Data Structures (2025 Fall)

Assignment 03*

Chuang-Chieh Lin

Department of Computer Science and Engineering,
National Taiwan Ocean University

Due date: 3 December 2025

1. (25%) Rewrite the postorder tree traversal algorithm in the lecture to be an iterative one. (**Note:** You can submit a C function or a pseudocode).

2. (25%) Each node of a binary tree has fields $key(x)$, $left(x)$, $right(x)$, and $parent(x)$ (where $parent(\text{root}) =$ `NULL`). Assume all keys in the tree are distinct. Write an algorithm MoveToRoot(x, k) that takes as input a pointer x to the *root* of a binary tree and a key k, and behaves as follows:
   (a) If there is no node v in the tree with $key(v) = k$, then the algorithm
      i. must not modify the tree, and
      ii. must return the original root x.
   (b) If there is a node v in the tree with $key(v) = k$, then the algorithm must:
      i. find such a node v;
      ii. repeatedly *swap* the key values on the unique path from v up to the root, that is, while $parent(v) \neq$ `NULL`, exchange $key(v)$ and $key(parent(v))$, and then set $v \leftarrow parent(v)$;
      iii. after these swaps, ensure that the root node has key k, while the shape of the tree and all pointer fields $left(\cdot)$, $right(\cdot)$, and $parent(\cdot)$ remain unchanged;
      iv. return the root node x.

   Your algorithm is allowed to read and write the $key(\cdot)$ fields of nodes but may not change any $left(\cdot)$, $right(\cdot)$, or $parent(\cdot)$ pointers and may not create or delete nodes. Use clear pseudocode.

3. (30%) Consider the following array:

$$A = \langle 4, 33, 6, 90, 33, 32, 31, 91, 90, 89, 50, 33 \rangle.$$

   (a) (15%) Is A a min-heap? Justify your answer by briefly explaining the min-heap property.
   (b) (15%) Please write an $O(n)$ time algorithm which checks whether the input binary tree (stored in an array) is a min-heap. Justify your answer and analyze the time complexity.

* List the required intermediate steps next to each problem. Note that any answers generated directly by AI are invalid for this assignment.

4. (20%) Transforming the forest into a binary tree using the rule:
   - If $T_1, \ldots, T_n$ is a forest of trees, then the binary tree corresponding to this forest is denoted by $B(T_1, \ldots, T_n)$.
   - The root of this binary tree is root(T_1).
   - Its left subtree is $B(T_{11}, T_{12}, \ldots, T_{1m})$, where $T_{11}, T_{12}, \ldots, T_{1m}$ are the subtrees of root(T_1); and its right subtree is $B(T_2, \ldots, T_n)$.