CIS 121 — Data Structures and Algorithms
Homework Assignment 3

Assigned: September 25, 2018       Due: October 3, 2018

Note: The homework is due electronically on Gradescope and Canvas on Wednesday, October 3 by 11:59 pm EDT. For late submissions, please refer to the Late Submission Policy on the course webpage. You may use a maximum of 2 late days on this homework.

A. Gradescope: You must select the appropriate pages on Gradescope. Gradescope makes this easy for you: before you submit, it asks you to associate pages with the homework questions. Failing to do so will get you 5% off, which cannot be argued against after the fact. Gradescope may prompt you with a warning to select your cover page, please ignore this warning.

B. Canvas: You must also submit your assignment on Canvas. Forgetting to do so will incur a 10% penalty.

C. LATEX: You must use the `hw121.cls` Latex template provided on the course website, or a 5% penalty will be incurred. Handwritten solutions or solutions not typeset in Latex will not be accepted.

D. Solutions: Please write concise and clear solutions; you will get only a partial credit for correct solutions that are either unnecessarily long or not clear. Please refer to the Written Homework Guidelines for all the requirements. Piazza will also contain a complete sample solution.

E. Algorithms: Whenever you present an algorithm, your answer must include 3 separate sections. Please see Piazza for an example complete solution.

   1. A precise description of your algorithm in English. No pseudocode, no code.
   2. Proof of correctness of your algorithm
   3. Analysis of the running time complexity of your algorithm

F. Collaboration: You are allowed to discuss ideas for solving homework problems in groups of up to 3 people but you must write your solutions independently. Also, you must write on your homework the names of the people with whom you discussed. For more on the collaboration policy, please see the course webpage.

G. Outside Resources: Finally, you are not allowed to use any material outside of the class notes and the textbook. Any violation of this policy may seriously affect your grade in the class. If you're unsure if something violates our policy, please ask.
1. **[15pts - Divide & Conquer]** You are given a function `Magic(int lo, int hi, int[] arr)` that magically gives the sum of `arr[lo...hi]` in $O(1)$ time. You are also given an array of $n$ positive integers, $A$, and a second array, $S$, that is the same as the first array except with a constant number of integers turned into zeros. Design a divide-and-conquer algorithm that turns $S$ into $A$ in $O(\lg n)$ time.

For example: $A = \{1, 2, 3, 4, 5\}$ and $S = \{1, 2, 0, 0, 5\}$. After running your algorithm, $S$ should have its zeros replaced to become $S = \{1, 2, 3, 4, 5\}$

2. **[25pts - Tree Traversals]**

(a.) Draw the binary tree (note, not necessarily a BST) corresponding to this level-order traversal (null nodes have been included):

```
P E S A N V L Y I null null null null null null null null null
```

(b.) Give the in-order, pre-order, and post-order traversal of the tree that you drew. Make sure to include null children when printing out nodes.

As an example, given the binary tree corresponding to the level-order traversal 1 (null nodes omitted), your in-order traversal should be: `null 1 null`.

(c.) For each type of traversal (in-order, pre-order, and post-order), prove with an algorithm or disprove with a counterexample: given the result of the traversal including the null nodes, it is **always** possible to construct the original tree.

**Note:** In class (slide 22), you discussed this problem **without** the null links. Answer to this question may or may not be different – that’s for you to figure out.

3. **[10pts - BST Properties]** Prove that if a node in a BST has two non-null children, its successor has no left child and its predecessor has no right child.

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**Feedback:** How long did you spend on this assignment? What did you think of it, and how can we improve written assignments in the future? Let us know anonymously at: https://tinyurl.com/CIS121-18fa-hw-feedback

We really appreciate your feedback!