Find the Missing Number*

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Abstract: An equation may be used to factor a positive composite number.

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Contents

1. Introduction

Given an array of nature numbers staring from 1 to n, we are asked to find a missing number in this array. Implicitly, the array size is $n - 1$. The first question is that the array of numbers is sorted, how to design the program and give the complexity of the algorithm. The second question is what if the array is not sorted.

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2. Sorted Array

Algorithm 1 Find a missing number in an array of successive integers

```
input: array a with max index I_max, minimum index I_min.
output: an integer missed in the array of integers a.
u ⇐ I_max
l ⇐ I_min
ci ⇐ (u + l)/2, namely current index.
while (r = (a[ci] − a[l])) ≠ (ci − l) do
   if r = 0 then
      u = ci
   else
      l = ci
   end if
   if l = u − 1 then
      break
   end if
end while
return (a[u] + a[l])/2
```

From the 1, we can see this algorithm is a binary search. It is $O(logn)$.

3. Non Sorted Array

If the array is not sorted, Algorithm(1) is not applicable. A solution is to sum up the whole array. Then subtract it from $n(n+1)/2$. But to sum up an array with n numbers may not $O(n)$. The result can be $n(n+1)/2$. To represent $n(n+1)/2$, it will need $log(n(n+1)/2)$ bits. The space complexity is $O(n\ log\ n)$ and the time complexity is $O(n)$.
As a remedy, we take the following way to sum the numbers up. Suppose n is a even number, if not, add a one more element to the array, as we sum up the numbers, we add odd numbers and subtract even number then compare the result with $-n/2$. So the space complexity remains $O(n)$. If and only if there is exactly one number missing, the missing number is sum result minus $-n/2$.
There can be a bad case, for example, the first $n/4$ numbers are just the top biggest even numbers or all are top odd numbers. The space complexity can still be $O(n\ log\ n)$. We can overcome this by sampling the numbers. We can access the array by a multiple pass. For example, the first pass will access all elements that their index modulus a number is 0, then 1 etc. If we change the number we used for the modulus operation, the pattern to access the array will be changed greatly. So the chance for the bad cases to happen is very rare.

4. Discussion

This article is not peer reviewed. Neither are the methods tested and verified by concrete computer program. Discretion advised for serious readers.

References