350. Intersection of Two Arrays II

Problem Description

The problem provides us with two integer arrays, `nums1` and `nums2`, and asks us to find the intersection of these two arrays. The intersection consists of elements that appear in both arrays. If an element occurs multiple times in both arrays, it should appear in the final result as many times as it is common to both. The result can be returned in any order.

To elaborate, we need to identify all the unique elements that the two arrays have in common. Then, for each unique element found in both arrays, we need to include that element in our result array as many times as it occurs in both. For example, if the number 3 appears twice in `nums1` and four times in `nums2`, it should appear twice in the intersection array since that's the minimum count between the two arrays.

Intuition

The foundation of the solution is to count the frequency of each element in the first array, which is `nums1`. We then iterate through the second array, `nums2`, checking if the elements appear in the counter we created from `nums1`. If an element from `nums2` is found in the counter and has a count greater than zero, it is part of the intersection. We add this element to the result list and decrease its count in the counter by one to ensure that we don't include more occurrences of an element than it appears in both arrays.

Here's how we arrive at the solution step by step:

1. **Count Elements of `nums1`:** By creating a counter (a specific type of dictionary) for `nums1`, we efficiently track how many times each element occurs.
2. **Iterate Over `nums2` and Collect Intersection:** We go through each element in `nums2`. If the element is found in the counter with a non-zero count, this indicates that the element is both in `nums1` and `nums2`.
3. **Add to Result and Update Counter:** For every such element found, we add it to our result list and then decrement the count for that element in the counter to ensure we only include as many instances as are present in `nums1`.

The above steps are simple and use the property of counters to help us easily and efficiently find the intersection of the two arrays.

Solution Approach

The implementation of the solution makes use of the following concepts:

- **Counter (from collections module):** This is used to construct a hash map (dictionary) that counts the frequency of each element in `nums1`. It's a subclass of a dictionary which is specifically designed to count hashable objects.

The code implementation goes as follows:

1. We start by importing `Counter` from the `collections` module.

```
from collections import Counter
```

2. We then use `Counter` to create a frequency map of all the elements present in `nums1`.

```
counter = Counter(nums1)
```

3. We initialize an empty list `res` which will hold the elements of the intersection.

```
res = []
```

4. Next, we iterate over each element `num` in `nums2`. During each iteration, we perform the following actions:
   - Check if `num` exists in the `counter` and its count is greater than 0. This confirms whether `num` should be a part of the intersection.

```
if counter[num] > 0:
```

   - If the above condition is true, we append `num` to our `res` list. This adds `num` to our intersection list.

```
res.append(num)
```

   - Then we decrement the count of `num` in the `counter` by one to ensure we do not include it more times than it appears in `nums1`.

```
counter[num] -= 1
```

5. Finally, once we've completed iterating over `nums2`, we return the `res` list which contains the intersection of `nums1` and `nums2`.

```
return res
```

The choice of `Counter` and the decrementing logic ensures that each element is counted and included in the result only as many times as it is present in both input arrays. This method is efficient because creating a counter is a linear operation (O(n)) and iterating through the second list is also linear (O(m)), where n and m are the sizes of `nums1` and `nums2` respectively. The conditional check and decrement operation during the iteration are constant time (O(1)) since hash map access is in constant time.

Example Walkthrough

Let's use a small example to illustrate the solution approach. Assume we have the following two arrays:

- `nums1 = [1,2,2,1]`
- `nums2 = [2,2]`

We want to find the intersection of these two arrays.

Following the described solution approach:

1. `Counter` is used to create a frequency map for `nums1`. After this step, we have:

```
counter = Counter({1:2,2:2})
# counter = {1: 2, 2: 2}
```

   The counter represents that the number 1 appears twice and the number 2 appears twice in `nums1`.

2. We initialize an empty list `res` to store the intersection.

```
res = []
```

3. We iterate over each element in `nums2`.

   a. First, we check if `2` (the first element of `nums2`) exists in `counter` and has a count greater than 0.

   Since `counter[2]` is indeed greater than 0, we append `2` to our `res` list. Then, we decrement the count of `2` in the `counter` by one to reflect the updated count.

```
res.append(2)
counter[2] -= 1
# Now, counter = {1: 2, 2: 1}
```

   b. We move to the next element which is again `2`. We perform the same check and find that `counter[2]` is still greater than 0. So, we append this `2` to `res` and again decrement the counter for `2`.

```
res.append(2)
counter[2] -= 1
# Finally, counter = {1: 2, 2: 0}
```

Since there are no more elements in `nums2` to iterate over, our `res` list currently looks like this:

```
res = [2, 2]
```

4. We return the `res` list which is `[2, 2]` as the final result. This reflects the intersection of `nums1` and `nums2`, indicating that the element `2` appears in both arrays and does so exactly twice, which is the minimum number of times it appears in any one array.

The final intersection array is `[2, 2]`, and it is derived through the efficient counting and iteration method described in the solution approach.

Python Solution

```
from collections import Counter
from typing import List

class Solution:
    def intersect(self, nums1: List[int], nums2: List[int]) -> List[int]:
        # Count the occurrences of each element in the first list
        element_counter = Counter(nums1)

        # Initialize the result list which will store the intersection
        intersection_result = []

        # Iterate through each element in the second list
        for num in nums2:
            # If the current element is present in the element counter
            # and the count is more than 0, it's part of the intersection.
            if element_counter[num] > 0:
                # Append the element to the result list
                intersection_result.append(num)

                # Decrement the count of the current element in the counter
                element_counter[num] -= 1

        # Return the final list of intersection elements
        return intersection_result
```

Java Solution

```
class Solution {
    public int[] intersect(int[] nums1, int[] nums2) {
        // Create a map to store the count of each number in nums1
        Map<Integer, Integer> numberCounts = new HashMap<>();
        // Iterate over the first array and fill the numberCounts map
        for (int number : nums1) {
            // Increment the count for the current number in the map
            numberCounts.put(number, numberCounts.getOrDefault(number, 0) + 1);
        }

        // List to store the intersection elements
        List<Integer> intersectionList = new ArrayList<>();
        // Iterate over the second array to find common elements
        for (int number : nums2) {
            // If the current number is in the map and count is greater than 0
            if (numberCounts.getOrDefault(number, 0) > 0) {
                // Add the number to the intersection list
                intersectionList.add(number);
                // Decrement the count for the current number in the map
                numberCounts.put(number, numberCounts.get(number) - 1);
            }
        }

        // Convert the list of intersection elements to an array
        int[] result = new int[intersectionList.size()];
        for (int i = 0; i < result.length; ++i) {
            result[i] = intersectionList.get(i);
        }

        // Return the final array containing the intersection of both input arrays
        return result;
    }
}
```

C++ Solution

```
#include <vector>
#include <unordered_map>
using namespace std;

class Solution {
public:
    // Function to find the intersection of two arrays.
    vector<int> intersect(vector<int>& nums1, vector<int>& nums2) {
        // Create a hash map to store the frequency of each element in nums1.
        unordered_map<int, int> element_count_map;

        // Iterate over the first array (nums1)
        // and populate the map with the count of each element.
        for (int num : nums1) {
            ++element_count_map[num]; // Increment the count for the number.
        }

        // Create a vector to store the result (intersection elements).
        vector<int> intersection_result;

        // Iterate over the second array (nums2).
        for (int num : nums2) {
            // Check if the current number exists in the map (from nums1)
            // and it has a non-zero count, meaning it's a common element.
            if (element_count_map[num] > 0) {
                --element_count_map[num]; // Decrement the count.
                intersection_result.push_back(num); // Add to the intersection result.
            }
        }

        // Return the result of the intersection.
        return intersection_result;
    }
};
```

Typescript Solution

```
function intersect(nums1: number[], nums2: number[]): number[] {
    // Create a map to keep a count of each number in the first array
    const numberFrequencyMap = new Map<number, number>();

    // Populate the frequency map with the count of each number in nums1
    for (const number of nums1) {
        numberFrequencyMap.set(number, (numberFrequencyMap.get(number) ?? 0) + 1);
    }

    // Initialize an array to store the intersection
    const intersectionArray = [];

    // Iterate over the second array to find common elements
    for (const number of nums2) {
        // If the number is in the map and the count is not zero,
        // then add it to the intersection array
        if (numberFrequencyMap.has(number) && numberFrequencyMap.get(number) !== 0) {
            intersectionArray.push(number);
            // Decrease the count of the number in the map
            numberFrequencyMap.set(number, numberFrequencyMap.get(number) - 1);
        }
    }

    // Return the resultant array
    return intersectionArray;
}
```

Time and Space Complexity

Time Complexity

The time complexity of the given code can be analyzed in two parts:

1. Building a counter from `nums1` takes `O(n)` time, where `n` is the length of `nums1`, as each element is processed once.
2. Iterating over `nums2` and updating the counter takes `O(m)` time, where `m` is the length of `nums2`, as each element is processed once.

Hence, the overall time complexity is `O(n + m)`, where `n` is the length of `nums1` and `m` is the length of `nums2`.

Space Complexity

The space complexity of the code depends on the space used by the `counter` data structure:

1. The `counter` keeps track of elements from `nums1`, therefore it uses `O(n)` space, where `n` is the unique number of elements in `nums1`.
2. The `res` list contains the intersected elements. In the worst case, if all elements in `nums2` are present in `nums1`, it can take `O(min(n, m))` space, where `n` is the length of `nums1` and `m` is the length of `nums2`.

Taking both into account, the space complexity is `O(n + min(n, m))` which simplifies to `O(n)` as `min(n, m)` is bounded by `n`.

Overall, the space complexity of the code is `O(n)` where `n` represents the number of unique elements in `nums1`.