1 Introduction and Objective

This tutorial marks the end of the first $\frac{1}{3}$ of CS2040C: Basic C++, basic analysis of algorithms (worst case time complexity only), various sorting algorithms, and various linear Data Structures (DSes).

This tutorial also marks the start of the next $\frac{1}{3}$ of CS2040C: Various non-linear DSes. We start by reviewing a bit of CS1231 topics of graphs and trees, discuss the Priority Queue (PQ) ADT with its Binary Heap implementation (use https://visualgo.net/en/heap to help you answer some questions in this tutorial).

Finally, we will have a 15% midterm test about the first $\frac{1}{3}$ of CS2040C + a little bit of Binary Heap data structure. Thus we will spend the remaining time of this tutorial time to discuss questions that have appeared in Steven’s past relevant midterm test and thus will not appear again verbatim in CS2040C midterm test this semester.

2 Tutorial 04 Questions

CS1231 Review (Focus on Trees)

Q1). Prove or disprove: “There is a unique path between any two distinct vertices of a Tree (a connected acyclic undirected graph)”.

Q2). Prove or disprove: “In a complete binary tree with $N$ vertices, the number of vertices with degree 2 (or more) is greater than $N/2$”.

Basic Binary Heap Stuffs

Q3). Quick check: Let’s review all 5 basic operations of Binary Heap (use the Exploration mode of http://visualgo.net/en/heap). During the tutorial session, the tutor will randomize the Binary
Heap structure, ask student to \texttt{Insert(random-integer)}, perform \texttt{ExtractMax()} operations (or the first few steps of \texttt{HeapSort()}), and/or the \(O(N \log N)\) or the \(O(N)\) \texttt{Create(from-a-random-array)}.

More About Binary Heap Data Structure

Q4). What is the minimum and maximum number of comparisons between Binary Heap elements required to construct a Binary (Max) Heap of arbitrary \(n\) elements using the \(O(n)\) \texttt{Create(array)}? Note that this question has been integrated in VisuAlgo Online Quiz, so it may appear in future Online Quizzes :).
To help you understand the sample test case, here are the states of your troop for that test case:

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3 6</td>
</tr>
<tr>
<td>3</td>
<td>-1 6</td>
</tr>
<tr>
<td>4 5</td>
<td>→ 6 8</td>
</tr>
<tr>
<td>0 3</td>
<td></td>
</tr>
<tr>
<td>7 7</td>
<td></td>
</tr>
</tbody>
</table>

0123456789 // initial state, you have 10 soldiers, with 3 casualty reports
01236789   // after 1st report (soldiers 4 and 5 perish), 3 and 6 close gap
6789       // after 2nd report (soldiers 0, 1, 2, and 3 perish), 6 is the leftmost
689        // after 3rd report (soldiers 7 perish), 6 and 8 close gap

You can stay back and ask the tutor about any other questions that you may have to prepare you for the more challenging Midterm Test on Friday, 22 September 2017, 12.00-13.30.

**Problem Set 2**

We will end the tutorial with discussion of near-deadline PS2.