

Introduction to Programming and Data Structures

Binary Search Trees

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1 Basics

2 Implementation

3 Problems

Binary search trees

Definition

A binary search tree is principally a binary tree in which the following properties hold for all the nodes:

- key values in left subtree are less than the key value in the node
- key values in right subtree are greater than the key value in the node

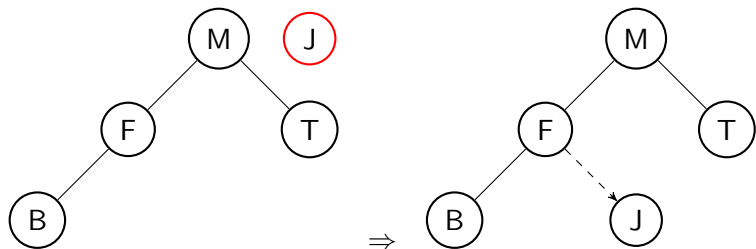
Main operations

- Insertion
- Search
- Deletion

Auxiliary operations

- Find successor
- Find predecessor

Conventional implementation – Insertion



Conventional implementation – Deletion

Let X be the node to be deleted.

Case I: X is a leaf node.

– Simply delete X .

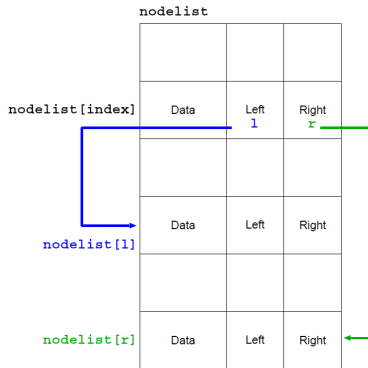
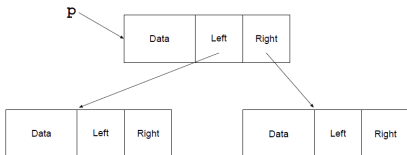
Case II: X has one child.

– Replace the link to X with a link to its only child.

Case III: X has 2 children.

- 1 Find S , the successor of X (node with the smallest key in the right subtree of X or with the largest key in the left subtree).
- 2 Replace the value in X by the value in S .
- 3 Delete node S from the tree (see Cases I and II above).

Conventional versus Alternative implementation



Alternative implementation

```
class BinarySearchTree(BST):
    # If no init is provided, the init inherited from the superclass'
    # will be called. Since that is all we're doing here, we don't
    # really need this __init__.
    # NOTE: If we do provide an __init__, that init will not
    # automatically call super().__init__()
    def __init__(self, capacity):
        super().__init__(capacity)
    def search(self, start_index, d):
        if index == -1:
            return -1
        if d < self.nodelist[index].Data:
            return self.search(self.nodelist[index].Left, d)
        elif d > self.nodelist[index].Data:
            return self.search(self.nodelist[index].Right, d)
        else:
            return index
```

Problems

- 1 Write a program which, given a pair of BSTs, print the data elements common to the two trees. For this program, assume that the data elements are integers.
- 2 Given a BST, and two numbers min , max with $\text{min} \leq \text{max}$, trim the tree so that all its elements lie in $[\text{min}, \text{max}]$. Return the root of the new, trimmed tree. Note that the root of the tree may change.
- 3 Given a binary search tree, write a program to delete the leaf nodes from the binary search tree. You can consider your own representation of the tree.