

## Dynamic Programming | Set 33 (Find if a string is interleaved of two other strings)

Given three strings A, B and C. Write a function that checks whether C is an interleaving of A and B. C is said to be interleaving A and B, if it contains all characters of A and B and order of all characters in individual strings is preserved.

We have discussed a simple solution of this problem [here](#). The simple solution doesn't work if strings A and B have some common characters. For example A = "XXY", string B = "XXZ" and string C = "XXZXXY". To handle all cases, two possibilities need to be considered.

- If first character of C matches with first character of A, we move one character ahead in A and C and recursively check.
- If first character of C matches with first character of B, we move one character ahead in B and C and recursively check.

If any of the above two cases is true, we return true, else false. Following is simple recursive implementation of this approach (Thanks to [Frederic](#) for suggesting this)

```
// A simple recursive function to check whether C is an interleaving of A and B
bool isInterleaved(char *A, char *B, char *C)
{
    // Base Case: If all strings are empty
    if (!(*A || *B || *C))
        return true;

    // If C is empty and any of the two strings is not empty
    if (*C == '\0')
        return false;
}
```

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```
// If any of the above mentioned two possibilities is true,
// then return true, otherwise false
return ( (*C == *A) && isInterleaved(A+1, B, C+1))
        || ((*C == *B) && isInterleaved(A, B+1, C+1));
}
```

## Dynamic Programming

The worst case time complexity of recursive solution is  $O(2^n)$ . The above recursive solution certainly has many overlapping subproblems. For example, if we consider  $A = \text{"XXX"}$ ,  $B = \text{"XXX"}$  and  $C = \text{"XXXXX"}$  and draw recursion tree, there will be many overlapping subproblems.

Therefore, like other typical **Dynamic Programming problems**, we can solve it by creating a table and store results of subproblems in bottom up manner. Thanks to **Abhinav Ramana** for suggesting this method and implementation.

```
// A Dynamic Programming based program to check whether a string C is
// an interleaving of two other strings A and B.
#include <iostream>
#include <string.h>
using namespace std;
```

```
// The main function that returns true if C is
// an interleaving of A and B, otherwise false.
bool isInterleaved(char* A, char* B, char* C)
{
    // Find lengths of the two strings
    int M = strlen(A), N = strlen(B);

    // Let us create a 2D table to store solutions of
    // subproblems. C[i][j] will be true if C[0..i+j-1]
    // is an interleaving of A[0..i-1] and B[0..j-1].
    bool IL[M+1][N+1];

    memset(IL, 0, sizeof(IL)); // Initialize all values as false.

    // C can be an interleaving of A and B only if sum
    // of lengths of A & B is equal to length of C.
    if ((M+N) != strlen(C))
        return false;

    // Process all characters of A and B
    for (int i=0; i<=M; ++i)
    {
        for (int j=0; j<=N; ++j)
        {
```



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```

// two empty strings have an empty string
// as interleaving
if (i==0 && j==0)
    IL[i][j] = true;

// A is empty
else if (i==0 && B[j-1]==C[j-1])
    IL[i][j] = IL[i][j-1];

// B is empty
else if (j==0 && A[i-1]==C[i-1])
    IL[i][j] = IL[i-1][j];

// Current character of C matches with current character of A
// but doesn't match with current character of B
else if (A[i-1]==C[i+j-1] && B[j-1]!=C[i+j-1])
    IL[i][j] = IL[i-1][j];

// Current character of C matches with current character of B
// but doesn't match with current character of A
else if (A[i-1]!=C[i+j-1] && B[j-1]==C[i+j-1])
    IL[i][j] = IL[i][j-1];

// Current character of C matches with that of both A and B
else if (A[i-1]==C[i+j-1] && B[j-1]==C[i+j-1])
    IL[i][j]=(IL[i-1][j] || IL[i][j-1]) ;
    }
}

return IL[M][N];
}

```

```

// A function to run test cases
void test(char *A, char *B, char *C)
{
    if (isInterleaved(A, B, C))
        cout << C << " is interleaved of " << A << " and " << B << endl;
    else
        cout << C << " is not interleaved of " << A << " and " << B << endl;
}

// Driver program to test above functions
int main()
{
    test("XXY", "XXZ", "XXZXXXY");
    test("XY", "WZ", "WZXY");
}

```

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```

test ("XY", "X", "XXY");
test ("YX", "X", "XXY");
test ("XXY", "XXZ", "XXXXZY");
return 0;
}

```

Output:

```

XXZXXXY is not interleaved of XXY and XXZ
WZXY is interleaved of XY and WZ
XXY is interleaved of XY and X
XXY is not interleaved of YX and X
XXXXZY is interleaved of XXY and XXZ

```

See [this](#) for more test cases.

Time Complexity:  $O(MN)$

Auxiliary Space:  $O(MN)$

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