1370. Increasing Decreasing String

Easy Hash Table String Counting

Leetcode Link

Problem Description

The given problem requires us to reorder a given string `s` following a specific algorithm. The algorithm involves repeatedly picking the smallest and largest characters from the string according to given rules and appending them to form a new result string. The rules for picking characters are as follows:

1. Select the smallest character from `s` and append it to the result.
2. Choose the next-smallest character that is greater than the last appended one and append it.
3. Continue with step 2 until no more characters can be picked.
4. Select the largest character from `s` and append it to the result.
5. Choose the next-largest character that is smaller than the last appended one and append it.
6. Continue with step 5 until no more characters can be picked.
7. Repeat steps 1 to 6 until all characters from `s` have been picked and appended.

The algorithm allows for any occurrence of the smallest or largest character to be chosen if there are multiple.

Intuition

The solution to this problem uses a frequency counter to keep track of how many times each character appears in the string `s`. We use an array `counter` of length 26 to represent the frequency of each lowercase English letter.

Here's how the solution is constructed:

1. Count the frequency of each character in the string `s` and store it in `counter`. This allows us to know how many times we need to pick each character during the reordering process.
2. Initialize an empty list `ans` to build up the result string.
3. Use a while loop that continues until the length of `ans` matches the length of the input string `s`.
4. Inside the loop, iterate over the `counter` from start to end to append the smallest character (if available) to `ans` and decrease its count.
5. Then iterate over the `counter` from end to start to append the largest character (if available) to `ans` and decrease its count.
6. The process repeats, alternating between picking the smallest and largest character until all characters are used.
7. Convert the list `ans` to a string and return it as the final reordered string.

By following these steps, the algorithm efficiently fulfills the provided reordering rules, and characters are picked in the required order to form the result string.

Solution Approach

The solution implementation utilizes a straightforward approach that involves counting, iterating, and string building.

Here's a detailed walk-through of the implementation using Python:

1. **Character Frequency Counting**: We start by creating a list of zeroes called `counter` to maintain a count of each letter in the string. The length of the list is 26, one for each letter of the English alphabet. We then iterate over each character of the string `s`, and for each character, we find its corresponding index (0 for 'a', 1 for 'b', etc.) by subtracting the ASCII value of 'a' from the ASCII value of the character. We increment the count at this index in the `counter` list.

```
counter = [0] * 26
for c in s:
    counter[ord(c) - ord('a')] += 1
```

2. **Result String Assembly**: We define a list `ans` to accumulate the characters in the order we choose them based on the algorithm rules—the resulting string after the reordering will be formed by concatenating the characters in this list.

3. **Main Loop - Building the Result**: We use a `while` loop to repeat the process of picking characters from the string `s` according to the described algorithm. The loop will continue until the length of `ans` becomes equal to the length of the original string `s`, signaling that all characters have been chosen and appended.

```
while len(ans) < len(s):
    # ...
```

4. **Picking the Smallest Character**: Inside the loop, we iterate over the `counter` from the start (0) to the end (25) which corresponds to characters 'a' to 'z'. If the current character's counter is not zero, indicating that it is available to be picked, we append the corresponding character to `ans` and decrement its count in `counter`.

```
for i in range(26):
    if counter[i]:
        ans.append(chr(i + ord('a')))
        counter[i] -= 1
```

5. **Picking the Largest Character**: We do the same for picking the largest character, but in reverse order, iterating over the `counter` from the end (25) to the start (0). Again, if the current character's counter is not zero, we append the corresponding character to `ans` and decrement its count.

```
for i in range(25, -1, -1):
    if counter[i]:
        ans.append(chr(i + ord('a')))
        counter[i] -= 1
```

6. **Returning the Result**: Finally, after the `while` loop concludes, we join the list of characters in `ans` using `''.join(ans)` to return the final string, which is the original string `s` reordered according to the algorithm described.

The above steps translate the problem's algorithm into Python code in a way that is both efficient (since the actions within the loop are simple and fast) and clean, leading to a solution that straightforwardly follows the rules laid out in the problem statement.

Example Walkthrough

Let's walk through a small example to illustrate the solution approach. Suppose our input string `s` is `"bacab"`.

1. **Character Frequency Counting**: We count the frequency of every character in the string.

   For the string `"bacab"`, the frequency counter `counter` would look like this after counting: `[2, 2, 1]`, where `2` at the first position represents `'a'`, `2` at the second position is for `'b'`, and `1` at the third position is for `'c'`.

2. **Result String Assembly**: We initialize an empty list `ans` to store the characters as we pick them following the algorithm.

3. **Main Loop - Building the Result**: We start the while loop since `len(ans) < len(s)`, which is `5` in this case.

4. **Picking the Smallest Character**: On the first iteration, we look for the smallest character, which is `'a'`. We add `'a'` to `ans`, and the `counter` becomes `[1, 2, 1]`.

5. **Picking the Largest Character**: We now pick the largest character, which is `'c'`. After appending `'c'` to `ans`, the `counter` list updates to `[1, 2, 0]`.

6. **Picking the Smallest Character**: We pick `'a'` again as it is the next available smallest character. The `ans` list becomes `['a', 'c', 'a']` and `counter` is `[0, 2, 0]`.

7. **Picking the Largest Character**: We need to pick the largest character now, which is `'b'`. After doing so, the `ans` list is `['a', 'c', 'a', 'b']` and `counter` is `[0, 1, 0]`.

8. **Picking the Largest Character**: As per our steps, we continue to pick the largest character left, which is still `'b'`, updating `ans` to `['a', 'c', 'a', 'b', 'b']` and `counter` to `[0, 0, 0]`.

9. **Returning the Result**: The while loop exits since `len(ans)` is now equal to `len(s)`. We join the elements of `ans` to form the final string. Therefore, the final reordered string is `"acabb"`.

By following the steps laid out in the solution approach, we successfully applied the algorithm to the example input and achieved the expected outcome. The method of counting characters, appending the smallest and largest in order, and decrementing their count ensures that the rules of the problem statement are adhered to at every step of the process.

Python Solution

```
class Solution:
    def sortString(self, s: str) -> str:
        # Initialize a list to keep track of the count of each character in the string
        char_count = [0] * 26

        # Count the occurrences of each character in the string
        for char in s:
            char_count[ord(char) - ord('a')] += 1

        # Initialize a list to build the sorted string
        sorted_chars = []

        # Continue until the sorted string's length equals the input string's length
        while len(sorted_chars) < len(s):
            # Traverse the `char_count` list from start to end and add each character once if it's present
            for i in range(26):
                if char_count[i] > 0:
                    sorted_chars.append(chr(i + ord('a')))
                    char_count[i] -= 1  # Decrement the count of the added character

            # Traverse the `char_count` list from end to start and add each character once if it's present
            for i in range(25, -1, -1):
                if char_count[i] > 0:
                    sorted_chars.append(chr(i + ord('a')))
                    char_count[i] -= 1  # Decrement the count of the added character

        # Join the list of characters into a string and return it
        return ''.join(sorted_chars)
```

Java Solution

```
class Solution {

    // Method to sort the string in a custom order
    public String sortString(String s) {
        // Counter array to hold frequency of each character 'a'-'z'
        int[] frequency = new int[26];
        // Fill the frequency array with count of each character
        for (char ch : s.toCharArray()) {
            frequency[ch - 'a']++;
        }

        // StringBuilder to hold the result
        StringBuilder sortedString = new StringBuilder();

        // Loop until the sortedString's length is less than the original string length
        while (sortedString.length() < s.length()) {
            // Loop from 'a' to 'z'
            for (int i = 0; i < 26; ++i) {
                // Check if the character is present
                if (frequency[i] > 0) {
                    // Append the character to sortedString
                    sortedString.append((char) ('a' + i));
                    // Decrement the frequency of appended character
                    frequency[i]--;
                }
            }
            // Loop from 'z' to 'a'
            for (int i = 25; i >= 0; --i) {
                // Check if the character is present
                if (frequency[i] > 0) {
                    // Append the character to sortedString
                    sortedString.append((char) ('a' + i));
                    // Decrement the frequency of appended character
                    frequency[i]--;
                }
            }
        }
        // Return the resultant sorted string
        return sortedString.toString();
    }
}
```

C++ Solution

```
class Solution {
public:
    // Method to sort the string in a specific pattern
    string sortString(string s) {
        // Create a frequency counter for each letter in the alphabet
        vector<int> frequency(26, 0);
        for (char c : s) {
            ++frequency[c - 'a'];  // Increment the count of the current letter
        }

        // Initialize the answer string
        string result = "";

        // Keep building the result until its size matches the original string size
        while (result.size() < s.size()) {
            // Append characters from 'a' to 'z' to the result string if they are present
            for (int i = 0; i < 26; ++i) {
                if (frequency[i] > 0) {  // Check if the character is present
                    result += (char)('a' + i);  // Convert index to char and append
                    --frequency[i];  // Decrement the frequency of the used character
                }
            }

            // Append characters from 'z' to 'a' to the result string if they are present
            for (int i = 25; i >= 0; --i) {  // Start from 'z' to 'a'
                if (frequency[i] > 0) {  // Check if the character is present
                    result += (char)('a' + i);  // Convert index to char and append
                    --frequency[i];  // Decrement the frequency of the used character
                }
            }
        }

        // Return the sorted string
        return result;
    }
};
```

Typescript Solution

```
/**
 * Sort the string based on the custom order: ascending characters followed by descending characters
 * @param {string} str - The original string to be sorted.
 * @return {string} - The sorted string.
 */
function sortString(str: string): string {
    let resultString: string = '';
    const charMap: Map<string, number> = new Map();

    // Count the occurrences of each character in the string
    for (let char of str) {
        charMap.set(char, (charMap.get(char) || 0) + 1);
    }

    // Keep constructing the string until the resultString's length equals the input string's length
    while (resultString.length < str.length) {
        // Append characters in ascending order to the result string
        for (let key of keys) {
            if (charMap.get(key) > 0) {  // Ensure the character count is not zero
                resultString += key;
                charMap.set(key, charMap.get(key)! - 1);  // Decrement the count in the map
            }
        }

        // Append characters in descending order to the result string
        for (let i = keys.length - 1; i >= 0; i--) {
            if (charMap.get(keys[i]) > 0) {
                resultString += keys[i];
                charMap.set(keys[i], charMap.get(keys[i])! - 1);  // Decrement the count in the map
            }
        }
    }

    return resultString;
}
```

Time and Space Complexity

Time Complexity

The provided Python function `sortString` starts with an initial counting pass over the input string `s`, incrementing values in `counter` which takes $O(n)$ time, where n is the length of `s`.

After that, it enters a loop that continues until the length of `ans` matches that of `s`. Within this loop, there are two for-loops: the first iterates in ascending order, the second in descending order. Each of these for-loops iterates over the 26 possible characters (from `'a'` to `'z'`).

For each character, if that character count is non-zero, it is appended to `ans` and the count decremented. Since each character in `s` is processed exactly once (each is appended and then decremented), and there are two passes for each character (one in ascending and one in descending order), the total count of operations inside the while-loop is $2n$, leading to an additional $O(n)$ time complexity.

Thus, the time complexity of the entire function is $O(n)$.

Space Complexity

The space complexity includes:

1. The `counter` array which is always 26 elements long, thus it is a constant space $O(1)$.
2. The `ans` list that will eventually grow to be the same size as `s` to accommodate all characters, which is $O(n)$.

Therefore, the total space complexity is $O(n)$, where n is the length of the input string `s`.