2025-10-13

# AVL Trees

## Description

### Purpose

This project is designed to help you develop a better understanding of binary search trees and AVL trees. It requires you to manipulate trees in various ways, and to understand the different cases requiring re-balancing a tree.

### Challenge

#### In short

Our goal is improve the [second implementation of AVL tree](https://princomp.github.io/lectures/data/AVLtrees#computing-the-height-on-the-fly) and to understand it better. You will be asked to write additional methods, develop new examples, and comment your code.

#### In more details

We want to implement a more pedagogical version of AVL trees, where operations such as re-balancing are easier to observe step-by-step.

* [Start by downloading the existing implementation](https://princomp.github.io/code/projects/AVLTree_I.zip),
* Add your name in a delimited comment at the top of Program.cs,
* Observe how there is currently some illustration as to how RotateleftChild and DoubleleftChild operate, using the public methods Rotateleft and Doubleleft, when trees are unbalanced after insertion.

Your goal is to edit and expand the solution as follows:

* Inside Program.cs, illustrate similarly with Rotateright and Doubleright from IBtree how RotaterightChild and DoublerightChild operate. Create a tree by inserting values, note (in the comments) why it becomes un-balanced, and how it is possible to re-balance it using one of the aforementioned method. Create another example to illustrate the other method.
* Inside Program.cs, create a BSTree tree object that is “overall” balanced, but that has sub-tree(s) with a balance greater than or equal to 2 or less than or equal to -2.
* Create an “Improved” AVL tree class called IAVLTree that inherits from AVLTree, and contains a Depth method that computes the depth of a value: given a value of type T, the method should return the depth of the node containing this value, or -1 if this value is not in the tree. [Remember](https://stackoverflow.com/questions/2603692/what-is-the-difference-between-depth-and-height-in-a-tree) that
* The depth of a node is the number of edges from the node to the tree’s root node.
* Inside Program.cs, write a snippet of code that
  + Create an IAVLTree containing ints,
  + Insert 10 random values between 1 and 49 inside of it,
  + Ask the user to enter a number,
  + Displays the depth of the number in the tree.

**Pay attention to details**:

* Your program should catch possible exceptions.
* **Do not modify any file other than** Program.cs**, do not create any file other than** IAVLTree.cs. If you *really* need to edit some other file, *please indicate it very clearly at the beginning of* Program.cs*.*
* **Do not load any additional libraries**, in particular, **do not use C# native lists or LINQ**.

### Bonuses

Bonus points will be given if:

* (easy) Illustrate how
  + RotaterightChild,
  + RotateleftChild,
  + DoublerightChild or
  + DoubleleftChild
* operate after a tree becomes unbalanced after a **deletion** (the examples above had trees unbalanced following an **insertion**).
* (medium) Override the Insert from AVLTree in your IAVLTree class so that it uses SubtreeBalance (like Delete do). Write good test cases to make sure your method behaves as expected.

### Submission

Please, follow our [guideline on project submission](https:/princomp.github.io/projects/submission). In particular, make sure you write your name and the date in a delimited comment at the beginning of your file.