

You will submit this homework via the LMS system. You should follow the file-naming conventions and guidelines below.

- You should submit your source files as a **ZIP** archive file (**NOT** RAR or other formats). The name of the file should be in format "**<USER-ID>_hw<HOMEWORK-NR>.zip**". For example, if your username is vy1043, then the name of the submitted file should be "vy1043_hw5.zip". Pay attention that all the letters are in lower-case. ZIP archive is supposed to contain **just the source files**, no folders are allowed by any means.

- The contents of the ZIP file should be as follows:
  - **main.cpp** (includes the *main* function)
  - **TestBed.h** (TestBed class definition)
  - **TestBed.cpp** (TestBed class implementation)
  - **SelectionAlgorithm.h** (SelectionAlgorithm class definition)
  - **SelectionAlgorithm.cpp** (SelectionAlgorithm class implementation)
  - **AlgorithmSortQuick.h** (AlgorithmSortQuick class definition)
  - **AlgorithmSortQuick.cpp** (AlgorithmSortQuick class implementation)
  - **AlgorithmSortK.h** (AlgorithmSortK class definition)
  - **AlgorithmSortK.cpp** (AlgorithmSortK class implementation)
  - **AlgorithmSortAll.h** (AlgorithmSortAll class definition)
  - **AlgorithmSortAll.cpp** (AlgorithmSortAll class implementation)
  - **AlgorithmSortHeap.h** (AlgorithmSortHeap class definition)
  - **AlgorithmSortHeap.cpp** (AlgorithmSortHeap class implementation)
  - **BinaryHeap.h** (BinaryHeap class definition)
  - **BinaryHeap.cpp** (BinaryHeap class implementation)

- Late submissions and C++ files that do not compile are **not** accepted.

- You can resubmit your homework (until the deadline) if you need to.

- Make sure that your program does **not** include commands specific to a development environment, e.g., `system("pause")` or `#pragma once` in Visual Studio.

* **Optional:** The last 8 files are to be submitted if implemented as an extension of Homework 1 and/or Homework 3. The corresponding algorithms will not be tested for evaluating Homework 4. The algorithm type will always be set as 4 in the test cases.