← Notes

Change Making Problem

11 Dynamic Programming

The change making problem is an optimization problem that asks "**What is the minimum number of coins I need to make up a specific total?**"

The input to the Change Making Problem is a sequence of positive integers `[d1, d2, d3 ... dn]` and `T`, where `di` represents a coin denomination and `T` is the target amount. Assuming an unlimited supply of coins of each denomination, we need to find the number of coins `N` required to form the given amount. An extra effort would be to find the exact coins to build up the amount.

> The above problem represents an optimal sub-structure, which means that the problem can be broken down into smaller parts. Suppose there is an optimal solution for amount `T` and if we break the target amount into two parts `m` and `T-m`, then there will be optimal solution for making amount `m` using some portion from the optimal solution for amount `T` and the remaining coins from the solution will be the optimal solution for making amount `T-m`.

Let C[m] be the minimum number of coins of denominations d1,d2,...,dk needed to make change for m amount. In the optimal solution to making change for `m` amount, there must exist some first coin `di`, where `di < m`. Furthermore, the remaining coins in the solution must themselves be the optimal solution to making change for `m- di`.

Thus, if `di` is the first coin in the optimal solution to making change for m amount, then `C[m]=1 + C[m - di]` i.e. one di coin plus `C[m - di]` coins to optimally make change for `m - di` amount. We don't know which coin `di` is the first coin; however, we may check all n such possibilities (subject to the constraint that `di < m`), and the value of the optimal solution must correspond to the minimum value of `1 + C[m - di]`, by definition.

Furthermore, when making change for 0, the value of the optimal solution is clearly 0 coins. We thus have the following recurrence.

```
C[p]    =     0                                if p = 0
               min(i: di < p) {1 + C[p - di]}   if p > 0
```

Below is the code given for the above algorithm

```
#include <iostream>
#define N 4
#define C 17
using namespace std;

// In this example we take the amount as 17, and a total of
// 4 denominations of coins

int main()
{
    // contains the coin denominations
    int coins[N]={1,2,5,10};

    // C[i] contains the minimum number of coins required
    // to form the sum i
    int amount[C+1]={0};

    for(int amt = 1; amt <= C ;amt++)
    {
        amount[amt] = INT_MAX;
        int temp = INT_MAX;
        for(int c = 0; c < N;c++)
        {
            // if the value of the coin is less than the amount
                    if(coins[c] <= amt)
            {
                // What is the other number of coins that will b
                // if coins[c] is used in the solution for amoun
                int temp_amt = amount[amt-coins[c]] + 1;

                // choose the minimum number of coins that will
                // for the amount i

                if(temp_amt < temp)
                {
                    temp = temp_amt;
                    amount[amt] = temp;
                }
            }
```

```
        }
    }
    cout << amount[C] << endl;
    return 0;
}
```


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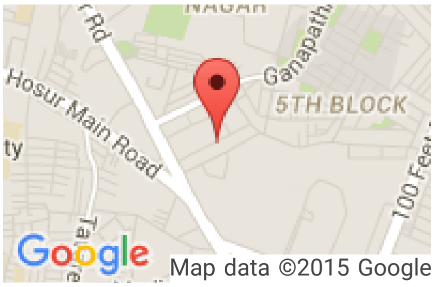

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