



DATA STRUCTURES

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UNIT 1

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AVL Tree



AVL tree is a self balanced binary search tree. That means, an AVL tree is also a binary search tree but it is a balanced tree. A binary tree is said to be balanced, if the difference between the heights of left and right subtrees of every node in the tree is either -1, 0 or +1. In other words, a binary tree is said to be balanced if for every node, height of its children differ by at most one. In an AVL tree, every node maintains an extra information known as **balance factor**. The AVL tree was introduced in the year of 1962 by G.M. Adelson-Velsky and E.M. Landis.

An AVL tree is defined as follows...

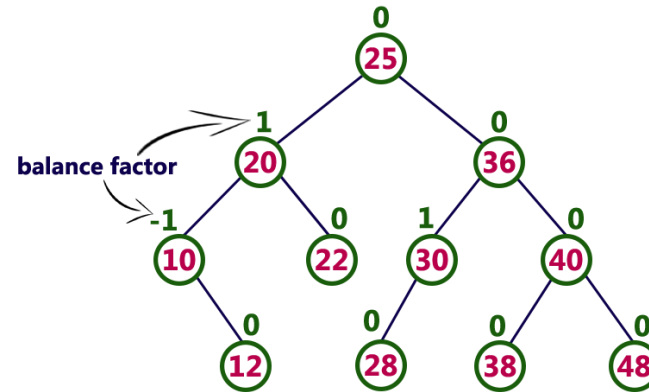
An AVL tree is a balanced binary search tree. In an AVL tree, balance factor of every node is either -1, 0 or +1.

Balance factor of a node is the difference between the heights of left and right subtrees of that node. The balance factor of a node is calculated either **height of left subtree - height of right subtree** (OR) **height of right subtree - height of left subtree**. In the following explanation, we are calculating as follows...

Balance factor = heightOfLeftSubtree - heightOfRightSubtree

Example

Queue Using Linked List
 Circular Queue
 Double Ended Queue
UNIT 3
 Tree - Terminology
 Tree Representations
 Binary Tree
 Binary Tree Representations
 Binary Tree Traversals
 Threaded Binary trees
 Priority Queue
 Max Heap
 Introduction to Graphs
 Graph Representations
 Graph Traversal - DFS
 Graph Traversal - BFS
UNIT 4
 Linear Search
 Binary Search
 Hashing
 Insertion Sort
 Selection Sort
 Radix Sort
 Quick Sort
 Heap Sort
 Comparison of Sorting Methods



The above tree is a binary search tree and every node is satisfying balance factor condition. So this tree is said to be an AVL tree.

Every AVL Tree is a binary search tree but all the Binary Search Trees need not to be AVL trees.

AVL Tree Rotations

In AVL tree, after performing every operation like insertion and deletion we need to check the **balance factor** of every node in the tree. If every node satisfies the balance factor condition then we conclude the operation otherwise we must make it balanced. We use **rotation** operations to make the tree balanced whenever the tree is becoming imbalanced due to any operation.

Rotation operations are used to make a tree balanced.

Rotation is the process of moving the nodes to either left or right to make tree balanced.

There are **four** rotations and they are classified into **two** types.

UNIT 5

Binary Search Tree

AVL Trees

B - Trees

Red - Black Trees

Splay Trees

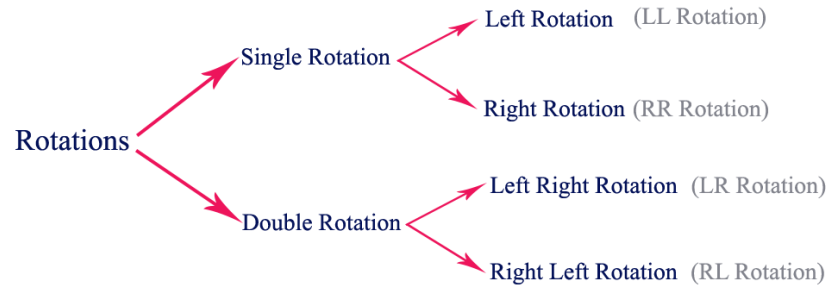
Comparison of Search

Trees

Knuth-Morris-Pratt

Algorithm

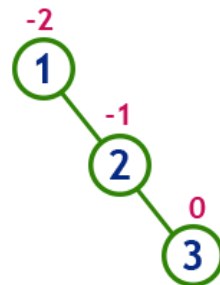
Tries



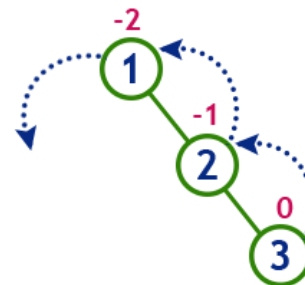
Single Left Rotation (LL Rotation)

In LL Rotation every node moves one position to left from the current position. To understand LL Rotation, let us consider following insertion operations into an AVL Tree...

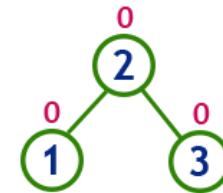
insert 1, 2 and 3



Tree is imbalanced



To make balanced we use LL Rotation which moves nodes one position to left

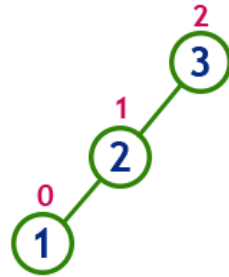


After LL Rotation Tree is Balanced

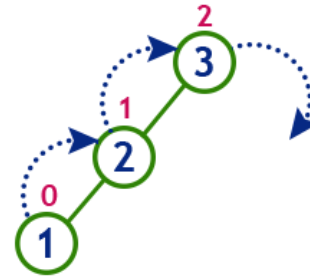
Single Right Rotation (RR Rotation)

In RR Rotation every node moves one position to right from the current position. To understand RR Rotation, let us consider following insertion operations into an AVL Tree...

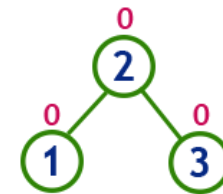
insert 3, 2 and 1



Tree is imbalanced
because node 3 has balance factor 2



To make balanced we use
RR Rotation which moves
nodes one position to right

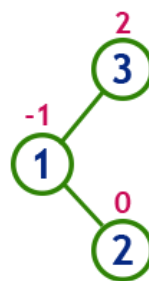


After RR Rotation
Tree is Balanced

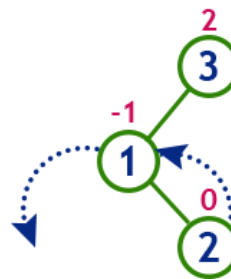
Left Right Rotation (LR Rotation)

The LR Rotation is combination of single left rotation followed by single right rotation. In LR Rotation, first every node moves one position to left then one position to right from the current position. To understand LR Rotation, let us consider following insertion operations into an AVL Tree...

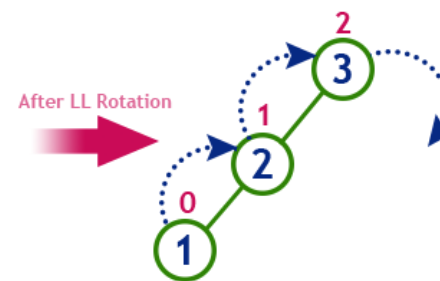
insert 3, 1 and 2



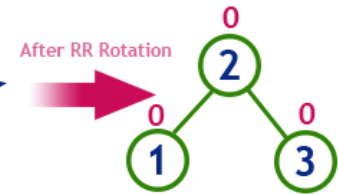
Tree is imbalanced
because node 3 has balance factor 2



LL Rotation



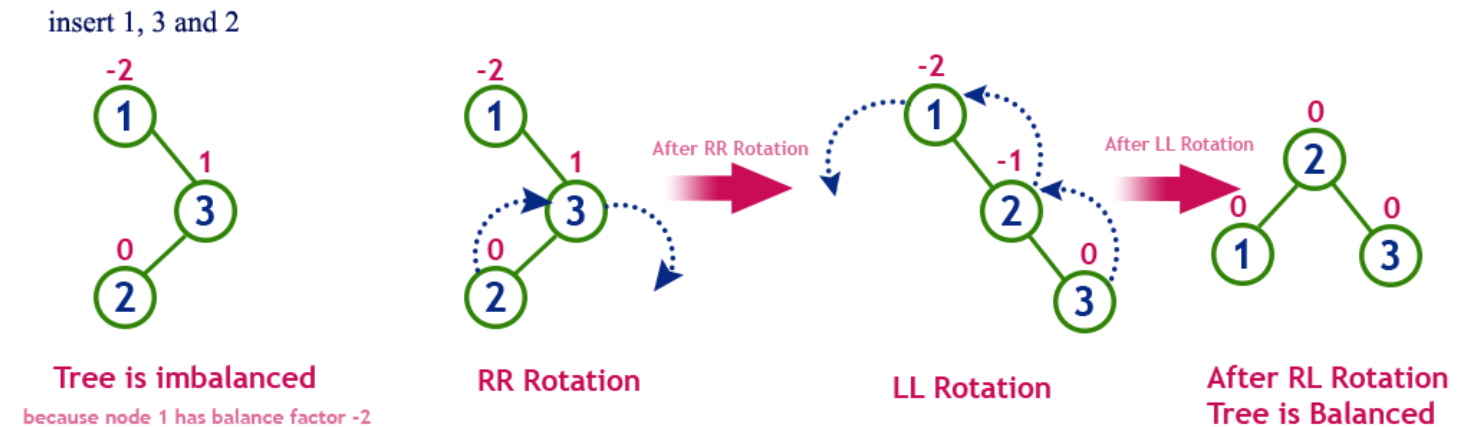
RR Rotation



After LR Rotation
Tree is Balanced

Right Left Rotation (RL Rotation)

The RL Rotation is combination of single right rotation followed by single left rotation. In RL Rotation, first every node moves one position to right then one position to left from the current position. To understand RL Rotation, let us consider following insertion operations into an AVL Tree...



Operations on an AVL Tree

The following operations are performed on an AVL tree...

1. Search
2. Insertion
3. Deletion

Search Operation in AVL Tree

In an AVL tree, the search operation is performed with $O(\log n)$ time complexity. The search operation is performed similar to Binary search tree search operation. We use the following steps to search an element in AVL tree...

Step 1: Read the search element from the user

Step 2: Compare, the search element with the value of root node in the tree.

Step 3: If both are matching, then display "Given node found!!!" and terminate the function

Step 4: If both are not matching, then check whether search element is smaller or larger than that node value.

Step 5: If search element is smaller, then continue the search process in left subtree.

Step 6: If search element is larger, then continue the search process in right subtree.

Step 7: Repeat the same until we found exact element or we completed with a leaf node

Step 8: If we reach to the node with search value, then display "Element is found" and terminate the function.

Step 9: If we reach to a leaf node and it is also not matching, then display "Element not found" and terminate the function.

Insertion Operation in AVL Tree

In an AVL tree, the insertion operation is performed with $O(\log n)$ time complexity. In AVL Tree, new node is always inserted as a leaf node. The insertion operation is performed as follows...

Step 1: Insert the new element into the tree using Binary Search Tree insertion logic.

Step 2: After insertion, check the **Balance Factor** of every node.

Step 3: If the **Balance Factor** of every node is 0 or 1 or -1 then go for next operation.

Step 4: If the **Balance Factor** of any node is other than 0 or 1 or -1 then tree is said to be imbalanced. Then perform the suitable **Rotation** to make it balanced. And go for next operation.

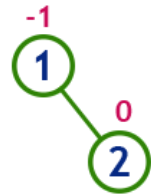
Example: Construct an AVL Tree by inserting numbers from 1 to 8.

insert 1



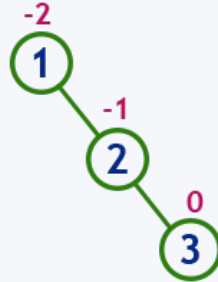
Tree is balanced

insert 2

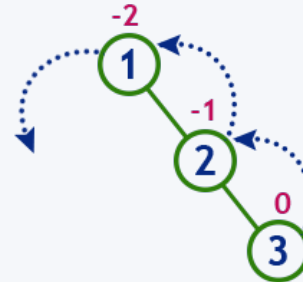


Tree is balanced

insert 3

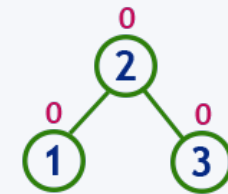


Tree is imbalanced



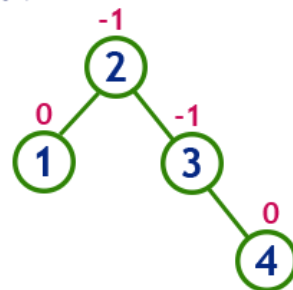
LL Rotation

After LL Rotation



Tree is balanced

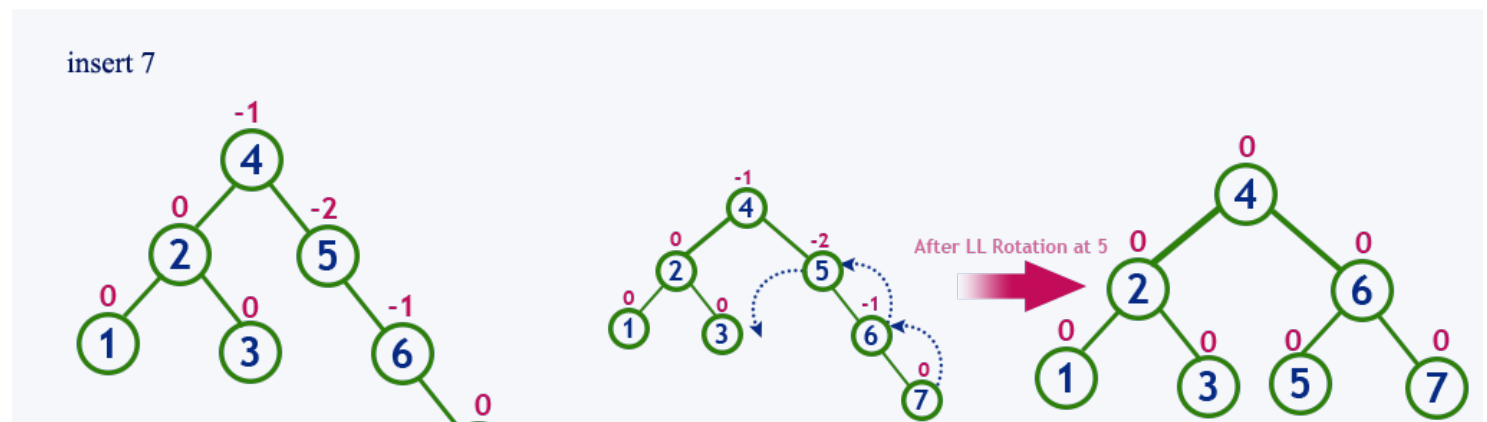
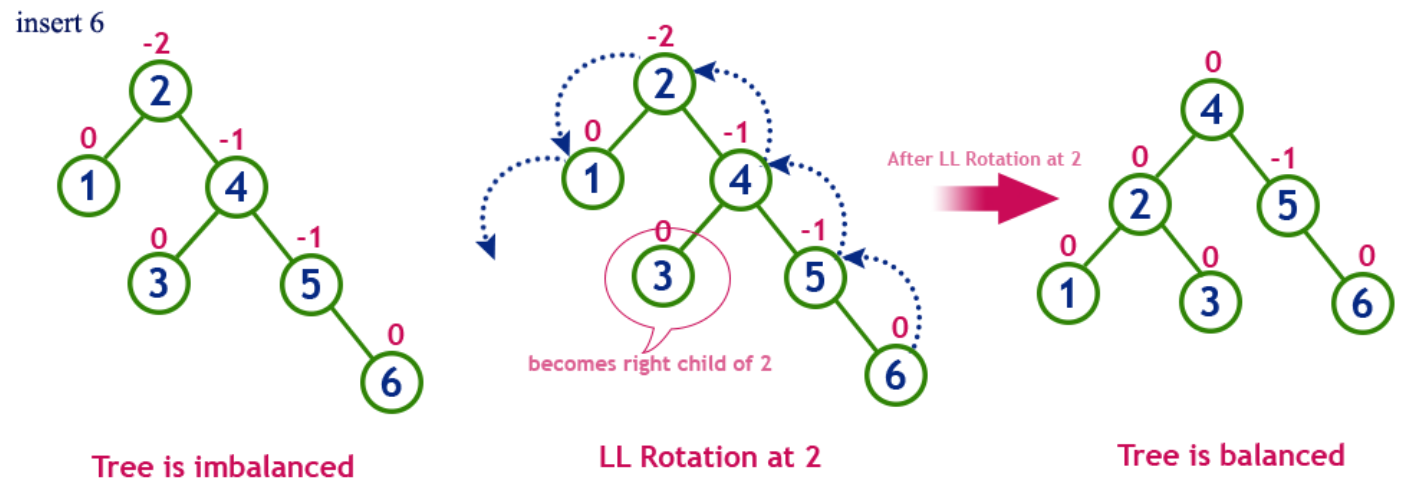
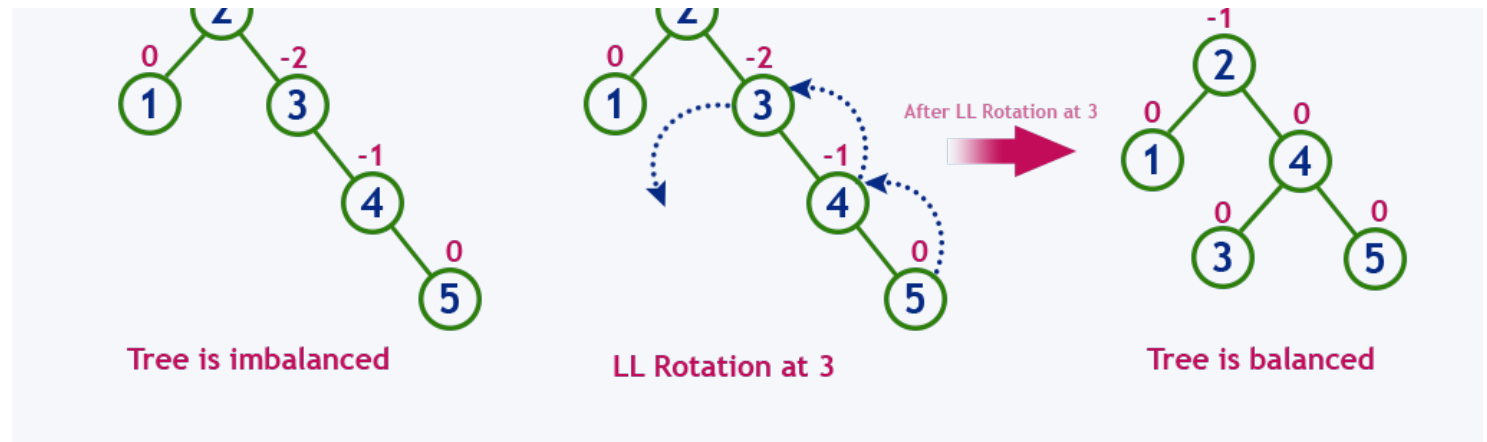
insert 4



Tree is balanced

insert 5





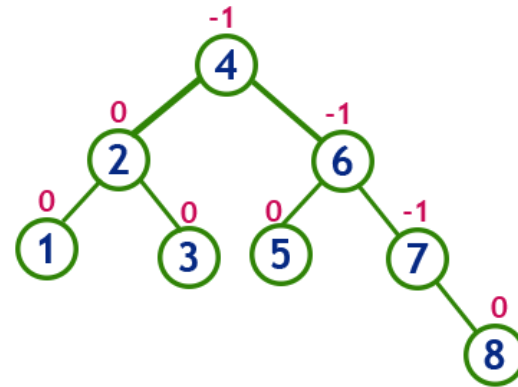
Tree is imbalanced

7

LL Rotation at 5

Tree is balanced

insert 8



Tree is balanced

Deletion Operation in AVL Tree

In an AVL Tree, the deletion operation is similar to deletion operation in BST. But after every deletion operation we need to check with the Balance Factor condition. If the tree is balanced after deletion then go for next operation otherwise perform the suitable rotation to make the tree Balanced.

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Website designed by RAJINIKANTH B