Assignment 6

GROUP 16

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Abstract

For a given large binary string, the project aims at calculating the length of substring which is having maximum difference of number of 0s and number of 1s.

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Introduction

A string that consists of only 1's and 0's is said to be a binary string.

In our project, we tested various algorithms on different sample test cases for time complexity and space complexity. In our report, we tend to focus on establishing a rule or a relationship between the time and input data.

We have analysed two different approaches -

(i) Brute force

(ii) Dynamic Programming

Algorithm Design - Brute force

Approach

In brute force implementation, for every possible sub array of every possible size, we calculate difference of number of 0's and number of 1's. This can be done using combination of 3 nested loops. We keep track of the maximum value of difference and corresponding sub array size till that instant and print its value in the end.

Algorithm Design - Brute force

Algorithm

1. The outermost loop keeps track of current size of the sub array.
2. The middle loop will keep track of current starting index of the sub array.
3. The innermost loop will traverse the current sub array and count the number of 0's and number of 1's for it.
4. For every sub array, we find the difference of number of 0's and number of 1's. If this difference exceeds maximum value of difference till that instant, we assign current difference's value to maximum difference and update size accordingly.
5. Finally, we print the size of the sub array corresponding to the maximum value of difference.

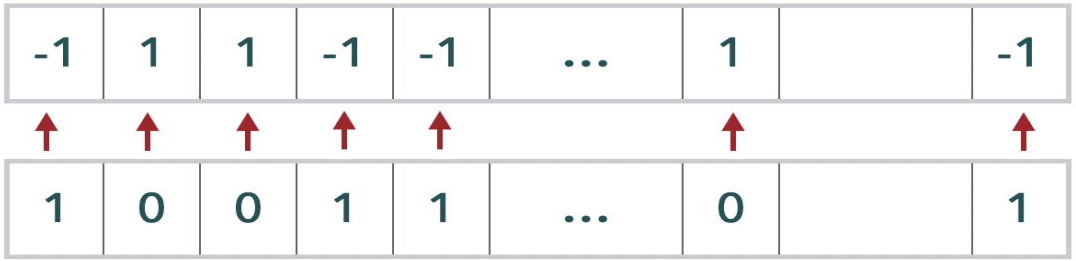
Kadane’s Algorithm

Given an array, Kadane’s algorithm is able to find the maximum sum and size of a contiguous sub array in an array with a run time of O(n). Kadane’s algorithm uses the concept of dynamic programming.

Algorithm Design - Dynamic Programming

Approach

In this approach, we convert all 0's in the binary string into 1's and all 1's into -1's. Now, all we have to do is to find out the size of subarray with maximum Using Kadane's Algorithm.



Algorithm Design - Dynamic Programming

Algorithm

1. In this implementation, we traverse the binary string from left to right.
2. We maintain four variables. They will signify values of current sum, maximum sum and current size, maximum size.
3. If the ith character of the binary string is 0 then we will add 1 to the current sum else we will decrement current sum by 1.
4. At any instant, if current sum becomes less than 0, we set current sum and current size to zero.At any instant, if current sum becomes greater than maximum sum, we set maximum sum to current sum and maximum size to current size.
5. Print the maximum size.

Algorithm Implementation - Brute force

```
Inputs:
N, string str
procedure findMaxLength(N, string str)
Initialize:
size=0,count0s=0,count1s=0,maxLength=0,maxDiff
erence=0, i,j,tempDifference
for size = 1; size < n; size++ do
        for  i = 0; i < n-size; i++ do
                count0s = 0
                count1a = 0
                for j = i; j < size+i; j++ do
                        if str[i] == 0 then
                                count0s++;
                        end if
                        if str[i] == 1 then
                                count1s++;
                        end if
                end for
                tempDifference = (count0s-count1s);
                if tempDifference>=maxDifference
                then
                        diff_max = temp;
                         length_max=size;
                end if
        end for
end for
return maxLength
end procedure
```

Algorithm Implementation - Dynamic Programming

Inputs:

N, string str

procedure *findMaxLength(N, string str)*

Initialize:

summax = 0, sumcurrent = 0,sizemax = 0,

sizecurrent = 0, i = 0

for i = 0; i < n; i++ **do**

if str[i] == 0 **then**

sumcurrent = sumcurrent + 1

Else

sumcurrent = sumcurrent − 1

end if

sizecurrent = sizecurrent + 1

if sumcurrent < 0 **then**

sumcurrent = 0

sizecurrent = 0

end if

if sumcurrent > summax **then**

summax = sumcurrent

sizemax = sizecurrent

end if

end for

return sizemax

end procedure

Algorithm Analysis - Brute force

In case of brute force algorithm, three nested loops are needed to for calculation of difference of number of 0's and number of 1's for all possible sub arrays, so the overall time complexity is O(n^3) while no extra space is required resulting into O(1) space complexity.

Time complexity: O(n^3)

Space complexity: O(1)

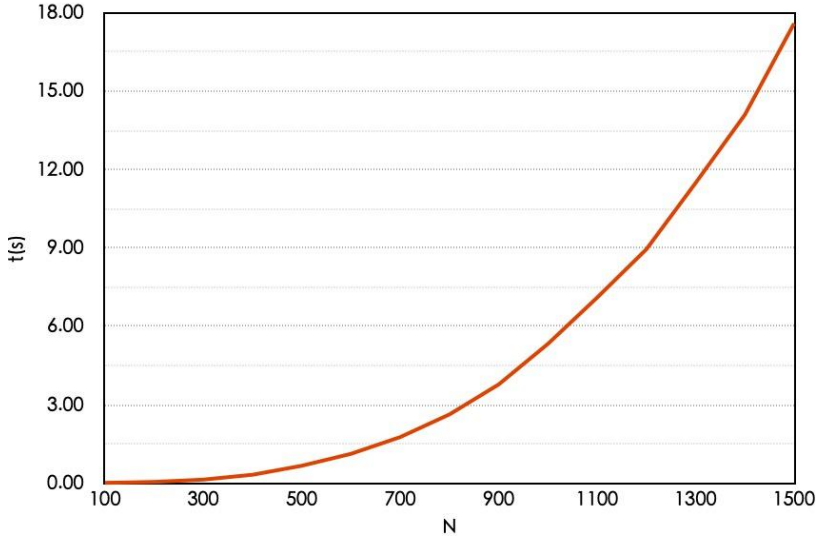
Algorithm Analysis - Dynamic Programming

In case of iterative implementation, the concept of 1D dynamic programming is used. One full array traversal is needed, so the time complexity is O(n). In this implementation, we don't need to tabulate all the sub results, but only the recently derived ones. This results in O(1) space complexity.

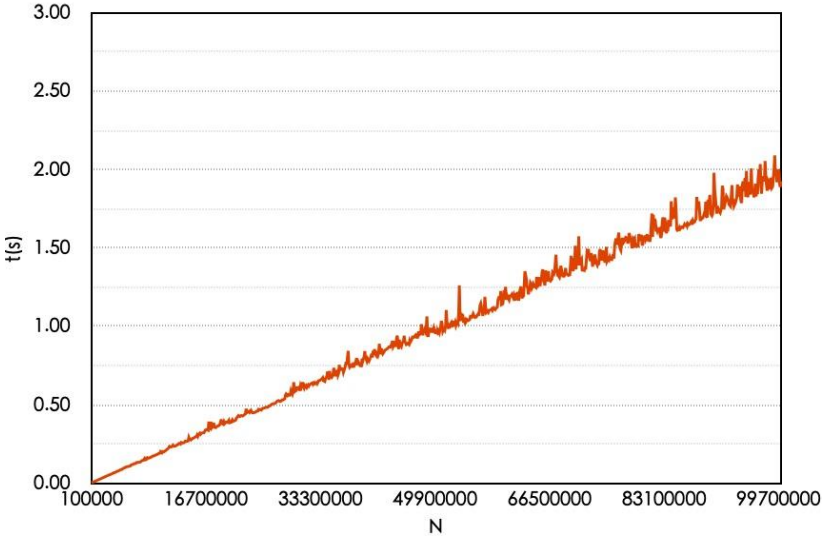
Time complexity:O(n)

Space complexity:O(1)

Experimental Data



The graph for the first algorithm shows the non-linear behaviour as n increases, this behaviour is in fact of n^3.



The graph for the second algorithm shows the linear behaviour as n increases, this behaviour is in fact of n.

Conclusion

From the experimental result we concluded that the average running time of Dynamic Programming algorithm is best which can be observed from the mutual graphs of Brute Force algorithm and Dynamic Programming algorithm.

Thank you!