CS 240 Programming in C

Recursion

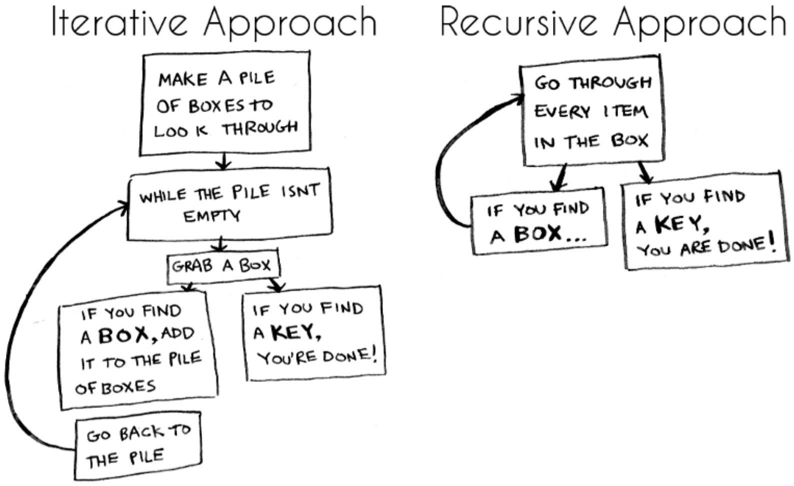
March 28, 2022

Recursion

Recursion is a method of solving a computational problem where the solution depends on solutions to smaller instances of the same problem. Recursion solves such recursive problems by using functions that call themselves from within their own code. The approach can be applied to many types of problems, and recursion is one of the central ideas of computer science.
[1]

[1] https://en.wikipedia.org/wiki/Recursion_(computer_science)

Recursion



Iterative Approach
MAKE A PILE OF BOXES TO LOOK THROUGH
WHILE THE PILE ISNT EMPTY
GRAB A BOX
IF YOU FIND A BOX, ADD IT TO THE PILE OF BOXES
IF YOU FIND A KEY, YOU'RE DONE!
GO BACK TO THE PILE
Recursive Approach
GO THROUGH EVERY ITEM IN THE BOX
IF YOU FIND A BOX...
IF YOU FIND A KEY, YOU ARE DONE!

2

[2]https://www.freecodecamp.org/news/how-recursion-works-explained-with-flowcharts-and-a-video-de61f40cb7f9

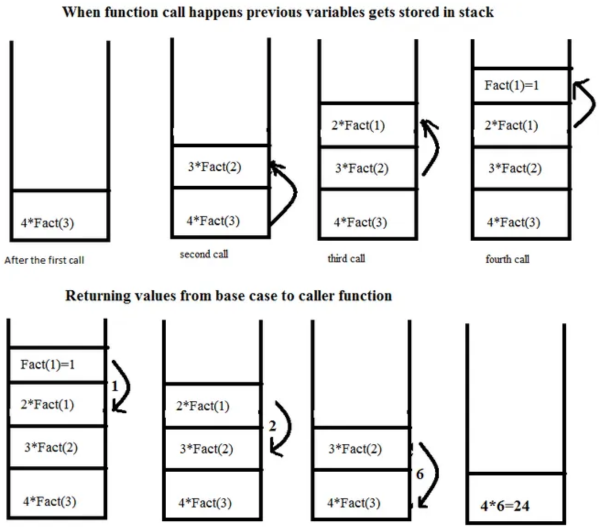
Factorial using Iteration

```
int factorial(int n)
{
    int fact = 1;
    for (int i = 1; i <= n; i++)
    {
        fact = fact * i;
    }
    return fact;
}

int main()
{
    int n = 4;
    printf("factorial(%d) = %d\n", n, factorial(n));
}
```

Factorial using Recursion

```c
int factorial(int n)
{
    if (n == 1)
        return 1;
    else
        return n * factorial(n - 1);
}

int main()
{
    int n = 4;
    printf("factorial(%d) = %d\n", n, factorial(n));
}
```

Stack



3

[3] https://medium.com/@williambdale/recursion-the-pros-and-cons-76d32d75973a

How to read a recursive function

- Always identify the base case of the function before anything else.
- Pass arguments to the function that will immediately reach the base case.
- Identify the arguments that will at least execute the recursive function call once. [4]

[4] https://www.freecodecamp.org/news/what-is-recursion-in-javascript

How to write a recursive function

- Create a regular function with a base case that can be reached with its parameters
- Pass arguments into the function that immediately trigger the base case
- Pass the next arguments that trigger the recursive call just once.

Recursion

a recursive function might end up performing the same calculation with the same input multiple times. This means it could end up taking longer than the iterative alternative.

Memoization

A memoization function allows us to store input alongside the result of the calculation. Therefore, rather than having to do the same work again using the same input, it can simply return the value stored in the array/cache.

After Memoization

```
int fact(int n, int memo[])
{
    if (memo[n])
        return memo[n];
    else
        memo[n] = n * fact(n - 1, memo);
    return memo[n];
}
int main()
{
    int memo[] = {1, 0, 0, 0, 0, 0, 0, 0, 0, 0};
    int n = 5;
    printf("fact(%d) = %d\n", n, fact(n, memo));
    n = 6;
    printf("fact(%d) = %d\n", n, fact(n, memo));
}
```

Tree data structure

- A tree is a hierarchical data structure that consists of nodes connected by edges. Each node in a tree can have zero or more child nodes, and there is always a single node called the root that has no parent. Every other node in the tree has exactly one parent.
- Trees are commonly used in algorithms and data structures because they allow efficient searching, insertion, and deletion of elements.
- Tree data structures and their traversals are used in
    - Directory structure
    - Compiler design - syntax tree
    - Web crawling
    - Artificial intelligence - decision trees

Tree traversal

In tree traversal, recursion is often used to visit each node in the tree. The traversal function is defined recursively, with each call of the function visiting the current node and then recursively visiting its child nodes. There are three main ways to traverse a tree: in-order traversal, pre-order traversal, and post-order traversal. Each of these traversal methods can be implemented using recursion.

Coin change problem

The coin change problem is a classic problem in computer science and mathematics that asks: given a set of coin denominations and a target amount, what is the minimum number of coins required to make change for the target amount?
For example, suppose we have coins with denominations of 1, 5, 10, and 25 cents, and we want to make change for 53 cents. The minimum number of coins required to do so is 6: two quarters (25 cents each), one dime (10 cents), and three pennies (1 cent each).