Problem Set 3

Assigned: June 10
Due: June 17

Problem 1.

Suppose that you are given the problem of returning in sorted order the $k$ smallest elements in an array of size $n$, where $k$ is much smaller than $\log(n)$, but much larger than 1.

Describe how quicksort can be adapted to this problem.

Problem 2.

Suppose that we modify the standard definition of a binary search tree to add a field $N.size$ at each node, which records the size of the subtree under $N$ (including $N$ itself).

A. Explain how to modify the procedure for adding an element $X$ to a tree. Be sure to consider both the case where $X$ is not yet in the tree and is added, and the case where $X$ is already in the tree, and the tree remains unchanged.

You only need to describe the changes that are made to the standard algorithm; you do not have to repeat the standard algorithm.

B. Explain how to modify the procedure for deleting an element. As in (A), consider both cases.

C. Describe a procedure for finding the $k$th largest element in the tree.

D. Describe a procedure for finding the number of elements in the tree less than $X$.

All of these procedures should run in time proportional to the height of the tree.

Problem 3

Suppose you have two binary search trees $P$ and $Q$. Let $|P|$ and $|Q|$ be the number of elements in $P$ and $Q$, and let $h_P$ and $h_Q$ be the heights of $P$ and $Q$. Assume that that is, $h_P \ll h_Q \ll |P| \ll |Q|$

A. Give a destructive algorithm for creating a binary search tree containing the union $P \cup Q$ that runs in time $O(|P|^2)$ in the worst case.

B. Assume now that it is known that the largest element of $P$ is less than the smallest element of $Q$. Give a destructive algorithm for creating a binary search tree containing the union $P \cup Q$ that runs in time $h_P$.

C. (1 point extra credit). Find a solution to part (A) that runs in time $O(|P| \cdot h_Q)$ in the worst case, and additionally guarantees that the height of the output tree is no greater than $h_P + h_Q$. 

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