Lab_trees : Tempestuous Trees

Lab #7 – March 17 – March 28, 2021

Welcome to Lab Trees!

Course Website: https://courses.engr.illinois.edu/cs225/sp2021/assignments/

Overview

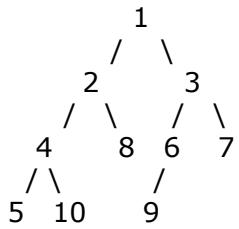
In this week's lab, you will work with binary trees, learn about tree traversals and implement them using iterators, thinking recursively while working with helper functions.

Tree Traversals

Tree traversals refer to the process of ***visiting each node in the tree data structure exactly once***. The order in which the nodes are visited determines the type of traversal:

- **Inorder:** left subtree -> current node -> right subtree (useful for checking if the tree is a Binary Search Tree)
- **Preorder:** current node -> left subtree -> right subtree (useful for copying the tree)
- **Postorder:** left subtree -> right subtree -> current node (useful for deleting the tree)

Exercise 1.1: What will an Inorder traversal of the following tree print out if we start at the root (node **1**)??



Inorder traversal: 5 4 10 2 8 1 9 6 3 7

Exercise 1.2: Write the printInOrder() function. The function should print the values of the nodes in in-order traversal to the standard out.

tree.h

```
1  #pragma once
2  class Tree {
3    public:
4        struct Node {
5              int value;
6              Node* left;
7              Node* right;
8              Node(int value = 0, Node left = NULL,
9              Node right = NULL):
10             value(value),left(left),right(right){}
11       };
12       Node* root;
13       int findLargest();
14       void printInOrder(const Node* subRoot) const;
15
16   private:
         int findLargest(const Node* subRoot) const;
};
```

tree.cpp

```
1  #include "tree.h"
2  void Tree::printInOrder(const Node* subRoot) const
3  {
4    //YOUR CODE HERE
5    if(subRoot == NULL) {
6      return;
7    }
8    printInOrder(subRoot->left);
9    cout << subRoot->value << " ";
10   printInOrder(subRoot->right);
11 }
```

Exercise 1.3: What is the worst case running time (in big O) of the following operations, assuming you start at the root node?

Printing the value of the root node	**O(1)**
Printing the value of any leaf node	**O(h)**
Finding the node with the largest value	**O(n)**

Using a Helper Function

When using recursive functions, we would like the externally used function call to directly call the functions on their object without needing to know/provide information about subproblems and parameters. This is why we use helper functions: they allow us to pass in parameters, separately handle the subproblems, and make our code much more user-friendly and readable.

Exercise 2: Now that we know the runtime of finding the largest value in a binary tree from the previous exercise, write a function that will find the largest node value. In the code below, findLargest() is a public member function of the Tree class introduced in **Exercise 1**. Assume the values are non-negative.

tree.cpp (CONTINUED)

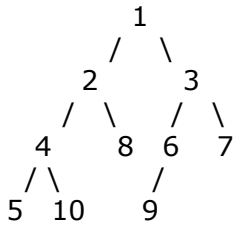
```
1  int Tree::findLargest() {
2    if (root != NULL) {
3     return findLargest(root);
4    }
5    else {
6      return -1; // Assume all values are non-
7  negative
8    }
9  }
10
11 int Tree::findLargest(const Node* subRoot) const{
12  int currentMax = subRoot->value;
13  if (subRoot->left!=NULL){
14    currentMax = std::max(currentMax,
15                     findLargest(subRoot->left));
16  }
17  if (subRoot->right!=NULL){
18    currentMax = std::max(currentMax,
19                     findLargest(subRoot->right));
20  }
21  return currentMax;
22 }
```

Iterators

In the previous exercise, we saw how to traverse trees using recursion. Another way to do this is by using a temporary data structure such as a **stack** to keep track of where we are as we traverse the tree. You will use this method when implementing tree traversal iterator classes in the coding part of this lab.

Exercise 3.1: Fill in the blanks in this pseudo code implementation of Inorder traversal using a stack as a placeholder for the traversal.

```
1) Create an empty stack S.
2) Initialize current node as root
3) Until current = NULL, push current node to S and set
   current = current->left
4) If current = NULL and S is not empty then
   a) Print the top item in the stack
   b) Set current = top_item->right
   c) Pop the top item from stack
   d) Go to step 3
5) If current = NULL and S is empty then we are done
```



Exercise 3.2: Suppose we run this pseudo code on the tree above, what does the stack **S** look like when **current** is pointing to node **9**?

S =