Algorithms, Spring 2020 at CIS

Homework 1 **Due: 3/28/20 11:59pm China time**

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1. Suppose you are in the comparison-based model and you are given a list of n distinct numbers, $a_1, a_2, a_3, \ldots, a_n$. Define the *rank* of an item a_j to be its position i, in a sorted order of these numbers. So if π is a permutation from $\{1, 2, \ldots, n\}$ to $\{1, 2, \ldots, n\}$, and $a_{\pi(1)} < a_{\pi(2)} < \cdots < a_{\pi(n)}$, then the rank of a_j is equal to the index i for which $\pi(i) = j$.

   Give a deterministic algorithm for outputting the entire set of items of rank 3^i, for $i = 0, 1, 2, 3, 4, \ldots, \lfloor \log_3 n \rfloor$. Your algorithm should use $O(n)$ comparisons.

2. Suppose you are in the comparison-based model are you are given a list of n distinct numbers, $a_1, a_2, a_3, \ldots, a_n$. You are also given an integer B, and suppose B divides n. Your job is to arbitrarily partition these n numbers into B groups $G_1, \ldots, G_B$, so that

   (a) each group G_i has n/B items, and

   (b) inside of each group G_i, the numbers are sorted.

   First argue that if $B = \Theta(n)$, then this can be done deterministically using $O(n)$ comparisons. Second, show that if $B = \Theta(n^{1/3})$, then this requires $\Omega(n \log n)$ comparisons for any deterministic algorithm in the comparison-based model.

3. True or False: given a list $a_1, \ldots, a_n$, one can output a sorted list of the smallest $n^{1/3}$ items in $O(n)$ time.