lab_quacks : Spiteful Stacks, Questionable Queues
Week #5 – September 23-27, 2020

Welcome to Lab Quacks!

Course Website: https://courses.engr.illinois.edu/cs225/fa2020/assignments/

Overview

In this week's lab, you will refresh your memory in an important programming concept: recursion, and you will have a chance to practice with two new data structures we learned in lecture: stacks and queues.

Recursion

Recursion refers to a style of writing functions where: ***a function calls itself within its definition***. If you have already taken CS 125 or ECE 220 this will be a familiar topic for you. One advantage to writing functions recursively is that more often than not, it makes function definitions shorter, more elegant, and easier to follow for a human reader. However, recursion often times trades runtime efficiency for its sleek style; we must carefully decide when it is advantageous to use recursion. Always remember that while not every function can be written recursively, ***every recursive function can be rewritten iteratively (using loops instead of recursion)***.

Exercise 1.1: The Fibonacci sequence start with 0 and 1: $F_0 = 0$, $F_1=1$. The rule for the nth Fibonacci number is: $F_n=F_{n-1} + F_{n-2}$. The iterative function iterativeFib() has been provided for you. Complete the function recursiveFib to calculate the nth Fibonacci number recursively.

main.cpp

```
1  int recursiveFib(int n){
2    cout << "recursiveFib gets called!" << endl;
3
4  //YOUR CODE HERE
5    if (n == 0 || n == 1)
6      return n;
7    return recursiveFib(n-1)+recursiveFib(n-2);
8
9
10
11
12
13 }
```

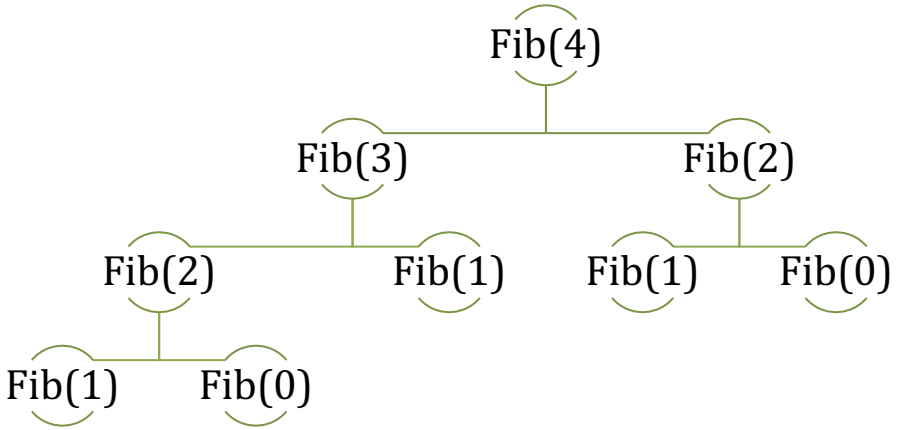
```
14 int iterativeFib(int n){
15   int n1 = 1; int n2 = 1; int result = 1;
16   for(int i = 2; i < n; i++) {
17     cout << "one iteration!" << endl;
18     result = n1 + n2; n2 = n1; n1 = result;
19   }
20   return result;
21 }
22
23 int main() {
24   int recur = recursiveFib(4);
25   int iter = iterativeFib(4);
26 }
```

Exercise 1.2:

In the main function, F_4 gets computed by the two different algorithms.

How many print statements will be called in the **recursive algorithm**? To better understand the number of recursion calls, draw the recursion tree of **recursiveFib(4)** in the space below.

9 print statements will be called in recursiveFib(4).



How many print statements will be called in the **iterative algorithm** to calculate the same result?

Iterative algorithm will print out 2 lines.

Stack and Q

Stacks and queues are two of the most popular one-dimensional data structures in CS. Remember from lecture that elements in a queue follow the FIFO rule: First In First Out, while elements in a stack follow the LIFO rule: Last In First Out. In this lab we will use the STL's (Standard Template Library) queue<T> and stack<T> classes.

Exercise 2.1: Complete the definitions of the following two functions. popLast() takes in a queue by reference and pops out the last element of the queue (at the back of the queue), the remaining elements in the queue should maintain their initial order. reverseQ() takes in a queue by reference and reverses the order of its elements.

Do not create new queues/stacks in your implementation! (you can use the stack that is already given to you)

Useful stack and queue functions:
queue.front() **stack.top()**

push() **pop()** **size()**

main.cpp

```
1  template <typename T>
2  void popLast(queue<T> &q){
3    //YOUR CODE HERE
4    size_t s = q.size();
5    for (int i=0; i<s-1; i++){
6      T temp = q.front();
7      q.pop();
8      q.push(temp);
9    }
10   q.pop();
11
12 }
13 template <typename T>
14 void reverseQ(queue<T> &q){
15   stack<T> s;
16   //YOUR CODE HERE
17   while (!q.empty()){
18     s.push(q.front());
19     q.pop();
20   }while(!s.empty()){
21     q.push(s.top());
22     s.pop();
23   }
24
25 }
```

Time Complexity

Recall that in computer science we use Big O notation to describe the runtimes of functions and programs. In Big O runtime analysis, **n** usually denotes the size of the arguments/objects/variables/data structures that the function or program manipulates. In the following exercise, you will analyze and compare the run time of Stack and Queue operations on elements in different positions.

Exercise 3: Looking at the main function below, write the time complexities (in big O) of **popping out** the following elements.

1 on **q** **O(1)**
1 on **s** **O(n)**
n on **q** **O(n)**
n on **s** **O(1)**

main.cpp

```
1  int main() {
2      queue<int> q;
3      stack<int> s;
4
5      for(int i = 1; i <=n; i++) {
6          q.push(i);
7          s.push(i);
8      }
9  }
10
```

In the programming part of this lab, you will:

- Get familiar with Stacks and Queues
- Practice writing recursive functions
- Have fun solving clever Queue and Stack puzzle problems!

As your TA and CAs, we're here to help with your programming for the rest of this lab section! 😉