1 Introduction and Objective

The purpose of this tutorial is to reinforce the concepts of Binary Search Tree (BST) and the importance of having a balanced BST. In CS2010, we learn Adelson-Velskii Landis (AVL) Tree as one such possible balanced BST implementation.

We will also discuss various techniques that may be useful to handle Subtask C+D of PS2 during this tutorial.
2 Tutorial 03 Questions

Basic Operations of (balanced) Binary Search Tree: AVL Tree

Q1. We will start this tutorial 03 with a quick review of basic BST operations, but on a balanced BST: AVL Tree. Tutor will first open [http://visualgo.net/bst.html?mode=AVL](http://visualgo.net/bst.html?mode=AVL) click Create → Random. Then, the tutor will ask students to Search for some integers, find Successor of existing integers, perform Inorder Traversal, Insert a few random integers, and also Remove existing integers.

Q2. Draw a valid AVL Tree and nominate a vertex to be deleted such that if that vertex is deleted:
   a). No rotation happens
   b). Exactly one of the four rotation cases happens
   c). Exactly two of the four rotation cases happens (you cannot use the sample given in Lecture 04, which is [http://visualgo.net/bst.html?mode=AVL&create=8,6,16,3,7,13,19,2,11,15,18,10](http://visualgo.net/bst.html?mode=AVL&create=8,6,16,3,7,13,19,2,11,15,18,10), delete vertex 7)

Extra BST Operations

Q3. There are two important BST operations: Select and Rank that are not included in VisuAlgo yet but useful for PS2. Those operations are discussed very briefly at the end of Lecture 04. Please discuss on how to implement these two operations efficiently.

Q4. What sequence does a preorder traversal of the BST in Figure 1 yield?
   Preorder traversal is very similar to Inorder traversal that we have seen earlier in Lecture 03.
   Preorder traversal is just like this:

   PreOrder(T)
   if T is null, stop
   Visit/Process T (see, the visitation is done first)
   PreOrder(T.left)
   PreOrder(T.right)

![Figure 1: BST for Q3](image)

What about a postorder traversal of the same BST? (Select from the same options above)
Postorder traversal is just like this:
PostOrder(T)
    if T is null, stop
    PostOrder(T.left)
    PostOrder(T.right)
    Visit/Process T (see, the visitation is done last)

Think Carefully

Q5. What is the minimum number of vertices in an AVL Tree of arbitrary height \( h \)?
Note that this question has been integrated in VisuAlgo Online Quiz, so it may appear in future Online Quizzes :).

Problem Set 2

Discussion of PS2 subtask C+D.