Iterative Postorder Traversal | Set 1 (Using Two Stacks)

We have discussed iterative inorder and iterative preorder traversals. In this post, iterative postorder traversal is discussed which is more complex than the other two traversals (due to its nature of non-tail recursion, there is an extra statement after the final recursive call to itself). The postorder traversal can easily be done using two stacks though. The idea is to push reverse postorder traversal to a stack. Once we have reverse postorder traversal in a stack, we can just pop all items one by one from the stack and print them, this order of printing will be in postorder because of LIFO property of stacks. Now the question is, how to get reverse post order elements in a stack – the other stack is used for this purpose. For example, in the following tree, we need to get 1, 3, 7, 6, 2, 5, 4 in a stack. If take a closer look at this sequence, we can observe that this sequence is very similar to preorder traversal. The only difference is right child is visited before left child and therefore sequence is "root right left" instead of "root left right". So we can do something like iterative preorder traversal with following differences.

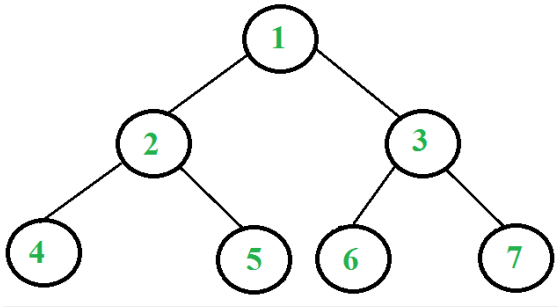
a) Instead of printing an item, we push it to a stack.

b) We push left subtree before right subtree.

Following is the complete algorithm. After step 2, we get reverse postorder traversal in second stack. We use first stack to get this order.

```
1. Push root to first stack.
2. Loop while first stack is not empty
   2.1 Pop a node from first stack and push it to second stack
   2.2 Push left and right children of the popped node to first stack
3. Print contents of second stack
```

Let us consider the following tree



Following are the steps to print postorder traversal of the above tree using two stacks.

```
1. Push 1 to first stack.
      First stack: 1
      Second stack: Empty

2. Pop 1 from first stack and push it to second stack.
   Push left and right children of 1 to first stack
      First stack: 2, 3
      Second stack: 1

3. Pop 3 from first stack and push it to second stack.
   Push left and right children of 3 to first stack
      First stack: 2, 6, 7
      Second stack:1, 3

4. Pop 7 from first stack and push it to second stack.
      First stack: 2, 6
      Second stack:1, 3, 7

5. Pop 6 from first stack and push it to second stack.
      First stack: 2
      Second stack:1, 3, 7, 6

6. Pop 2 from first stack and push it to second stack.
   Push left and right children of 2 to first stack
      First stack: 4, 5
      Second stack:1, 3, 7, 6, 2

7. Pop 5 from first stack and push it to second stack.
      First stack: 4
      Second stack: 1, 3, 7, 6, 2, 5

8. Pop 4 from first stack and push it to second stack.
      First stack: Empty
      Second stack: 1, 3, 7, 6, 2, 5, 4

The algorithm stops since there is no more item in first stack.
Observe that content of second stack is in postorder fashion. Print them.
```

Following is C implementation of iterative postorder traversal using two stacks.

C

```
#include <stdio.h>
#include <stdlib.h>

// Maximum stack size
#define MAX_SIZE 100

// A tree node
struct Node
{
    int data;
    struct Node *left, *right;
};

// Stack type
struct Stack
{
    int size;
    int top;
    struct Node* *array;
};

// A utility function to create a new tree node
struct Node* newNode(int data)
{
    struct Node* node = (struct Node*) malloc(sizeof(struct Node));
    node->data = data;
    node->left = node->right = NULL;
    return node;
```

```
}

// A utility function to create a stack of given size
struct Stack* createStack(int size)
{
    struct Stack* stack =
            (struct Stack*) malloc(sizeof(struct Stack));
    stack->size = size;
    stack->top = -1;
    stack->array =
           (struct Node**) malloc(stack->size * sizeof(struct Node*));
    return stack;
}

// BASIC OPERATIONS OF STACK
int isFull(struct Stack* stack)
{  return stack->top - 1 == stack->size; }

int isEmpty(struct Stack* stack)
{  return stack->top == -1;  }

void push(struct Stack* stack, struct Node* node)
{
    if (isFull(stack))
        return;
    stack->array[++stack->top] = node;
}

struct Node* pop(struct Stack* stack)
{
    if (isEmpty(stack))
        return NULL;
    return stack->array[stack->top--];
}

// An iterative function to do post order traversal of a given binary tree
void postOrderIterative(struct Node* root)
{
    // Create two stacks
    struct Stack* s1 = createStack(MAX_SIZE);
    struct Stack* s2 = createStack(MAX_SIZE);

    // push root to first stack
    push(s1, root);
    struct Node* node;

    // Run while first stack is not empty
    while (!isEmpty(s1))
    {
        // Pop an item from s1 and push it to s2
        node = pop(s1);
        push(s2, node);

        // Push left and right children of removed item to s1
        if (node->left)
            push(s1, node->left);
        if (node->right)
            push(s1, node->right);
    }

    // Print all elements of second stack
    while (!isEmpty(s2))
    {
        node = pop(s2);
        printf("%d ", node->data);
    }
}

// Driver program to test above functions
int main()
{
    // Let us construct the tree shown in above figure
    struct Node* root = NULL;
```

```
    struct Node* root = NULL;
    root = newNode(1);
    root->left = newNode(2);
    root->right = newNode(3);
    root->left->left = newNode(4);
    root->left->right = newNode(5);
    root->right->left = newNode(6);
    root->right->right = newNode(7);

    postOrderIterative(root);

    return 0;
}
```

Python

```
# Python porgram for iterative postorder traversal using
# two stacks

# 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

# An iterative function to do postorder traversal of a
# given binary tree
def postOrderIterative(root):

    # Create two stacks
    s1 = []
    s2 = []

    # Push root to first stack
    s1.append(root)

    # Run while first stack is not empty
    while(len(s1) >0):

        # Pop an item from s1 and append it to s2
        node = s1.pop()
        s2.append(node)

        # Push left and right children of removed item to s1
        if node.left is not None:
            s1.append(node.left)
        if node.right is not None :
            s1.append(node.right)

        # Print all eleements of second stack
    while(len(s2) > 0):
        node = s2.pop()
        print node.data,

# Driver program to test above function
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
root.right.left = Node(6)
root.right.right = Node(7)
postOrderIterative(root)
```

Output:

```
4 5 2 6 7 3 1
```

Following is overview of the above post.
Iterative preorder traversal can be easily implemented using two stacks. The first stack is used to get the reverse postorder traversal in second stack. The steps to get reverse postorder are similar to iterative preorder.

You may also like to see a method which uses only one stack.