Minimum Absolute Difference in BST

Given a binary search tree with non-negative values, find the minimum absolute difference between values of any two nodes.

Example:

```
Input:

   1
    \
     3
    /
   2

Output:
1

Explanation:
The minimum absolute difference is 1, which is the difference between 2 and 1 (or b
etween 2 and 3).
```

Note: There are at least two nodes in this BST.

Solution 1

The most common idea is to first `inOrder` traverse the tree and compare the delta between each of the adjacent values. It's guaranteed to have the correct answer because it is a `BST` thus `inOrder` traversal values are `sorted`.

Solution 1 - In-Order traverse, time complexity O(N), space complexity O(1).

```
public class Solution {
    int min = Integer.MAX_VALUE;
    Integer prev = null;

    public int getMinimumDifference(TreeNode root) {
        if (root == null) return min;

        getMinimumDifference(root.left);

        if (prev != null) {
            min = Math.min(min, root.val - prev);
        }
        prev = root.val;

        getMinimumDifference(root.right);

        return min;
    }

}
```

What if it is not a `BST`? (Follow up of the problem) The idea is to put values in a TreeSet and then every time we can use `O(lgN)` time to lookup for the nearest values.

Solution 2 - Pre-Order traverse, time complexity O(NlgN), space complexity O(N).

```java
public class Solution {
    TreeSet<Integer> set = new TreeSet<>();
    int min = Integer.MAX_VALUE;

    public int getMinimumDifference(TreeNode root) {
        if (root == null) return min;

        if (!set.isEmpty()) {
            if (set.floor(root.val) != null) {
                min = Math.min(min, Math.abs(root.val - set.floor(root.val)));
            }
            if (set.ceiling(root.val) != null) {
                min = Math.min(min, Math.abs(root.val - set.ceiling(root.val)));
            }
        }

        set.add(root.val);

        getMinimumDifference(root.left);
        getMinimumDifference(root.right);

        return min;
    }
}
```

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Solution 2

In-order traversal of BST yields sorted sequence. So, we just need to subtract the previous element from the current one, and keep track of the minimum. We need O(1) memory as we only store the previous element, but we still need O(h) for the stack.

```
void inorderTraverse(TreeNode* root, int& val, int& min_dif) {
    if (root->left != NULL) inorderTraverse(root->left, val, min_dif);
    if (val >= 0) min_dif = min(min_dif, root->val - val);
    val = root->val;
    if (root->right != NULL) inorderTraverse(root->right, val, min_dif);
}
int getMinimumDifference(TreeNode* root) {
    auto min_dif = INT_MAX, val = -1;
    inorderTraverse(root, val, min_dif);
    return min_dif;
}
```

Another solution with the member variables (6 lines):

```
class Solution {
    int min_dif = INT_MAX, val = -1;
public:
int getMinimumDifference(TreeNode* root) {
    if (root->left != NULL) getMinimumDifference(root->left);
    if (val >= 0) min_dif = min(min_dif, root->val - val);
    val = root->val;
    if (root->right != NULL) getMinimumDifference(root->right);
    return min_dif;
}
```

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Solution 3

Make use of the property of BST that value of nodes is bounded by their "previous" and "next" node.

```
int minDiff = Integer.MAX_VALUE;
public int getMinimumDifference(TreeNode root) {
    helper(root,Integer.MIN_VALUE,Integer.MAX_VALUE);
    return minDiff;
}
private void helper(TreeNode curr, int lb, int rb){
    if(curr==null) return;
    if(lb!=Integer.MIN_VALUE){
        minDiff = Math.min(minDiff,curr.val - lb);
    }
    if(rb!=Integer.MAX_VALUE){
        minDiff = Math.min(minDiff,rb - curr.val);
    }
    helper(curr.left,lb,curr.val);
    helper(curr.right,curr.val,rb);
}
```

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