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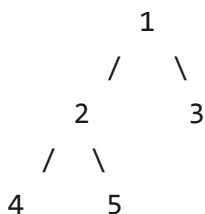


Inorder Tree Traversal without Recursion

Using **Stack** is the obvious way to traverse tree without recursion. Below is an algorithm for traversing binary tree using stack. See [this](#) for step wise step execution of the algorithm.

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

Let us consider the below tree for example



Step 1 Creates an empty stack: S = NULL

Step 2 sets current as address of root: current -> 1



Step 3 Pushes the current node and set current = current->left until current
current -> 1
push 1: Stack S -> 1
current -> 2
push 2: Stack S -> 2, 1
current -> 4
push 4: Stack S -> 4, 2, 1
current = NULL

Step 4 pops from S
a) Pop 4: Stack S -> 2, 1
b) print "4"
c) current = NULL /*right of 4 */ and go to step 3
Since current is NULL step 3 doesn't do anything.

Step 4 pops again.
a) Pop 2: Stack S -> 1
b) print "2"
c) current -> 5/*right of 2 */ and go to step 3

Step 3 pushes 5 to stack and makes current NULL
Stack S -> 5, 1
current = NULL

Step 4 pops from S
a) Pop 5: Stack S -> 1
b) print "5"
c) current = NULL /*right of 5 */ and go to step 3
Since current is NULL step 3 doesn't do anything

Step 4 pops again.
a) Pop 1: Stack S -> NULL
b) print "1"
c) current -> 3 /*right of 5 */

Step 3 pushes 3 to stack and makes current NULL
Stack S -> 3
current = NULL

Step 4 pops from S
a) Pop 3: Stack S -> NULL
b) print "3"



c) current = NULL /*right of 3 */

Traversal is done now as stack S is empty and current is NULL.

C++

```
// C++ program to print inorder traversal
// using stack.
#include<bits/stdc++.h>
using namespace std;

/* A binary tree Node has data, pointer to left child
   and a pointer to right child */
struct Node
{
    int data;
    struct Node* left;
    struct Node* right;
    Node (int data)
    {
        this->data = data;
        left = right = NULL;
    }
};

/* Iterative function for inorder tree
   traversal */
void inOrder(struct Node *root)
{
    stack<Node *> s;
    Node *curr = root;

    while (curr != NULL || s.empty() == false)
    {
        /* Reach the left most Node of the
           curr Node */
        while (curr != NULL)
        {
            /* place pointer to a tree node on
               the stack before traversing
               the node's left subtree */
            s.push(curr);
            curr = curr->left;
        }

        /* Current must be NULL at this point */
        curr = s.top();
        s.pop();

        cout << curr->data << " ";

        /* we have visited the node and its
```



```

        left subtree. Now, it's right
        subtree's turn */
        curr = curr->right;

    } /* end of while */
}

/* Driver program to test above functions*/
int main()
{
    /* Constructed binary tree is
        1
       / \
      2   3
     / \
    4   5
    */
    struct Node *root = new Node(1);
    root->left = new Node(2);
    root->right = new Node(3);
    root->left->left = new Node(4);
    root->left->right = new Node(5);

    inOrder(root);
    return 0;
}

```

C

```

#include<stdio.h>
#include<stdlib.h>
#define bool int

/* A binary tree tNode has data, pointer to left child
   and a pointer to right child */
struct tNode
{
    int data;
    struct tNode* left;
    struct tNode* right;
};

/* Structure of a stack node. Linked List implementation is used for
   stack. A stack node contains a pointer to tree node and a pointer to
   next stack node */
struct sNode
{
    struct tNode *t;
    struct sNode *next;
};

```



```

/* Stack related functions */
void push(struct sNode** top_ref, struct tNode *t);
struct tNode *pop(struct sNode** top_ref);
bool isEmpty(struct sNode *top);

/* Iterative function for inorder tree traversal */
void inOrder(struct tNode *root)
{
    /* set current to root of binary tree */
    struct tNode *current = root;
    struct sNode *s = NULL; /* Initialize stack s */
    bool done = 0;

    while (!done)
    {
        /* Reach the left most tNode of the current tNode */
        if(current != NULL)
        {
            /* place pointer to a tree node on the stack before traversing
            the node's left subtree */
            push(&s, current);
            current = current->left;
        }

        /* backtrack from the empty subtree and visit the tNode
        at the top of the stack; however, if the stack is empty,
        you are done */
        else
        {
            if (!isEmpty(s))
            {
                current = pop(&s);
                printf("%d ", current->data);

                /* we have visited the node and its left subtree.
                Now, it's right subtree's turn */
                current = current->right;
            }
            else
            {
                done = 1;
            }
        }
    } /* end of while */
}

/* UTILITY FUNCTIONS */
/* Function to push an item to sNode*/
void push(struct sNode** top_ref, struct tNode *t)
{
    /* allocate tNode */
    struct sNode* new_tNode =
        (struct sNode*) malloc(sizeof(struct sNode));

    if(new_tNode == NULL)
    {

```



```

        printf("Stack Overflow \n");
        getchar();
        exit(0);
    }

    /* put in the data */
    new_tNode->t = t;

    /* link the old list off the new tNode */
    new_tNode->next = (*top_ref);

    /* move the head to point to the new tNode */
    (*top_ref) = new_tNode;
}

/* The function returns true if stack is empty, otherwise false */
bool isEmpty(struct sNode *top)
{
    return (top == NULL)? 1 : 0;
}

/* Function to pop an item from stack*/
struct tNode *pop(struct sNode** top_ref)
{
    struct tNode *res;
    struct sNode *top;

    /*If sNode is empty then error */
    if(isEmpty(*top_ref))
    {
        printf("Stack Underflow \n");
        getchar();
        exit(0);
    }
    else
    {
        top = *top_ref;
        res = top->t;
        *top_ref = top->next;
        free(top);
        return res;
    }
}

/* Helper function that allocates a new tNode with the
   given data and NULL left and right pointers. */
struct tNode* newtNode(int data)
{
    struct tNode* tNode = (struct tNode*)
                           malloc(sizeof(struct tNode));
    tNode->data = data;
    tNode->left = NULL;
    tNode->right = NULL;
}

```



```

    return(tNode);
}

/* Driver program to test above functions*/
int main()
{
    /* Constructed binary tree is
        1
       / \
      2   3
     / \
    4   5
    */
    struct tNode *root = newtNode(1);
    root->left      = newtNode(2);
    root->right     = newtNode(3);
    root->left->left = newtNode(4);
    root->left->right = newtNode(5);

    inOrder(root);

    getch();
    return 0;
}

```

Java

```

// non-recursive java program for inorder traversal
import java.util.Stack;

/* Class containing left and right child of
current node and key value*/
class Node
{
    int data;
    Node left, right;

    public Node(int item)
    {
        data = item;
        left = right = null;
    }
}

/* Class to print the inorder traversal */
class BinaryTree
{
    Node root;

    void inorder()
    {
        if (root == null)

```

```

        return;

Stack<Node> s = new Stack<Node>();
Node curr = root;

// traverse the tree
while (curr != null || s.size() > 0)
{
    /* Reach the left most Node of the
    curr Node */
    while (curr != null)
    {
        /* place pointer to a tree node on
        the stack before traversing
        the node's left subtree */
        s.push(curr);
        curr = curr.left;
    }

    /* Current must be NULL at this point */
    curr = s.pop();

    System.out.print(curr.data + " ");

    /* we have visited the node and its
    left subtree. Now, it's right
    subtree's turn */
    curr = curr.right;
}

}

public static void main(String args[])
{
    /* creating a binary tree and entering
    the nodes */
    BinaryTree tree = new BinaryTree();
    tree.root = new Node(1);
    tree.root.left = new Node(2);
    tree.root.right = new Node(3);
    tree.root.left.left = new Node(4);
    tree.root.left.right = new Node(5);
    tree.inorder();
}
}

```

Python

Python program to do inorder traversal without recursion




```

# A binary tree node
class Node:

    # Constructor to create a new node
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Iterative function for inorder tree traversal
def inOrder(root):

    # Set current to root of binary tree
    current = root
    stack = [] # initialize stack
    done = 0

    while True:

        # Reach the left most Node of the current Node
        if current is not None:

            # Place pointer to a tree node on the stack
            # before traversing the node's left subtree
            stack.append(current)

            current = current.left

        # BackTrack from the empty subtree and visit the Node
        # at the top of the stack; however, if the stack is
        # empty you are done
        elif(stack):
            current = stack.pop()
            print(current.data, end=" ") # Python 3 printing

            # We have visited the node and its left
            # subtree. Now, it's right subtree's turn
            current = current.right

        else:
            break

    print()

# Driver program to test above function

""" Constructed binary tree is
      1
     / \
    2   3
   / \
  4   5 """

```



```
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
```

```
inOrder(root)
```

```
# This code is contributed by Nikhil Kumar Singh(nickzuck_007)
```

C#

```
// Non-recursive C# program for inorder traversal
```

```
using System;
using System.Collections.Generic;
```

```
/* Class containing left and right child of
current node and key value*/
```

```
public class Node
{
    public int data;
    public Node left, right;

    public Node(int item)
    {
        data = item;
        left = right = null;
    }
}
```

```
/* Class to print the inorder traversal */
```

```
public class BinaryTree
{
    public Node root;
    public virtual void inorder()
    {
        if (root == null)
        {
            return;
        }

        Stack<Node> s = new Stack<Node>();
        Node curr = root;

        // traverse the tree
        while (curr != null || s.Count > 0)
        {
            /* Reach the left most Node of the
            curr Node */
```

```

        while (curr != null)
        {
            /* place pointer to a tree node on
               the stack before traversing
               the node's left subtree */
            s.Push(curr);
            curr = curr.left;
        }

        /* Current must be NULL at this point */
        curr = s.Pop();

        Console.Write(curr.data + " ");

        /* we have visited the node and its
           left subtree. Now, it's right
           subtree's turn */
        curr = curr.right;
    }
}

public static void Main(string[] args)
{
    /* creating a binary tree and entering
       the nodes */
    BinaryTree tree = new BinaryTree();
    tree.root = new Node(1);
    tree.root.left = new Node(2);
    tree.root.right = new Node(3);
    tree.root.left.left = new Node(4);
    tree.root.left.right = new Node(5);
    tree.inorder();
}

// This code is contributed by Shrikant13

```

Output:

4 2 5 1 3

Time Complexity: O(n)



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References:

<http://web.cs.wpi.edu/~cs2005/common/iterative.inorder>

<http://neural.cs.nthu.edu.tw/jang/courses/cs2351/slide/animation/Iterative%20Inorder%20Traversal.pps>

See [this post](#) for another approach of Inorder Tree Traversal without recursion and without stack!

Please write comments if you find any bug in above code/algorithm, or want to share more information about stack based Inorder Tree Traversal.

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