3-Balanced String

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pseudocode representation of the (non-recursive) algorithm:

```
algorithm longest_balanced_substring(s) \\ for get longest balanced substring
   n <- length(s)
   max_length <- 0
   for i <- 0 to n-1 do
      for j <- i+2 to n do
         substr <- s[i:j]  // Extract the substring
         if is_balanced(substr) and length(substr) > max_length then
          max_length <- length(substr)  // Update the maximum length
    return max_length
 algorithm is_balanced(substr) \\ for check if string is balanced or not
   count <- [0, 0]
   for i <- 0 to length(substr)-1 do{
      if substr[i] == substr[0] then
         count[0]++
      else
         count[1]++
if (count[0] == count[1]) then return 1
return 0
```

Analysis of this algorithm:

The outer loop of the **longest_balanced_substring** algorithm iterates over all possible starting indices **i** in the input string, from 0 to **n-2**. This takes O(n) time.

The inner loop iterates over all possible ending indices **j** in the input string, starting from **i+2** and going up to **n**. This also takes O(n) time.

For each pair of indices **(i, j)**, the algorithm extracts a substring using **strncpy**, which takes O(j-i) time. This is the time required to copy the characters from the input string to the **substr** array. Since there are at most O(n^2) pairs of indices **(i, j)** to consider, the total time taken for all substring extractions is O(n^3).

Finally, the **is_balanced** algorithm is called on each extracted substring, which takes O(k) time, where **k** is the length of the substring. Since the total length of all extracted substrings is O(n^3), the total time taken by **is_balanced** is O(n^3) as well.

Adding up these time complexities, we get a total time complexity of O(n^3) for the entire algorithm.

pseudocode representation of the (Recursive) algorithm:

```
algorithm longest_balanced_substring(s)

RETURN longest_balanced_substring_helper (s, 0,length(s) - 1)


algorithm longest_balanced_substring_helper(s, start, end)

  IF end - start + 1 < 2 THEN
    RETURN 0
  freq [26] <- {0}
  FOR i <- start to end    Do
    freq[s[i] - 'a'] <- freq[s[i] - 'a'] + 1
  IF is_balanced(freq) THEN
    RETURN end - start + 1
  len1 <-longest_balanced_substring _helper (s, start, end - 1)
  len2<- longest_balanced_substring_helper (s, start + 1, end)
  IF len1 > len2 THEN
    RETURN len1
ELSE
    RETURN len2


algorithm is_balanced(freq)

  count <- 0
  diff_chars <- 0
  FOR i <- 0 to 25   Do
    IF freq[i] > 0 THEN
      diff_chars <- diff_chars + 1
```

```
    IF freq[i] == freq[0] AND freq[i] > 0 THEN
      count <- count + 1
  IF diff_chars == 2 AND count == 2 THEN
    RETURN 1
  ELSE
    RETURN 0
```

Analysis of this algorithm:

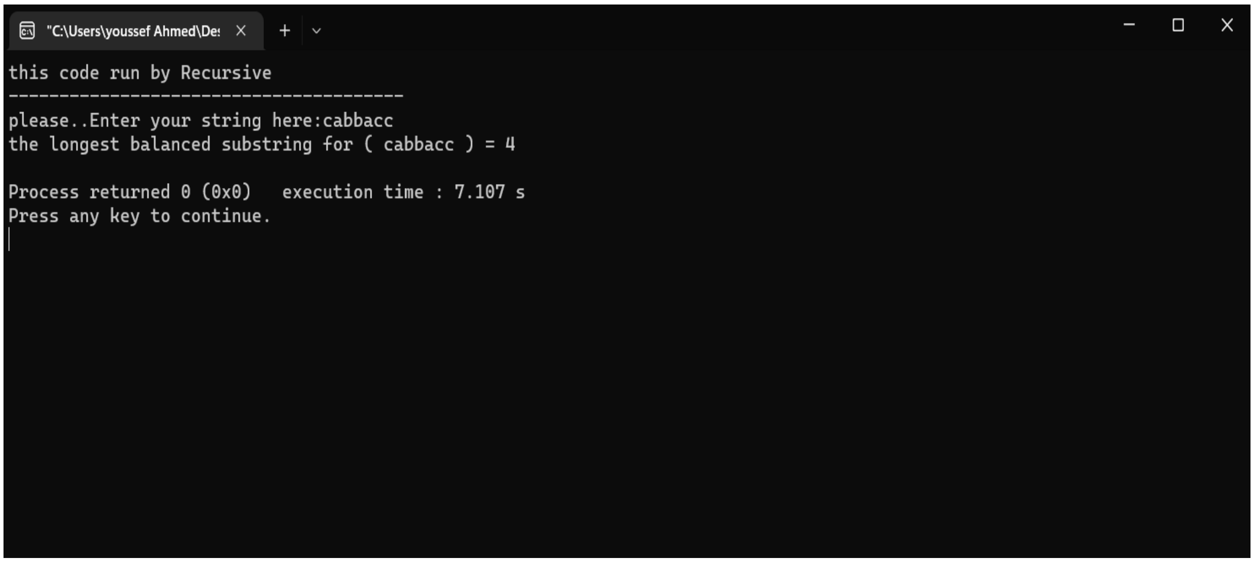
The time complexity of the **longest_balanced_substring** function is O(n^2) because in the worst case scenario, each recursive call to the function processes a substring that is only one character smaller than the previous substring. This means that the function makes n recursive calls in total, where n is the length of the input string.

For each recursive call, the function iterates over the characters in the substring and builds a frequency array, which takes O(n) time. This means that the total time complexity of building frequency arrays for all substrings is O(n^2).

After building the frequency array for a substring, the function calls the **is_balanced** function to check if the substring is balanced. This operation takes constant time, or O(1).

Finally, the function returns the length of the longest balanced substring from among the two substrings obtained by removing either the first or the last character of the current substring. This operation takes constant time, or O(1).

Therefore, the total time complexity of the **longest_balanced_substring** function is the sum of the time complexity of building frequency arrays for all substrings, which is O(n^2), and the time complexity of the constant time operations, which is O(n). This gives a total time complexity of O(n^2).



	Recursive algorithm	*Non-Recursive algorithm*
Complexity	O(n^2)	O(n^3)
Understanding	more challenging to follow because of the recursion.	simpler and easier to understand

- The recursive algorithm has a lower time complexity than the non-recursive algorithm because the time complexity of the non-recursive is O(n^3) and the recursive is O(n^2). , so it is more efficient in terms of time complexity.