02 traverse_a_tree_dfs_solution

May 4, 2020

0.1 Traverse a tree (depth first search)

Traversing a tree means "visiting" all the nodes in the tree once. Unlike an array or linked list, there's more than one way to walk through a tree, starting from the root node.

Traversing a tree is helpful for printing out all the values stored in the tree, as well as searching for a value in a tree, inserting into or deleting values from the tree. There's depth first search and breadth first search.

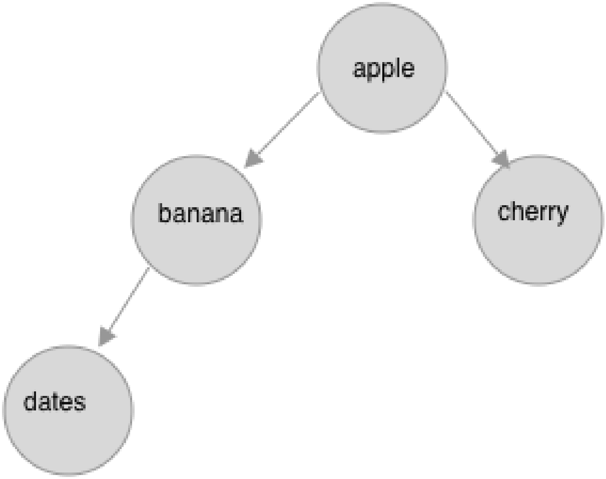
Depth first search has 3 types: pre-order, in-order, and post-order.

Let's walk through pre-order traversal by hand first, and then try it out in code.

0.2 Creating a sample tree

We'll create a tree that looks like the following:

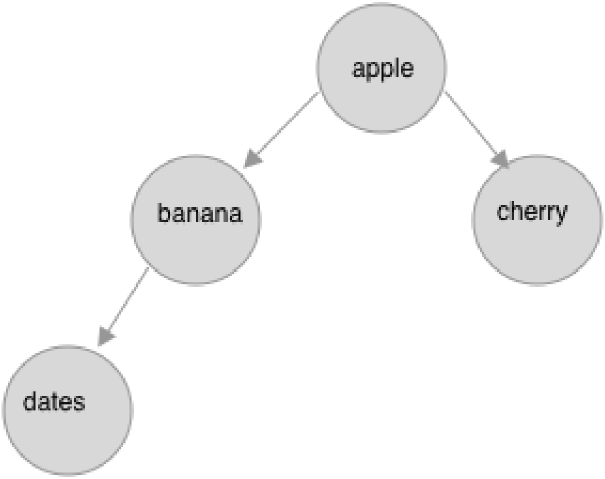
```
In [ ]: # this code makes the tree that we'll traverse

        class Node(object):

            def __init__(self,value = None):
                self.value = value
                self.left = None
                self.right = None

            def set_value(self,value):
                self.value = value

            def get_value(self):
                return self.value

            def set_left_child(self,left):
                self.left = left

            def set_right_child(self, right):
                self.right = right

            def get_left_child(self):
                return self.left
```



tree image

```
    def get_right_child(self):
        return self.right

    def has_left_child(self):
        return self.left != None

    def has_right_child(self):
        return self.right != None

    # define __repr_ to decide what a print statement displays for a Node object
    def __repr__(self):
        return f"Node({self.get_value()})"

    def __str__(self):
        return f"Node({self.get_value()})"


class Tree():
    def __init__(self, value=None):
        self.root = Node(value)

    def get_root(self):
        return self.root
```

```
In [ ]: # create a tree and add some nodes
        tree = Tree("apple")
        tree.get_root().set_left_child(Node("banana"))
        tree.get_root().set_right_child(Node("cherry"))
        tree.get_root().get_left_child().set_left_child(Node("dates"))
```



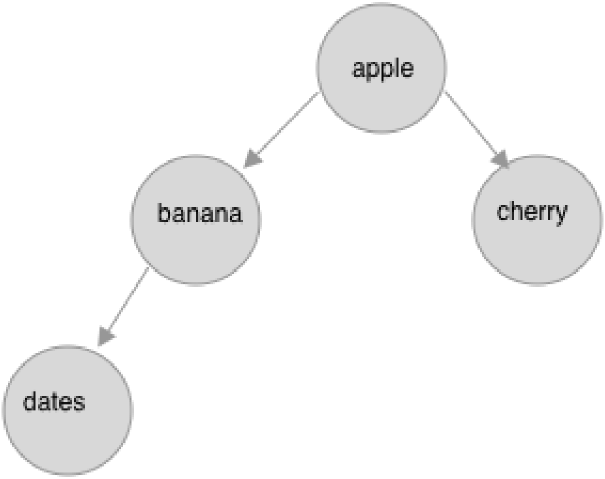
tree image

0.3 Depth first, pre-order traversal

pre-order traversal of the tree would visit the nodes in this order:
    apple, banana, dates, cherry

Stack Notice how we're retracing our steps. It's like we are hiking on a trail, and trying to retrace our steps on the way back. This is an indication that we should use a stack.

```
In [ ]: # Let's define a stack to help keep track of the tree nodes
        class Stack():
            def __init__(self):
                self.list = list()

            def push(self,value):
                self.list.append(value)

            def pop(self):
                return self.list.pop()

            def top(self):
                if len(self.list) > 0:
                    return self.list[-1]
                else:
                    return None

            def is_empty(self):
                return len(self.list) == 0

            def __repr__(self):
                if len(self.list) > 0:
                    s = "<top of stack>\n_________________\n"
                    s += "\n_________________\n".join([str(item) for item in self.list[::-1]])
```



tree image

```
            s += "\n_________________\n<bottom of stack>"
            return s

        else:
            return "<stack is empty>"
```

```
In [ ]: # check Stack
        stack = Stack()
        stack.push("apple")
        stack.push("banana")
        stack.push("cherry")
        stack.push("dates")
        print(stack.pop())
        print("\n")
        print(stack)
```

0.4 Walk through the steps with code

We're going to translate what we're doing by hand into code, one step at a time. This will help us check if our code is doing what we expect it to do.

```
In [ ]: visit_order = list()
        stack = Stack()

        # start at the root node, visit it and then add it to the stack
        node = tree.get_root()
        visit_order.append(node.get_value())
        stack.push(node)

        print(f"""
        visit_order {visit_order}
        stack:
```

```
        {stack}
        """)
```

```
In [ ]: # check if apple has a left child
        print(f"{node} has left child? {node.has_left_child()}")

        # since apple has a left child (banana)
        # we'll visit banana and add it to the stack
        if( node.has_left_child()):
            node = node.get_left_child()
            print(f"visit {node}")
            visit_order.append(node.get_value())
            stack.push(node)

        print(f"""
        visit_order {visit_order}
        stack:
        {stack}
        """)
```

```
In [ ]: # check if banana has a left child
        print(f"{node} has left child? {node.has_left_child()}")

        # since banana has a left child "dates"
        # we'll visit "dates" and add it to the stack
        if( node.has_left_child()):
            node = node.get_left_child()
            print(f"visit {node}")
            visit_order.append(node.get_value())
            stack.push(node)

        print(f"""
        visit_order {visit_order}
        stack:
        {stack}
        """)
```

```
In [ ]: # check if "dates" has a left child
        print(f"{node} has left child? {node.has_left_child()}")
```

```
In [ ]: # since dates doesn't have a left child, we'll check if it has a right child
        print(f"{node} has right child? {node.has_right_child()}")
```

```
In [ ]: # since "dates" is a leaf node (has no children), we can start to retrace our steps
        # in other words, we can pop it off the stack.
        print(stack.pop())
```

```
In [ ]: stack
In [ ]: # now we'll set the node to the new top of the stack, which is banana
        node = stack.top()
        print(node)
```

```
In [ ]: # we already checked for banana's left child, so we'll check for its right child
        print(f"{node} has right child? {node.has_right_child()}")
```

```
In [ ]: # banana doesn't have a right child, so we're also done tracking it.
        # so we can pop banana off the stack
        print(f"pop {stack.pop()} off stack")
        print(f"""
        stack
        {stack}
        """)
```

```
In [ ]: # now we'll track the new top of the stack, which is apple
        node = stack.top()
        print(node)
```

```
In [ ]: # we've already checked if apple has a left child; we'll check if it has a right child
        print(f"{node} has right child? {node.has_right_child()}")
```

```
In [ ]: # since it has a right child (cherry),
        # we'll visit cherry and add it to the stack.
        if node.has_right_child():
            node = node.get_right_child()
            print(f"visit {node}")
            visit_order.append(node.get_value())
            stack.push(node)

        print(f"""
        visit_order {visit_order}
        stack
        {stack}
        """)
```

```
In [ ]: # Now we'll check if cherry has a left child
        print(f"{node} has left child? {node.has_left_child()}")

        # it doesn't, so we'll check if it has a right child
        print(f"{node} has right child? {node.has_right_child()}")
```

```
In [ ]: # since cherry has neither left nor right child nodes,
        # we are done tracking it, and can pop it off the stack

        print(f"pop {stack.pop()} off the stack")

        print(f"""
        visit_order {visit_order}
        stack
        {stack}
        """)
```

```
In [ ]: # now we're back to apple at the top of the stack.
        # since we've already checked apple's left and right child nodes,
        # we can pop apple off the stack

        print(f"pop {stack.pop()} off stack")
        print(f"pre-order traversal visited nodes in this order: {visit_order}")
```

```
In [ ]: print(f"""stack
        {stack}""")
```

0.5 pre-order traversal using a stack (something's missing)

Here is some code that has an error, so it will have an infinite loop. There is a counter to make the loop stop so that it doesn't run forever.

```
In [ ]: def pre_order_with_stack_buggy(tree):
            visit_order = list()
            stack = Stack()
            node = tree.get_root()
            visit_order.append(node.get_value())
            stack.push(node)
            count = 0
            loop_limit = 7
            while(node and count < loop_limit):
                print(f"""
        loop count: {count}
        current node: {node}
        stack:
        {stack}
                """)
                count +=1
                if node.has_left_child():
                    node = node.get_left_child()
                    visit_order.append(node.get_value())
                    stack.push(node)

                elif node.has_right_child():
                    node = node.get_right_child()
                    visit_order.append(node.get_value())
                    stack.push(node)

                else:
                    stack.pop()
                    if not stack.is_empty():
                        node = stack.top()
                    else:
                        node = None


            return visit_order
```

```
In [ ]: pre_order_with_stack_buggy(tree)
```

```
In [ ]:
```

0.6 pre-order traversal using a stack, tracking state

Here's how we implement DFS with a stack, where we also track whether we've already visited the left or right child of the node.

```
In [ ]: class State(object):
            def __init__(self,node):
                self.node = node
                self.visited_left = False
                self.visited_right = False

            def get_node(self):
                return self.node

            def get_visited_left(self):
                return self.visited_left

            def get_visited_right(self):
                return self.visited_right

            def set_visited_left(self):
                self.visited_left = True

            def set_visited_right(self):
                self.visited_right = True

            def __repr__(self):
                s = f"""{self.node}
        visited_left: {self.visited_left}
        visited_right: {self.visited_right}
                """
                return s
```

```
In [ ]: def pre_order_with_stack(tree, debug_mode=False):
            visit_order = list()
            stack = Stack()
            node = tree.get_root()
            visit_order.append(node.get_value())
            state = State(node)
```

```
    stack.push(state)
    count = 0
    while(node):
        if debug_mode:
            print(f"""
loop count: {count}
current node: {node}
stack:
{stack}
            """)
        count +=1
        if node.has_left_child() and not state.get_visited_left():
            state.set_visited_left()
            node = node.get_left_child()
            visit_order.append(node.get_value())
            state = State(node)
            stack.push(state)

        elif node.has_right_child() and not state.get_visited_right():
            state.set_visited_right()
            node = node.get_right_child()
            visit_order.append(node.get_value())
            state = State(node)

        else:
            stack.pop()
            if not stack.is_empty():
                state = stack.top()
                node = state.get_node()
            else:
                node = None

    if debug_mode:
            print(f"""
loop count: {count}
current node: {node}
stack:
{stack}
            """)
    return visit_order
```

```
In [ ]: # check pre-order traversal

        pre_order_with_stack(tree, debug_mode=True)
```

0.7 task 01: pre-order traversal with recursion

Use recursion and perform pre_order traversal.

```
In [ ]: def pre_order(tree):

            visit_order = list()

            def traverse(node):
                if node:
                    # visit the node
                    visit_order.append(node.get_value())

                    # traverse left subtree
                    traverse(node.get_left_child())

                    # traverse right subtree
                    traverse(node.get_right_child())

            traverse(tree.get_root())

            return visit_order
```

```
In [ ]: pre_order(tree)
```

0.8 Task: do in-order traversal

We want to traverse the left subtree, then visit the node, and then traverse the right subtree. **hint**: it's very similar in structure to the pre-order traversal.

```
In [ ]: # define in-order traversal
```

```
In [ ]: # solution
        def in_order(tree):

            visit_order = list()

            def traverse(node):
                if node:
                    # traverse left subtree
                    traverse(node.get_left_child())

                    # visit node
                    visit_order.append(node.get_value())

                    # traverse right sub-tree
                    traverse(node.get_right_child())

            traverse(tree.get_root())

            return visit_order
```

```
In [ ]: # check solution: should get: ['dates', 'banana', 'apple', 'cherry']
        in_order(tree)
```

0.9 Task: post-order traversal

Traverse left subtree, then right subtree, and then visit the node.

```
In [ ]: # define post_order traversal
```

```
In [ ]: # solution
        def post_order(tree):

            visit_order = list()

            def traverse(node):
                if node:
                    # traverse left subtree
                    traverse(node.get_left_child())

                    # traverse right subtree
                    traverse(node.get_right_child())

                    # visit node
                    visit_order.append(node.get_value())

            traverse(tree.get_root())

            return visit_order
```

```
In [ ]: # check solution: should get: ['dates', 'banana', 'cherry', 'apple']
        post_order(tree)
```

```
In [ ]:
```